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Flight-crew human factors handbook

CAP 737

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Contents

Contributors 5

Glossary of acronyms 7

Introduction to Crew Resource Management (CRM) and Threat and Error Management (TEM) 10

Section A. Human factors knowledge and application 15

Section A, Part 1. The Individual (summary) 17

Section A, Part 1, Chapter 1. Information processing 18

Chapter 2. Perception 22

Chapter 3. Attention 30

Chapter 4. Vigilance and monitoring 33

Chapter 5. Human error, skill, reliability,and error management 39

Chapter 6. Workload 55

Chapter 7. Surprise and startle 65

Chapter 8. Situational Awareness (SA) 72

Chapter 9. Decision Making 80

Chapter 9, Sub-chapter 1.

Rational (classical) decision making 81

Chapter 9, Sub-chapter 2.

Quicker decision making mechanisms and shortcuts 89

Chapter 9, Sub-chapter 3.

Very fast (intuitive) decision-making 97

Chapter 10. Stress in Aviation 101

Chapter 11. Sleep and fatigue 110

Chapter 12. Personality and cultural differences 118

Section A, Part 2. The Crew 123

Chapter 13.

Effects of groups and teams (coordination, teamwork, roles and group decisions) 124

Chapter 14. Leadership 133

Chapter 15.

Communication (communication, language, sharing mental models, assertiveness and verbal intervention) 138

Section B, Part 1. Specific Context Guidance 147

Chapter 16. Automation human factors 148

Chapter 17. Working with external teams 156

Chapter 18. Specific guidance for cabin crew CRM trainers 164

Section B, Part 2. CRM assessment and behavioural markers 169

Chapter 19. CRM assessments 170

Chapter 20. Behavioural marker systems 180

Part B, Part 3. CRM effectiveness 185

Chapter 21. Facilitation skills 186

Chapter 22. Resources for improving CRM effectiveness 191

Chapter 22a.

Checklist of 10 practical indicators of effective CRM 192

Chapter 22b. Guide to assessing a CRM ground trainer 194

Chapter 22c.

Short guide to performance standards for CRM trainers 197

Chapter 22d.

Informal checklist for CRM trainer competencies 205

Chapter 22e.

Informal guide to twenty instructional traps and faults of CRM trainers 207

Chapter 22f.

Trainer competencies – simulator and aeroplane 209

Chapter 22g. Examiner competencies – simulator 216

Chapter 22h. Report writing and handover guide 218

Section B, Part 4. CRM in safety management 220

Chapter 23. CRM in safety management 221

Chapter 24. Use of taxonomies 224

Section B, Part 5. CRM regulation 225

Chapter 25. CRM regulations 226

References 236

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Glossary of acronyms

AAIB	Air Accident Investigation Branch
AMC	Acceptable Means of Compliance
ASR	Air Safety Report
CEO	Chief Executive Operator
CRM	Crew Resource Management
CRMI	Crew Resource Management Instructor
CRMIE	Crew Resource Management Instructor Examiner
CSA	Customer Service Agent
CTA	Cognitive Task Analysis
CVR	Cockpit Voice Recorder
EASA	European Aviation Safety Agency
EEG	Electroencephalogram
EFB	Electronic Flight Bag
FCL	Flight Crew Licensing
FMA	Flight Mode Annunciator
FAA	Federal Aviation Administration
FCU	Flight Control Unit
FDM	Flight Data Monitoring
GOR	Ground Occurrence Report
HF	Human Factors
HUD	Head-Up Display
ISP	Inflight Service Personnel
JAA	Joint Aviation Authorities
LOSA	Line Oriented Safety Audit
LPC	Line Proficiency Check
LTM	Long Term Memory
NOTECHS	Non-Technical Skills
MCC	Multi-Crew Cooperation
MCP	Mode Control Panel
MOR	Mandatory Occurrence Report
OPC	Operator Proficiency Check
OTP	On Time Performance
PF	Pilot Flying
PM	Pilot Monitoring
REM	Rapid Eye Movement
RNP	Required Navigational Performance
SCCM	Senior Cabin Crew Member
SIM	Simulator
SMS	Safety Management System
SOP	Standard Operating Procedure
TCO	Turnaround Co-ordinator
TEM	Threat and Error Management
TRE	Type Rating Examiner
TRI	Type-Rating Instructor
UT	University of Texas

