The Human Factors Implications for Flight Safety of Recent Developments in the Airline Industry

A Research Study for the JAA

FINAL REPORT

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ABBREVIATIONS

ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
CRM	Crew Resource Management
EC	European Commission
EU	European Union
FMAQ	Flight Management Attitudes Questionnaire
FOQA	Flight Operation Quality Analysis
FTL	Flight Time Limitation
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
IMO	International Maritime Organisation
ISM	International Safety Management
JAA	Joint Aviation Authorities
JAR	Joint Aviation Requirement
QAR	Quick Access Recorder
SMS	Safety Management System
SOP	Standard Operating Procedure
US	United States of America

EXECUTIVE SUMMARY

Introduction

The Study was carried out during 2000, on behalf of the JAA, by a team led by Icon Consulting and including Human Reliability Associates, IATA Aviation & Research[1] and experienced pilots. The aim of the study is to consider the human factors implications of recent commercial developments in the airline industry and to assess their potential impact, if any, on flight-deck safety.

Approach

The overall approach was as follows:

- to investigate whether there is a theoretical possibility of commercial developments having a safety impact on the flight deck – it was concluded that there is a possibility;
- if there is a theoretical possibility, to identify whether the conditions exist for a safety impact to occur – it was concluded that the conditions do exist and that continuing changes in the industry are increasing the likelihood of their occurrence;
- if the conditions exist, to seek evidence on whether incidents are occurring as a consequence – relevant incidents were identified but it was concluded that there is insufficient evidence to link them directly to this cause
- and to identify any mitigating factors that could be used to reduce the threat – it was concluded that there are factors and that they should be enhanced to deal with this threat.

A wide range of people were consulted for the study, including airline management, management pilots, line pilots, safety regulators, an airframe manufacturer, a flight crew agency and pilots representative organisations. The airlines consulted included national, regional and cargo carriers, charter airlines and new entrants in the low-cost sector. The countries represent a broad cross-section of the whole of the JAA region and are not biased towards any one part of Europe.

All contributions to the study are confidential to the study team.

At the beginning of the study, the team reviewed commercial developments in the air transport industry and the published literature on possible human factors impacts. The following paragraphs provide a very short summary of the principal dimensions in which commercial developments potentially have a human factor impact.

Culture

The impacts of national, professional and organisational cultures were investigated.

A link between national culture and potential flight-deck behaviour was established. National differences were identified In the dimensions of Individualism-Collectivism (achieving individual desires as opposed to group harmony), Power Distance (relationship between subordinates and superiors) and Uncertainty Avoidance (tolerance to risk and uncertainty). These differences may result in different attitudes to following Standard Operating Procedures, to the use of automation and to relationships and management on the flight deck.

[1] IATA-AIR input was related to describing and analysing commercial trends in the industry

In terms of globalisation, therefore, flight deck crews composed of individuals from different cultural backgrounds might experience conflict in the dimensions identified.

The professional culture of the flight crew is strong. However, the satisfaction level achieved is largely determined by the organisations that they work for and the conditions under which they work. In addition, the sense of professional pride can result in an unrealistic denial of vulnerability to factors such as fatigue.

A link between a negative organisational culture and negative attitudes and behaviour was established which would not necessarily be mitigated by the high level of professionalism of flight crews.

Flight Deck Error

Researchers have recorded that errors were made on 68% of flights they observed, with an average of two errors per flight. Not all crew errors will lead to adverse consequences. This report identifies the types of error and their causes.

Direct causes of failures are primarily due to a breakdown in crew-related interactions such as decision-making, verbal communication, team organisation and workload distribution rather than a lack of technical proficiency. Team skills are, therefore, vital to a safe flight. The indirect or latent causes of failures can be due to inadequate training, supervision, resources or oversight, and faulty procedures and policies.

Commercial Developments

The report describes past, recent and possible future developments in the air transport industry, which have been motivated by deregulation, liberalisation and privatisation.

Alliances are formed partly to improve market access and partly to reduce cost. Cost reduction mechanisms include:

- Management contracts, leading to the reduction in the management head count of members;
- Joint ventures in areas such as ground handling and aircraft maintenance, which allow alliance members to enjoy the benefits of bulk purchasing from key suppliers;
- Sharing of facilities such as training, maintenance and aircraft spares; and
- Higher utilisation of aircraft.

Cost efficiency does not automatically mean a loss of safety, particularly as all carriers are subject to the same regulation. However, the emergence of numerous new entrant airlines, each of which requires specific regulatory effort, may stretch the resources of the regulators.

While previous airline mergers generally took place between airlines within the same country, mergers that cross national boundaries are becoming increasingly common. This is likely to give rise to a more complex mix of cultural factors to be dealt with by the new companies. Further mixing is likely to result from an increase in the number of pilots from the former Soviet Bloc seeking improved employment conditions in western airlines.

The growth of the low cost carriers has generated new demand for air travel, a new market sector, and new commercial pressures. Not all low cost carriers have survived and those that have face increased costs, not least because they now have to compete in the market place for the considerable number of pilots they require. Overall, they have contributed towards an increase in volatility in the employment of pilots.

The Effect of Commercial Developments

The consequences of recent developments have the potential to affect flight deck performance. Airline mergers and alliances will change the organisational culture in which individuals work, and this in turn may influence individual performance. They are likely, also, to increase the incidence of multi-national flight crew. As more flexibility is required of airline staff, effects such as changes in morale and increased fatigue may be seen.

Of all the potential problems arising from multinational flight crew, differences in language are an obvious concern and an increase in mixed language operations is likely to have a negative effect on safety. Language is also a social issue affecting both duty and off-duty time. Social interaction may help to reduce fatigue, maintain alertness between the crew and contribute to team working during flights. A lack of conversational or colloquial ability in a common language may have an adverse effect on interpersonal relations during off duty periods, which will reduce the likelihood of the crew building up a shared knowledge base and a shared set of assumptions about how the team should work together.

Other factors that are thought to cause difficulties are different religious beliefs, membership of different trade unions, different safety or CRM philosophies and concerns over flying skills and technical knowledge.

Commercial Pressure

In some instances there is strong pressure to increase flying hours up to the legal limits. Many airlines treat the legal limit as a performance target to be achieved if utilisation of flight crew is to be maximised and operational costs reduced. In addition, some airlines allow very little, if any, reduction in flying hours for management pilots, some with critical responsibilities such as flight safety.

Unsympathetic rostering increases fatigue, upsets sleep patterns, reduces morale and has a detrimental effect on the personal life of crew. In some cases this is combined with a reduced ratio of crew per aircraft, leading to a loss of flexibility and pressure to fly despite personal welfare.

Many pilots interviewed in a wide range of airlines observed that there is a tendency for business people with no flying experience to fill senior operational positions. Their concern was that these managers might not understand the implications of their decisions.

Training is an expensive activity and there is a fear that training budgets might be reduced to achieve cost savings.

Captains are increasingly being required to make economic decisions, which is often counter to their traditional role of safely flying the aircraft. There is sometimes a dilemma between safety and economics: a Captain has the responsibility for the safety of a flight but may be blamed by management if he or she is thought to have taken a commercially detrimental decision. If a pilot succumbs to commercial pressure and as a result is involved in an incident, he cannot, in law, defend his position by saying that the company pressured him to take the actions that he did. Some pilots find this dilemma difficult to resolve on a day to day basis.

Mitigating Factors

During the research, a number of factors that might mitigate the effects of globalisation were identified. These factors have been classified into three categories: CRM Training, Standard Operating Procedures (SOPs), and Professional Culture. Safety Regulation is also available as a controlling measure. The report identifies to what extent each category is likely to produce effective mitigation and whether other control measures can be brought to bear.

CRM training is the approach used within aviation to tackle issues of teamwork amongst flight crew. Whereas benefits have been claimed by the industry from the use of CRM, there is little hard evidence that CRM has a measurable effect on safety. There are particular concerns that behaviour in training sessions is not correlated with behaviour under real circumstances. In addition, CRM cannot deal with other causes of error such as fatigue, poor interfaces, cockpit automation issues and problems related to SOP quality and compliance.

The use of a standard, outsourced CRM "product" which has not been adapted for the particular culture in which it is applied, may also reduce its effectiveness. There appears to be no process in place in the industry to spread to others either the experience gained in developing appropriate CRM training or best practice.

The scope of CRM is being extended in some airlines. While the previous emphasis was on team-building skills and communications, other aspects are now being introduced such as monitoring skills and the management of time and workload. Some airlines run CRM training for mixed groups of cabin and flight deck crew and in one case also maintenance personnel.

However, there is a serious danger that CRM will be seen as the solution to all human factors issues in commercial aviation. This is reflected in the fact that the Human Factors Departments of airlines are often staffed by CRM specialists rather than by human factors professionals .

The emphasis on CRM may in some cases lead to a culture where all errors are considered to arise (and be contained) in the cockpit environment. However, many factors that may adversely influence flight safety originate, as in all other industries, from management and organisational failures that occur deeper in the system and are outside the control of individual flight crew members. High levels of flight crew training, experience or personal capability will not automatically mitigate the adverse effects of such factors.

The CRM industry is responding to changes due to globalisation and no doubt the more recent versions of such training will improve its effectiveness.

SOPs form the basis for the operation of the aircraft and it is thought by the whole industry that very few incidents would occur if SOPs were adhered to rigidly. However, it is clear that, in common with most safety critical industries, absolute compliance with the letter of all written procedures is not regarded as feasible. The extent of the non-compliance is influenced by the prevailing safety culture in the company. In addition, pilots who have experience of more than one set of procedures may inadvertently revert to a previously familiar procedure, particularly under conditions of duress. In a multicultural environment, a flight crew member's knowledge of an SOP may lead them to interpret ambiguous communications in terms of SOPs with which they are familiar.

Several airlines stressed the highly proceduralised nature of the flying task, claiming that procedures existed for every eventuality. However, crew working in highly proceduralised environments may encounter difficulties when faced with a situation that is not covered by a procedure. Furthermore, crew who normally use SOPs when working for an airline that strongly adheres to procedures may experience difficulties should they then operate in an airline which allows a greater degree of individual interpretation of SOPs.

Airline personnel display strong ownership towards their own SOPs. It would appear that new entrant airlines tend to adopt manufacturers' SOPs with little, if any, modification, whereas established airlines will often have adapted these SOPs quite considerably. Problems may arise if there are differences in the degree of compliance to SOPs by flight crew from different airlines.

Safety Regulators do not allow the operation of mixed SOPs within a single aircraft type under an AOC. Therefore, it would be difficult to mix crew within an alliance unless all partners of the alliance were using the same SOPs.

The **Professional Culture** in aviation is strong and distinctive and this is particularly apparent in the professional culture among pilots.

Flight crew were described as intelligent, although not necessarily formally educated, with a high degree of self-confidence. Strong self-discipline and self-motivation were said to be essential to cope with the working environment. Flight crew tend to be conservative in nature and are generally uncomfortable with change unless it is long term and gradual.

A strong professional culture has both strengths and weaknesses. On the positive side, pilots take great pride in their profession and have a strong motivation to perform to the best of their ability. On the negative side, there may be an unrealistic denial of vulnerability to factors such as fatigue, stress or personal issues. Given the great responsibility of pilots, this may be a psychological defence mechanism to avoid performance anxiety.

There is a danger that globalisation may degrade those aspects of professional culture that do act as a control mechanism. For example, the movement of crew between countries and companies may diminish the perception of a common identity.

Safety Regulation in Europe is not yet harmonised. Differences among member states mean that European airlines are not overseen by a coherent legal entity, unlike the situation in the US. Given that overall regulation is the remaining control mechanism to deal with conditions not controlled by the other three identified mitigating factors, this has to be a matter of concern to the JAA.

Some Regulators are taking a less active role in enforcing standards by allowing airlines to take greater responsibility for their own oversight by means of self-audits. However, it is apparently becoming increasingly difficult for airlines to recruit suitably experienced people as nominated post holders to carry out this important role.

Conclusions

The aviation industry in Europe is developing rapidly and a number of human factors effects that can arise from these commercial developments have been identified. Some of these effects have the potential to impact negatively on flight safety and this threat is likely to increase as the pace of commercial developments increases.

There is a belief in the industry that the control measures of CRM, SOPs and Professional Culture will mitigate these threats. This report suggests that these measures may not be fully effective in preventing or controlling the issues. An evaluation of the extent to which the three measures are thought to be effective is presented in the following table.

Human Factors Issue	Mitigation Effectiveness		
	CRM	SOPs	Professional culture
Team working / power gradient	Medium	Medium	Medium
Communication	Medium	Medium	Low
Fatigue	Low	Medium	Low
Morale and job satisfaction	None	Low	Low
Experience / competence	Medium	Medium	None
Situational awareness and mental models	Medium	Low	Medium

Tabulation of Human Factors Issues and Mitigating Factors

1. INTRODUCTION

1.1 BACKGROUND TO THE STUDY

The aim of this study is to consider the human factors implications for flight safety, if any, of recent commercial developments in the airline industry. In particular, the study focuses on recent tendencies for airlines to merge and form global alliances, and the growth in new entrants with different business models.

The functional reliability of aircraft has improved beyond all recognition over the course of the last century. This improvement, however, has drawn attention to the importance of the human element in determining system safety (David, 1997). It has been suggested that around 70% of aviation incidents and accidents are attributable to human errors on the flight deck (Foushee, 1984).

Hawkins (1993) states that, despite the low level of accidents per passenger carried, or hour flown, the current accident rate is still too high for the comfort of the public. The US Presidential Report (1998) states that if the current accident rate is maintained, the expected growth in air transport means that by 2015 there will be one major accident somewhere in the world each day, a situation which would be totally untenable. Therefore, the accident rate must be reduced to ensure that the total number of accidents per annum is no greater and, hopefully, lower than current figures. As a part of this improvement process, human factors issues need to be addressed.

The global nature of aviation means that issues of communication and interaction between cultures are of particular interest, perhaps more so than in any other industry, apart from international shipping (see Chapter 8). The constant drive for cheaper and more flexible travel may lead airlines to look further afield for their flight crews and to increase their use of multicultural crews.

However, it would be a mistake to assume that issues arising from differences in national cultures are the only or even the most important flight safety issue arising from commercial developments in the airline industry. Mergers between airlines also involve a merger of the individual cultures and practices that have existed in the previously independent companies.

To remain competitive, airlines will also seek more efficient and cheaper ways of doing business, which is likely to result in greater flexibility being required of flight crew and may increase their sense of commercial pressure. The rapid expansion in low-cost carriers and the future movement of flight crew between these airlines and more conventional carriers with very different company cultures may also have human factors implications.

1.2 SCOPE OF THE STUDY

The scope of the study is countries in the JAA area. No organisations were consulted from outside this area although, during the course of the study, some examples were provided of airlines based beyond the boundaries of the JAA that have experienced and resolved human factors issues that are relevant to this study. Some of these examples are referred to in this report.

The main thrust of the study has been in obtaining the views, concerns and experience of a variety of stakeholders in European aviation. Table 1 shows the sample of different types of organisation that were consulted by means of either a questionnaire or a face-to-face interview, and their geographic spread.

Organisation Type	Number Consulted	Countries Represented
Airline	21	14
Safety Regulator	4	4
Airframe Manufacturer	1	1
Flight Crew Agency	1	1
Pilot's Representative Assn.	1	Europe

Table 1: Dimensions of Representation in the Study

The airlines consulted include national, regional and cargo carriers, charter airlines, and new entrants in the low-cost sector. Airline managers, management pilots and line pilots were interviewed. The countries represent a broad cross section of the whole of the JAA region and are not biased towards any one part of Europe. To preserve confidentiality neither the organisations nor the countries are named.

It should be noted that in this report "flight crew" refers to all those members of the crew who work on the flight deck, including Captains, First Officers and Flight Engineers. It does not include cabin crew.

1.3 METHODOLOGY

To set the scene at the beginning of the study, two pieces of research were carried out:

- a review of significant historical and current developments in the structure of the air transport industry, together with a look at likely future developments; and
- a review of published literature relating to the professional culture of pilots, the mixing of national and organisational cultures, the management of culture on the flight deck and the causes of flight deck errors.

Using the output from this research, two questionnaires were developed to elicit relevant information from airlines. The first was a postal questionnaire that could be sent out to selected airlines to obtain some preliminary information. The second was a list of follow-up questions that could be used by members of the team in a face-to-face, structured interview. The interview questionnaire provided a framework for the meeting but was used flexibly to ensure that all matters relevant to the study could be pursued as they arose. The postal questionnaire appears in Appendix A, and the interview questionnaire in Appendix B.

These two questionnaires were particularly suitable for interviewing management and management pilots in airlines and a less structured approach was taken with line pilots and safety regulators. In particular, questions that were asked at meetings with regulators were based on issues that had already emerged from the airline interviews.

Much of the content of the main part of this report is derived from an analysis of the information collected at meetings and from questionnaires.

The human factors issues identified are not only being experienced in the aviation industry but also occur in other safety critical industries where globalisation is taking place. The study team has used its prior experience of the marine industry to compare it with aviation to determine if there are lessons that can be learnt.

1.4 LAYOUT OF REPORT

Chapter 2 puts the remainder of this report into context by reviewing previous work that has been carried out on cultural factors in aviation. It discusses three types of culture: professional, organisational and national; and explores how flight crew attitudes are influenced by these cultures. It also considers how cultural issues might be managed on the flight deck.

Chapter 3 reviews different types and causes of human error on the flight deck. It provides a framework model of flight deck error based on the acquisition of information, the sharing of this information between the flight crew, and its use for decision making. A summary table is provided to illustrate the type of error that can occur during each stage of the framework and relates each error type to possible cultural causes.

Chapter 4 highlights some of the significant historic and current structural changes in the air transport industry of particular relevance to this study. It considers the effects of deregulation, its impact on different types of carrier, the rapid growth in global airline alliances and the emergence of low-cost carriers.

Chapters 5 to 7 are based on the results of the interviews.

Chapter 5 describes the primary results of the survey in terms of the effects arising from the commercial developments described in Chapter 4 that have human factors implications which have a bearing on flight deck errors. Three separate effects are identified:

- Multicultural flight crews;
- The merging of company cultures; and
- Commercial pressure.

For each effect, the human factors issues and their potential consequences for flight safety are identified.

Chapter 6 considers the factors that could mitigate the adverse effects of the potential human factors problem areas that have been identified. These mitigating factors are:

- Crew resource management (CRM);
- Standard operating procedures (SOPs); and
- Professional culture.

A number of issues are raised with respect to each mitigating factor and their potential consequences are identified. The chapter concludes with a discussion of the role of safety regulation.

Chapter 7 discusses several recurring human factors issues that have been identified in previous chapters as influencing the likelihood of flight deck errors. These issues are:

- Team working;
- Communication;
- Fatigue;
- Morale and job satisfaction;
- Experience and competence; and
- Situational awareness.

Safety auditing and internal oversight is also considered.

These issues are evaluated in terms of the extent to which their negative effects will be reduced by the mitigating factors of CRM, SOPs and Professional Culture. A summary table assesses their relative effectiveness in terms of their impact on each of the human factors issues.

Chapter 8 summarises the similarities and differences between aviation and the marine industry and considers whether there are any areas where aviation might learn from shipping. A more detailed discussion is provided in Appendix D.

Chapter 9 considers different approaches that are taken to human factors in other safety critical industries and draws together some lessons that could be learnt by the aviation industry.

Chapter 10 summarises the overall findings and conclusions of the previous chapters and Chapter 11 contains some recommendations.

2. CULTURE

Merritt & Helmreich (1995) define culture as "the values, beliefs and behaviours that we share with others that help us define a group, especially in relation to other groups". Individuals can be members of any number of groups, defined by a wide range of values, beliefs and behaviours. For example, a 40-year old, female pilot who works for a regional airline and lives in Madrid is a member of several different cultures. These different cultures defined by age, gender, organisation and location, will all affect a person's conduct at work.

Helmreich & Wilhelm (1997) identify three main cultural groups that need concern researchers in this field; professional, organisational and national cultures.

2.1 PROFESSIONAL CULTURE

Pilots, like many other professions with a strong professional culture, such as medicine, place great value on their work. Helmreich and Merritt (1998) report that pilots describe a greater liking for their job than probably any other profession. They go on to stress, however, that this liking for the job does not mean they are completely satisfied with their working conditions. The organisations that they work for and the conditions under which they work largely determine this satisfaction level.

There are undoubted benefits in individuals taking pride in the work that they do and striving to live up to the reputation that a profession has developed. However, this sense of professional pride can result in an unrealistic denial of vulnerability to factors such as fatigue (see Section 6.3.2).

2.2 ORGANISATIONAL CULTURE

The majority of the research examining the influence of culture on aviation has focussed on international cultural differences; in particular, how they may pose a threat to the safety of aircraft staffed by multicultural crews. However, Merritt & Ratwatte (1997) query whether there is such a thing as a mono-cultural crew. They suggest that airline mergers and the movement of pilots between airlines always result in intra-crew cultural differences. However, these cultural concerns are not national but organisational. Pilots may not be fully aware of the differences in Standard Operating Procedures (SOPs) between their new and previous companies or, if they are aware, they may revert to the SOPs used in a previous company when distracted or under stress (referred to as strong stereotype takeover) or due to personal preference. This is just one example of an organisational cultural issue.

2.2.1 The effect of organisational culture upon safety

There is an extensive literature that reports a link between the strength of organisational culture and organisational performance. Helmreich & Merritt (1998) review the area and conclude that the level of coherence and stability of views held within an organisation define a strong unified culture. They suggest that it does not particularly matter what these views are, only that they are held by the whole organisation. As an example they compare British Airways and Virgin Atlantic, two successful airlines with markedly different organisational cultures.

In terms of this study, however, the important issue is whether organisational factors can affect safety. Helmreich & Merritt (1998) compared two American airlines with this issue in mind. In the first airline 87% of pilots agreed that morale was high, compared with only 3% in the second. The second airline's pilots were cynical about the motives of management, and only 12% agreed with the statement 'management never compromises safety for profit'. Perhaps the most important response, however, was to the statement 'crews I fly with adhere to standard operating procedures'; 93% concurred with this statement in the first airline, compared with only 73% in the second. This latter finding indicates an important link between attitudes and behaviour, and

implies that the high level of professionalism of pilots may not make them immune from the influence of a negative organisational culture, in this case reflected by the degree of compliance with SOPs.

The European aviation industry has undergone considerable organisational change over the last 15 years; liberalisation of airlines has followed changes in the Regulatory climate, making it easier for new entrant carriers to commence operations. The increased competition has resulted in continuing downward pressure on revenue yields and consequent business re-organisation. A report commissioned by the UK's Health and Safety Executive into business re-engineering and its effects upon health and safety management (HSE, 1996), found very little firm evidence to support the hypothesis that business re-engineering negatively impacts upon occupational health and safety. They were, however, able to cite examples where re-organisation had contributed to major systems accidents. Equally, however, occupational accident statistics had generally improved during the period examined, despite individual setbacks. They did find that re-organisation could be a major source of stress in individuals and consequently could negatively influence job satisfaction. They concluded that re-organisation is a stressful process, that its effect upon safety can be both positive and negative (depending on the nature of the re-organisation and the sensitivity with which it is conducted). However, it is difficult to be more specific due to the lack of research evidence in this field.

Many people would consider safety culture to be an aspect of organisational culture. Helmreich & Wilhelm (1997), however, argue that the extremely safety critical nature of aviation means that it warrants individual consideration. They suggest that the trade-offs that an organisation is willing to make between increased productivity and safety concerns is the principal measure by which employees gauge the extent of that organisation's commitment to safety.

2.3 NATIONAL CULTURE

2.3.1 Hofstede's cultural dimensions

One of the most influential individuals in the field of cultural variation is the Dutch engineer and social scientist, Geert Hofstede (Merritt, 1997). Hofstede, using questionnaire data from 80,000 IBM employees in 66 countries across seven occupations, established four dimensions of national culture (Hofstede, 1980, 1991):

- Individualism-Collectivism
- Power Distance
- Uncertainty Avoidance
- Masculinity-Femininity

Merritt (1997) attempted to replicate Hofstede's survey using commercial pilots. She found that all of Hofstede's dimensions could be found within the pilot sample with the exception of 'masculinity-femininity'. This dimension is linked with achievement and the value placed upon it. Merritt suggested that this dimension was absent because aviation is already a financially rewarding profession and, therefore, has little concern for masculine traits such as 'the opportunity for high earnings'.

The other dimensions are discussed below:

Individualism/Collectivism

This relates to the extent to which people are supposed to take care of themselves and be emotionally independent from others. A highly individual culture is one that is characterised by egalitarian relationships, social interaction is conceptualised in terms of costs, rewards and outcomes and self-sufficiency is valued. A collective culture values loyalty to and harmony within the group, and conceptualises resources, responsibilities and outcomes as shared. There is a

powerful motivation in trying not to disgrace the extended group, as mistakes and failure are blamed upon the whole group. Merritt found evidence for the existence of this dimension in pilots, but found more individualism and less difference between countries than would be expected in the general population. She suggests that individualists self-selecting into aviation may cause this difference. This was the only dimension to show higher, more convergent scores than those reported in Hofstede's study, and may illustrate why pilots are perceived to have similar values worldwide.

Power Distance

This is the extent to which a culture accepts that power is distributed unequally among the members of a group and the extent to which the decisions of power holders are challenged. Low power distance implies limited dependence of a subordinate on a superior and a preference for consultation. Subordinates are comfortable in approaching their superiors and challenging them when necessary. In contrast, high power distance implies considerable dependence of subordinates on their superiors, with subordinates unlikely to approach their superiors and superiors unlikely to consult their subordinates. These patterns of dependence pervade all human interaction.

Uncertainty Avoidance

This is the extent to which members of a culture feel uncomfortable with risk and uncertainty. A culture with high uncertainty avoidance will often attempt to avoid uncertainty by establishing more structure within an environment by means of rules and procedures. Cultures that have low uncertainty avoidance are likely to accept and encourage dissenting views and try new experiences. Interestingly, Merritt found that cultures that believe strongly in the importance of rules and procedures are also strong advocates of automation.

Hofstede's classification provides a useful framework for examining culture in aviation. This area is one that has been addressed by several researchers, using Hofstede's dimensions (Anca et al. 1996; Merritt, 1993; Merritt & Helmreich, 1995). As an example, they suggest that a typical Asian flight crew (which will usually be collective and have a high power distance) will place great emphasis on maintaining group harmony. Conversation will be characteristically discrete and elaborate, and seek to avoid conflict; the focus will be on the 'social process'. In contrast, a typical Western flight crew, (individual and low power distance), will place emphasis upon 'social product'. Here, therefore, conversation will be succinct, personal and instrumental.

If these dimensions can be used to describe the cultural aspects of an individual's personality, then there may be implications for the selection, training and mixing of flight crews. This is particularly the case if it could be shown that certain scores on these dimensions are predictive of friction between individuals.

However, care must be taken in using the results of these surveys. For example, by using nationality as the unit of analysis, there is a danger of reducing complex social interactions to simple stereotypes.

2.3.2 The influence of national culture on flight crew attitudes

Since Hofstede's classifications were derived from studies using IBM employees in the late 1960's and early 1970's, they may not necessarily apply to flight crew. As Merritt (1997) states, with regard to pilots:

> *"These pilots are typically at the technological and modernised forefront of their countries' workforce - many are trained or travel overseas as part of their jobs - and it seems likely that pilots working in such a regulated high technology environment might transcend national influences in favour of a universal standard of behaviour."*

Merritt & Ratwatte (1997) even question whether a multicultural flight crew is a hazard. They suggest that it may reduce complacency, forcing pilots to adhere to the best CRM (Crew Resource Management) practices, which may not be the case in a mono-cultural environment. They also postulate that communications need to be precise and unambiguous to ensure understanding, and that, after a while, this precision becomes the norm rather than the exception, thus improving system safety.

To ascertain exactly where flight crew attitudes converge and diverge with respect to nationality, Helmreich et al (1996) used a survey tool, the 'Flight Management Attitudes Questionnaire' (FMAQ). The questionnaire was designed to examine attitudes and values of pilots. They collected data from more than 13,000 pilots in 25 airlines, in 16 countries. They found considerable consistency of attitudes in some areas and great variability in others. The attitudes that were universally endorsed by pilots were:

- Good communication and crew co-ordination are as important as technical proficiency for the safety of flight;
- The Captain's responsibilities include co-ordination between cockpit and crews;
- The pre-flight briefing is important for safety and effective crew management;
- The pilot flying the aircraft should verbalise plans…and be sure the information is understood and acknowledged;
- Pilots should monitor each other for signs of stress and fatigue.

These findings indicate that all pilots, worldwide, agree about the importance of safety in aviation. However, the results in Table 2 demonstrate that there are areas, like command interactions and attitudes to rules and restrictions, that differ significantly across nations. The authors do not give the distribution of these scores.

Statement	Range of national responses agreeing	
	Lowest national response	Highest national response
Crew members should not question the decisions or actions of the Captain except where they threaten the safety of the flight	15%	93%
If I perceive a problem with the flight, I will speak up, regardless of who might be affected	36%	98%
Written procedures are required for all in-flight situations	15%	84%
The organisation's rules should not be broken – even where the employee thinks it is in the company's best interests	22%	76%

Table 2: Culturally Variable Pilot Attitudes - Across 16 Countries (After Helmreich)

Differing attitudes to flight crew interactions

Command interactions on the flight deck are vital to flight safety. The next example illustrates an extreme case of how serious differences in attitude can affect flight safety.

On the 13th January 1977, a Japan Airlines DC-8 crashed shortly after take off from Anchorage International Airport, Alaska. The aircraft was flown by a 53 year-old American pilot with 23,000 hours flying experience; his Japanese co-pilot was a 31 year-old with 1,600 hours experience. The Captain was found to be more than three times over the legal alcohol limit for driving a car.

Example 1: Anchorage, Alaska 1977

It is difficult to know exactly what happened on this flight. However, it seems likely that the crash was a partial consequence of the co-pilot's perception of the command relationships on the flight deck. Stereotypically, an American culture would be low power distance and individualistic, whereas Japan has a culture that has high power distance and is collective in nature. In this particular situation, the Captain was far senior to the co-pilot who would have been conscious of his role within the cockpit. The co-pilot may well have questioned the Captain but it would have been in a discreet manner, mindful of preserving working relationships when a more assertive challenge was required given the intoxicated state of the Captain.

Differing attitudes to standard operating procedures (SOPs)

Difference in attitudes to SOPs can have an effect on aviation safety. The example below again gives an extreme example of the potential consequences of these differences:

An investigation into the 1987 Detroit MD-80 accident revealed that the taxi checklist had not been completed. The aircraft took off without flaps or slats and 156 passengers and crew were killed. The airline had a history of a lack of checklist discipline (Hawkins, 1993)

Example 2: Detroit 1987

Differing attitudes to automation

Sherman & Helmreich (1995), again using the FMAQ, report that pilot attitudes to automation are affected by three main factors:

- National culture
- Time spent flying automated aircraft
- Seniority of crew member

National culture was the most important of these, responsible for considerably more diversity of response in the acceptability of automation than any other tested factor. In general, cultures that scored highly in terms of power distance tended to be more accepting of automation. The authors speculate that this may be due to an acceptance of automation as a highly competent authority, endorsed by the company.

In addition, pilots that flew automated aircraft exhibited a slightly more positive attitude toward automation than others, and there were some differences between the attitudes of senior pilots and less experienced co-pilots. Junior officers tended to endorse pilot discretion and scored more highly on automation concern.

The authors speculate that members of both low and high power distance cultures may characterise automation as an 'electronic crew member'. Low power distance cultures see authority without question as a bad thing and are consequently suspicious of automation. Conversely, high power distance cultures see automation as being endorsed by their organisation and hence something to be trusted.

2.4 MANAGING CULTURAL ISSUES ON THE FLIGHT DECK

CRM (Crew Resource Management) training is the approach that is used within aviation to tackle issues of teamwork amongst all those individuals involved in the execution of the flight. CRM has existed in many guises, its main aim being to tackle human error through training individuals in effective team working. One criticism of CRM, based on the experience of airlines employing multicultural flight crew, is that it does not travel well between different cultures. A representative of the International Civil Aviation Organisation (ICAO) has observed, "CRM is based on social psychology. This school of thought is scarcely known outside North America; yet CRM has been accepted as gospel by the international aviation community without cultural adaptation" (Maurino, 1993, cited in Kaplan, 1995).

Helmreich et al (1996) suggest one possible reason for this, using their exhaustive studies of international cultural differences. Namely, that no one culture is exactly congruent with the underlying principles of CRM. One can illustrate this by taking one of Hofstede's dimensions, uncertainty avoidance (UA). High UA scores suggest that an individual will be meticulous in his or her adherence to SOPs, a good thing. However, a second individual who comes from a low UA culture, will feel less threatened by novel situations and be more able to make effective decisions than the first individual. Both of these attributes are desirable, depending upon the situation, but it is difficult for one individual to possess both.

A further complication occurs when one considers the interaction between Hofstede's dimensions within an individual. For example, a low power distance score (as characterised by a Western crew) would be considered a desirable attribute in CRM, as such relationships facilitate open and frank idea sharing, an important aspect of good crew decision-making (Orasanu et al. 1997). However, this is likely to be tempered in a Western crew by high individualism/low collectivism scores. Information sharing, and the construction of shared plans, will be easier in a culture with low individualism/high collectivism scores.

In terms of globalisation, therefore, flight deck crews composed of individuals from different cultural backgrounds might experience conflict in these dimensions. Whilst it is unlikely that any one nation has the optimum cultural values for good CRM, at least mono-cultural flight deck crews are made up of individuals pulling in the same direction. As an example, a flight deck consisting of individuals from a high Power Distance culture will be accepting of the high power distance between Captain and co-pilot, even though CRM principles suggest this is a bad thing. When a low Power Distance co-pilot is introduced into this environment, the first time he or she challenges a decision or even uses the first name of the Captain, a conflict situation could arise.

There have been attempts to design CRM training programmes that tackle these issues. Orasanu et al. (1997, citing Merritt, 1995), describe a CRM programme tailored to a high power distance/collectivist culture. To overcome the possible communication difficulties that may occur in this sort of culture the crew is represented as a family business. In the role-playing process, the Captain is the head of the business and the co-pilot is his elder son who will one day inherit everything. The premise is that the Captain will be more accepting of a questioning co-pilot if he thinks of him in these terms. In addition, the co-pilot is requested to think of the pilot as a close friend, in an attempt to stimulate a questioning attitude.

Helmreich et al (1996) propose a new generation of CRM that has, as its clearly defined objective: the 'management of human error'. They suggest that this focus has several benefits. Firstly, it moves away from a blame culture and recognises that human error is something that is likely to occur. This, in turn, fosters an environment that enables open reporting systems to be put in place, and active efforts made to reduce error-producing conditions. This type of model of CRM facilitates the consideration of cultural issues.

This model allows Captains from a collectivist culture to accept suggestions from junior co-pilots, as they are able to appreciate that the suggestion is not a threat to authority, but an attempt to preserve the integrity of the organisation. Individualists can feel more at ease relying upon the team unit to manage safety, as the organisation promotes the view that individual errors are possible and not necessarily blameworthy.

2.5 CONCLUSIONS

The discussion of culture suggests that the consequences of recent developments in the airline industry have the potential to affect flight deck performance. Airline mergers and alliances will change the organisational culture in which individuals work, and this in turn may influence individual performance. As more flexibility is required of airline staff, effects such as changes in morale and increased fatigue may be seen. Finally, increased communications errors could arise if globalisation and the introduction of the common European Flight Crew Licence result in the greater use of multinational flight crews, since this could lead to conflicting expectations regarding the power distance relationship held by different members of the flight crew.

All these potential issues have been tested against the experience and opinion of flight crew, airline management and Regulators. The results are described in Chapter 5.

3. ERRORS ARISING FROM THE PERFORMANCE OF TEAM TASKS

3.1 INTRODUCTION

Researchers at the University of Texas Human Factors Research Project have reported that errors were made on 68% of a large number of flights that they observed, with an average of two errors per flight. Helmreich, who led the Texas Project, defines flight crew error as:

> *"Action or inaction that leads to deviation from organisational expectations or crew intentions."*

However, not all crew errors will lead to adverse consequences. Errors are normally recovered by the person who made the error, another flight crew member or ground support personnel such as ATC. Helmreich (1998) defines error management as:

> *"'The process of correcting an error before it becomes consequential to safety."*

The first section in this chapter provides a framework model of flight deck error based upon the acquisition of information, the sharing of this information between the flight deck crew, and its use for group decision making. In subsequent sections, each of these stages is described in more detail, and the factors that affect the likelihood of error at each stage are evaluated. Finally, the results are summarised in terms of the factors that affect each stage.

To gain an insight into the types of flight deck errors that teams can make, we will use a simplified model of the stages in *normal* performance of team tasks. These stages are loosely based on Rasmussen's (1982) model of the information processes underlying decision-making:

- **Information acquisition:** Detection and collection of significant information.
- **Information sharing**: Imparting information to enable a shared understanding of a situation to be established.
- **Decision-making**: Interpreting the meaning of the information and developing a plan or strategy for action. This will often require Standard Operating Procedures (SOPs) to be followed, either by the use of external checklists or procedures memorised from training.
- **Action**: Executing the chosen course of action.

Both pilots on the flight deck will engage in each of these processes to a greater or lesser extent whilst performing a team task. Their roles will depend on which of them has been designated, at a particular stage of a flight, as 'pilot flying' (PF) and which of them 'pilot not flying' (PNF). For example, the PNF may *monito*r certain equipment and *pass on* any information to the PF who will make a *decision,* which the PNF may be asked to *execute*. The interactions of the two pilots at the stages of their independent information processing systems are illustrated diagrammatically in Figure 1.

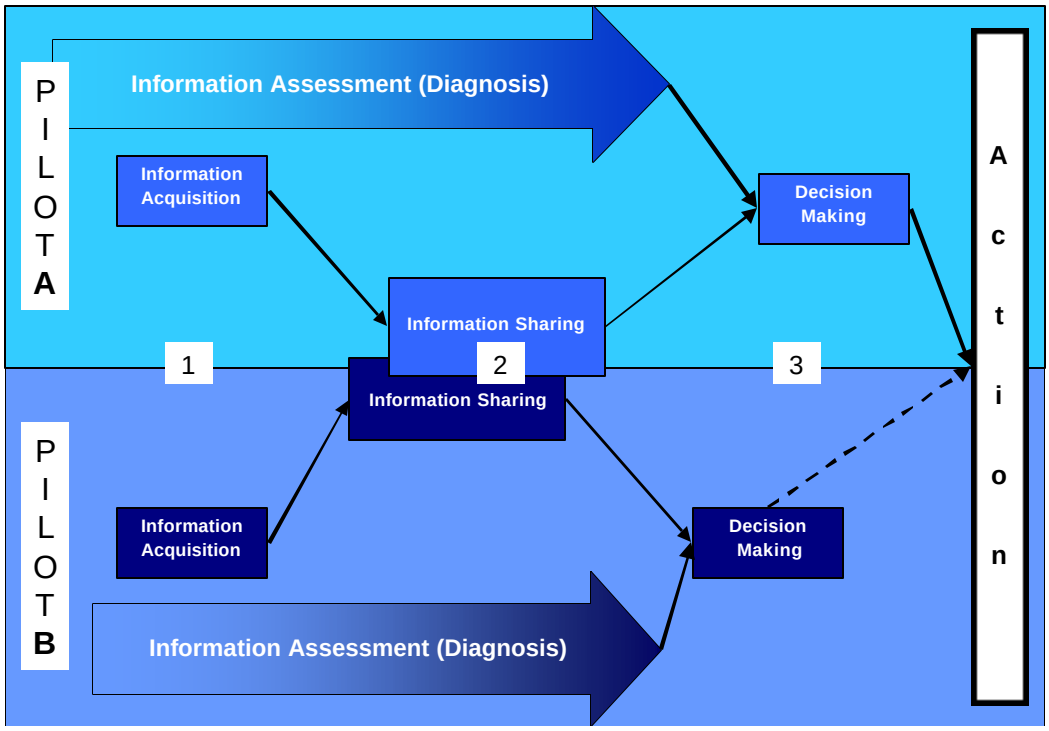

Figure 1: Characterisation of Flight Deck Interaction

The stages of information acquisition, information sharing and decision-making (including information assessment) and the factors that are known to affect error causation will be discussed in the following sections. Some factors that affect errors on the flight deck may not be altered by the changes associated with globalisation and mergers. For example, errors that are influenced by the design of the cockpit human machine interfaces will not be expected to change, as long as the pilots have received appropriate conversion training if the results of the commercial developments involve an aircraft change. The factors that are expected to be susceptible to changes due to globalisation will be highlighted in more detail. The action stage in the model has not been considered in this report because most flight deck errors have been shown to be due to crew related phenomena not technical proficiency, and this is unlikely to be affected by globalisation.

3.2 INFORMATION ACQUISITION

Complete and accurate information is critical for correct task performance in any environment. The information that flight crews acquire to aid them in performing their tasks comes from a number of sources, e.g. flight deck displays, external environment, SOPs, ATC and cabin crew. The latter two sources of information may also be considered under the information sharing section of the model, as they involve interaction, but are outside the scope of this study.

3.2.1 Information from Cockpit Displays

Information extraction from flight deck equipment is a skill that is developed through training and experience. This technical proficiency is largely beyond the scope of this study. However, errors arising from the automated component of flight deck equipment will be considered due to the link between attitudes to automation and national culture described in previous sections. A recent study has identified two classes of error that commonly emerge on automated flight decks (Mosier et al 1998).

- Omission errors – failures to respond to system irregularities.

- Commission errors – incorrectly following an automated directive without verifying it against other information or in spite of other contra-indications from other sources of information.

It is hypothesised that these errors are due to automation bias – the use of automation as a replacement for actively seeking information. In Klinect et al's (1999) study, 65% of automation errors were associated with failures to cross-verify settings rather than incorrect switch settings or execution modes (21%). Laboratory attempts to reduce automation bias through training have not been successful (Mosier et al, 1998). This bias may be connected to the finding that acceptance and perception of automation varies greatly across cultures. It is, however, difficult to anticipate how the interaction between two different attitudes to automation might affect performance at the information acquisition stage.

The acquisition of information from cockpit technology may be hampered by the number of aircraft types that a pilot may be required to fly. Wise et al. (1993) cite a report stating that corporate pilots will maintain the capability to fly at least two different aircraft types. They suggest that the potential for performance degradation in these situations is high, due to different software systems used to operate different aircraft. This might become an issue if globalisation was to result in a requirement for pilots to be qualified to fly two or more aircraft types. However, no evidence has been found in this study to indicate that this might be an outcome of globalisation and current practice is generally for pilots to operate aircraft that have identical or very similar flight decks, e.g. B.757/B.767 or many of the Airbus types.

A crucial factor that can have an impact on gathering information from flight deck equipment is the level of pilot vigilance. The nature of the aviation industry often means non-standard and altered work schedules and disturbances in circadian rhythms. Fatigue is widely recognised as an important factor leading to decreases in vigilance, and regularly features in incident reports (Rosekind, 1994). Considerable research has been conducted in this area. Pilot fatigue levels may well be influenced by organisational changes. If globalisation means that pilots are required to be more flexible, this could result in a greater number of fatigued pilots flying, thereby affecting vigilance levels and quality of equipment monitoring.

3.2.2 Information from Standard Operating Procedures

Checklists and other operating procedures act as a guide to ensure that relevant information is checked and verified. The intent is to provide guidance to pilots and ensure a safe, efficient and predictable (standardised) means of carrying out tasks.

Different airlines normally have different SOPs that reflect the manner in which operational management intends to have various tasks carried out. When the way of performing tasks is quite different between airlines then the quality of the re-adjustment training to a new company's way of doing things is obviously important. Firstly, differences in the structure and layout of different company procedures can lead to problems in acquiring information.

Differences in procedures are especially important if there are differences in roles and responsibilities for gathering information. Some responsibilities on the flight deck remain fixed with team member status but others change with role assignment changes. The role of pilot flying (PF) and pilot-not-flying (PNF) normally changes on every leg of a journey, or on a day-by-day basis. Team member assignment affects the degree of attention that different flight crew members pay to different information sources, and the assignment of responsibility to make decisions and monitor them (Bowers, et al 1995). Critical information may not be gathered due to an assumption by one crew member that it is the responsibility of the other to check and verify. However, this practice has been common for many years and the roles of both PF and PNF are taught very carefully.

3.3 INFORMATION SHARING

3.3.1 Purpose of Sharing Information

The objective of the information sharing stage is to enable a shared understanding (or mental model) of a situation to be established. The concept of shared mental models has been proposed as a means of explaining co-ordinated performance in teams (Stout et al 1997). Through teamwork, crews develop shared understanding of the nature of problems, solution strategies, cue significance and participants roles and responsibilities. Shared mental models assure that all participants are solving the same problem and create a context in which all can contribute efficiently (Orasanu, 1991).

This stage is central to any team activity. Communication is the primary means by which individuals develop and co-ordinate activities in order to achieve goals. Therefore, communication can be seen as the mediator of team processes (Helmreich & Foushee, 1989). Over 70% of reports made to the U.S. Confidential Air Safety Reporting System (ASRS) are related to communication problems (Billings & Cheaney, 1981; Connell, 1995). Language on the flight deck is used to issue commands, state intentions, acknowledge information, ask questions and convey information. Kanki (1996) has divided communication acts that occur on the flight deck into:

- Procedural speech - adherence to regulations, policies and protocol. Routine communication required to fly the aircraft which is highly formulaic and shows little deviation from crew to crew within in an airline.
- Task-related speech – firstly, resource management during routine flight conditions e.g. managing time and co-ordinating actions on the flight deck and with ATC. Secondly, meta-cognitive problem solving talk during abnormal conditions e.g. specifying what the problem is and how to go about solving it.

Previous NASA research (Foushee & Manos, 1981) has found that on flight decks where information sharing is good (e.g. high numbers of crew observations about flight status, statements of intent to perform actions, acknowledgements of others messages and verbal agreements) fewer crew errors occurred. During low workload periods captains and co-pilots in effective teams tend to engage in more planning behaviours articulating their plans and strategies. In situations of high workload, co-pilots increase the amount of information provided in advance, thus reducing the Captain's need to request information (Orasanu, 1990).

Crews experiencing high workload were found to share similar communication patterns regardless of whether or not they had flown together before (Kanki et al, 1991). It is suggested that a standardised communication pattern increases the extent to which flight crew can predict each other's actions.

The next sections will examine the following two types of communication failure:

- Failure to share information: the sender does not realise the need for communication or does not actively participate in communication
- Misinterpretation of information: the sender's message is not intelligible for the receiver or the receiver decodes a message accurately but misinterpret the meaning. This causes an illusory understanding and reduces the probability of recovery via a re-send request.

3.3.2 Failure to Share Information

Social impediments

A crucial factor that can affect information sharing is the command structure that exists on the flight deck. The Captain remains largely responsible for the flight and makes any *major* strategic and tactical decisions regardless of whether they are the PF or the PNF. While one person may

have ultimate responsibility for decision-making and the overall safety of the flight, team members can provide critical redundancy. In addition to performing their own tasks, team members support each other by monitoring the situation and the performance of others. This 'cross-monitoring' allows 'primary errors' (procedural, technical or decision errors) to be picked up and rectified before they cause undesirable outcomes (Ruffell-Smith, 1979). Observers in Klinect et al's (1999) study suggested that flight crew members verbalising pertinent information and challenging others actions and decisions were vital factors in the management of error.

Unfortunately, this ideal is not always attained and failures to notice or react can cause 'secondary errors':

- Monitoring failures – failure to detect the primary error or problem.
- Challenging failures – failure to act effectively to mitigate the error (sometimes referred to as assertiveness failures).

Reviews of accidents and incidents indicate that the Captain usually commits the primary error and the first officer usually fails to catch or correct it (NTSB, 1994; Jentsch et al 1997). In Klinect et al's (1999) naturalistic study, 53% of responses to primary errors were failures to respond. These errors are significant as they often represent the last opportunity to break the chain of events that lead to an accident. Failure to challenge a questionable decision or action taken by another crew member may occur due to choice or pressure not to say anything.

On the flight deck, the Captain has the responsibility for the flight and is effectively the senior member or leader of the team. The relationship or command structure between the Captain and co-pilot is referred to as the 'trans-cockpit authority gradient' (Edwards, 1975). Figure 2 illustrates the different gradient relationships that may occur between a Captain (C) and his co-pilot (CP).

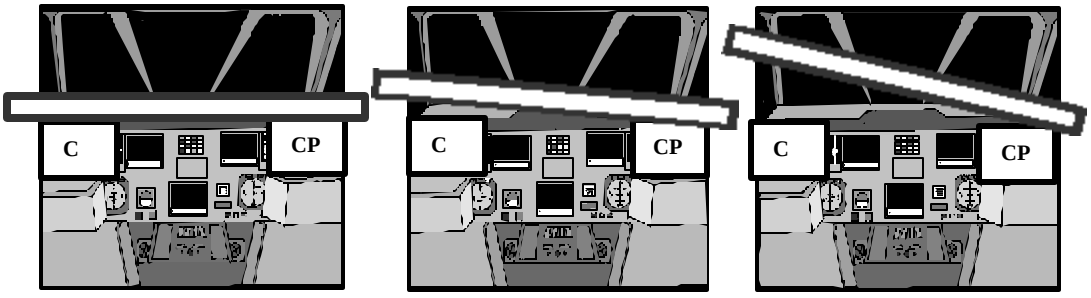

Figure 2: The Trans-Cockpit Authority Gradient

Essentially, the angle of the slope describes the power relationship between the two individuals. A too flat cockpit gradient implies that the Captain is adopting a weak leadership role with a consequent lack of authority. A too steep gradient may result in the co-pilot feeling unable to question any of the Captain's actions or decisions.

Research has found that the degree of challenge to the status or integrity of the challenged person will affect the likelihood of individuals making suggestions (Brown & Levinson, 1987; Jentsch et al 1997). For example, if the primary error has originated from the Captain's actions, or inaction, then calling attention to it involves a higher degree of face threat than if the primary error has occurred due to a problem outside the Captain's control (weather or traffic). The other factor that affects this cross monitoring is the trans-cockpit authority gradient or the power relationship of team members on the flight deck. The effectiveness of the cross monitoring by the crew team member depends on the response that the query generates.

National culture also has an impact on leadership and command structures. It is known that different cultures have different attitudes to power distance that will affect the cockpit authority gradient. For example, a co-pilot who comes from a high power distance culture may not provide

the level of information that a Captain from a low power distance culture would expect. In terms of safety, the influence of these expectation mismatches may range from a frosty cockpit atmosphere to poor teamwork and poor information sharing in an emergency. This issue is discussed in more detail in the section on culture in Chapter 2.

Knowledge impediments

It was mentioned in sub-section 3.2.2 that different companies might specify different roles and responsibilities for gathering information. SOPs can be used to dictate what should be said, when and by whom on a flight deck (Orasanu et al. 1997). If globalisation means companies merge procedures, training issues will arise. A pilot not familiar with a new company and their SOPs, for example, may not verbalise certain important information that he or she possesses. This will cause problems if the other flight crew members assume non-verbalisation means that the relevant information is not available or is not an issue.

3.3.3 Misinterpretations

Language usage

In this section, communication is discussed in terms of language usage. English is the standard language of aviation and language is an obvious area in which globalisation and multiculturalism may affect the flight deck.

The quality of information transfer is critical to a successful cockpit environment (Orasanu et al, 1997). Much research has been conducted on the problems involving flight deck and ATC communications. The information sharing process that occurs in this interaction is similar in many ways to the sharing of information between the two pilots on the flight deck. In addition, a great deal of the research with ATC involves interactions between participants of different national cultures. It is possible, therefore, to learn a lot about the possible impact of mixed national crews from research in this area.

In a recent study by Orasanu et al (1997) investigators took a random sample of 100 reports made in ASRS and searched for the terms ‘culture’ and ‘communication’. They also examined 60 reports that dealt with communication problems from the IATA database. Table 3 shows the results of this study.