Foreword

Cap 737 has been re-structured in response to commercial air transport needs, identified by the Crew Resource Management Advisory Panel, to provide more focussed and applied practical CRM training guidance. The civil aviation community has fully embraced the need for change and have made significant contributions in the form of anecdotal experiences to provide context to the complex human behaviours described in the document.

The document is structured into 6 main parts:

- **Human Factors knowledge and application** comprises 15 chapters covering the full range of individual and team human characteristics that manifest themselves within aircraft operational roles. The approach adopted throughout these chapters is threefold:
  - Firstly a theoretical explanation relating to each of the human processes or behaviours is provided to equip the trainers with the pertinent knowledge
  - Secondly a description of the application of the specific human attributes within roles and tasks is provided and is supported by contextual anecdotal illustrations.
  - Thirdly practical guidance in how the specific human vulnerabilities can be understood through suggested CRM training activities is provided.
- **Specific context guidance** comprises 3 chapters which explores the application of CRM training within three focal areas.
  - The first area is automation and the challenges in mode management and its impact on situation awareness and workload are discussed. The impact of manual flying skills and its contribution to predictive monitoring skills is debated. CRM challenges associated with novel interfaces (e.g. electronic flight bags) are tabled.
  - The second area relates to the interfaces that the aircrew and cabin crew have with external agencies (turnaround co-ordinators, dispatchers, cargo and ground handlers, line engineering, customer service agents and airport operations staff) and identifies the value of aligning cultures and attitudes through a more comprehensive approach to CRM training. Case study material reinforces the need to widen the CRM training net.

- The third area provides guidance in the delivery of CRM training to cabin crew and emphasises the contribution that cabin crew can make to flight safety with examples provided.

- **CRM assessment** comprises 2 chapters which detail the instructor competencies required to carry out CRM and TEM assessment and the behavioural marker system as a method of feedback to the crew. This will enable Instructors and Examiners to understand and comply with the EASA requirements contained in AMC1 FCL.920 and AMC1 ORO.FC 115 & 215 (h). Observation skills are key attributes and example case studies are provided. Candidate behavioural markers are provided.

- **CRM effectiveness** comprises guidance in the development and application of facilitation skills which are an essential part of the assessment task. It also provides a set of guidelines and checklists which underpin good CRM practices in terms of required trainer attributes and competencies. The overall aim is to ensure that the Air Transport Operators are able to recognise indicators which contribute towards effective CRM.

- **CRM in safety management** emphasises the importance of recognising poor CRM as an aviation hazard and good CRM as risk mitigation strategy. It provides advice in the capturing and classifying of accident and incident data where human vulnerabilities are identified as contributing factors. The encouragement of non-punitive reporting to capture human error safety trends for internal occurrence reporting is very important as this provides feedback to the CRM trainers to ensure that robust risk mitigation strategies are in place.

- **CRM regulation** has changed in that the UK CRMI accreditation scheme is no longer in place (apart from ground trainers). The responsibility for development and maintenance of CRM training in accordance with EASA regulation (AMC1 FCL.920 and AMC1 ORO.FC 115 & 215 (h) and Standards Document 29 will be devolved to the Air Transport Operators. This section of the report summarises the CRM training expectations from the perspective of the regulator.

Introduction to Crew Resource Management (CRM) and Threat and Error Management (TEM)

Crew Resource Management (CRM)

Originally called Cockpit Resource Management, CRM training emerged after the recognition that the technical skills of piloting an aircraft were insufficient to ensure safety and best performance; accidents were occurring for reasons other than inadequate piloting skills.