Language Category	ASRS (U.S.)	IATA (International)
Language / accent	47	5
Partial readback	24	8
Dual language switching	23	2
Unfamiliar terminology	17	4
Speech acts	12	0
False assumptions	9	23
Homophony	7	1
Unclear hand-off	5	3
Repetition across languages	4	2
Uncertain addressee	3	13
Lexical interference	1	0
Lexical confusion	0	4
Unexplained	0	3

Table 3: Comparison of Language Problems in ASRS and IATA Reports

In the ASRS analysis, three categories of error were affected by national language differences (language-accent, dual language switching and repetition across languages). The IATA database findings, however, had few reports that dealt directly with national language problems and the most common category of problems involved false assumptions. Orasanu speculated that the unexpected low level of national language difference problems in the IATA database reflects a greater attention to clear communication, or a high level of adaptation to linguistic diversity on the part of non-US pilots who operate daily in multicultural airspace.

The use of 'unfamiliar terminology' highlights another common communication problem. In aviation, numerous standard words and phrases have been developed, and their consistent use is essential for the limitation of misinterpretation. Both pilots and controllers, however, have been found to use non-standard phraseology in procedural speech. US pilots show lower levels of adherence to standard communication protocols (Connell, 1996). Moreover, in emergencies flight crews often revert to everyday speech patterns rather than the highly formulaic communication of clearances and procedures (Orasanu, 1994; Morrow & Rodvold, 1993). These speech patterns differ enormously across cultures and hence promote misunderstanding.

In terms of national culture, it is anticipated that globalisation may influence flight deck communication. This will be particularly the case where crews are of mixed culture and there are large differences in the languages, accents and verbal styles of the individuals involved. An example is two flight crew members communicating in a language that is the mother tongue of neither (as a result of the use of English as the international language of aviation). Whilst this may cause difficulties in interpretation, one might also argue that awareness of this potential problem will cause the crew to take particular care to avoid misinterpretation by using precise, standardised communications (by comparison with a familiar crew that becomes sloppy with their standardised language use and unwary of ambiguous communication).

Higher-level meaning

Even if the initial message transfer is adequate then successful information sharing is still not guaranteed. The message may not have adequately conveyed the sender's intent. These types of misinterpretation lead to an 'illusory understanding' (Orasanu et al, 1997). Here the sender and

receiver both believe that they have communicated successfully but in fact the message that is received, interpreted and acted upon is not the message intended.

This miscommunication can result from a range of factors. For example, there are only a few basic forms that a message can take: a statement, an instruction or a question. By using a certain construction, a sender expects the receiver to recognise the purpose of the communication and to act accordingly. If a sender asks a question, they expect the receiver to respond with an answer. If the receiver fails to appreciate this intention, they are judged as having misunderstood the message, even though they may have accurately de-coded everything else about the utterance. This type of communication problem is probably more likely where the speaker and addressee do not share the same culture or language.

Orasanu's (1997) study of the IATA database showed a high level of false assumptions or illusory understanding. This may simply be an artefact of the two different cultures of controllers and pilots. However, it is possible that this reflects differences in national culture and the interpretation of information.

Any receiver in a communication act will interpret a message using previous experience, learning and expectation. This creates the danger of false hypothesis formation (Hawkins, 1993). The previous experience and learning of pilots from different cultures and organisations will vary along a continuum from very similar to very diverse. The further away two pilots are on this scale, the greater the likelihood that the two will form different expectations and assumptions leading to misinterpretation. This situation might be expected to become more common with the increase of mixed company and mixed national flight deck crews.

3.3.4 Social Communication

The third type of speech act that occurs on the flight deck is non-task related speech. This social communication develops general flight deck atmosphere and interpersonal relationships between flight crew members (Kanki, 1996). The introduction of mixed cultural crews may result in a lack of non-task related 'banter 'on the flight deck.. If banter is difficult due to lack of a common language then this may lead to boredom in flight (Smith-Cristensen & Duckert, 1995), although this is unlikely to be safety critical. If there is a cultural clash between individuals, then non-task oriented communication may lead to a possible reduction in morale. Although low morale may not have a direct affect on flight deck errors it would be wrong to ignore the possible indirect consequences that could occur.

3.4 DECISION MAKING

To discuss decision making in aviation we shall adopt a model designed by Orasanu & Fischer (1997), which is illustrated in Figure 3.

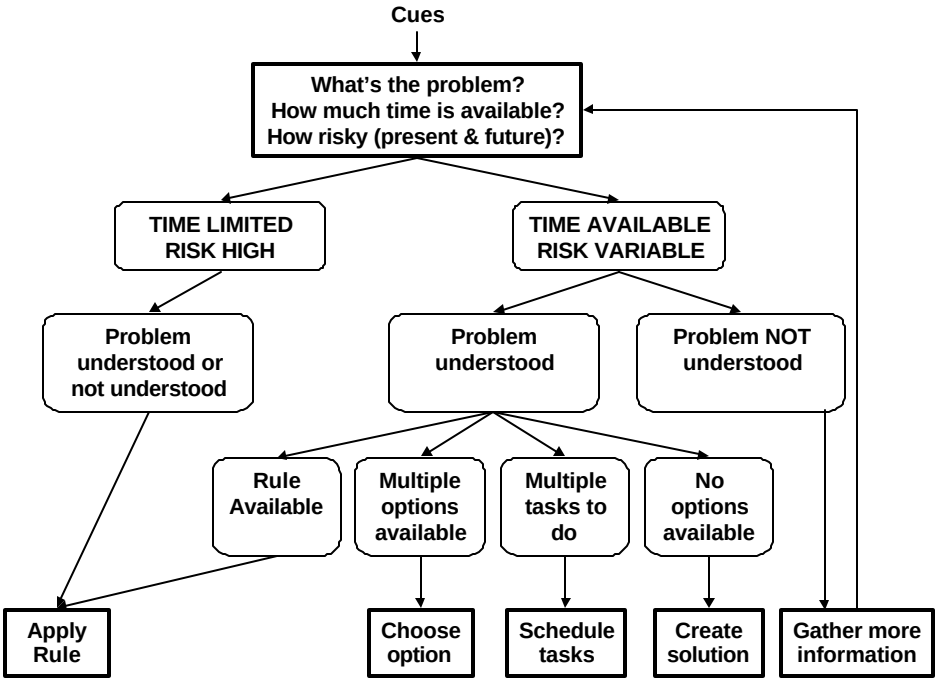

Figure 3: Aviation Decision Process Model (Adapted from Orasanu & Fischer, 1997)

This model is based on a paradigm called 'naturalistic decision making'. This means that it accounts for the way in which individuals use their own knowledge to make decisions under dynamic conditions. Orasanu (1997) concludes that a naturalistic model of decision-making in aviation will be different to such a model in any other domain. This is because any such model requires consideration of the structures, demands and expertise required by a specific domain.

Because information acquisition and information assessment involve interaction between individuals, they will be more influenced by globalisation issues than decision-making. Moreover, the proceduralised nature of the aviation industry means that if information has been adequately obtained and information sharing has been good (in other words if situation awareness is high), then it is highly likely that a procedure can be applied, limiting the need for creative decision-making.

There is certainly little research linking decision-making and cultural factors. It is possible to speculate, however, where cultural change or interaction may indirectly affect decision-making. These issues are drawn out in the sections below.

3.4.1 Decisions under Time Pressure with High Risk

Performance under these conditions will be affected primarily by an individual's training and experience. This hypothesis is supported by Stokes & Kite (1994) who found that more experienced pilots make the right decision under stress more often than inexperienced pilots. The primary issue is that experience enables individuals to locate the vital cues and act on them. Knowing how to respond in an emergency and the capability to act in a timely manner obviously increases the likelihood of a correct response. A finding from stress research is that people under stress tend to make premature hypotheses, based only on the information that is originally available at the onset of the situation, or is subsequently easy to obtain. This is a result of the finite information process capacity available in novel situations. The Kegworth accident was an example of this tendency.

In terms of globalisation issues, this implies that any decision to fly two inexperienced pilots together, in an attempt to drive down costs, should be resisted. A good organisational culture will provide pilots with specific training to help them cope with high stress situations such as these.

3.4.2 Choice of Action under Variable Risk

Due to its safety critical nature, aviation is a highly proceduralised operation. In the vast majority of situations, decision-making is limited to deciding which standard operating procedure (SOP) should be used. SOPs are integral to the correct performance of complex tasks on the flight deck, and are one way in which an organisation can exert control over the decision-making process. Ideally, SOPs provide a logical, efficient and safe means of carrying out set tasks, with the further virtue of predictability. Even pilots who have never flown together in the same cockpit should be able to work smoothly as a team because they have learned to perform the same functions in the same way. However, if there is little consistency between the procedures used by different carriers that pilots move between, then this level of predictability will be lost. When airlines merge, care must be taken to ensure that pilots are given proper training to familiarise themselves with any new procedures they are likely to encounter.

National culture may influence the choice of action. For example, mistrust of automation in low power distance countries may manifest itself in a preference for manual flying. Sherman & Helmreich (1995) found that national culture strongly predicted automation usage.

3.4.3 Choice of Action with No Standard Options Available

This situation should be experienced very rarely. Under such conditions, there is a need for creative thinking. The professional culture of pilots is informed by tales of brave pilots improvising and remaining calm under extreme stress. Although the need for this kind of response is less likely in modern aviation due to the reliability of the technology involved, there are still examples that perpetuate the stereotype.

In terms of national culture, high Uncertainty Avoidance scores may increase stress in situations where no standard options are available and consequently hinder decision-making.

3.5 LATENT FAILURES

There are other indirect factors operating at the Regulatory, organisational and cultural levels that have the potential to increase the likelihood of a human error being made. They result from latent causes such as inadequate training, supervision, resources or oversight, and faulty procedures and policies. They are known as latent failures and may be present for many months or years prior to an incident.

Failure to identify the underlying causes of error results in a ‘fire-fighting’ response and means that similar or more serious incidents are still likely to recur. If the error-maker is blamed or punished, the reporting of other incidents will be suppressed. As a consequence, fundamental failures in management or Regulatory policy remain unaddressed and resources may be squandered on ineffective initiatives.

Given that each latent failure has the potential to influence several active failures (immediate causes), removing latent failures is a cost-effective method of incident prevention. Latent failures will only be discovered if the root cause of a crew error is established by adopting a fact-finding rather than a blame assigning approach.

3.6 SUMMARY OF FACTORS INFLUENCING FLIGHT DECK ERRORS

In the following tables, the main types of flight deck errors are summarised, together with their primary causes.

Information Acquisition Source	Error Types	Factors Influencing Errors
Cockpit displays	Use of cockpit displays for monitoring and situation awareness instead of actively searching for information ('Automation bias') Poor monitoring of displays	Cultural attitudes to automation (mistrust of automation in low power distance cultures) Number of aircraft types pilot is required to fly Loss of vigilance due to fatigue, possibly arising from rostering policies
Standard Operating Procedures (SOPs)	Failure to monitor information sources	Lack of clarity of roles and responsibilities arising from different interpretations of SOPs

Table 4: Errors during Information Acquisition

Information Sharing Process	Error Types	Factors Influencing Errors
Information sharing between flight crew	Failure to detect primary error (monitoring failures)	Command structure on flight deck (Trans-cockpit authority gradient) Cultural differences in power distance Lack of verbalisation about problems due to assumptions about shared SOPs
	Failure to challenge incorrect decisions or actions (error recovery or assertiveness failures)	

Table 5: Errors during Information Sharing

Aspect of Interpretation	Error Types	Factors Influencing Errors
Interpretation of simple information	Misinterpretation	Language differences Use of unfamiliar terminology Lack of social communication during or between flights leading to failure to build up shared knowledge of experience and attitudes
Interpretation of higher level meaning	Surface meaning of message understood, but higher level significance not appreciated	
Shared knowledge of other crew member attitudes and knowledge	Incorrect expectations arising from different cultures or experience understanding Boredom leading to lack of vigilance	

Table 6: Misinterpretation Errors

Decision Making Process	Error Types	Factors Influencing Errors
Decision making in high time pressure and high risk situations	Only easily available information used-leading to premature hypotheses	Level of experience Quality of information provided in cockpit
Choice of action in standard (i.e. included in SOPs) contingency situations	Pilots used to differing procedures may not co-ordinate effectively	Degree of difference between procedures normally used by different crew members
Diagnosis and choice of action in non-anticipated situations	Inability to diagnose and formulate corrective strategy under stress	Persons from high uncertainty avoidance cultures may lack experience in operating outside standardised procedures

Table 7: Decision Making Errors

It can be seen from these tables that many of the causes of errors can be related to the effects of mergers and globalisation. These linkages will be explored further in subsequent chapters.

Figure 4, on the next page, presents a model of the possible effects of structural changes in the industry, and provides links showing how these changes could cascade down through an organisation to affect the likelihood of flight deck errors via the influencing factors identified in Table 4 to Table 7.

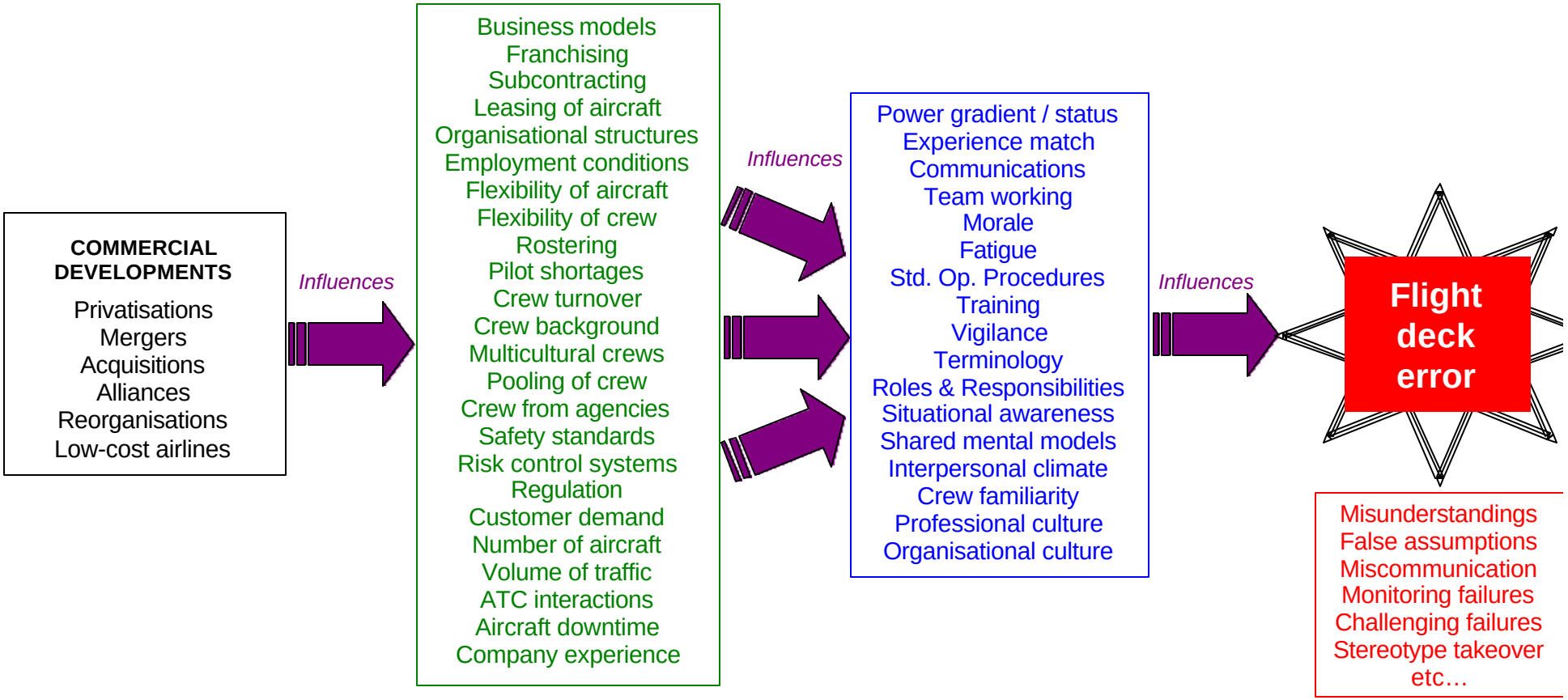

Figure 4: The Effects of Commercial Developments on Flight Deck Errors

4. COMMERCIAL DEVELOPMENTS IN THE AIRLINE INDUSTRY

4.1 HISTORICAL PERSPECTIVE

Historically, state-owned and state-funded national carriers operated the majority of strategically and commercially important international and domestic air services. Other airlines within Western Europe generally fed key trunk and long haul routes from hub airports. At the time, this was probably the only possible structure for developing a new and expanding industry. The economic climate was essentially protectionist, and few truly global entities existed in any industry. Since ownership structures were largely government led, there was no clear commercial imperative.

Scheduled international air traffic was regulated for economic purposes on the basis of bilateral agreements negotiated between respective national governments. The main element of these agreements was the principle of reciprocity, effectively creating cartel dominance on routes, either by limiting the number of designated carriers, frequency (number of operations) or capacity (number of seats offered). Standard tariffs (fares) on these routes were also agreed by carriers, with clauses concerning reciprocal acceptance of fare structures. Carriers were often required by their governments to operate unprofitable routes for socio-political reasons.

There was limited opportunity for “second-force” airlines to establish themselves in the market as national carriers had strong market position on the most lucrative routes and could act to reduce competitive threats. Bilateral agreements could also prevent entry by other carriers on to key routes through use of carrier designation clauses.

During the development phase of the industry there was a tendency on the part of governments to protect incumbent carriers. Where a country had more than one international airline, routes were allocated on a geographic or shared basis. In addition, there was only limited scope for multiple designation, since both the originating and destination countries had to agree to add a second or third airline.

Eventually market pressure and competition rules saw Economic Regulators, particularly in the US and Europe, intervene to open up markets to more competition. Governments increasingly came to accept that airlines should be run as commercial businesses, and not as an extension of government activity. This created the conditions for a number of airline privatisations.

De-regulation of air services within the US paved the way (Airline Deregulation Act of 1978), and the liberalisation of air services within Europe followed. Nevertheless, forms of bilateral agreements are still in place for operations between Europe and certain countries outside Europe.

4.2 THE EFFECTS OF DEREGULATION

Deregulation proved to be a decisive watershed in the structural development of the air transport industry, particularly in the United States and Europe.

In outline, the results of US de-regulation were:

- An overall reduction in the number of carriers offering international services;
- The creation of a series of “fortress” hubs dominated by 5 major carriers; and
- The development of low-cost feeder carriers, often owned by the major carriers, supplying traffic into “mother” hubs.

European liberalisation began in earnest from 1987 and the results have been:

- Significant growth in passenger demand;
- Carriers allowed more flexibility to enter markets, leading to greater competition; and

- The formation of low-cost carriers.

An international trend that has arisen as a result of deregulation and the privatisation of aviation markets is the creation of larger, more cost efficient airline business structures where economies of scale can operate. An example is the growth in global airline alliances in recent years. Year-on-year unit costs have reduced for all but one of the years between 1993 and 1999 inclusive, and this is illustrated in Figure 5.

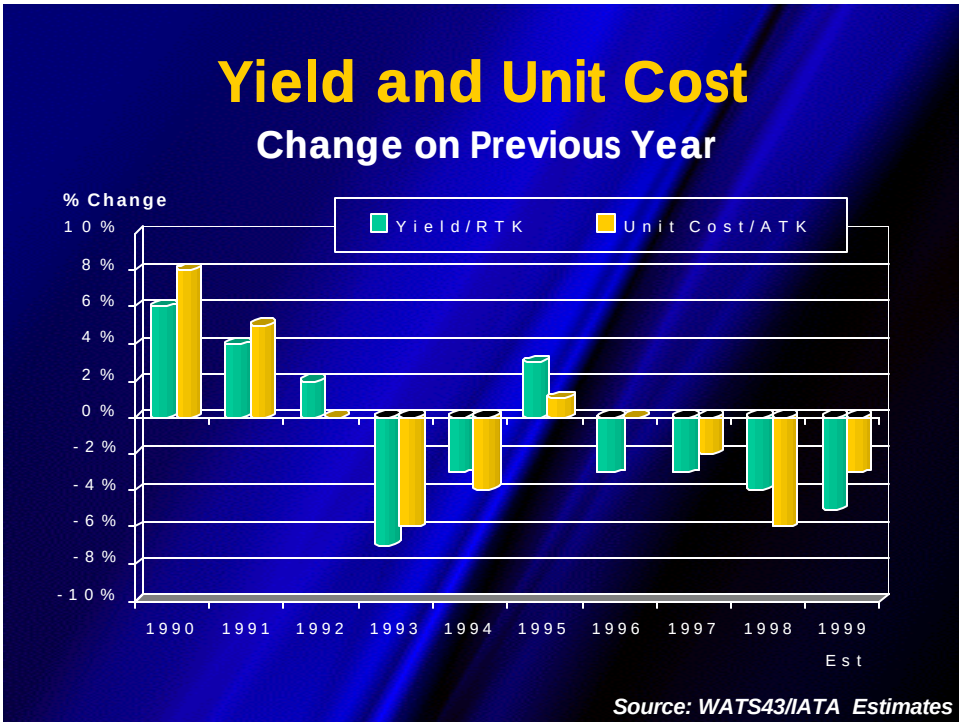

Figure 5: World Airline Unit Cost

Cost efficiency should not come at the expense of safety, however. In the fourteenth report of the U.K. Select Committee on Environment, Transport and Regional Affairs (1999) concerned with aviation safety, easyJet Managing Director Ray Webster is quoted as saying:

> *"Airline de-regulation applies to control measures over commercial activity and not to airworthiness standards and, therefore, any assumption or implication that safety standards have lowered as a direct consequence of de-regulation would be false. It is such false assumptions that give rise to comment that an airline that offers low cost, value for money fares must be cutting back on something, with safety being the most frequently quoted area by the less informed. We should be actively dispelling such views because value based airlines are regulated in exactly the same way and to the same standards as the larger established airlines."*

However, the Director of the Safety Regulation Group (SRG) of the UK CAA is quoted in the same report as saying:

> *"The emergence of low-cost carriers is 'stretching our resources insofar as we have to put specific regulatory effort into these new start-ups"*

The remainder of this chapter describes current and possible future developments in the European air transport market resulting from deregulation.

4.3 PRIVATISATION

Some previously state-owned carriers have adapted more quickly to the new environment than others. A variety of factors account for this disparity, from customer driven management success to the characteristics of the market places in which they operate. All of the major carriers have faced some degree of negotiation with key staff, including flight crew, as they face the challenge of the need for continuous productivity improvements within the new economic forces at work in a global business.

Nevertheless, the rate of return achieved by airline businesses has not, on average, compared well with typical stock market returns, and there is a need to improve performance further to guarantee the viability of the industry. Despite the inherent challenges, few international carriers within Europe have actually gone out of business. Where necessary, financial rescues have been achieved either through partnership with other airlines, or by government or private capital injections.

Competitive pressures continue to build, and it would be surprising if Europe can continue to support the number of major national carriers that it currently does in a fully competitive market place.

The consolidation of airlines that has taken place in the US is likely to be replicated in Europe. Whereas most nations within Europe are likely to retain a national carrier in name, some of these carriers may become subordinate entities within perhaps four or five major alliance groupings.

Another strategy developed by major carriers to broaden the service offering has involved franchising smaller (lower cost) regional carriers, within their organisation to operate as feeders to hubs.

The break up of former Soviet Union, both geographically and economically, has had a major influence on aviation in the former eastern bloc. The trends seen include:

- an undoubted latent demand for travel released by the end of travel restrictions;
- the emergence of significant airline growth among former satellite countries;
- the replacement of Russia aircraft by western aircraft requiring fewer flight crew; and
- a reduction in demand for military pilots.

Some of these countries appear to be establishing successful airline businesses, but are growing from a low base and with a high exposure to market volatility. They generally have sufficient flight crew and staff, but this is outweighed by capital shortage, market size and dollar denominated costs. It can be speculated that there will be a reservoir of former military and other Eastern bloc pilots with a keen interest in employment at Western European airline salaries if the opportunity arose.

4.4 ALLIANCES

Strategic alliances have become as common in commercial aviation as in other industries, and are formed between competitors and collaborators. Although such agreements have always been a feature of the airline industry, there has been a rapid expansion in the number of alliances in recent years, which almost doubled in the four years from 1994 to 1998.

Most airline alliances are loose, flexible and based on relationship-oriented partnering. They tend to be strategic alliances involving inter-organisational co-operation, but lacking the formation of a joint legal entity. Given prohibitions by some states on the foreign ownership of airlines, these companies forge international alliances seeking to capture some of the benefits normally achieved through a merger.

The true global airline alliance requires a combination of carriers from each of the major traffic-generating regions of Europe, Asia and the US. Currently there are five major alliance groupings namely: Star; oneworld; Wings; Qualiflyer; and Sky Team. These groupings are still in some degree of flux and differ in the degree of integration that has been achieved.

The degree of volatility of the alliance groupings is indicated by the changes that have taken place since April 2000, involving additional carriers joining alliances, and a break up in part of the Wings grouping.

The rapid development of global alliances between 1996 and 1999 is demonstrated in the table below:

	1996	1997	1998	1999
Global Total (million)	381.8	414.0	432.2	459.0
Alliances (million)	34.4	85.7	134.9	212.5
Alliances Share	9%	21%	31%	46%

Table 8: Numbers of International Air Travellers 1996 - 1999[2]

There are a number of key drivers that led to the creation of global airline alliances. These can be grouped under market access and cost-based motives.

Market access motives are:

- Greater global reach from linking into the networks of other carriers;
- Circumvention of restrictions imposed by the bilateral system;
- Creation of corporate sales and marketing teams to co-ordinate activities across all airline members;
- Joint passenger and cargo flights;
- Co-ordination of flight schedules, leading to the optimisation of connecting opportunities at each carrier's home base;
- Codesharing agreements, which are particularly important for developing new route opportunities; and
- Links between frequent flyer programmes, which extend the benefits to passengers by increasing the available network for free flight opportunities.

Cost-based motives are:

- Management contracts, leading to the reduction in the management head count of alliance members;
- Joint ventures in areas such as ground handling and aircraft maintenance, which allow alliance members to enjoy the benefits of bulk purchasing from key suppliers;
- Sharing of facilities such as training, maintenance, and aircraft spares;
- Higher utilisation of aircraft.

[2] Source: IATA World Air Transport Statistics Annual Reports 1996-1999

There is no inherent economic justification for a national carrier framework, and therefore alliances and marketing co-operation provide a good way to achieve these benefits within the existing political and regulatory framework. The cost benefits are difficult to quantify and will be less than their full potential when the alliance members continue to operate as separate businesses. Efficiency gains are more likely to occur on the demand side, where higher frequencies and more routes attract more passengers onto the network of the alliance.

Alliances are not as efficient as full mergers. For example, the joint investment is likely to be lower, as airlines will fear a breakdown of the alliance. Nevertheless, in a deep alliance the exit costs may be prohibitive.

The Organisation for Economic Co-operation and Development (OECD) reports a tendency towards deeper alliances involving co-operation on all aspects of the airline business, from marketing to procurement. It further reports that 70% of alliances include provision for code sharing[3]; 50% include provision to share frequent flyer programmes and 15% include agreement to share facilities such as catering, training, maintenance and aircraft purchases.

Pressure is being felt within some alliances for a degree of convergence. In the future SOPs may become more similar within the member airlines of an alliance and there may be some movement of pilots between alliance partners.

Global alliances look likely to continue as the major force in the commercial development of the industry. Although there will almost certainly be some changes in airlines between the major groupings, the degree of concentration will continue. Economic Regulators and politicians in both the US and in Europe are likely to continue to investigate the perceived "competitiveness" of these groupings. The limits on what such Regulators will accept are unclear and may always remain so.

4.5 MERGERS AND ACQUISITIONS

The merging of two airlines is perhaps the largest organisational change that those airlines may ever face. The potential for such mergers is increasing significantly around the globe, as the national basis of air carrier structure and operations becomes weaker, and the search for greater operational efficiency increases. Such mergers have already become commonplace in other global industries such as banking, telecommunications, pharmaceuticals and media. While previous airline mergers generally took place between airlines within the same country, mergers which cross national boundaries are becoming increasingly common. This is likely to give rise to a more complex mix of cultural factors to be dealt with by the new companies.

Generally, the economic drivers for change and the economic consequences of change are thoroughly considered. However, the priority accorded to the effect of the merging of companies on the employees is generally lower. Paying too little attention to the social effects of a merger can have negative consequences, and these have been illustrated particularly in the US and Canada with Continental/Eastern, Pan Am/United, and CP/Wardair given as examples.

4.6 LOW-COST CARRIERS

The broad business philosophy of the low-cost carriers is that money can be made on any route where a carrier can fly three times a day to a low-cost airport, based on a minimum market size of around 200,000 passengers per annum.

[3] Code-sharing refers to the practice of one airline selling seats on a flight operated by another airline, a practice assisted by the development of advanced computer reservation systems. Airlines share the two-letter code used to identify carriers in these reservation systems used by travel agents.

The basis of commercial success for such entry airlines is maintaining a 30-40% cost advantage over established airlines. This is primarily done in several ways:

- Use of secondary airports, enabling lower airport landing fees, lower ground handling charges, and fast turnarounds, typically 30 minutes or less;
- Lower passenger costs achieved through no passenger frills and the use of direct selling techniques, particularly the internet, to reduce distribution charges from travel agent commissions and computer reservation system costs. These currently average 16% of international carrier costs;
- Implementing a new set of processes to optimise operational efficiency and minimise overhead costs; and
- Higher average passenger load factors.

Cost advantages are passed on to passengers by means of low fares. As well as taking market share from national carriers, low-cost carriers are creating additional demand for air travel.

The corporate structure of these carriers often reflects their niche player role and they are frequently able to benefit from the latest technology and working practices. Many low-cost carriers standardise on a single aircraft type and purchase new aircraft in bulk, thereby minimising maintenance costs. Their financial performance is regarded as being attractive to the stock market and this is exemplified in the US by Southwest Airlines whose market capitalisation and financial performance currently exceeds any of the major US airlines that are many times its operating size.

The European low-cost carriers seek to emulate the success of their counterparts in the US, most notably Southwest. This is achieved through high load factors, together with tight cost control. They are the fastest growing segment of the European airline industry and new routes are being opened each year. The leading European low-cost carriers are planning to double their aircraft fleets over the next 3-4 years.

In spite of the successful profit record of Southwest Airlines, the experience of US low-cost carriers has been mixed and many have failed. In Europe, Debonair has been the highest profile casualty.

Debonair embarked on a strategy to form a multi-hub system and pan-European network by setting up alliances with regional airlines, aimed at establishing a strong presence in Continental Europe. It attempted to distance itself from the low-cost carrier culture and introduced a dedicated business class cabin. In doing this, it departed from the true low cost philosophy and was caught between the market segments of the low-cost carriers and the established carriers.

The major carriers initially adopted a “wait and see” attitude towards the low-cost segment, taking time to assess the impact on their own traffic, particularly with regard to any dilution in the number of premium class passengers carried. Eventually competitive reaction came with the creation of Go by British Airways, which is now being sold, and Buzz by KLM. At the present time, other major European carriers are actively considering the introduction of low-cost subsidiary airlines. The dedicated low-cost carriers are therefore facing increased competition and the charter sector may also react aggressively, particularly on the important leisure markets out of the UK.

The low-cost carriers are facing rising costs, particularly in the areas of fuel, airport charges and salaries. In addition, they are generally limited at the present time to regional operations, which does not allow them to develop a more balanced portfolio of services. This restriction might widen their exposure to increasing delay costs in Europe due to shortage of airport capacity and airspace. Finally the levels of initial growth they have achieved are unlikely to be continued as they extend to weaker markets.

5. EFFECTS ON FLIGHT CREW OF COMMERCIAL DEVELOPMENTS

Three major effects occur from recent commercial developments in the airline industry that could give rise to human factors issues. They are:

(i) The mixing on the flight deck of crew from different cultural and national backgrounds;

(ii) The merging of company cultures when one airline takes over or merges with another; and;

(iii) Commercial pressure, which arises from greater competition between the airline companies.

5.1 MULTICULTURAL FLIGHT CREWS

5.1.1 Introduction

In 80% of the airlines returning questionnaires and in all of the national flag carriers interviewed, at least 95% of the flight crew employed are local nationals. In many Southern European states all the flight crew employed are local nationals and, as a consequence, multicultural flight crews are more frequently found in airlines operating out of Northern Europe. The highest proportion of non-nationals was found at a small operator in Northern Europe where 70% of the flight crew originate from outside the local state, coming from around 20 different countries within and outside Europe.

Although the number of aircraft movements in Europe with multicultural flight crews is relatively small at present, there are indications that this will increase in the future for the following reasons:

- The segment of the market employing the highest proportion of non-nationals was found to be the low-cost sector where, typically, 25% of the pilots employed are non-nationals. Since low-cost entrant airlines are expanding rapidly, it can be expected that mixed flight crew will become a greater proportion of the whole.
- More than half the people surveyed believe that a pilot shortage will occur in Europe in the short to medium term and that this will encourage a greater movement of trained flight crew between airlines and between member states. This movement will be facilitated by a common European Flight Crew Licence and the freedom of movement of labour within the European Union.
- In a climate where the demand for experienced pilots exceeds supply, qualified foreign nationals from outside Europe are also likely to be attracted to working for European airlines, particularly if the salaries on offer are greater than they could earn in their own countries.
- It is anticipated that there will be a growth in airline mergers that cross national boundaries (see Section 4.5) with a consequent mixing of crews from both airlines.

The standard industry practice and aim is to be able to roster any Captain with any co-pilot in order to give maximum company and personal rostering flexibility. Normally the only time this might not be appropriate from a safety viewpoint would be to prevent a new Captain and a new co-pilot on a fleet to fly together. Not surprisingly, therefore, none of the airlines that employ foreign nationals attempt to match flight crew of the same nationality together.

However, the small airline employing a very large number of different foreign nationals, rosters very carefully to ensure that flight crew are mixed in what the airline considers to be a safe combination. Acceptable combinations take into account language ability, experience of flying in Europe and length of flying experience. Certain nationalities in this airline are never permitted to fly together.

Another airline with subsidiaries in three different states mixes crew between the subsidiaries to provide short-term flexibility and reports that this mixing has been successful and is likely to increase.

While most airlines say rostering is carried out on a random basis to provide the greatest flexibility, informal rostering systems sometimes operate to avoid known personality clashes.

None of the airline management interviewed could give any examples of problems that had been experienced with mixed national crews in their own airlines and a few saw the mixture of different nationalities and cultures in the cockpit as a strength. However, some said that crew training is challenging when a wide range of cultural backgrounds is mixed.

A different view was given by a line Captain who said that he and his colleagues had experienced problems on the flight deck with crew members of certain nationalities. These problems were related to their language ability and general safety philosophy.

While the subject of this study is mixed flight crew, it should be noted that it is quite common for airlines to mix nationalities within the cabin crew and between the flight deck and the cabin.

5.1.2 Language Issues

Of all the potential problems from multinational flight crew, differences in language are an obvious concern.

With a flight crew of two, there are four distinct language combinations. Since English is the standard language of aviation it will be used to demonstrate these combinations:

(i) Both native English-speaking;

(ii) One native English-speaking, the other non-native English-speaking;

(iii) Both non-native English-speaking of the same nationality;

(iv) Both non-native English-speaking of different nationalities;

Several people said that flight crew tend to think in their own language and are likely to revert to their mother tongues when an abnormal situation or emergency arises. Non-native English speakers commented that they have to adapt their minds to work in English and become familiar with working in a foreign language. While communication between different nationalities may be perfectly acceptable under normal operating circumstances, communication may become impaired in certain situations, which may lead to a loss of situational awareness. This is particularly true when decisions that have to be made are time-critical.

Not only is effective communication a problem between people of different native languages. Two people who share a common language but come from different countries can also misunderstand each other. For example, countries such as the UK, the US and Australia often have different interpretations of the same words or phrases. Although this is not an issue in the use of a standardised aviation language, non-technical words may be misunderstood. Furthermore, there may be difficulties in understanding accents or dialects. An example quoted by Helmreich is that of an Australian pilot's pronunciation of 'Mode A' being heard by an ATCO in the UK as 'Mayday'.

It was suggested that language differences between the flight deck and airport services could be important. For example, when a maintenance engineer or dispatcher is of the same nationality as a member of the flight crew they may converse in their native language. If the other flight crew member is of different nationality, he or she may not understand the communication and misunderstandings may result unless a (correct) translation is given.

Counter measures to misunderstandings are greater cross-checking and more rigid use of SOPs. One person said that SOPs are particularly important when nationalities are mixed as they

provide discipline and encourage safety. However, the rigid use of SOPs may lead to non-native English speakers anticipating what will be said next by knowing the subsequent step in the SOP. An example reported by a line Captain was of a non-native English-speaking First Officer who mistook a casual remark for an anticipated instruction. The result was that the undercarriage was lowered prematurely. In other words, there may be an increased tendency for crew whose English is relatively poor to hear what they expect to hear, rather than what is actually being said.

Not only should language be considered in terms of the flying task; it is also a concern where multinational crews are unable to fully engage in social conversation either inside or outside the cockpit. On long-haul flights, social interaction may help to reduce fatigue, maintain alertness between the crew and contribute to team working. A lack of conversational or colloquial ability in a common language may have an adverse effect on interpersonal relations, with flight safety implications.

Furthermore, language and sociability are both barriers to a satisfying social relationship with all the members of the crew during rest periods. Being excluded in this social interaction for reasons of language or personality will have a negative effect on team building. It was reported that someone would be treated as an outsider if they had difficulty in or were resistant to speaking the native language of the airline, particularly in social situations, and that this treatment would carry across to the flight deck.

The correlation between age and the likelihood of a person being able to speak a foreign language was raised by several people. Younger pilots tend to be reasonably fluent in more than one language, whereas older pilots tend not to be. Poor language ability may, therefore, be a significant factor in the employment of crew after they have passed an airline's retirement age, perhaps by an agency.

A Safety Regulator said he concentrates on people's general ability to speak and understand English, not just on their technical use of the language. His reason for doing this is a concern that flight crew will use non-technical language in degraded situations and, if their mastery of English is poor, they will revert to their native language.

5.1.3 Resistance to Recruitment of Non-Nationals

Given the relatively low rates of pay in Eastern Europe, it is more likely that experienced Eastern European flight crew will join a Western European airline than vice-versa. However, in the past there has been resistance from some pilot unions to the employment of Eastern Europeans. Reasons given were that their handling skills and/or technical knowledge were alleged to be poor, and their English language skills were alleged to be inadequate. In addition, because they may be prepared to join an airline in Western Europe for less than the normal rate of pay, some unions have been concerned that jobs might be taken away from local nationals.

Resistance to the employment of Eastern Europeans has also come from some Safety Regulators. For example, it was reported that one Regulator has refused to allow an airline to recruit flight crew again from a certain Eastern European country because of a previous bad experience. Reasons given were that these flight crew had displayed undesirable national characteristics such as dogmatism and authoritarianism, and that the concept of CRM was unfamiliar to them.

The influence of Russian aviation is strong in Eastern Europe where most pilots have a military background and are accustomed to flying single-seater aircraft. They are required to learn procedures by heart, whereas the use of checklists is the standard in Western Europe and most of the remainder of the world. An Eastern European airline reported that some experienced Captains found it difficult to make the transition from Russian to Western aircraft types, and it took them a year to complete transition training. Others were unsuccessful and no longer work for the airline.

Cuba has always had a close relationship with the Former Soviet Union and one airline stated that they found it necessary to double the simulator time when training Cuban flight crew in order to obtain the standard that they required.

Eastern European and some Southern European countries also resist the employment of non-nationals. Several examples were given:

- Unions and representative associations may be strongly opposed because of high local unemployment;
- Work permits may be difficult to obtain;
- A state may have a regulation that a minimum proportion of all flight crew should be local nationals.

When foreign nationals are employed by an airline, the morale of local nationals may be affected, perhaps unreasonably. An example was given of an airline with a base in a foreign country where the newest aircraft are located. This base employs many different nationalities, and senior flight crew at the home base feel resentment because the new aircraft are being commanded by foreign nationals, sometimes with less experience than themselves. Conflict may arise if crew at the two bases are mixed in the future.

5.1.4 The Role of CRM

Several people stressed the importance of CRM when mixing flight crew of different nationalities and culture. One Regulator said that CRM is the glue that ensures flight safety. The management of an airline employing over twenty nationalities said that this mix of nationalities requires them to be more proactive in the implementation of CRM because it is used to help manage the cultural issues. They suggested that with further globalisation of the industry, greater emphasis will need to be placed on the development of CRM training, as the mixing of cultures will only work if CRM is effective. They recognise that the necessary development of CRM will be expensive.

It should be noted that while many airlines and Regulators believe that CRM is an effective tool, the standard of CRM training and its implementation is perceived by many flight crew to be variable. There is little doubt that some airlines have devoted substantial resources to try to achieve the highest standards, while for others it is more a question of providing what might be described as a barely adequate course to meet the legal requirements, with little positive commitment from senior management.

5.1.5 Summary – Multicultural Flight Crews

Issue	Potential Consequences
Flying-task communications between flight crew (of different nationalities)	Misunderstandings may occur in verbal communications and may not be recovered if both crew believe that they are understood
The use of multinational and multicultural crews requires careful and specific management	May not always be provided, particularly where resources are tight; reduced internal oversight
Social communications between flight deck crew (of different nationalities), both in-flight and on the ground	Language/cultural differences may lead to difficult interpersonal relationships, loss of team spirit etc.

Issue (continued)	Potential Consequences (continued)
Communications between crew of different nationalities in non-routine situations where language becomes less formal/structured	Misunderstandings may occur; crew unable to form coherent team to solve the problem; crew may not be able to communicate situation effectively to ATC or others
Communications between crew of different nationalities in time-critical situations	As above
Communications between flight crew sharing a common language but with different dialects/accents/meanings	Misunderstandings may occur, but aviation requires standard language
Increased reliance on SOPs	May lead to anticipation errors where crew hear what they expect rather than what has been communicated
Older crew may be less able/willing to communicate in a common language	Misunderstandings; difficult interpersonal relationships; CRM issues
Wide disparity in religious etc. beliefs	Leading to, for example, feelings of 'nothing in common'
Different CRM philosophies for example between East and West Europe or lack of CRM training,	May be poor team players or bring different power gradient issues
Experience on very different types of aircraft (for example, Russian fleets)	Low CRM skills
Resentment over non-nationals taking jobs away from local pilots	Leading to difficult interpersonal relations
Concerns over alleged deficiencies in flying skills and technical knowledge of pilots from certain regions/countries	Reduced experience or technical competence, either real or perceived, may directly affect flight safety or affect interpersonal relationships with other crew
Concerns over safety philosophy/performance of pilots from certain regions/countries	Reduced safety philosophy may directly affect flight safety or affect interpersonal relationships with other crew

Table 9: Multicultural Crews: Human Factors Issues

5.2 MERGING OF COMPANY CULTURES

5.2.1 Introduction

The discussion of multicultural crews has focussed on differences between national cultures, such as language and behaviour. However, several management pilots have suggested that the difference in culture between countries may be less than the difference in culture between companies within the same country. For example, there are great differences between the cultures of a national flag carrier and a low-cost airline where simplicity and efficiency are built into every business process and little, if any, importance is placed on seniority.

This view about the relative strength of company culture is supported by work being carried out on the JAR-TEL (Joint Aviation Requirements – Translation, Elaboration and Legislation) project that is being funded by the European Commission.

5.2.2 The Nature of Company Culture

National carriers, whether Government owned or privatised, might be expected to have a strong national culture. They are often referred to as flag carriers and, to an extent, represent their countries overseas. They have prestige, and one national carrier said that crew tend to stay for the duration of their career. It may be postulated that part of the company culture will be influenced by this stability.

However, sometimes the cultural roots of an airline may be found in a country that is remote from where the airline is located. For example, the business model of more than one Northern European low-cost airline is based on Southwest Airlines, a very successful and profitable US carrier, and many of its cultural values have been adopted.

Because of the limited opportunities for contact between company managers and flight crew, company practices and culture are normally instilled during initial training and reinforced in all subsequent training. In a few airlines, and particularly those based on the Southwest model, company culture may be promoted by staff briefings and social events that are held on a frequent basis.

Several airlines stressed the importance of crew fitting in with their culture. When these airlines select new pilots, the ability to fit in is considered to be just as important as the possession of appropriate technical skills. In some cases, an airline will try to avoid the use of agency crew to prevent potential cultural clashes. The view of one management pilot was that personal qualities are difficult to change, whereas technical skills can to a large extent be taught.

5.2.3 Mergers and Culture

Mergers often reveal the cultural differences between airlines. One example given was of a national carrier that merged with a regional carrier providing domestic services, both owned by the state. The business case for a merger was strong as the route networks of the two carriers were complementary, but many human factors difficulties were experienced in attempting to merge the two cultures. Both airlines had identical A320 fleets but “Merger CRM” had to be put into place to allow both populations to fly together. After 3 years, some cultural differences are still causing friction within the merged airline.

A similar but less extreme example was given of a merger between a national carrier and a combined charter/freight carrier where the employment conditions and attitudes of the two groups of flight crew were very different.

Another example was referred to of a major airline in the US where almost all the positive aspects of its organisational culture were affected by cultural clashes arising from a series of mergers in which it had engaged.

Prospective mergers do not always succeed. An example was given of a failed merger between an airline in Northern Europe and an airline in Southern Europe. Cultural differences were given as a contributory cause. The way of doing business in the two companies was different and was eventually found to be incompatible. Both airlines were strongly influenced by national culture.

Past mergers appear to have been most successful when both airlines have been operating in similar markets and have the same national identity. A manager from one airline said that very few human factors problems were experienced as the result of mergers that his airline had been involved in, primarily due to the fact that the mergers were with other airlines in the same country where the culture was similar. Several other people thought that there would be few problems in

merging a Northern European airline with a US airline as flight crew in both are likely to have similar standards and status. The same people believed that mergers between Eastern and Western European airlines and between European and Asian airlines would have the greatest potential for producing human factors problems related to culture.

Several management pilots interviewed were of the view that a merger between a large and a small airline would be much easier to handle than a merger between two airlines of a similar size. When two airlines of dissimilar sizes merge, it is normally the case that the larger partner will impose its culture on the smaller partner. Part of the culture of the smaller airline that will be subsumed will be the working conditions and operating practices under which flight crew are expected to work including SOPs, flight time limitations (FLTs) and stopover policy. However, all these changes frequently lead to resentment amongst the staff of the smaller airline who may fondly refer to the way that things used to be done.

Pilot Unions may also create problems following a merger, particularly when different Unions operate in each of the companies. In some cases integration between the Unions is never achieved. Friction can arise when pilots belonging to different Unions are rostered together, and it was suggested that this can lead to distraction on the flight deck. Examples were given of pilots leaving one Union to join another that is willing to exert greater pressure on the airline. Some airlines do not recognise a Trades Union, but generally Unions remain a powerful influence,

Many people raised seniority as the most contentious issue for flight crew arising from a merger. A pilot's seniority in an airline determines several important aspects of his/her professional life, including promotion prospects, bids for annual leave and work selection/allocation. The merging of seniority lists is a major cause of resentment and can lead to disrespect when flight crew members previously employed by the different merger partners are mixed. This disrespect can lead to distraction and inattention in the cockpit when one of the flight crew displays his or her resentment. It can even cause a pilot from one of the merged airlines to refuse to work on the same flight deck with a pilot from the other airline.

Resentment can lie dormant in an organisation for a considerable period of time and may eventually emerge as a latent failure (see Section 3.5). From a human factors viewpoint, resentment could probably be minimised by involving flight crew more in operational decisions arising from a merger and by adopting best practice from both airlines, particularly in the area of staff benefits. A suggestion was made that representatives from both airlines could be used in focus groups in an open forum to identify differences between the companies and to discuss the way forward.

The merger of seniority lists can take a considerable time to complete; one example that was given was a period of almost ten years before the flight crew seniority lists were fully merged.

A large airline often assumes that it has nothing to learn from the smaller partner and finds it easier to impose its own culture on the new organisation. However, one Captain from a national carrier said that a merger was a learning opportunity for the larger partner to improve its own processes and procedures. It is interesting that this Captain made reference to the adoption of principles of the Dupont Safety System, a world leader in industrial safety management. One of these principles is to make people feel involved in and contribute to safety. The uniting of employees towards a single clear goal or direction is a recognised tool in integrating two cultures.

The most dangerous period in a merger was considered to be the transition phase, when misunderstandings could occur in SOPs. It was suggested that the transition phase should be carefully managed with targeted and effective training, and that eventually the two cultures would become integrated and there would no longer be a safety issue. However, this may be a little optimistic. First, it could be argued that cultural integration may never be achieved completely. Second, in a degraded or emergency situation, even a few years later, crew may revert to the procedures that they first learnt, which may no longer be the appropriate and expected action.

Flight crew may see mergers and acquisitions as a threat, especially if they have worked for an airline for many years. One person said that people experience a fear of the unknown and added

that whereas some aspects to be managed in a merger are visible and concrete (such as SOPs) other aspects are less tangible. For example, there may be even more mistrust of the new management than the old one.

To avoid all these problems, a merged airline may operate its bases as independent subsidiaries for a while. The subsidiaries retain their company culture and operating practices but the result is that some of the potential benefits of the merger will be lost. One airline that operates in this way said that they will not form a single integrated company in the foreseeable future, as the industrial relations issues concerning seniority, pensions etc. are too great. They anticipate a gradual integration as the harmonisation of laws across Europe increases.

The management of another airline that is planning further bases in Europe said that they are aware that they will experience problems in integrating new employees into the company culture and added that managing these cultural issues will be the major challenge of globalisation.

One airline has a policy of encouraging management to move between companies in a merger. Such movement may assist in the integration of the two cultures or the installation of the parent company's culture in an acquired company. However, they realise that the relocation of executives in the merged organisation may actually create cultural problems. Therefore, it should be recognised that a clash of cultures may not just occur between flight crew, it may also exert a strong influence on the interactions between management – before, during and after a merger.

5.2.4 Alliances and Culture

Alliances between airlines are very different from mergers and acquisitions, as their aim is to extend their networks to create seamless travel for passengers and to achieve economies of scale in purchasing and the sharing of support facilities. Individual members of the alliance continue to operate as separate entities and cultural integration is not attempted. An airline can, and sometimes does, move from one global alliance to another and will wish to maintain its own identity and differentiators from other airlines.

It is in the interest of all the members of an alliance to maintain a high level of safety performance. It is noted that in mid 1999, Air France and others in the Sky Team alliance suspended code-sharing arrangements with Korean Airlines on account of its poor safety record. If safety standards are a condition of entry into an alliance, global alliances may play a role in the self-regulation of safety. There may be pressure, encouragement and assistance from members to lift the safety performance of all member airlines towards that of the best performer in the alliance. A member of one alliance said that it is normal practice for the senior operator in an alliance to carry out safety audits on other members and potential members to ensure that suitable processes are in place to maintain an adequate safety standard. Another alliance member said that multi-company teams very often carry out the audit.

Mixing of crews within an alliance does not take place at present and, from a regulatory point of view, the harmonisation of SOPs of all the airlines in the alliance would be a necessary prerequisite. But entire flight crews do sometimes operate the aircraft of another alliance partner using their own SOPs. Sometimes there may be minor differences between the flight decks of the same aircraft type and this could lead to transition problems when crew move between aircraft that are essentially similar, but not exactly the same. However, some operators carrying out this practice say that they do not experience this problem as the flight decks are standardised for the particular aircraft type.

It is possible that alliances will form their own cultures in the future based on their increasingly integrated working relationships. It is not clear whether such alliance cultures will become more pervasive than company cultures.

5.2.5 Conclusions

The interpersonal skills required in order to manage the social aspects of a merger successfully involve similar principles to those that characterise most CRM courses, namely:

- active listening;
- developing a co-operative, problem-solving relationship with others; and
- establishing a climate that encourages group decision making.

Despite the difficulties, the merging of two companies provides the opportunity to create a new organisational culture, constructed from the more positive elements of the two cultures involved. However, any process of culture change is a slow one and should be measured in years rather than months. In the early stages of a merger it is very easy to create problems that may take years to resolve.