It was apparent that pilots needed to learn more about how best to manage all the resources available to them in the cockpit including other crew-members, procedures, the machine interface, and themselves (i.e. recognising where they were most vulnerable and what their strengths were). This management of resources was the original essence of CRM training (hence the term). Many of the elements identified as necessary to support pilots in this process were borrowed from the scientific or management domain (e.g. communication, personality theory, error and leadership). Others came from common aviation practice (e.g. ‘airmanship’ and ‘captaincy’).

Cockpit resource management quickly grew to encompass wider crew resources, including cabin crew, and was renamed Crew Resource Management, hence retaining the same acronym. CRM is now considered essential training for most aviation professionals who make an operational contribution, including air traffic controllers and engineers. This document is written primarily for flight crew, and then cabin crew. However the first sections of the chapters in Part A are deliberately generic and can therefore apply across contexts.

The scope of CRM has also grown and diversified to the extent that it is now easier to list the sorts of areas that get taught in CRM than to attempt to define exactly what CRM training is. A general but inadequate definition would be the training of the cognitive and social skills needed to support technical training in order to optimise safe and efficient aircraft operation. It is clear that to be most effective, such skills must be integrated into the job role, and this integration is something that CRM has traditionally struggled with. This document attempts to address this by including a second section in each knowledge chapter (Part A, Chapters 1 – 15) called ‘application’ which puts the knowledge within an operational context (mainly for flight crew, with a variety of operations represented).

Finally, good use of CRM skills relies on effective training and assessment by practitioners (CRM trainers, flying instructors, examiners, etc.). To support this, the third and final section of each knowledge chapter (Part A, Chapters 1 – 15) deals with the teaching and delivery of that subject, and where possible examples are included. Additionally, there is a

section dedicated to resources, including assessment and requirements (from EASA regulatory guidance material).

In this handbook, the use of the term ‘Human Factors’ (HF) includes CRM along with other aspects of human performance.

Emergence and development of CRM

The introduction of cockpit voice recorders (CVR) in the 1970s strongly suggested that non-technical operational elements (often called ‘human factors’) were contributing strongly to many accidents. CVR data, along with analyses of accident causation (e.g. Ruffle-Smith 1979) led to a US based conference entitled ‘Resource Management on the Flight Deck’ in 1979. It was concluded that the majority of pilot-related errors were failures of interpersonal skills, communications, decision-making, and leadership (Cooper, White, & Lauber, 1980).

The loss of a United Airlines DC 8 at Portland in 1978 was an important driver for the introduction of CRM training. Analysis of the cockpit voice recordings led the National Transportation Safety Board (1979) to conclude that a contributory factor was the captain’s failure to accept input from other flight crew members, as well as the lack of assertiveness from those crew members themselves. Following this United Airlines set up the very first comprehensive CRM course in 1981 (see Helmreich et al. 1999).

Since then research findings have consistently cited human contribution and CRM (under many labels) as contributory factors in the majority of accidents, but it is not known exactly how CRM training has influenced the situation.

Cockpit Voice Recorders can only uncover audible evidence, so understandably the content of early CRM courses tended towards areas within social psychology and group dynamics such as leadership, communication and interpersonal skills, because these could be deduced from the CVR conversations. A common theme was the perceived authoritarian role of captains and the lack of assertiveness from other crew-members as inferred from accident CVRs. Because of the areas being addressed, early courses were often developed and run by people whose backgrounds were primarily in psychology or management, and these people often extended CRM ideas further into their own domain. These courses had mixed reviews from pilots, one problem being a lack of direct application and integration of CRM to the flight deck (pilots themselves were left to work out how to integrate it into their job roles).

Content of CRM grew with recognition that many important issues were out of direct reach of the CVR, such as monitoring and mode awareness, fatigue and vigilance, situational awareness and individual decision-making. Although retaining the title ‘CRM’, such training now covers a much wider scope that is often referred to under the umbrella terms of ‘non-technical skills’ and ‘human factors’.

Threat and Error Management (TEM)

In the 1990s, threat and error management (TEM) was introduced, and under current EASA FCL regulations it should be covered during all training events.

The practical summation of threat and error management for flight crew is the practice of thinking ahead in order to predict and avoid errors and operational threats, and manage any that occur (similar to the practice of defensive driving). There is an old saying (that emerges in various forms):

> *A superior pilot uses his superior judgement to avoid situations that would require his superior skills*

Like all great sayings, the source of it is contested (and probably unknown) but it probably dates back to the 1940s at least. Certainly the UK's Royal Air Force has used it on posters over many decades.

Threat and Error Management gives this message a more formal and theoretical underpinning, but TEM is more than just a re-application of a good mantra.

Threat and error management uses accident theory based on the work of James Reason (see Reason 1990). It has three elements relevant to flight crew; threats, errors and undesired aircraft states. Threats and errors have the potential to cause undesired aircraft states, and when they do so, those states must be managed (Maurino 2005). A foundation of TEM is the acceptance that threats will occur and errors will be made. Hence TEM is not an attempt to eliminate threats and errors, but is concerned with the management of them.

The model of flight crew error management (Helmreich et al 1999a) expands these ideas. The model (see Figure 1 below) describes how risks to the operation can be expected (e.g. terrain and runway length) or unexpected (e.g. emergencies, malfunctions, traffic, etc.). Such threats are external to the operation and generally beyond the control of the flight crew, and must be managed by the CRM behaviours of threat recognition and avoidance in order to achieve a safe operation (hence the term 'threat management'). Additional risk comes from errors made by those other than the flight crew (external threats, such as errors made by air traffic controllers) and errors made by the flight crew (internal threats). These errors must be managed by the CRM skills of error detection and management, and if mismanaged can lead to further errors and potential incidents or accidents.

Helmreich et al (1999b) describe how CRM as a countermeasure to error has three lines of defence. The optimum state of error management (first line of defence) is the avoidance of errors before they occur. This is sometimes said to involve a high level of situational awareness in order that pilots can foresee issues and threats that may cause errors. Errors that are not avoided need to be recognised and understood (trapped) immediately so that they do not occur or there are no consequences (second line of defence). On rare occasions, if errors and threats are not trapped, then they might have consequences that will require mitigation. Mitigation is the last line of defence and is the least desirable state

of error management. It is said that a crew that have to continually trap and mitigate errors is probably one working at a low level of situational awareness (caused by any number of factors including high workload on other tasks, low currency, stress, fatigue, fight or flight, emotional pressure, etc.).