5.2.6 Summary – Merging of Company Cultures

Issue	Potential Consequences
Not recognising that differences between airline cultures within a single nation are important when mixing crews	Failure to manage different company cultures
Differences in CRM philosophies	Confusion; adoption of an inadequate compromise of the merged philosophies
Merging of seniority lists	Threats to promotion prospects, bids for shifts/routes/leave/new aircraft etc., impact upon discontent and morale, may impair cockpit relations if resentment is harboured towards other crew who fared better in the merger. All of these factors can lead to distraction on the flight deck
Differences in rostering terms (for example, less sympathetic rostering)	Increased fatigue, reduced morale
Changes in employment conditions, such as annual/parental leave allowances or other benefits such as pension contributions	Reduced morale/job satisfaction
Differences in SOPs – particular concerns in the transition phase, or in emergency situation	Reversion to previous SOP in error or otherwise; interpersonal conflict as to 'the way of doing things'
Differences in speeds of promotion	Reduced experience on the flight deck; impact on merging of seniority lists – resentment towards crew from other company who were promoted sooner
Airlines of different type/size merging, for example, flag carrier and small charter operation (whether within or between countries)	Different company cultures not recognised as being as important as national cultures when airlines merge. Resentment to pilots from the smaller airline which may be seen as less prestigious

Issue (continued)	Potential Consequences (continued)
Failure to recognise that the transition phase is a critical time	Increased risk from all issues during this period
Resentment at the loss of a company and its identity in the event of a takeover	Reduced morale; interpersonal conflicts between crews
'Fear of the unknown'; dislike of change, etc.	Reduced morale
Larger organisations becoming less flexible or able to change/adapt	Loss of management control
Reluctance by larger partner to consider the procedures etc. of the smaller partner	Resentment towards the pilots from the larger partner in the merger
Airlines in alliance may share aircraft	Differences in cockpit layouts
Alliances members may share training functions to reduce cost	Training may no longer be tailored to the airline (e.g. CRM training)

Table 10: Merging of Company Cultures: Human Factors Issues

5.3 COMMERCIAL PRESSURE

5.3.1 Introduction

As the market for air travel becomes more competitive, airlines are forced to reduce costs and increasing globalisation is one of the consequences. Passengers increasingly expect more for less, partly as a result of the emergence of low-cost airlines and their very low fares to certain destinations. A manager in one airline said that there are great economic pressures in the industry and suggested that these pressures may be more significant than any other globalisation factor. Another commented that there is pressure to reduce every aspect of cost to that being achieved in the lowest cost airline and that alliances are driven by cost savings.

However, it should be noted that in the view of one Regulator, commercial pressures do exist, but they are no greater than in the past. Furthermore, personnel in several airlines thought that commercial pressures would not affect their airline because they are already efficient, but might adversely affect others.

Cost reduction is clearly leading to changes in the industry, although the influences on flight deck safety are not clear-cut.

Many airline managers thought that certain structural changes in the industry that would have a potential impact on safety, such as the mixing of crews from different airlines in an alliance, were unlikely to occur. However, it is difficult to predict how increasing commercial pressure will change the nature of aviation. For example, five years ago very few global alliances existed, whereas in 1999 46% of global air transport movements took place within an alliance. Change is very rapid within aviation and the structure of the industry and its operating practices could be very different in five year's time.

The following sub-sections provide examples of possible links between commercial pressure and flight safety.

5.3.2 Flying Hours and Rostering

Flying hours in some airlines were reported to be very high, bordering on legal limits in several cases. Many airlines treat the legal limit as a performance target to be achieved in order to maximise the utilisation of flight crew and reduce operational costs. Within the airlines interviewed, there is wide variation in the average number of hours flown, ranging from 500 to 950 hours per annum. Some, but not all of this variation can be explained by the length of sectors flown.

In addition, some airlines allow very little, if any, reduction in flying hours for management pilots, some with critical responsibilities such as flight safety.

Some flight crew members said they were unhappy with the rostering system in use in their airlines. They frequently operate five sector days alternating between early starts and late finishes, and work such long hours that they have little leisure time during the working week. Crew in one airline reported difficulties in obtaining compassionate leave because of commercial pressure, indicating a lack of sufficient crew. Although annual leave allowances are quite reasonable in comparison with most other professions, flight crew are often not able to take leave when they wish, with, for some, seniority as a determinant in the allocation process.

Unsympathetic rostering increases fatigue, upsets sleep patterns, reduces morale and has a detrimental effect on the personal life of crew.

One airline believes that flight crew should be educated so that they are aware of the effects of fatigue from both their work and their lifestyle outside work, and should adjust their personal lifestyles accordingly.

Management in several airlines said that lifestyle is becoming a major issue with flight crew who are increasingly willing to trade money for a better lifestyle. It is interesting to note that at least one airline is addressing the lifestyle issue. It has been widely reported in the aviation press that easyJet is currently trying to recruit a large number of experienced pilots partly to support a rapidly growing aircraft fleet but partly to increase the ratio of flight crew per aircraft so that lifestyle can be improved.

5.3.3 Holders of Senior Management Positions

Many pilots interviewed in a wide range of airlines observed that there is a tendency for business people with no flying experience to fill senior operational positions. The concern of these pilots is that the people taking up these critical positions may have less understanding of flight safety. One pilot commented that middle management in the airline he works for tends to be young with no previous experience of working in the airline industry and little understanding of the practices used in other airlines. Pilots may not be able to relate to such commercially oriented personnel and relationships between flight crew and management may become degraded.

There clearly needs to be a balance between the commercialism of management and the safety performance of the airline. Some senior Captains holding management positions have been very successful in selling the concept of safety to their bosses. The expression “If you think that safety is expensive then try an accident” was quoted by more than one person as a means of effectively communicating the message.

5.3.4 Aircraft Turnaround

The efficient utilisation of aircraft is a critical factor in aviation economics. Low-cost airlines achieve this partly by minimising delay through the use of uncongested airports and partly by minimising turnaround times between sectors flown. Short turnaround times are achieved by streamlining procedures and not serving meals and other amenities, thus reducing subsequent ‘mess’. All members of the crew are involved in the turnaround process.

However, a potential danger is that pressure to achieve a fast turnaround may result in external and flight deck checks being hurried (or even omitted). This may particularly be the case if an airline is trying to reduce turnaround time without making the necessary changes to its procedures or if an aircraft is running late.

5.3.5 Training Budgets

Because emergencies rarely occur in the air, simulator training is the means by which flight crew are taught how to deal with such events and build their confidence in correctly handling these abnormal situations. Regular refresher training in the simulator is necessary to ensure a continued satisfactory standard and to eliminate any bad flying habits that may have been detected between such training sessions. Although recurrent CRM training might be viewed as the means by which non-technical skills may be maintained or improved, such training should ideally be incorporated into the annual simulator training programme and be supplemented by classroom instruction, as is the case in some airlines.

As commercial pressure increases and organisations reach the point where all unnecessary overhead cost has been removed, perhaps by outsourcing non-core activities, management will begin to look for cost reduction in the core activities of the business. Since training is an expensive activity, training budgets will be scrutinised for cost savings. A consequence might be pressure to reduce the frequency of recurrent training to the minimum laid down by JAR FCL, or outsource it to a third party. However, since the importance attached to company culture varies between airlines and differing SOPs may be used, there are concerns that third-party instructors who may train a variety of airlines might be in the wrong 'company mode' when training.

Airlines in general, and new entrants in particular, are acutely aware of the public relations damage that a serious incident would inflict on their success. One new entrant emphasised that expenditure on training is generally forthcoming and fully supported by senior management. This airline is making large investments in training, although it was suggested by this one individual that this was unusual in the industry.

It was suggested that airlines only provided CRM training originally because it was imposed on them, but now that their CRM trainers have a better understanding of its benefits, they wish to develop and extend the syllabus. However, senior management are frequently only willing to do what the JAA stipulate, since such additional training would be expensive. These trainers would like the JAA to increase its CRM requirements and are actively promoting its development within the airline management community.

5.3.6 Commercial Decision Making

Management at one airline reported that Captains are increasingly being required to make economic decisions. A Captain at another airline said that his job was to satisfy himself that his aircraft was fully serviceable, irrespective of any economic consequences and knock-on effects that might arise from delaying departure to have a problem fixed.

There is clearly a dilemma between safety and economics: a Captain has the responsibility for the safety of a flight but may be blamed by management if he or she is thought to have taken a commercially detrimental decision. If a pilot succumbs to commercial pressure and as a result is involved in an incident, he cannot, in law, defend his position by saying that the company pressured him to take the actions that he did.

5.3.7 Summary – Commercial Pressure

Issue	Potential Consequences
High flying hours	Fatigue, low morale, adverse effects on lifestyle
Unsympathetic rostering	Fatigue, low morale, adverse effects on lifestyle
Management pilots achieving high flying hours	As above; reduction in internal oversight and safety auditing
Reduced ratio of crew per aircraft, with resultant loss of flexibility	Reduced flexibility and possibly increased pressure to fly in adverse conditions (for example, when flight deck crew ill)
Senior management positions held by non-pilots	Lack of understanding of operational and flight safety issues, poor interpersonal relationships between pilots and management
Reduced turnaround times	Pressure to hurry/omit external or flight deck pre-flight checks
Reduced training budgets, particularly for areas that are not legislated (e.g. CRM)	Reduced exposure to training scenarios and reduced team-working /error management; particular issue when combined with crew of lower experience or multinationals
Use of third party training organisations	Inconsistency of trainers who work for a variety of airlines leading to incorrect training; or adoption of generic training by trainers for range of airlines
The contracting out of functions such as training and maintenance to third parties	Less direct control over the quality of such functions
Captains increasingly being required to make commercial decisions	Conflict between flight safety issues and commercial issues may influence decisions to operate in cases where the Captain is not 100% satisfied

Table 11: Commercial Pressures: Human Factors Issues

6. MITIGATING FACTORS

The previous chapter discussed the effects that commercial development in the aviation industry can have on flight crew. While many of these effects have the potential to impact on flight safety, there are mitigating factors at work to compensate. Three distinct mitigating factors were identified during the study.

CRM and SOPs were mentioned by everyone as a means by which human factors problems are anticipated and overcome, and safety during flight is maintained.

Although not explicitly referred to as a mitigating factor, the professionalism of pilots was mentioned frequently in the interviews and is thought by many people to counter some of the potential problems that have been identified.

In addition to the three mitigating factors, safety regulation sets the safety standards for the industry and defines the limits within which airlines must perform. It therefore acts as a control on the industry and attempts to ensure that any negative effects that may arise from globalisation are prevented.

This chapter discusses each of these mitigating factors in turn and considers the influence of safety regulation.

6.1 CREW RESOURCE MANAGEMENT (CRM)

Research in the 1970s into the causes of aviation disasters revealed that the majority of accidents and incidents in aviation involve human error rather than equipment failure or adverse weather. The most common types of errors made by the flight crew involve failures in leadership, team co-ordination and decision-making.

Subsequently, training courses were developed for flight crew to try to reduce these errors by focusing on their human factors causes. Initially known as Cockpit Resource Management (CRM), this training was a radical shift from traditional pilot training, concerned with the technical aspects of flying.

CRM training has been widely adopted by airlines throughout the world and its scope has been extended in some airlines in recent years to include other aspects such as monitoring skills, and the management of time, workload and stress. It is now known as Crew Resource Management. Sometimes other personnel such as cabin crew and ground engineers are included in the training.

6.1.1 CRM as a Means of Reducing Human Error

CRM was initially applied to improving team performance within flight crews of the same nationality, but is increasingly being applied to avoid any negative effects in situations where crew from different national and cultural backgrounds are mixed on the flight deck. A Regulator said that CRM has to work "… because it is the glue that holds a multicultural crew together". He also said that CRM has to be effective in extreme situations such as a 19-year-old *ab initio* pilot flying with a 59-year-old Captain with 20,000 flying hours.

It is widely believed in the civil aviation industry that CRM is successful within mono-cultural organisations, but a question that this study has had to address is whether CRM is as effective in improving the performance of multicultural flight crews.

One airline gave us an example of the success of CRM in their training of Filipinos. Initially the Filipinos had difficulty in reducing the steepness of the power gradient between Captain and First Officer but after a year they were able to overcome this problem. They believe that CRM has helped them to define their roles and responsibilities.

Two Cuban pilots said that CRM enabled them to increase their knowledge and awareness of crew behaviour and allowed them to improve their performance when flying. It also alerted them to conflict situations that might arise during a flight and helped them understand why these situations might arise and how to handle them.

An airline said that it is difficult to quantify the benefits of CRM because it becomes part of the system, as indeed it is supposed to. This airline also has a concern that although the quality of CRM instruction is continuously improving, crews may not comply with the lessons which they should have learned.

While everyone that was interviewed said that CRM training was important and had potential benefits, there appeared to be a variation in their depth of understanding about the need to modify the training to make it effective for a group containing a diverse cultural mix. Not surprisingly, airlines employing mono-cultural crew were less perceptive about this need than airlines employing crew of many different nationalities. One airline employing flight crew from more than twenty different countries quickly discovered that the outsourcing of CRM training was not effective and, after bringing it in-house, has found it necessary to develop the training over a period of several years to make it effective in a multinational environment. It was suggested that no process appears to exist in the industry to spread this learning experience to others.

Despite the widespread use of CRM as the primary strategy for the reduction of human error on the flight deck, there are some dissenting voices regarding its efficacy. This is supported by recent research (Johnson, 1999) which reports that the successful introduction of CRM training into many US airlines has not been mirrored by any quantifiable reduction in the number of incidents and accidents that stem from crew co-ordination and communication problems. The same author states that *'the relatively high frequency of incidents caused by poor flight crew performance also indicates the failure of existing CRM training techniques'* (Johnson, 2000). While no evidence has been found in Europe to either confirm or deny the conclusion of this research, it raises fundamental questions about the overall effectiveness of existing CRM training and the efficacy or cost effectiveness of the approach itself compared with other possible strategies for reducing human error in aviation.

6.1.2 CRM and Human Factors

The Human Factors Departments of airlines tend not to employ human factors professionals with appropriate qualifications. Instead, they generally consist of CRM trainers and line pilots who have developed an interest in the subject of human performance. Although these personnel have the appropriate industry-specific knowledge, the lack of human factors professionals in the airlines is perhaps surprising compared to other safety critical industries. This is also true of some Safety Regulators where it is rare to find professional expertise in human factors.

The implications of not having qualified human factors specialists working in the safety function of airlines is that the opportunity to capitalise on the broader base of human factors knowledge including that used in other safety critical industries (see Chapter 9) will be missed. Also the current tendency within the Operational area to suggest that CRM and Human Factors are synonymous will continue unchallenged.

6.1.3 CRM in Different Cultures

One Safety Regulator said that to be effective CRM must be tailored to an airline's culture. In his opinion, CRM should not be purchased as a package since people from different cultures think differently to arrive at the same solution. He believes that CRM should first be adapted to a country and then to an airline within the country.

A UK airline reported that they train CRM trainers from overseas subsidiaries in the UK. These trainers then return to their home base to train staff in a manner appropriate to their own national culture. They believed this approach to be effective.

An Eastern European airline that has only recently started to provide CRM training said that the principles of CRM have been carried out informally for a number of years. The airline has purchased a package developed by a UK company. They recognise that culture is important in the presentation of the material and the supplier has adapted the package to suit the local culture.

Cultural adaptation of CRM material is therefore taking place in two distinct ways: within an airline and by the supplier. It has not been possible to collect any evidence in this study of the effectiveness of these two approaches.

CRM appears not to be adopted by all cultures; for example, pilots from a certain Eastern European country were described by one airline as being poor team workers and unfamiliar with the concepts of CRM. From the evidence collected during this study, it would appear that some Eastern European countries are addressing this omission.

A Japanese company suggested to one Regulator that CRM is a solution to Western problems and that it may not be appropriate in cultures that experience different problems.

An interesting situation exists when non-European pilots wish to maintain their licences in their countries of origin and in Europe. Two Cuban pilots said that they are required to maintain their Cuban licence as well as their European licence. To meet this requirement they have to undertake CRM training in Spanish in Cuba and in English in Europe. There may be flight deck safety implications should the philosophies of these two CRM training courses differ. On the other hand, there may be positive effects if the two CRM courses reinforce each other.

6.1.4 CRM Expectations

CRM creates expectations for the relationship between flight crew, cabin crew and engineering staff, and one airline said that there has been confrontation in the past when these expectations have not been met. An interesting comment made about CRM is that younger crew tend to have great expectations about teamwork after training in CRM, which are not always met when working with a much older Captain. In one sense, therefore, CRM may actually make matters worse in a relationship when expectations are unfulfilled.

6.1.5 Outsourcing of CRM Training

Outsourcing of CRM training is generally considered to be undesirable. For example, one airline's experience of external CRM trainers was that their material was too generic. The solution for this airline was to bring the training in-house and develop the material to make it more suitable for many different nationalities.

Nevertheless, outsourcing of CRM training is common, particularly for smaller airlines who believe it would be uneconomic to run their own training. When CRM training is outsourced, it may not be company specific. For example, one airline that was interviewed uses a local company that includes pilots from other airlines operating out of the same hub in their training sessions.

6.1.6 Integrated CRM

In some airlines, there are few barriers between the cabin crew and the flight deck. For example, one airline described the relationship between the two as being very relaxed, and said that cabin crew have ready access to the flight deck. However, this is not the case in all airlines or on specific aircraft types. Some airlines run CRM training for mixed groups of cabin crew and flight deck. One airline said that they also involve maintenance and engineering personnel in the CRM training. Feedback from participants is that the integrated approach is successful.

However this practice is not adopted in all airlines and it is often the management of the airline who are not convinced about the value of integrated CRM. One airline interviewed used to carry out joint cabin and flight deck crew training but the practice has now been stopped at the request

of management. This attitude may indicate a lack of understanding of the purpose of CRM. Interestingly, one Regulator said that the "C" in CRM should stand for "Company", since in his view the philosophy of CRM should pervade the entire organisation.

Finally, as noted earlier, while CRM is believed in the industry to be a very effective tool, the standard of CRM training and implementation is perceived by many flight crew to be to very varying standards, both nationally and internationally. There is little doubt that some airlines have devoted substantial resources to try to achieve the highest standards, while for some others it is rather more a question of providing what might be described as a barely adequate course to comply with legal or authority requirements, with little positive commitment from senior management.

6.1.7 The Effect of Recent Commercial Developments on CRM

CRM training has undergone several updates since its inception over 30 years ago. The more recent versions of this training have undergone considerable development to take into account changes in the industry, such as the increased use of multicultural crews. The latter versions of CRM also consider human performance limitations such as fatigue and attention, widening the scope further to include more areas of traditional human factors rather than emphasising social psychological issues exclusively. It is therefore difficult to make generalisations regarding the efficacy of CRM as a control measure due to the many variations in the scope and content of CRM training programs. There is some evidence that the CRM industry is therefore responding to changes due to globalisation.

It should be noted that other approaches exist to tackle a wider range of human factors problems such as cockpit automation issues, fatigue and SOP compliance, and these approaches should not be neglected because CRM is seen as the solution to all human factors problems.

6.1.8 Summary - CRM

Issue	Potential Consequences
CRM training may not be tailored to reflect the increasing use of multinational crews	CRM initially devised for use within a sole country/culture and may not have been tailored for use in multinational crews
Reliance on CRM to solve all human factors issues	Neglect of other causes of error on the flight deck, e.g. fatigue, interface and automation issues.
Heavy reliance on CRM training to reduce errors, with little validation that it has the desired results on the flight deck	Crew may pay lip service to CRM, rather than embracing its principles; unjustified confidence by management that CRM will prevent incidents
CRM trainers are pilots, not human factors professionals	Concern that CRM trainers are part of the culture and therefore may be unable to assess CRM objectively, or may be unable to consider novel approaches to error management
CRM increases the expectations of younger crew and non-nationals	May make matters worse if the high expectations of these crew are not met
Outsourcing of CRM training	May not be successful if not tailored to the individual company

Issue (continued)	Potential Consequences (continued)
Crews maintaining licences in more than one country are required to attend several CRM courses	The different courses may reinforce each other, but they may have different or conflicting philosophies
Over-regulation of CRM	Standardisation and inflexibility may not allow for changes to the philosophy

Table 12: CRM: Human Factors Issues

6.2 STANDARD OPERATING PROCEDURES (SOPS)

6.2.1 Variation in SOPs between Airlines

Each airline may modify manufacturer's SOPs to a greater or lesser extent, and has a strong sense of ownership towards their own SOPs. Several airlines said that SOPs can vary greatly between carriers, although others suggested that most carriers' SOPs are only slight modifications from the manufacturers' versions. One Regulator said that SOPs are largely standard and that most airlines use those recommended by the manufacturers.

It would appear that new entrant airlines generally adopt manufacturers' SOPs with little, if any, modification, whereas established airlines will often have adapted these SOPs quite considerably.

Since Safety Regulators do not allow the operation of mixed SOPs, crew could not be mixed within an alliance unless all partners of the alliance were using the same SOPs.

In mergers and acquisitions, SOPs need to be harmonised and one of the airlines involved, usually the larger, will normally impose its SOPs on the other. Equitable harmonisation is unusual and was defined by one airline as '… where discussions take place and agreement is reached on a compromise where no party is satisfied'.

Merging SOPs may well be a lengthy procedure. One airline involved in a merger reported that in spite of both companies having sets of procedures that were very close to those issued by the aircraft manufacturer, merging them was still a major task. A long consultation process was necessary involving technical managers, training managers, and pilots' representatives.

6.2.2 Adherence to SOPs

One Safety Regulator said that he would be naïve if he thought that SOPs were followed all of the time, but believes that in the vast majority of cases they are. His opinion is that very few incidents would occur if SOPs were always adhered to rigidly.

The management of one airline stated that crew are trained to follow SOPs at all times since it is the primary means to reduce risk. Two pilots from the same airline said that they always follow SOPs and that almost everything is included within them, including how to deal with unusual problem situations. In their experience, if anyone deviates from the standard they are asked by the other member of the flight crew to desist. It follows that adherence to standards and procedures will be influenced by the prevailing safety culture in the company.

However, one airline raised a concern that as flying becomes increasingly routine, crew may not follow SOPs through a desire to be individualistic. A line Captain said that procedural violations are a fairly common practice. He gave an example of where he requested that another member of the crew follow the SOP to be told that 'this is not a line test'. A pilot from an airline in Southern Europe suggested that Southern Europeans are worse than Northern Europeans at following

procedures. The reason he gave is that SOP violations are tolerated more easily in his country than in some Northern European countries. He added that all rules have a philosophy behind them and pilots may try to follow the spirit of the rule rather than the rule itself.

There may be variations in SOP adherence at different times during a flight. For example, one pilot said that he would be more likely to follow SOPs if he was suffering from fatigue towards the end of a long flight.

Flight Operation Quality Analysis (FOQA) using Quick Access Recorders (QARs) to pick up deviations from the flight parameters specified in the SOPs is becoming increasingly common throughout Europe and all the major operators generally use such systems. These systems allow individual flight parameter exceedences to be identified. In cases of best practice, in the event of a major exceedence, the pilot is contacted by a 'trusted person' to give his or her version of the event. The most beneficial effect of using information from QARs is achieved in those airlines which have adopted a 'no blame' policy and where full and open reporting is actively encouraged without the fear of disciplinary action.

The use of QARs assists the safety process by highlighting areas of exceedence which will then be brought to the attention of the pilot force and which may require particular attention during the annual refresher training programme.

6.2.3 SOPs and Flight Deck Error

Many interviewees stressed the use of SOPs as an important factor in reducing pilot error, reinforcing the vital necessity of cross checking. Several airlines suggested that human factor issues should not arise if SOPs are strictly followed and CRM is effective. Another airline said that SOPs are particularly important when nationalities are mixed as they provide discipline. Singapore Airlines was given as an example of an airline employing many different nationalities where SOPs have been developed to cover all situations, and where there is a strong culture of enforcement.

Safety concerns arise where crew from an airline that has been taken over resent having to work to a new set of SOPs which they consider to be inferior. There may be a tendency to use the old SOPs at every opportunity, or the crew may revert to the old, more familiar SOP in error. Furthermore, crew may be more likely to revert to old procedures inadvertently in a degraded or emergency situation. When major changes are made to procedures there may well be a transition period of increased risk, which requires careful management.

Human factors issues relate not just to the content of the SOP, but also to the person who is required to perform each task in the procedure. Problems may occur when roles and responsibilities are different from those that the crew are used to. Given that many actions in an SOP require a response from one crew member to a request or challenge from the other, it is possible that an omissions error may occur if the request is not issued.

Agency crew are required to operate the SOPs of the airline to which they are seconded and thus need to be provided with the necessary training. The extensive nature of this training precludes very short-term contracts. Since agency personnel may quite frequently have to adjust to working with different sets of SOPs, they may inadvertently revert to a previously familiar procedure.

SOPs aim to ensure that all pilots within an airline fly to the same procedure on a particular aircraft type. This is desirable if the procedures are robust, but if there is a weakness in an SOP then problems will occur throughout the company.

6.2.4 The Effect of Recent Commercial Developments on SOPs

There may be a trend towards the greater adoption of manufacturers' SOPs by airlines and this may be a function of recent developments, as it is the new entrants that are leading this trend.

Manufacturers' SOPs may be adopted due to perceived cost benefits or where the airline lacks the operational experience to modify these procedures.

Although current SOPs may mitigate some of the effects of globalisation (such as the mixing of crews with different cultures, backgrounds, experience etc.), future SOPs will continue to evolve in light of operational experience with such issues. For example, they may become more structured and comprehensive in order to control risks associated with the increased variability of flight crew.

Furthermore, certain globalisation concerns actually stem from the SOPs themselves. For example, as discussed in Section 6.2.1, the harmonisation of SOPs between different airlines is a formidable barrier to airline mergers.

6.2.5 Summary - SOPs

Issue	Potential Consequences
Mixing of crews between mergers and alliances. Although not currently permitted in an alliance by Regulators, it may become more prevalent in coming years.	Confusion between different SOPs, reversion to more frequently applied SOPs, confusion as to flight deck roles and responsibilities
Differences in culture towards use of SOPs – following written checklists versus working from memory	Conflict of cultures where crew have different attitudes to use of (written) procedures
Differences in culture towards adherence to SOPs	Conflict of cultures where crew have different attitudes to adherence to procedures
Differences in culture towards following SOPs to the letter or following the spirit of the rule	Conflict of cultures where crew have different attitudes
Harmonisation of SOPs following a merger Increased use of agency crew	Crew inadvertently applying better-known SOP (particularly during transition period) or wilful reversion to the previous SOP: relates to definition of roles in the procedure as well as content
Increased requirement for SOPs for all tasks on the flight deck	Crew experience boredom and express individualistic tendencies (deviating from SOPs for variation); crew become less capable of intervening in a degraded situation 'outside' of SOPs; unrealistic faith in the use of SOPs as a measure to prevent human error; crew anticipate subsequent step in the procedure, hearing what they expect rather than what was said; if SOPs are poor then the quality in whole fleet or airline could be affected
Crew moving to an airline that places more or less emphasis on SOPs	Crew find difficulty in adjusting to the new environment

Table 13: SOPs: Human Factors Issues

6.3 PROFESSIONAL CULTURE

For an industry that is relatively young, aviation has developed a strong and distinctive professional identity and this is particularly apparent in the professional culture found among pilots. National and organisational (company) cultures have been discussed earlier, but professional culture may pervade all other cultural boundaries.

In the interviews, it was stated on a number of occasions that this professionalism counters many of the potential problems that have been identified.

6.3.1 Components of Professional Culture

Flight crew are required to maintain high vigilance during extended periods of low workload, and yet have to be able to make an abrupt transition to demanding, or occasionally overload conditions. Furthermore, they are normally required to form a coherent team from a group of strangers and immediately begin to perform demanding, safety critical work. This team formation may not always be successful. Research undertaken by the US National Transportation Safety Board (NTSB) has reported that a disproportionate percentage of accidents involve crew who are flying together for the first time.

Several management and line pilots spoke about the characteristics that are frequently found in flight crew and contribute to a strong professional culture. Flight crew were generally described as intelligent, although not necessarily with tertiary education qualifications, with a high degree of self-confidence. Strong self-discipline and self-motivation were said to be essential to cope with the working environment. Flight crew were also said to dislike change. Because they are conservative, they are more comfortable with change if it is long term and gradual.

In most European countries there is an element of self-selection before deciding to become a pilot. Selection for sponsored training, which is not currently the norm, is highly competitive and many crew pay the considerable training college fees themselves. A necessary prerequisite in these cases is, therefore, the possession of sufficient finance by them or their families. Few other professions require such significant private investment in order to be considered for employment. Clearly, those that enter training have a great enthusiasm for aviation and a strong desire to become a pilot. People do not drift into this.

In some airlines the selection process for *ab initio* and qualified pilots is extremely demanding and includes psychometric, intelligence and aptitude testing, group exercises, written questions, interviews and a substantial medical. In others it only includes an informal interview and a simulator assessment. One airline said that psychometric testing, which is more commonly used in the selection for sponsored training, had been tried for direct entry pilots, but was found to be superfluous since it did not enhance their selection process.

Pilots generally state that they enjoy their jobs a great deal. In a survey by Helmreich, 75% of pilots from 19 countries said they were extremely satisfied with their job, compared with only 36% of people in other occupations. However, this difference may be partly explained by a psychological theory that postulates that when individuals undergo extensive and expensive training and initiation, they may unrealistically perceive group identity as being highly worthwhile.

Invariably, the professional culture is not monolithic and there are a variety of subcultures in the industry. These subcultures may exist around several aspects such as:

- Background (commercial or military);
- Type of airline (flag carrier, regional carrier, etc.);
- Position (Management Captain, Captain, First Officer, Flight Engineer); or
- Gender (male, female).

6.3.2 Professional Culture and Safety

A strong professional culture has both strengths and weaknesses. On the positive side, pilots take great pride in their profession and have a strong motivation to perform to the best of their ability. However, there are negative aspects of a strong professional culture such as an unrealistic denial of vulnerability to factors such as fatigue, stress or personal issues. Given the great responsibility of pilots, denial of personal vulnerability may be a psychological defence mechanism to avoid performance anxiety. Researchers at the University of Texas Human Factors Research Project (Helmreich et al) report that the majority of pilots in all cultures agree that:

- their decision making is as good in emergencies as in normal situations;
- their performance is not affected by personal problems; and
- they do not make more errors under high stress.

This research was supported by evidence from the interviews that were carried out. One management pilot expressed the belief that the high level of professionalism of pilots rules out many potential problems from multinational flight crews. Several pilots said that commercial pressure would not lead a pilot to take risks because they have a very high regard for safety.

Another management pilot divided flight crew into three groups: those that avoid errors (Pro-active), those that get on to errors quickly (Mid-range), and those who are slow to react to errors (Reactive). His view is that the pro-active group is the safest, but he added that as technology advances and systems become increasingly complex, the vulnerability of humans grows. The consequence is that flight crew tend to become more reactive.

It can be hypothesised that some components of aviation professional culture may sometimes act to decrease flight deck safety, particularly if taken to the extreme. For example:

- A high level of pride in their work may make crew reluctant to admit to error;
- A high degree of personal confidence may lead to a disregard of the opinions of others or to the disregard of checklists and SOPs;
- An unrealistic perception of human limitations may reduce team working or lead crew to take risk in order to complete the flight.

Two instances were described which support this hypothesis.

The first was of a First Officer advising a Captain who had only previously flown domestic routes and was commanding his first long haul flight, of several operational problems that might arise because their destination was at the limit of the aircraft's range. The Captain was not prepared to listen because he thought that he was losing face in front of the rest of the crew and his professionalism was being questioned.

The second was of a Captain who made a series of errors, despite warnings from the flight management system, that resulted in an engine being shut down during the cruise phase of a flight. The very experienced First Officer was able to recover the situation quickly, but the Captain refused to admit that he had done something wrong and blamed the shutdown on an aircraft malfunction.

Given that work is a central aspect of our lives, it is not unreasonable that the values of professional culture become part of the self-concept. Therefore, a sense of invulnerability may become internalised and this may in part explain why evidence of personal limitation is often played down.

In their book 'Culture at Work in Aviation and Medicine' (1998), Helmreich and Merritt pose the following question:

'Do you think that your perceptions of your employer or organisation affect your level of commitment and job performance?'

Some may argue that, regardless of the environment, professionalism should, and does, transcend organisational difficulties. While this is a reassuring answer from a safety perspective, it may not necessarily be true. As has been discussed in section 5.2, issues with the company or management do occur in periods of extreme organisational change, such as mergers and acquisitions.

6.3.3 Professional Culture and CRM

Some researchers have developed a further revision of CRM centred on error management. This generation of CRM recognises that error is inevitable and attempts to change the professional culture by 'fostering a more realistic awareness of personal limits and capabilities' (Helmreich and Merritt, 1998). If pilots universally accept that human error is inevitable then measures to counter such error will be better received by crew in CRM training. Furthermore, acknowledging the inevitability of error also assists in the reporting of personal mistakes and mishaps, assuming that the airline has adopted a 'no blame' culture. This generation of CRM stresses that errors will occur despite best efforts to the contrary.

Attitudes are changing over time as CRM training focuses more on human error and the limitations of human performance. There is scientific evidence that agreement with statements such as 'Even when fatigued I perform effectively during critical periods' is reduced where the latest generation of CRM is practised. Clearly, professional culture can be changed, although as with any culture change this is a long-term process.

6.3.4 Professional Culture and Change in the Industry

It has been suggested earlier that a strong professional culture can have positive and negative implications for flight safety. The positive effects will act as mitigators, but should professional culture become degraded following any aspect of change in the aviation industry, the positive effects may lessen. If the components of professional culture can be identified, it may be possible to assess the effect that change in the industry will have on each component, and thence flight safety.

Some examples of the causes and effects of change in professional culture are described below. It should be noted that not all the examples have a negative effect on flight safety.

- Several people that were interviewed said that young people who might previously have trained to be pilots are being attracted into other lucrative professions. This will reduce the number of potential entrants to the profession, which perhaps already does not enjoy the prestige previously associated with a career in civil aviation;
- Mixing flight crew from all over the world may lead to the perception among pilots that they are less of a coherent group. In the past, mergers have tended to combine professionals in similar countries and companies, thereby reinforcing the belief in a common identity. However, as globalisation increases, the disparity in training/selection/procedural standards and pay/conditions, for example, may act to diminish the view of such a common identity;
- Increased attention on flight deck safety and human factors, the increased publication of aviation incidents and (particularly) the emphasis of human performance limitations in training may all act to reduce the perception of infallibility/invulnerability in crew;
- As technology advances and automation levels increase, the 'romance of flight' effect may be weakened. In the past, the heroic actions of pilots under conditions of extreme stress have contributed to the professional culture of aviation.

6.3.5 Summary – Professional Culture

Issue	Potential Consequences
Crew may have a high level of pride in their work	Crew may be reluctant to admit errors or report incidents
Crew may have a high level of personal confidence	Crew may disregard the opinions of other crew members or ignore checklists and SOPs
Crew may exhibit an unrealistic perception of human limitations	Crew may be unwilling to accept error reduction strategies
Globalisation may erode the positive effects of professional culture	Professional culture may have less of a mitigation effect on those issues that may adversely affect flight deck safety

Table 14: Professional Culture: Human Factors Issues

6.4 SAFETY REGULATION

Safety regulation is different from the other three mitigating factors since it sets standards and limits to which the airlines must perform. It therefore influences the application and, by extension, the effectiveness of both CRM and SOPs. However, safety regulation in Europe is not yet fully harmonised. Differences in the legal systems of each member state mean that European airlines are not overseen by a coherent legal entity, unlike the situation in the US.

6.4.1 Objective-based Regulation

Some Regulators are taking a less active role in enforcing standards by setting objectives and allowing airlines to take greater responsibility for their own oversight by means of self audits. One airline suggested that self-audits may work well in a disciplined society like the UK, but will be more difficult to implement successfully in other less disciplined countries. Another made a distinction between large established airlines where it was thought that self-auditing would generally be successful and small airlines where it might be more problematic.

One airline said that because of increasing commercial pressure, effective regulation is required to ensure that the required standards are maintained. Another said that regulation is necessary to ensure that airline management invest adequately on safety related matters. For example, management may only be prepared to purchase and install new equipment on an aircraft if there is a regulatory obligation to do so.

A problem that was raised with the increasing emphasis on self regulation was that it is becoming increasingly difficult for airlines to recruit suitably experienced people as nominated post holders to carry out this important role. There is, therefore, a need to provide better training to these people to ensure that they are competent to carry out their duties.

A Regulator said that an advantage of airlines working together in an alliance was that they audit each other's operations to ensure that they are of similar and adequate standard. This has the effect of raising the standards of all members of the alliance to the standards of the most rigorous member. Airlines also exert control over their franchisee holders by carrying out regular audits.

6.4.2 The Mixing of Flight Crew

In general, Regulators are not concerned about airlines operating with multicultural flight crews provided all the standards and regulations in force are satisfied and local licences or validations are held. One Regulator said that his organisation had already experienced a number of the effects of globalisation as many of the airlines under its jurisdiction employ or contract pilots from all over the world. He would be more concerned about mixing flight crew from different airlines within an alliance, which he said would be more of a challenge. It is interesting to note that several Regulators interviewed thought that mixing crew within an alliance was likely to take place in the future, whereas none of the airlines interviewed did.

One Regulator made a distinction between 'Globalisation' and 'Europeanisation'. He said that within Europe there are national differences but outside Europe there are continental differences. For example, Africans and those from Far Eastern nations have a very different outlook on life from North Americans. He believes that integration between the JAA and the FAA will be difficult and said he would be concerned about pilots who did not hold a JAA licence flying aircraft registered in Europe.

Cross-validation of foreign licences is reported to be an increasing problem by one airline which relies on non-JAA licensed pilots in some areas. These pilots need to validate their licences to operate in the JAA area and they are open to problems in transition between the two systems. The airline expects 'growing pains' as JARs are interpreted differently in different companies and countries. The same standards apply in all places where the company operates and the costs involved with compliance are reported to be huge. They said that one of their biggest challenges is to remain JAR-OPS compliant in some of these countries.

One Safety Regulator provided an interesting example which indicates that regulation can reduce the opportunity to mix flight crew.

The example concerns an operator with airlines in two countries operating under different approvals and licences. To increase efficiency, the operator wished to create a common pool of aircraft and crew that could be used in a flexible way, but did not want to merge the airlines for commercial reasons. This created several legal problems for the Regulator in one of the countries. For example:

- Regulations of the country do not permit a Captain to command an aircraft registered in that country unless he or she also holds a licence issued by that country;
- Each airline had its own Chief Pilot and set of operating manuals; and
- Regulations of the country specify that a minimum number of the cabin crew should hold certificates of competency issued by the Regulator of that country.

While rules, such as these, are not in force in all JAA countries, the example is given to illustrate how the Safety Regulator in a specific country can constrain the flexibility of an airline to mix crew.

6.4.3 JAR-OPS

There are difficulties being experienced by some regulators and airlines in the implementation of JAR-OPS. One airline said that although JAR-OPS is currently being introduced, full implementation is likely to take many years and it will have a large impact on the company. Another said that one of their biggest challenges is to remain JAR-OPS compliant in some of the countries that they serve outside the JAA area. They report huge costs in maintaining this compliance. Another airline said that they believe that there is a trade-off between the high cost of training and the benefits arising from this training. A Regulator said that they were unable to cope with the amount of work required to implement JAR-OPS as it requires significant resources.

6.4.4 CRM Training

One Captain suggested that CRM training was over-regulated. He was concerned that Europe simply took the US CRM approach and approved it, and said that this would be bad practice in a region with only one culture, but was even worse in an area such as Europe composed of many different cultures. He said that the implementation of CRM requires careful management and that a programme of research should be set up into how CRM can be effectively implemented in Europe. CRM is highly legislated, but there needs to be scope for the further development of the philosophy. The representatives of another airline believe that the JAR requirements for CRM are too low and believe that the JAA should be promoting the development of CRM and giving it a higher profile.

Not all countries have their own regulations for CRM training. For example, in Italy the only requirements for CRM at present are in JAR-OPS. Because the implementation of JAR-OPS is incomplete, CRM training is in effect an option for airlines.

In some countries, Regulators approve CRM courses, require sight of the airlines' syllabi and timetables for CRM training and sit in on CRM courses on a random basis in order to check the quality.

7. EFFECTIVENESS OF MITIGATING FACTORS ON HUMAN FACTORS PROBLEMS ARISING FROM COMMERCIAL DEVELOPMENTS

A number of tables of human factors issues and their potential consequences have been presented in Chapters 5 and 6. An analysis of these tables has identified several issues that have the potential to directly or indirectly affect the nature and likelihood of human error on the flight deck. They are:

- Team working
- Communication
- Fatigue
- Morale and job satisfaction
- Experience and competence
- Situational awareness

In addition, safety auditing and internal oversight has an overarching objective of ensuring that whatever changes take place in the industry, safety standards will be maintained.

This chapter analyses these issues and considers the extent to which the likelihood of any of them having a negative impact on human error may be reduced by the three factors of CRM, SOPs and Professional Culture. The impacts identified are partly based on the information gathered during the survey and partly based on the professional judgement of the study team. Direct links are made between structural changes in the industry, human factors issues, and flight deck errors. An overview of these links can be found in Figure 4 on page 29.

These issues are not necessarily independent. For example, fatigue and crew morale may be influenced by the same factors. Furthermore, some of these issues may also be influenced by a variety of factors unrelated to commercial developments in the industry.

7.1 TEAM WORKING

Team working has long been recognised by the industry as critical to safe operations, and this has led to the growth of CRM training. One of the key issues in team working is the cockpit power gradient (or authority gradient). This refers to the relationship or command structure between the Captain and co-pilot, including the definition of roles (the nature of the task) and responsibilities (who performs what task).

The ability of the flight crew to operate as an effective team may be influenced by a variety of crew characteristics (which may be inter-related), including:

- Nationality
- Native language
- Level of experience
- Technical ability
- Seniority
- Background
- Religion
- Age
- Attitudes
- Morale
- Job satisfaction

These characteristics may in turn be influenced by several factors resulting from commercial developments in the industry, including:

- The merging of national cultures;
- The merging of company cultures;
- The recruitment of non-nationals;
- The recruitment of less experienced crew;

- The recruitment of agency/contract crews; and
- The quality of training (both technical and non-technical).

The impact that each mitigating factor has on team working is shown in Table 15.

Mitigating factor	Impact on reducing the negative effects of commercial developments on team working
CRM training	May act to reduce the adverse effects of crew characteristics on flight safety (for example by ensuring an appropriate power gradient between crew regardless of background/seniority/age/experience). It may be less effective in addressing issues relating to: • multinational/multicultural crews, for which it was not originally designed; • Crews that have very different backgrounds (military versus commercial) • Crews who have been trained in differing CRM philosophies (e.g. from different national cultures)
SOPs	Adherence to SOPs may assist in team working. However, different cultures have varying attitudes towards the adherence to procedures, which may create conflict and therefore reduce effective team working.
Professional Culture	A 'bond' between aviators (in the sense of being fellow professionals) may act to encourage team spirit regardless of their background etc. However, it may not assist in team building where conflicts arise on significant issues, such as adherence to SOPs

Table 15: Effect of Mitigating Factors on Team Working

7.2 COMMUNICATION

Communication, as discussed here, does not include power gradient issues, which are included in the above analysis of teamwork. Communication issues may occur in relation to the flying task and to social situations outside the cockpit.

When communication between one flight crew member and ground crew or ATC takes place in the local language, the other crew member may be unable to monitor the conversation if his or her knowledge of the language is inadequate. As a result, misunderstandings may occur and situational awareness may be reduced.

Language relating to the flying task is largely standardised and the use of SOPs will mitigate against errors in standard situations or anticipated contingencies. However, in the case of degraded or emergency situations that are not covered by an SOP or where the situation is changing rapidly, the crew may not have the language ability to communicate effectively within the cockpit and may, therefore, be unable to work as a coherent team.

Although the formal communication between members of multinational crews may not be impaired in relation to the flying task, they may not have the language ability to be able to socialise properly either inside or outside of the cockpit, which is particularly important on long-haul flights and stopovers. This may further hinder the formation of a coherent team.

A range of factors will influence the success of flight deck communications and include:

- Nationality;
- Native language; and
- English language ability.

These factors will in turn be influenced by:

- The merging of national cultures; and
- The recruitment of non-nationals.

The impact that each mitigating factor has on communications is shown in Table 16.

Mitigating factor	Impact on reducing the effects of communications problems
CRM training	CRM may be expected to have positive effects on crew communication in the cockpit, especially in the sharing of information and decision making in emergency situations and their precursors. However, where the crew have no influence on the language spoken (for example, when ATC communicates in the local language to other aircraft) CRM will have no beneficial effect.
SOPs	Where the flying task is highly proceduralised, communications between different nationalities are driven by the SOPs. However, these will have little value in unexpected situations not covered by SOPs, where communications are less formal.
Professional Culture	It is not anticipated that professional culture will reduce communications problems apart from the benefits of shared technical knowledge.

Table 16: Effect of Mitigating Factors on Communication Problems

7.3 FATIGUE

Several of the findings discussed in the earlier sections suggest that recent commercial developments may increase flight crew fatigue, which could have an adverse effect on flight deck safety. Fatigue has direct and well-established influences on human performance. As early as the 1940's, fatigue was shown to produce a higher frequency of errors in pilots in a fully instrumented static aircraft cockpit. With increasing fatigue, pilots tended to scan instruments less effectively. Pilots increasingly thought that their performance was more efficient when in fact the reverse was true. Timing of actions and the ability to anticipate situations was particularly affected (Bartlett, 1943). More recent research (e.g. Meijman 1997, Hockey 1997) has confirmed these effects.

As a result of recent commercial developments, the likelihood of flight crew fatigue may be affected by:

- Increased flying hours;
- Unsympathetic rostering practices;
- The need to perform additional ground based/management tasks; and
- Absence of JAA/EU rules on Flight Time Limitations.

These factors in turn may be influenced by:

- Shortage of experienced pilots;

- High utilisation rates of crews; and
- Lack of operations / administration support.

The impact that each mitigating factor has on fatigue is shown in Table 17.

Mitigating Factor	Impact on Reducing the Effects of Fatigue
CRM training	Recent versions of CRM may educate crew as to human performance limits, making crew aware when and how they may be more likely to suffer from fatigue. They may also outline actions to be taken should pilots experience excessive fatigue (for example, increased checking or relying more on fellow crew). However, some versions of CRM do not consider such factors.
SOPs	SOPs may counteract the effects of fatigue by reducing the reliance on judgement and minimising the need to perform working memory intensive tasks such as diagnosis, decision making and strategy formulation. However, as discussed previously, this benefit will only apply to situations that can be anticipated in advance. Also, the effects of fatigue tend to be most manifest in low stimulation, sustained attention tasks such as monitoring instrumentation or airspace, or when dealing with unpredicted, stressful situations. These types of tasks are not generally governed by SOPs.
Professional Culture	Flight crew may be less aware of their limitations and consider that high levels of professionalism counter any adverse effects of fatigue. However, since the effects of fatigue operate at a physiological level, it is unlikely that they will be effectively controlled even by the levels of dedication and diligence associated with a highly professional attitude.

Table 17: Effect of Mitigating Factors on Fatigue

7.4 MORALE AND JOB SATISFACTION

Of all the human factors issues, the mechanisms by which morale and job satisfaction influence flight deck safety are the most tangible and to a certain extent controversial. However, in other safety critical industries, morale is considered to be a factor in incident causation. It is stressed that any adverse effect of low morale on flight deck safety is unlikely to be a deliberate decision or action (sabotage); but it may nevertheless influence performance.

There are a number of ways in which poor morale could contribute to flight deck errors. The level of morale of an individual or a team influences the amount of 'disgressional energy' that they are prepared to put into their tasks. If morale is low there may be a tendency to perform to the minimum standards rather than to exert extra effort to achieve best practice. The same factors that influence morale may also increase 'internal distractions'; for example, concern or preoccupation over significant employment issues (such as the merging of seniority lists during a merger or personal problems) may temporarily divert attention away from the flying task.

Morale may be influenced by:

- Increased flying hours;
- Unsympathetic rostering practices;
- Inability to achieve required or desired days off;

- Discontent with seniority issues (particularly the merging of seniority lists);
- Changes in other employment conditions (e.g. relating to leave or other benefits); and
- Uncertainty regarding the future of the company or the flight crew.

These factors may in turn be influenced by:

- Shortage of experienced pilots;
- High utilisation rates of crews;
- Lack of operations / administration support;
- Merging or acquisition of airlines (regardless of cultural issues); and
- Major organisational change.

The impact that each mitigating factor has on morale and job satisfaction is shown in Table 18.

Mitigating factor	Impact on reducing the effects of commercial developments on morale and job satisfaction
CRM training	CRM would not appear to mitigate the effects of low morale.
SOPs	SOPs will ensure that the minimum level of diligence required for safety critical tasks will be applied. However, some of the results of low morale that may affect flight deck errors, e.g. diversion of attention by internal pre-occupations, will not be compensated for by SOPs.
Professional Culture	The professional culture of aviators may to some extent reduce the impact of low morale on the flight deck in that it will ensure that flight crew adhere to the minimum standards of performance.

Table 18: Effect of Mitigating Factors on Morale and Job Satisfaction

7.5 EXPERIENCE AND COMPETENCE

The experience and technical competence of flight crew are critical to the safety of the flight. It has already been suggested that some of the effects of recent commercial developments may act to reduce the average level of experience or technical competence on the flight deck.

As a result of these developments, experience and competence may be influenced by:

- Recruitment of pilots with minimal flying hours;
- Recruitment of pilots from less developed aviation states;
- Reduced quality of training (both technical and non-technical);
- Reductions in safety auditing and internal oversight; and
- Early promotion to Command.

These factors may in turn be influenced by:

- Shortage of experienced pilots;
- Difficulty in retaining senior crew;
- Reductions in training budgets;
- Use of third party training organisations; and

- Increased load on management pilots during mergers, leading to neglect of training functions.

The impact that each mitigating factor has on experience / competence is shown in Table 19.

Mitigating factor	Impact on reducing the effects of commercial developments on experience / competence
CRM training	CRM training may ensure that the assignment of tasks to flight crew members takes into account their experience and competence levels and uses the cockpit resources to their best advantage. However, if all of the flight crew are inexperienced then it may be difficult for the Captain to exercise leadership
SOPs	To a certain extent, a highly proceduralised environment supported by extensive SOPs will compensate for inexperience. However, crew exist on the flight deck for the same reasons that other safety critical industries employ humans – partly in order to intervene in the event of an abnormal or degraded situation. Safety concerns may arise with inexperienced crews in the situations which require interventions not covered by SOPs.
Professional Culture	Professional culture will not directly compensate for inadequate experience or competency.

Table 19: Effect of Mitigating Factors on Experience and Competence

7.6 SITUATIONAL AWARENESS

Continual awareness by flight crew members of the operating state, location and other characteristics of the aircraft are necessary for a safe flight. This is generally referred to as 'situational awareness'. Situational awareness has an essential predictive element since it implies that a crew member is aware of how the situation is likely to develop forwards in time. From a team performance perspective, it is also important that the crew have a shared 'mental model' of the situation. The term 'mental model' refers to the simplified representation of the state of a situation that is held in a person's mind (or a team's collective mind) and is discussed in Section 3.3. Normally the mental model is based on the state of a relatively small number of significant variables in the environment, e.g. weather conditions, the proximity of other aircraft, the state of the aircraft systems and this status monitoring process is updated in line with the changing situation.

The guidance provided by SOPs, which are essentially static, and geared towards delineating specific responses to specific situations are of little assistance in maintaining situational awareness. They may provide some generalised guidance regarding what information it is important to monitor in order to achieve good situational awareness, but this knowledge is more likely to be acquired through training and experience.

There is evidence in the discussions that individual crew members may experience a temporary loss in situational awareness under certain conditions pertaining to recent commercial developments. A related issue is that each crew member could have a different 'mental model' of the situation and that the crew as a whole may not be aware of these differences. As a result, the individual crew members may have a different understanding of the situation and the decisions and/or actions to be taken.

Significant effects on flight safety can occur where a lack of situational awareness by a single member of the crew (or a loss of a shared mental model by all members of the crew) is not

identified. The following factors may reduce the likelihood of the crew holding a shared mental model of a situation:

- Different levels of operational experience;
- Different training experience;
- Different background (e.g. military or commercial);
- Poor local language skills;
- Increased workload; and
- Fatigue.

These issues may be influenced by several factors resulting from globalisation, including:

- The merging of national cultures;
- The merging of company cultures;
- The recruitment of non-nationals;
- The recruitment of less experienced crew;
- The quality of training (both technical and non-technical); and
- Lack of operations support.

The impact that each mitigating factor has on situational awareness is shown in Table 20.

Mitigating factor	Impact on reducing the effects of commercial developments on situational awareness and mental models
CRM training	CRM will assist in the integration of crew with differing backgrounds/experience and encourage the sharing of information to both enhance situational awareness and develop shared mental models of the situation
SOPs	Of limited assistance but may provide some generalised guidance regarding information to monitor
Professional Culture	Some benefits from a shared culture

Table 20: Effect of Mitigating Factors on Situational Awareness

7.7 Safety Auditing and Internal Oversight

There is some concern that the quality or effectiveness of an airline's Safety Management System (SMS) may degrade as a result of mergers and globalisation. Several structural changes to the industry have been identified as possibly increasing the risk of human error on the flight deck, such as the rostering of multicultural crews; the recruitment of agency crews and a reduction in recruitment standards (in terms of experience and technical ability). It is proposed that such structural changes require specific and focussed safety management and that this may not necessarily be provided.

A reduction in the effectiveness of an airline's SMS may be influenced by:

- Failure to set up an effective SMS during and following the changes associated with mergers and globalisation; and

- Over emphasis on commercial objectives.

These factors may arise because of:

- The emergence of new business fashions;
- The requirement for pilots with management responsibilities to also achieve high flying hours;
- Failure to give suitable priorities and resources to the SMS during periods of change;
- Lack of regulatory requirements for a formal SMS to be developed to ensure commercial developments do not compromise safety;
- Commercial pressures to reduce management and administration support; and
- Increased competition and reduced margins.

The impact that each mitigating factor has on safety auditing and oversight is shown in Table 21.

Mitigating factor	Impact on reducing the effects of commercial developments on safety auditing and internal oversight
CRM training	None
SOPs	May mitigate reductions in auditing or oversight; but these reductions may in fact fail to identify non-adherence to SOPs, or inadequate SOPs.
Professional Culture	Will promote some degree of internal oversight

Table 21: Effect of Mitigating Factors on Safety Auditing and Internal Oversight

Since none of the three mitigating factors considered up to now will have a major impact on the higher level issues of safety auditing and internal oversight, the role of regulatory agencies will be important in encouraging airlines to support these functions during mergers and other commercial developments.

7.8 SUMMARY OF MITIGATION EFFECTIVENESS

From the above analysis and discussion it is clear that the control measures that the people interviewed in this study felt would mitigate the effects of commercial developments on flight deck safety may not be completely effective. The extent to which the three measures of CRM, SOPs and Professional Culture are assessed to be effective, as concluded from the data and information collected from those European States participating in the study, is presented in Table 22.

Human Factors Issue	Mitigation Effectiveness		
	CRM	SOPs	Professional Culture
Team working / power gradient	Medium	Medium	Medium
Communication	Medium	Medium	Low
Fatigue	Low	Medium	Low
Morale and job satisfaction	None	Low	Low
Experience / competence	Medium	Medium	None
Situational awareness and mental models	Medium	Low	Medium

Table 22: Tabulation of Human Factors Issues and Mitigating Factors

By observation, it can be seen that CRM and SOPs have a greater mitigating effect than professional culture, and this conclusion is in line with what people in the industry believe.

8. COMPARISON WITH THE MARINE INDUSTRY

8.1 INTRODUCTION

The shipping industry has seen radical changes in the past 40 years. Most of these changes have been due to economies of scale. Between 1960 and 1980, the average size of tankers and dry bulk ships grew by a factor of five, and is continuing to grow. An even greater revolution has taken place with the introduction of container ships, where turnaround times in port have been reduced from weeks to hours. Competition has driven a large reduction in crew costs, and a ship today, five times the size of a ship forty years ago, will probably be manned by between one half and one third of the crew.

As a result of these changes together with technical innovation, shipping is the only industry recognisably the same as it was in 1960, which has come near to aviation in maintaining unit costs in real terms.

There are two factors that strongly influence the attitude toward safety in merchant shipping:

(i) In terms of capacity, more than 95% of the world deep-sea merchant shipping fleet is engaged in carrying cargo and only 5% in carrying passengers. Due to the relatively small numbers of passengers carried, exposure to risk is considerably smaller than in aviation, and the numbers of socially intolerable incidents are fewer.

(ii) In general, recovery from serious failures such as total engine failure or electrical blackout is much more likely to be successful in shipping than in aviation. This has led to fundamental differences in maintenance regimes between the two industries.

8.2 DIFFERENCES BETWEEN AIRCRAFT COCKPIT AND BRIDGE NAVIGATION OPERATIONS

There are several fundamental differences between ships and aircraft:

- The navigation of ships involves co-ordination between two teams, one on the bridge and the other in the engine-room. This co-ordination is a dimension which is missing from aircraft cockpit operations.
- Ships are piloted through inshore waters where most incidents occur. When negotiating in these areas, ships are required to carry a Pilot with specific local knowledge and competence in bringing ships in and out of port and through busy sea lanes. He or she is also able to communicate in the local language with other Pilots advising ships in the same area and with the local traffic control authorities. The Pilot's role is purely advisory, but many Masters effectively hand over control of the ship to the Pilot. A Pilot and Master who have not previously met will need to quickly establish a working relationship and subconsciously establish a power gradient between them as a component of that relationship. By passing an examination, Masters are able to obtain pilotage exemptions for ports that they visit regularly. The dialogue between them and the port authorities will then be much closer to the situation of an aircraft Captain liasing with ATC.
- There are often more individuals involved with a wider range of skills in ship manoeuvring than in the case of aircraft. Power gradients will therefore be operating at all levels between the Master or Pilot and the most junior officer present.
- There is an extraordinary diversity of ships, which has no parallel in aviation, and each ship type has its own special set of navigational and ship handling problems. For example, high-speed craft are highly susceptible to extreme environmental conditions and their operating licences prescribe the maximum wind and sea states in which they may operate.

8.3 MULTICULTURAL CREWS

Shipping was the original global industry and has a long tradition of employing multicultural crews, the use of which is far more widespread than in aviation. The driver for this high level of multiculturalism has been purely economic and as a result, the market for ships' crews is totally global, and is possibly the most global labour market in the world. Most ships owned by the industrialised world are crewed either completely by Third World or Former Soviet Union citizens of one or more nationalities, or by senior officers of the owning company's nation and junior officers and crew from elsewhere.

The global nature of the crewing market has led to concerns with regard to the quality of qualifications and certificates of competency issued by Flag States, some of which are less scrupulous than others. This has led to the adoption of the two International Maritime Organisation (IMO) Conventions of 1987 and 1995 relating to the selection, training and certification of watch-keeping officers. The Conventions have brought about significant improvements, but the use of underpaid ships' officers with dubious qualifications, sometimes "purchased", is still far too prevalent and has no parallel in commercial aviation.

A catalyst for multicultural crews has been the prevalence of English as the language of the sea. The IMO Conventions require proficiency in English as a prerequisite for senior deck officer qualifications for ships in international trades. However, problems do occur with language communication between crew members of different nationality and in ship to shore communications. These problems are gradually being overcome by the use of formal Standard Operating Procedures and standard vocabularies in ship-to-shore and ship-to-ship VHF radio communications. These procedures are a relatively recent innovation in merchant shipping and have received a significant boost from an International Safety Management code, which has forced their introduction.

8.4 CRM AND PROFESSIONAL CULTURE

CRM, as practised in aviation, is still at the experimental stage in shipping. Interestingly, it is used mainly in specialist passenger carrying operations such as high speed catamaran ferries, which have imported many aspects of their culture from aviation.

The marine industry has a strong professional culture, possibly equal to that of aviation. The seagoing qualifications of Master and Chief Engineer have a particularly high value and entry to many grades of management in ship operations are all but impossible without such qualifications. Although shipping companies, as airlines, are increasingly run by accountants, ship operations executives invariably have seagoing qualifications. There is often a reluctance of those who hold these qualifications to accept the opinions of those who have never been to sea on matters of ship operations.

8.5 SAFETY REGULATION

The Regulation of the shipping industry is complex and very different from aviation, although there are parallels, particularly in the enactment and enforcement of International Conventions.

There are three elements to the regulatory framework of Merchant Shipping:

(i) The Classification Societies

(ii) Flag States

(iii) Coastal and Port States.

The Classification Societies are self-regulatory bodies which oversee and certify the design, construction and maintenance of ships. They have been much criticised for failing to meet their obligations in the face of commercial pressures, and for the diversity of their rules. This led to the

formation in the mid 1980's of the International Association of Classification Societies, which has brought about significant improvements in the consistency of ship classification.

The Flag State is the country in which a ship is registered and whose maritime laws therefore control its operation. Here there is a direct parallel with aviation. The vast majority of maritime safety law is dominated by the International Maritime Organisation (IMO). Although criticised for being slow and sometimes over-conciliatory, the IMO has brought about a fundamental shift in attitudes to safety in the shipping industry, partly through the progressive introduction of auditable safety management systems.

There are significant differences in the speed with which various Flag States adopt IMO Conventions and the manner in which they interpret them, which has led to a great deal of criticism of certain flag states.

One of the most significant drivers toward globalisation in the marine industry has been the Flag of Convenience. Certain countries have enacted laws which enable non-resident ship owning companies to register their ships there and gain benefits of low registration fees and a liberal regulatory regime. The flag of convenience system has been much criticised for its safety record, but it has been one of the significant drivers in shaping the industry and keeping international transport costs down.

Port State Control is seen as redressing the deficiencies of Flag State control, to the extent that ships of certain flags receive particular attention from Port State surveyors. Port State Control has been particularly significant in providing a system of "spot audits" for the newly introduced International Safety Management code.

8.6 CONCLUSION

Although aviation may have learned from the marine sector in its early days, in recent years the learning has been in the opposite direction. Nevertheless, there are some areas of resource management in which aviation might learn from shipping, particularly in the area of multicultural crews.

9. APPROACHES TO HUMAN FACTORS IN OTHER SAFETY CRITICAL INDUSTRIES

In the previous sections, we have suggested that the application of human factors principles in the civil aviation industry has mainly focussed on the qualities of individuals and teams. This is typified by the strong emphasis on training and CRM. This is partly because the culture of civil aviation has been strongly influenced, particularly in the past, by the large influx of military trained pilots, who brought with them the ethos that individual discipline, commitment and adherence to procedures were the primary means to achieving objectives. Although former military pilots no longer dominate the industry, many of these beliefs remain in place.

These beliefs are well founded in systems that are largely under the control of individuals or operating teams. However, there are some useful lessons to learn from other safety critical industries where different approaches have been applied. In general, the introduction of human factors in safety critical systems has arisen from the occurrence of major disasters where human error has been implicated as the primary cause. In fact, the first area where research on human performance was applied to reduce losses was in military aviation during the Second World War. In the early stages of the war, losses from pilot error exceeded those from enemy action by a large margin. This led to considerable improvements in the design of cockpits and other systems such as navigation aids and radios. The design of the cockpit environment and other aspects of military systems is still one of the largest areas of employment for human factors specialists.

Another military system provided the starting point for a more systematic consideration of human performance. In the early days of the cold war in the late 1950s and 1960s it was found that the main cause of malfunctions in ballistic missiles was either assembly or software errors. This led to the development of human reliability analysis techniques, which attempted to assign error probabilities to human activities in assembly, maintenance and software development. This was essentially a mechanistic approach that treated people as system components such as pumps or valves, without any consideration of *why* errors arise.

The limitations of this approach were realised when a number of major disasters occurred in the nuclear power industry (Three Mile Island, Chernobyl), where human failures involving higher level *cognitive* functions (e.g. diagnosis, problem solving, decision making, action formulation) were the predominant types of errors. This, together with major accidents in the chemical industry (Piper Alpha, Flixborough), led to the development of new techniques to analyse these types of error. The cognitive approach to human error emphasised the fact that people are active participants in the tasks that they perform, and are strongly influenced by their prior expectations in how they interpret a situation, and the perceived benefits and costs of alternative actions. They are also critically dependent on the information that they receive, either from displays or the physical environment, or from instructions such as SOPs, or remote communications. These factors are often not under the direct control of individuals, and hence the strategy of trying to maximise commitment and motivation will not have a substantial impact on this aspect of human performance.

In recent years, there has been increasing influence in the effects on human performance of the organisational factors that create the preconditions for individual errors, the so-called latent failures. These concepts have been developed most extensively by workers such as Professor James Reason of Manchester University. The approach seeks to identify aspects of organisational policies that can degrade the factors influencing human error directly. For example, the absence of clear policies for training, procedures development, or shift work will eventually create the direct conditions for accidents. This approach has been developed into comprehensive methods for tracking the causal paths between organisational conditions and errors at the 'sharp end'. Recent examples of this approach are in the area of aviation maintenance, Embrey (2001), and the analysis of signals passed at danger in the rail sector (Wright et al, 2000). This approach, which explicitly models the ways in which specific errors can arise as a result of organisational changes, could potentially be applied to the topics considered in this project.

The occurrence of recent rail disasters such as the Ladbroke Grove and Southall accidents have led to an increased focus on the human factors of rail accidents. Systems are now being developed for confidential incident reporting systems in the rail sector, similar to the CHIRP system used in the UK aviation sector. There is also an increased emphasis on analysing the underlying human causes of rail accidents in a more systematic manner.

The other current area of interest for the application of human factors approaches to error reduction is in the field of medical error (or patient safety). There is an increasing realisation that medical procedures are subject to the same types of errors that can arise in the other types of safety critical systems discussed earlier. Interestingly, the long delay in the application of human factors approaches to human error in medicine can be ascribed to many of the same causes as in the civil aviation sector. The existence of a strong professional culture (particularly a strong hierarchy led by consultants) has tended to divert attention to the individual characteristics of surgeons, nurses and doctors, rather than to the systems and policy causes (e.g. inadequate procedures, understaffing leading to resource and time pressures) that underlie many of the medical errors that have recently been the focus of the media. The analogy between the flight deck and the hospital operating theatre is readily apparent. Interestingly, the initial response of the NHS has also been to recommend the setting up of a confidential near-miss reporting system analogous to the voluntary reporting systems sometimes found in aviation (e.g. the UK CHIRP system"). Aviation also has mandatory reporting systems for incidents and accidents.

In general, the application of human factors in safety critical industries has involved two main approaches, driven by very different philosophies. The systems approach, described in the earlier stages of this chapter, uses knowledge of the mechanisms of human error to optimise various aspects of the system in which the person or the team operate. For example, a typical systems approach might first analyse the critical tasks that the person or team is required to perform (e.g. land a Boeing 747 under extreme weather conditions, deal with an on-board fire, maintain a critical control system). The next stage would examine factors such as the training, procedures, human machine interfaces and communication systems in order to evaluate the extent to which they deviate from best practice. This profile can then be used to specify where the most cost-effective improvements should be made in order to minimise the probability of failures in the safety critical tasks. In addition to this proactive approach, a complementary reactive method would analyse the direct and underlying causes (including organisational) of failures that have already occurred.

The alternative behavioural approach only considers the externally observable aspects of behaviour and is therefore very different to the systems approach. The behavioural approach attempts to reinforce good behaviours (e.g. by giving feedback to pilots where they have minimised exceedences on approaches). In addition the aim is to minimise negative behaviours or unsafe acts (e.g. reckless landing practices) by providing feedback without necessarily invoking threats or blame. The effects of behavioural methods can be partly ascribed to changing the balance between the perceived costs and benefits of non-compliant behaviours. In general, the behavioural approach is most successful in simple tasks where the person or team has a high degree of control over the way in which the task is carried out. They are less successful in situations where the technology determines the way in which a task has to be performed. Behavioural approaches rely on the constant monitoring of behaviour and hence tend to be quite resource intensive. Another disadvantage of these approaches is that the positive effects may decay over time unless continually reinforced.

In summary, the need for the application of human factors principles to safety critical industries is becoming increasingly realised even though the quality of technical safety systems continues to improve. Many engineers believe that eventually all critical systems will be automated, and the problem of human error will then be eliminated. However, in reality, the human will always be needed to cope with the situations that the designer and engineer, who after all are only human, have not been able to anticipate.

10. CONCLUSIONS

The preceding chapters have provided an analysis, part structural and part anecdotal, of data collected in discussion with management and flight crew in a number of European airlines and Safety Regulators, together with insights from relevant Human Factors research. Three outcomes of commercial developments in the industry that have an effect on flight crew were identified in Chapter 5.

(i) Multicultural flight crews

In 80% of the airlines returning questionnaires, at least 95% of the flight crew employed are local nationals, and in many Southern European states all the flight crew employed are local nationals. The number of aircraft movements in Europe with multicultural flight crews is, therefore, fairly small at present. Multicultural flight crews are more frequently found in airlines operating out of Northern Europe, particularly in low-cost airlines where, typically, 25% of the pilots employed are non-nationals. Since low-cost entrant airlines are expanding rapidly, it can be expected that the frequency of flight crew from different cultures working together on the flight deck will increase in the future.

Other evidence supporting a growth in the number of mixed flight crews is that more than half of the people surveyed believe that a pilot shortage will occur in Europe in the short to medium term and that this will encourage a greater movement of trained flight crew between airlines and between states. A common European Flight Crew Licence will facilitate this movement. Foreign nationals from outside Europe are also likely to be attracted to working for European airlines, particularly if the growth in air transport is less, or even declining, in their own countries.

(ii) Merging of company cultures

Almost two thirds of the people surveyed have worked for an airline that has merged with or taken over another airline in the last ten years. Research into commercial developments in the airline industry has indicated that the potential for two airlines to merge is increasing as the search for greater operational efficiency grows. In addition, mergers which cross national boundaries are becoming increasingly common.

There is little evidence to suggest that individual airline cultures are affected when they become part of a strategic alliance or that flight crew from different airlines in the same alliance are likely to mix on the flight deck in the short to medium term.

(iii) Commercial pressure

As competition within the industry grows there is increasing pressure to reduce cost. Many of the people interviewed spoke of the increasing commercial pressure that they are expected to work under.

In conclusion, industry trends are likely to increase the likelihood of each of these three outcomes and these in turn will have an effect on flight crew errors.

Mitigating factors referred to by many of the participants in the study that are expected to reduce the adverse results of commercial developments are as follows:

- CRM training;
- SOPs; and
- Professional Culture.

In addition, safety regulation sets the safety standards for the industry and defines the minimum limits above which airlines must perform. In doing this it attempts to ensure that the first two mitigating factors are applied properly and that any potentially negative effects on human factors that may arise from globalisation are prevented.

The three mitigating factors and safety regulation were analysed and discussed in detail in Chapter 6 and six human factors issues that have the potential to directly or indirectly affect the nature and likelihood of human error on the flight deck were identified in Chapter 7. Several areas of concern were outlined for each mitigating factor and these will be discussed in the next sections.

10.1 CRM

CRM is widely used in the aviation industry and was considered by the airline representatives interviewed to be an effective tool for managing the human factors effects of globalisation. Nevertheless, the analysis has revealed some concerns that need to be addressed by the industry to ensure that CRM warrants the confidence placed in it.

1) Any form of training provided must be effective in an operational environment as well as in the training room. Many incidents have been caused or exacerbated by team performance problems, even when the crews involved have been trained in CRM practices and have performed well in simulated emergencies. There are particular concerns that behaviour in training sessions is not correlated with behaviour under extreme (real) circumstances. Individual airlines should, therefore, evaluate the effectiveness of CRM outside the training environment, and modify it where necessary.

2) The research cited by Johnson (2000) regarding the lack of evidence for the effectiveness of CRM (see Section 6.1.1) means that caution should be adopted in using CRM as the only approach to the reduction of flight deck errors.

3) The emphasis on CRM may in some cases lead to a culture where all errors are considered to arise (and be contained) in the cockpit environment. However, many factors that may adversely influence flight safety originate, as in all other industries, from management and organisational failures that occur deeper in the system and are outside the control of individual crew members (see section 3.5 for a discussion of latent failures). High levels of flight crew training, experience or personal capability will not automatically mitigate the adverse effects of such factors.

4) There is a growing awareness that CRM training should be applied to other working groups such as cabin crew, ground engineers, and air traffic controllers. Many airlines combine people from more than one working area in CRM training sessions to foster team working amongst those who depend on each other for flight safety. Sessions such as these help others to understand the difficulties that other working groups have to face and the judgements that they have to make.

5) The airlines interviewed tended to equate CRM with human factors, but few qualified human factors professionals are employed by airlines in the development of CRM programmes. Although later versions of CRM do consider aspects such as error management, some airlines are using versions of CRM that neglect fundamental human factor issues that could influence cockpit errors. The lack of qualified human factors professionals in airlines also raises some concerns that other human factors based interventions may not be applied.

6) Most airlines agree that CRM training material that has been developed for one culture should be modified and developed further to be effective with people from other cultures and with mixed cultural groups. No process is in place in the airline industry to promulgate experience and spread best practice in adapting CRM for different cultures.

10.2 SOPs

SOPs were put forward as a measure that will control the human factors risks on the flight deck to a significant extent. However, there may also be concerns with the effectiveness of SOPs.

1) As with CRM training, the presence of SOPs does not guarantee that they will be used all the time or will be followed to the letter by all flight crews. For example, it may be the case that crew will prefer to rely on memory in routine, highly practised situations where there is little

risk. Alternatively, crew may follow a slightly different procedure with which they are more familiar. There are also individual and cultural differences in the degree of adherence to aviation SOPs, as there are in other safety critical industries.

2) Experience in other industries is that management will tend to overestimate the extent to which procedures are followed. In many cases, a wide disparity has been found between the views of management and the actual working practices in these industries. Procedures are not adhered to for a variety of reasons, including problems with their quality, accuracy, relevance and usability. It is recognised that SOPs in commercial aviation may be more rigorously developed and more thoroughly validated than in other industries. However, there are always concerns where SOPs are being relied upon as a means of achieving safety compared with built-in error removal.

3) Although intentional violations of SOPs are relatively rare in aviation, unintentional errors when following procedures can occur, for example if crew are distracted during the procedure. Distractions arise from a variety of sources, ranging from those internal to the individual, to those arising from other crew members, ATC or instrumentation. Crew behaviour may differ significantly from that exhibited in training situations, partly as a result of increased stress in extreme conditions.

4) Several airlines stressed the highly proceduralised nature of the flying task, claiming that procedures existed for every eventuality. However, crew working in highly proceduralised environments may encounter difficulties when faced with a situation that is not covered by a procedure. This is being addressed by another ongoing EC-funded research project whose results have yet to be published. Furthermore, crew who work for an airline that strongly adheres to procedures may experience difficulties should they then operate in an airline that allows a greater degree of individual interpretation.

5) When working for a different airline or with a flight crew member from a different background, a person's knowledge of an SOP may lead them to interpret ambiguous communications in terms of the SOPs with which they are familiar. The flight crew members could also interpret the same procedure in a different way.

6) The free movement of crew within the industry, between countries and between airlines, may create situations where crew are required to operate to SOPs that differ from those on which they are more experienced (for example, in terms of content or allocation of responsibilities). In these cases, individual flight crew members may also inadvertently revert to a previous procedure.

10.3 PROFESSIONAL CULTURE

Professional culture, although mentioned extensively in the literature (for example, Helmreich, 1998), was not explicitly proposed by airline representatives as a risk reduction measure in the same vein as CRM and SOPs. Several interviewees did refer to the high professionalism of pilots or other factors considered to be components of professionalism. It is obviously true that a professional culture, which encourages responsibility, diligence, and the safety of passengers as a primary concern, will have positive benefits in reducing the incidence of human error. However, as with CRM, there is a danger that it may reduce the consideration of other measures to reduce flight deck errors. It is significant that in medicine, another area in which there has been a strong professional culture, there is an increasing recognition that errors will still arise regardless of the professionalism or diligence of the individual or team. This has lead to a realisation that the causes of errors need to be addressed at the level of the system as well as the individual.

Several of the human factors issues described in previous sections relate to human performance limitations (such as fatigue) or personal performance constraints (such as competence or technical skill). Although a strong professional culture may reduce the effects of low morale, its efficacy in compensating for human performance limitations will be considerably less.

10.4 OVERALL

In many safety critical industries, the traditional approach to reducing human error was to focus on blaming the individual if an accident occurred. However, there is now a much greater appreciation of the effects of the total system within which the team or the individual operates. The total approach considers the technical equipment with which the team have to interact, and also the organisational policies and changes which impact on areas such as team effectiveness, training, fatigue levels, and SOP compliance.

This study has shown that there is a widespread belief in the aviation industry that the effects of commercial developments such as mergers and globalisation can cascade down through an organisation to affect flight deck operations. While some incidents and accidents could have been caused by the effects of commercial developments currently in progress in the industry, no evidence has been found to state definitively that this was the cause. Nevertheless, it is clear that the potential for such a threat exists, and that this threat is likely to increase as the pace of commercial developments increases.

There was a belief by the airline industry participants in the study that the strategies of CRM, SOPs and professional culture will mitigate these threats. The study team has concluded that of these three mitigating factors, professional culture is the weakest, as demonstrated in Table 22. Furthermore, the evidence cited in this report suggests that the other two strategies are unlikely to be fully effective in dealing with the threats identified. This leads to a number of recommendations aimed at improving the effectiveness of the mitigating factors and developing more focussed methods for minimising the potential risks.

11. RECOMMENDATIONS

Although there is little definitive evidence for specific threats arising from globalisation and mergers, it is clear that the information gathered in this study indicates that there are a number of potential problems that will not be addressed fully by existing approaches to mitigation. A number of recommendations are made which will help to control the potential risks and increase the effectiveness of the mitigation strategies.

1. In order to provide more concrete information connecting the effects of commercial developments on specific classes of flight deck failures, an explicit model connecting these areas needs to be developed. This would enable the negative effects of these developments to be identified and ranked in order of importance. This model would identify the factors known from incident reports to affect flight deck errors directly,(e.g. fatigue, communications failures, assumptions about procedures) and connect these factors with underlying 'latent' error inducing factors arising from mergers and globalisation, e.g. dissatisfactions with changed new shift systems incompatible with the existing domestic arrangements of flight crew, assumptions made during communications which may not be valid with flight crew from different airlines[4]. The proposed research would include the analysis of incidents that had occurred in merged and non-merged airlines to identify the mechanisms of failure and any links with these developments. Based on the model, guidelines for handling the flight deck human factors issues associated with airline mergers, alliance formation and commercial pressure could be developed. The purpose of these guidelines would be to minimise the possible negative effects discussed in this report. For airlines that had already undergone these commercial developments, an audit process should be developed to enable such airlines to examine their systems to identify where any latent threats exist. The process should become part of an airline's safety management system and would assist an airline in generating preventative strategies if problems were identified.
2. An awareness campaign should be carried out within the aviation industry of the flight deck human factors issues that could arise from current commercial developments if appropriate strategies were not implemented. As a part of the campaign, airlines should be encouraged to identify, within their safety incident reporting systems, any incidents that may be ascribed to factors identified within this report.
3. Airlines should determine whether the CRM training that they provide covers all the elements that have been identified in this report. Where gaps exist, the training material should be adapted in an appropriate manner.
4. CRM has been adopted by the industry as the primary means of dealing with human factors issues. This study has found that globalisation is likely to increase the frequency of occurrence of these issues. A study should, therefore, be carried out to assess the effectiveness of CRM in the operational environment within different organisational and national cultures.
5. CRM training is perceived to be expensive by some airline managements who may be resistant to extending the training for flight crew and other working groups and may wish to reduce the training in the future. A study should, therefore, be undertaken to determine the cost effectiveness of the current method of delivering CRM training. The study should also consider alternative approaches to instilling the concepts of CRM into an organisation and continually reinforcing these concepts.

[4] An illustration of these factors is provided by the Air New Zealand Mount Erubus accident. Failures of procedures and communication led to changes in the co-ordinates of the final waypoints not being communicated to Dispatch and the flight crew. In addition there was lack of clarity with regard to minimum altitudes during the pre-flight route briefing. One of the possible effects of a merger, particularly during the early stages of the process, could be disruptions in the communications systems and hence a danger that critical information might not be communicated. Similarly, one of the contributors to the crash of Air Ontario Flight 1363 was ambiguity regarding which flight manual applied, following the creation of Air Ontario from a merger between Austin Airways Limited and Air Ontario Limited.

6. Safety Regulators should review their own regulatory procedures and their oversight of airlines to ensure that they will deal with the human factor risks described in this report. As part of this review, Regulators should consider how airlines satisfy themselves that CRM trainers have the relevant skills and whether appropriate human factor skills are available within the CRM process.

7. The research described in sub-section 3.2.1 of this report has suggested that the acceptance and perception of automation varies greatly across cultures. While outside the scope of this study, the link between cultural attitudes and the interaction with automation might be worth investigating.

8. This study has been limited to the effect on flight crew of recent commercial developments. Consideration should also be given to the impact that these developments may have in other functions that contribute to flight safety, such as maintenance, cabin crew, air traffic control, etc.

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APPENDICES

CONTENTS

APPENDIX A: POSTAL QUESTIONNAIRE

The purpose of this questionnaire is to gather some preliminary information for the study that we are undertaking for the JAA. The background to this study is briefly described in the accompanying letter.

During the study we are trying to identify potential flight safety problems that might result from recent trends in the aviation industry. We would encourage you to be open in your response, which will be treated in complete confidence.

If you are willing, we may wish to follow up the questionnaire with a more detailed face-to-face or telephone interview.

Thank you in advance for completing the questionnaire: you are contributing to a very valuable programme of research.

The ICON team

About you		
A1	Name	
A2	Name of your airline	
A3	Position	
A4	Brief summary of your role	
A5	Years of service with this airline	
A6	Years of service in total	
A7	Contact information: Phone E-mail	

About Your Airline		Yes	No	Don't know
B1	Is your airline a member of an alliance? • If yes, name of alliance and date of joining			
	• If no, does your airline envisage joining one in the next 5 years?			
B2	Has your airline been involved in a merger during the last 10 years? • If yes, when and with which airline(s)?			
B3	Has your airline taken over another airline during the last 10 years? • If yes, when and which airlines were taken over?			
	• Were you in an airline that was taken over by your present airline?			
B4	Describe any other top-level organisational changes that have taken place in your airline in the last 10 years that might have an impact on flight crew.			
B5	Does your airline have subsidiaries in two or more countries where there is the opportunity for flight crew members from one subsidiary to fly together with those from another?			

About Globalisation		Yes	No	Don't know
C1	Have human factors issues arisen as a result of any airline alliances, mergers or takeovers that you have experienced? • Briefly outline the reasons for your answer			
C2	Are there circumstances where human factors issues might arise as a result of airline alliances, mergers or takeovers? • Briefly outline the reasons for your answer			

Working Arrangements in Your Airline		Yes	No	Don't know
D1	Do flight crew from your airline fly with flight crew from other airlines?			
	• If yes, is this practice becoming more common?			
D2	Do you roster flight crew of different nationalities to fly together?			
	• If yes, is this practice becoming more common?			
D3	What percentage of flight crew are nationals of the country of your airline?			
D4	Are flight crew ever obtained from agencies?			
	• If yes, is this becoming an increasing trend?			
	• If no, would there be any benefits in this practice?			
D5	Have there been significant changes in the salaries and benefits offered to flight crew in the last 10 years?			
	• If yes, what changes have there been?			
D6	Are any flight crew employed under short-term contracts?			
	• If yes, is this becoming an increasing trend?			
	• If no, would there be any benefits in this practice?			
D7	Have there been any other significant changes in the working conditions of flight crew in the last 10 years?			
	• If yes, what changes have there been?			

Recruitment and Training in Your Airline		Yes	No	Don't know
E1	Have you experienced a change in the turnover of flight crew in the last 5 years?			
	• If yes, has turnover increased?			
E2	Do you expect to experience a shortage of flight crew in the future?			
E3	From where are your flight crew recruited?			
E4	Has your main source of flight crew changed in the last 5 years?			
E5	Has your airline ever sponsored *ab initio* training of flight crew in the last 10 years?			
	• If yes, do you still provide sponsorship			
E6	Is crew resource management (CRM) used in your airline?			
E7	Prior to joining your current airline,			
	• were you in the military?			
	• did you ever work on short-term contract?			

Flight Deck Errors		More likely	Neutral	Less likely
F1	What effect do you think the following will have on the likelihood of flight deck errors being made?			
	(i) A captain being significantly older and having much more flying experience than, say, the co-pilot.			
	(ii) The merging of organisational cultures as might occur when one airline takes over another and the two flight crew communities are merged.			
	(iii) Flight crew from different national cultures operating together			
	(iv) Flight crew from a single national culture operating together			
F2	What, in your opinion, are the three most common primary causes of flight deck errors?			
	1 2 3			
F3	What, in your opinion, will be the greatest threat to flight safety in the coming years, and why?			

Please return this questionnaire to:

Human Factors Study
Icon Consulting
31 Old Burlington Street
London
W1X 1LB
United Kingdom

or fax to: +44 20 7494 9995

APPENDIX B: INTERVIEW QUESTIONNAIRE

The structure of the interview and the questions that are used will depend on the airline's responses to the postal questionnaire. Not all the following questions will be appropriate for all airlines. Judgement will be required to decide which questions are relevant and will be the most revealing to meet the objectives of the study. Look for examples to illustrate the opinions that are given.

Airline:	
Place:	
Date and time:	

Present at interview	Position	Years of service	
		Airline	Total

About Your Airline			
B6	How is the Flight Operations Department organised in your airline?		
B7	How does management communicate with flight crew?		
B8	What attributes are sought in pilots and how are they selected?		
B9	How is the company culture instilled in flight crew?		
B10	If you have personal experience of the merging of two airlines or the takeover of one airline by another, were the flight crew seniority lists merged fairly?	Yes	No

About Globalisation		Yes	No
C3	Might flight crew from different airlines be mixed within an alliance and what human factors problems would arise if they were?		
C4	What benefits might arise from mixing crew within an alliance		
C5	What human factors issues might arise following a merger of two airlines?		
C6	What aspects of these issues would require careful management to ensure that they did not have a negative effect on flight safety?		

About Globalisation (continued)		Yes	No
C7	How might any of the human factors issues related to globalisation be resolved?		
C8	What internal systems and processes are in place to carry out risk assessment when two sets of SOPs are merged or large scale changes are made to SOPs?		
C9	And how is safety performance monitored following such changes?		

Working Arrangements in Your Airline		Yes	No
D2a	What problems or issues might arise as a result of flight crew of different nationalities flying together, and how could they be managed?		
D4a	What problems or issues might arise as a result of sourcing crew from agencies, and how could they be managed?		
D7a	In your opinion, what effects might there be on flight crew of changes in working conditions?		
D8	Might any of these effects lead to flight deck safety performance issues?		
	And what is the reason for your answer?		

Recruitment and Training in Your Airline		Yes	No
E1a	Why do you think staff turnover has changed in recent years?		
E2a	Why do you expect to experience a shortage of flight crew in the future?		
E4a	From where were your flight crew recruited in the past?		
E6a	How is crew resource management (CRM) implemented in your airline?		

Flight Deck Errors		Yes	No
F1a	What were the reasons behind the responses?		
F4	Has there been a change in the perceived incidence of flight deck errors in your airline in recent years?		
	What has been the nature of this change?		
F5	Do performance measurement systems exist, either in your airline or your State, that will identify causes of potential flight safety problems?		
	• If yes, what are these systems and are they effective?		

Other Comments

APPENDIX C: COMPARISON WITH THE MARINE INDUSTRY

C.1 INTRODUCTION

This appendix seeks to draw parallels between the results of this study and the merchant shipping industry. The overall objective is to indicate whether there are any areas of cockpit flight operations in respect of which the aviation industry might learn from shipping. It should be said at the outset that although aviation may have learned from the marine sector in the early days, in recent years it has been largely the other way around. Merchant shipping has adopted practices from the aviation sector, mainly through the interface between the two in the area of high-speed passenger craft (hovercraft initially in the 1960's, then hydrofoils and latterly, high-speed catamarans). However, there are some interesting parallels and differences between the two transport modes which assist in providing some further insights into the results of this study. There are also some areas of resource management in which aviation might learn from shipping, particularly in the area of multi-cultural crews.

C.2 GLOBALISATION

Shipping was the original global industry. Despite the advances made by air freight and transcontinental multi-modal shipping, including a substantial road transport element, in recent years the vast majority of international trade in goods is still carried by sea. By contrast, air freight still accounts for only 0.1% by volume. The global nature of seaborne trade and the ability to move goods around the world cheaply also promotes globalisation in other areas, for example of IT equipment.

Shipping also has a long tradition of employing multi-cultural crews. This tradition dates back to the early days of European imperialism, when sea power supported colonisation and at the same time offered employment opportunities for cheap labour in the newly acquired territories. The employment of crews from the Indian subcontinent, China and the West Indies was well established by the early days of steam.

Shipping is still a fragmented industry. Comparatively few ships are operated or even managed by their owners, and many are operated by charterers. Part, if not all of the management of most ships is contracted out by their owners to specialist ship management companies. The size of shipping companies varies from single ship companies owned by one or two individuals to the large fleets of the multinational oil companies of 50 or 100 ships, forming part of a vast vertically integrated industrial conglomerate.

C.3 THE ECONOMICS OF CHANGE IN MERCHANT SHIPPING

The shipping industry has seen radical changes in the past 40 years. It is even arguable that after the introduction of the first jet engine airliners, sea transport has seen greater technological change than air transport. Most of these changes have been due to economies of scale. In 1960, the average size of tanker was about 20,000 tonnes deadweight. By 1980, this had risen to 100,000 tonnes with a maximum of over 500,000 tonnes. Dry bulk ships also experienced a similar increase in size. An even greater revolution took place in the handling of small parcels of cargo with the introduction of containers, which reduced turnaround times in port from weeks to hours and introduced enormous economies of scale, with containerships of 10,000 twenty-foot container capacity now in the planning stage.

Shipping is the only industry recognisably the same as it was in 1960,[1] which has come near to aviation in maintaining unit costs in real terms. During the period 1960-1990, the price of a transatlantic air ticket rose by 10% and oil freight by about 80%, but the price of a new car increased by 800%. In both aviation and shipping, unit costs were kept down by a combination of technical innovation and economies of scale.

Competition in shipping has driven a large reduction in crew costs, arguably much greater than in aviation. A ship of five times the size of its 1960's forebear will now probably be manned by between one half and one third of the crew as it was then. The nationality of the crew will have changed from predominantly that of the owning company to predominantly third world countries such as the Philippines, India and Korea or latterly, former Soviet countries such as Russia, Ukraine and Poland.

C.4 CHARACTERISTICS OF THE MERCHANT SHIPPING INDUSTRY

There are two factors which strongly influence the attitude toward safety in merchant shipping.

The first factor is that, in terms of capacity, more than 95% of the world deep sea merchant shipping fleet is engaged in carrying cargo and only the remaining 5% in carrying passengers or passengers and vehicles. This is approximately the reverse of the pattern in civil aviation. Due to the relatively small numbers of passengers carried by ships, exposure to risk is smaller than in aviation and the numbers of socially intolerable incidents are fewer.

During the 1990's more than 100 bulk carriers were totally lost at sea, mainly with loss of all hands. However, because most of the crews were third World nationals and the total loss of life was only about 30 per ship, the heavy total loss of life due to these events has been eclipsed by high profile disasters of passenger ferries such as the "HERALD OF FREE ENTERPRISE" and the "ESTONIA". These two casualties have significantly skewed an otherwise excellent safety record, in terms of fatalities per passenger mile or journey.

The second factor is that in general, recovery from quite serious failures is much more likely to be successful in shipping than in aviation. In shipping, a complete recovery is usually achieved from total engine failure or electrical blackout whereas in aviation the reverse is true. This has led to fundamental differences in reliability and maintenance regimes between aviation and shipping, where failures are tolerated to a degree which many view as unacceptable.

C.5 REGULATION OF THE SHIPPING INDUSTRY

The Regulation of the shipping industry is complex and very different from aviation, although there are parallels, particularly in the enactment and enforcement of International Conventions.

There are three elements to the regulatory framework of Merchant Shipping:

(i) The Classification Societies

(ii) Flag States

(iii) Coastal and Port States.

Classification Societies

The Classification Societies are a form of self-regulatory body which oversee and certify the design, construction and maintenance of ships. The first was Lloyd's Register of Shipping, which came into existence to provide certification of the suitability of ships as an insured risk. This

[1] This excludes microelectronics and computing, in which change has been so fundamental that comparisons with 1980, let alone 1960, are meaningless

element of insurability still dominates the ethos of the Societies today. The Classification Societies tend have their origins in traditional maritime countries, the most significant being Lloyd's Register (UK), NKK (Japan), American Bureau of Shipping (USA), Det norske Veritas (Norway), Genrmanischer Lloyd (Germany), Bureau Veritas (BV) and the Helenic Register (Greece).

The Classification Societies have been much criticised for failing to meet their obligations to maritime community at large in the face of commercial pressures, particularly competition between them. They have also been criticised for the diversity of their rules, which led to the formation in the mid 1980's of the International Association of Classification Societies (IACS), which has brought about significant improvements in the consistency of ship classification.

Flag State Control

The Flag State is the country in which a ship is registered and whose maritime laws therefore control its operation. Here there is a direct parallel with aviation. The vast majority of maritime safety law is dominated by the International Maritime Organisation (IMO), which was set up as a United Nations agency in 1949 and has its headquarters in London. Although criticised for being slow and sometimes over-conciliatory, perhaps inevitable with over 160 member states, the IMO has brought about a fundamental shift in attitudes to safety in the shipping industry. Of particular significance are the International Conventions mentioned previously and the International Safety Management (ISM) Code, which has over the past 4 years led to the progressive introduction of auditable safety management systems on board ships and in shore based ship operations.

There are significant differences in the speed with which various flag states adopt IMO Conventions and the manner in which they interpret them, which has led to a great deal of criticism of certain flag states.

One of the most significant drivers toward globalisation in the marine industry has been the Flag of Convenience or "Open Registry" system. Certain countries have enacted laws which enable non-resident ship owning companies to register their ships there and gain benefits of low registration fees and a liberal regulatory regime. This practice became particularly prevalent immediately following the Second World War, which released a large number of second-hand merchant ships onto the market. The largest Flag of Convenience fleets remain Panama and Liberia, with Singapore, Somalia and several Caribbean island states also being significant. The flag of convenience system has been much criticised for its safety record, but it has been one of the significant drivers in shaping the industry and keeping international transport costs down.

Coastal and Port State Control

During the past 20 years, the countries to which ships trade have assumed increased significance in enforcing both local maritime safety laws and IMO conventions. This role is carried out either through a central agency such as the US Coast Guard or the UK's Maritime and Coastguard Agency, or through port authorities. The US Coast Guard initially led the way in this area but the EC now exerts a comparable degree of regulation following the Paris Memorandum on Port State Control.

Port State Control is seen as redressing the deficiencies of flag state control, to the extent that ships of certain flags receive particular attention from port state surveyors. Port State Control has been particularly significant in providing a system of "spot audits" for the newly introduced ISM code.

C.6 DIFFERENCES BETWEEN AIRCRAFT COCKPIT AND BRIDGE NAVIGATION OPERATIONS

The study for the JAA has focused on flight deck issues, which for most purposes these days is restricted to the Captain and First Officer. In drawing a comparison with shipping it is appropriate to include all shipboard personnel of officer status, which will generally comprise a Master, three

watch-keeping officers, a Chief Engineer and two or three watch-keeping engineer officers. Some ships may also carry an electrician and a cargo engineer of officer status.

One of the most fundamental differences between ships and aircraft is that the navigation of ships in effect involves co-ordination between two teams, one on the bridge and the other in the engine-room. Some ships have automated engine control systems which can be and usually are operated solely from the bridge, with no-one in the engine-room outside day work hours. Others have manual telegraph systems which require a response from an engineer in the machinery control room. Even where control of the engines is fully automated, many emergency situations require intervention from the engine-room team. For example, an emergency full astern manoeuvre may require engineer intervention to avoid damage to the main engine. Emergency measures following an incident (for example engine failure, electrical blackout, collision or grounding) will often require engineer intervention. This co-ordination between bridge and machinery control room teams is a dimension which is missing from aircraft cockpit operations.

A second fundamental difference centres around ship pilotage through inshore waters. Most aircraft incidents occur at or near take-off and landing. Similarly with ships, most incidents occur in or near ports and harbours or busy sea lanes such as the Straits of Dover and the Bosphorus. Ships approaching or leaving most significant ports and harbours or negotiating restricted channels are required to carry a Pilot, a Master mariner with specific local knowledge and competence in bringing ships in and out of port. The Pilot performs several crucial tasks, namely:

- Advising the Master on local navigational hazards, including recent changes,
- Liaison with Pilots on board other vessels in the area,
- Liaison with local ports authorities and traffic monitoring facilities.

The fundamental difference between pilotage and air traffic control is that the Pilot comes to the ship (by small boat, boarding by means of a ladder, often itself a hazardous task). In this manner, someone is always present on the Bridge who has knowledge of local hazards and has a common language with other Pilots advising ships in the area and the local traffic control authorities.

The role of a ship's Pilot does not subsume the role of the Master. The Pilot's role is purely advisory. However, many Masters effectively hand over control of the ship to the Pilot. Some Pilots are more assertive than others and some Masters more prepared to hand over control. A Pilot and Master who have not previously met will need to quickly establish a working relationship and subconsciously establish a power gradient between them as a component of that relationship. Often there are only a few minutes to establish this working relationship before the first navigational decisions have to be taken and implemented.

A detailed consideration of pilotage is to an extent irrelevant to aircraft cockpit operations, because the concept of pilotage cannot be used for aircraft. However, it does provide some further insights into some of the human factors issues raised by this project.

> In 1993, a collision took place in the Suez Canal between two general cargo ships, the "IRANABAD", owned by the Iranian national shipping line and a Sudanese vessel, the "MERAWI". Both ships were carrying Suez Canal Pilots. The "IRANABAD", designated as the second ship in a Southbound convoy from the Great Bitter Lake, collided with the "MERAWI", designated as the first ship, which was lying across the channel, manoeuvring to enter it. Shortly before the collision, a conversation took place over VHF radio between the two Pilots in Arabic, a language not understood by the Master of "IRANABAD" (who first language was Farsi). The Pilot of "IRANABAD" assured the Master in their common language, English, that it was safe to proceed down the channel and that the "MERAWI" would clear the channel before "IRANABAD" arrived at her position.

Many ships' Masters obtain pilotage exemptions for ports which they visit regularly. In order to obtain an exemption, a Master has to be examined in local navigational knowledge while taking his ship in and out of port, in the same way as a Pilot would be examined. The dialogue between a ship whose Master has pilotage exemption and the port authorities is much closer to the situation of an aircraft Captain liaising with ATC.

A third fundamental difference between ship and aircraft operations is that there will often be a wider range of skills and more individuals involved in ship manoeuvring than in the case of aircraft. Marine casualties do occur during times when there is only one person on the Bridge (the Officer of the Watch) and none in the engine-room (there are even documented cases of casualties occurring with no-one on the Bridge). However, during "Stand-By" periods, entering and leaving port and in confined waters, there will invariably be the Master, at least one Deck Officer and a Helmsman on the Bridge (and also in many cases a Pilot) and a team of two or three engineers in the machinery control room. There may also be one or two persons on the Forecastle as look-outs and available for standby duties[2], often including a deck officer. During Stand-By periods there will be a wide variation in skill levels between the Master or Pilot and the most junior officer present or the Helmsman. There will also be a corresponding power gradient. The problems of power gradient which exist between an aircraft Captain and First Officer have their parallels in ship navigation. However, below the rank of Chief Officer or Chief Engineer, power gradient does not create comparable problems to those identified by this study for aircraft, because a junior officer simply would not question the decision of the Captain.

A final fundamental difference between commercial aircraft and ship navigation is the extraordinary diversity of ships, which has no parallel in aviation. Ships come in all shapes and sizes from small trawlers to supertankers. Each ship type has its own special set of navigational and ship handling problems; in the case of large tankers and bulk carriers it is sheer size and the lead time required to alter course and speed. Containerships have particular problems with regard to visibility when carrying containers on deck (which is most of the time). Fishing vessels have particular problems of manoeuvrability when fishing. All ship types have differing levels of vulnerability to wind and waves and have to be operated accordingly. High Speed Craft, assuming increasing significance in ferry operations, have completely different handling characteristics from displacement vessels and have adapted some of their operating procedures from aircraft operations. These craft are highly susceptible to extreme environmental conditions and their operating licences prescribe the maximum wind and sea states in which they may operate.

C.7 MULTI-CULTURAL CREWS IN SHIPPING

Multi-cultural crewing of ships has been a seafaring tradition and has become common in the past 30 years, being far more widespread than in aviation. Very few ships which are owned or operated by companies in the industrialised World have "native" crews. Exceptions include ferries on short sea routes. Most ships owned by the industrialised world are crewed either completely by third World or former soviet bloc citizens of one or more nationalities or by senior officers of the owning company's nation and junior officers and crew from elsewhere. The driver for this advanced level of multiculturalism has been purely economic and as a result, the market for ships' crews is totally global, possibly the most global labour market in the world.

The global nature of the ships' crewing market has led to two problems, exploitation and concerns with regard to the quality of qualifications and Certificates of Competency, which are issued by Flag States (q. v.), some of which are less scrupulous than others. Exploitation has been addressed by two global organisations, the International Labour Organisation and the International Transport Workers' Federation. However, economic exploitation is still widespread. The quality of Certificates is potentially more serious and has led to the adoption of the two IMO STCW[3] Conventions of 1987 and 1995, which have brought about significant improvements.

[2] For example, emergency lowering of an anchor.

[3] Convention(s) on the Selection, Training and Certification of Watchkeeping officers.

However, the use of underpaid ships' officers with dubious qualifications, sometimes "purchased", is still far too prevalent and has no parallel in commercial aviation.

A catalyst for multicultural crews has been the prevalence of English as the language of the sea. The STCW conventions require proficiency in English as a prerequisite for senior deck officer qualifications for ships in international trades. However, problems with language communication between crew members of different nationality and in ship to shore communications do occur. These are being progressively overcome by the use of Standard Operating Procedures and standard vocabularies in ship to shore and ship to ship VHF radio communications.

C.8 STANDARD OPERATING PROCEDURES

Formal (i.e. written) Standard Operating Procedures in navigating bridge operations are a relative innovation in merchant shipping. Progress in this area has received a significant boost with the introduction of the ISM code, which has forced the introduction of SOP's. It is thought that the introduction of SOP's has overcome many of the linguistic and cultural problems traditionally associated with multi-cultural crewing, but the implementation of ISM is so new that it is too early to draw any conclusions.

C.9 CREW RESOURCE MANAGEMENT

Crew Resource Management as it is practised in aviation is still at the experimental stage in shipping. Where it has been introduced, it is in specialist passenger carrying operations such as high speed catamaran ferries, which have imported many aspects of their culture from aviation. This is one area where shipping has yet to learn from aviation and there is little to offer in the opposite direction.

C.10 PROFESSIONAL CULTURE

The marine industry has a strong professional culture, possibly equal to that of aviation. The seagoing qualifications of Master and Chief Engineer have a particularly high value and entry to many grades of management in ship operations are all but impossible without such qualifications. Although shipping companies, as airlines, are increasingly run by accountants, ship operations executives invariably have seagoing qualifications. There is often a reluctance of those who hold superior seagoing qualifications to accept the opinions of those who have never been to sea on matters of ship operations. However, this pride in qualifications and culture is not backed by the same salary levels as in aviation, which may suggest that financial reward does not play a significant part in the establishment of this type of professional culture.

There is not the same movement between the military and civilian worlds in shipping as there is in aviation. One reason for this may be that the Royal Navy has always viewed itself as the Senior Service. Former naval officers are more likely to find civilian jobs in shore based industry than at sea in the merchant navy. Life in military and merchant navies is totally dissimilar and there is only partial overlap in the skills required between merchant ship and naval ship captains.

C.11 REFERENCE

Stopford. , M. , "Maritime Economics", 1997, Routledge, ISBN 0-415-14310-7