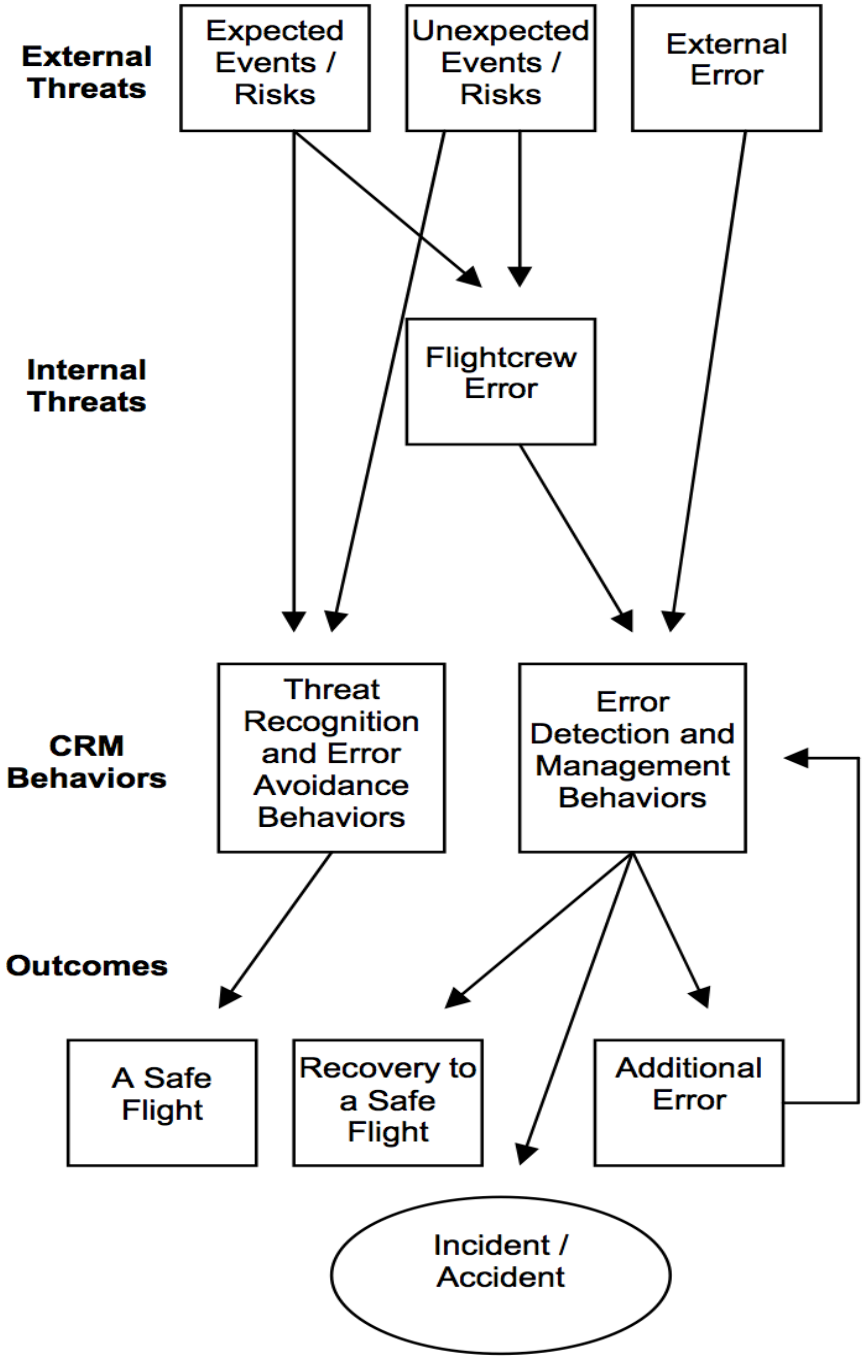


Figure 1. Model of flight crew error management. From Helmreich et al (1999a)

A central practical mantra of TEM is ‘avoid, trap, mitigate’. Helmreich et al’s (1999b) error troika (Figure 2 below) proposes that most errors are avoided and of those that occur, most are trapped.

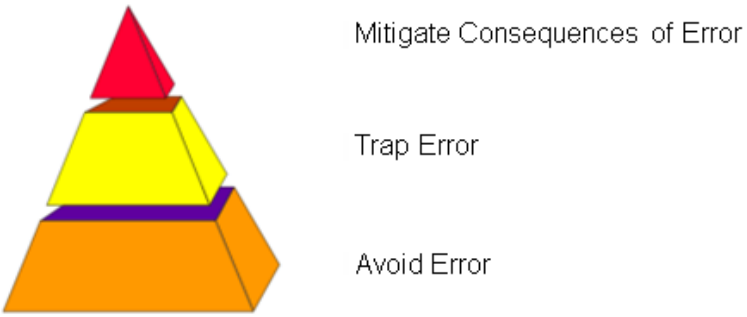


Figure 2. The error troika. From Helmreich et al, 1999b

In the UK, TEM is usually seen as sitting within CRM, but the flight crew error management model (Figure 1) explains how the opposite view can exist (and is possibly even predominant in some countries) since CRM behaviours can be viewed as a part of overall threat and error management.

Whichever perspective one takes it is clear that there are many links between TEM and CRM. Research has found evidence that strong leadership, inquiry, workload management and automation management are correlated with fewer mismanaged errors and undesired aircraft states (Helmreich 2006). Additionally, crews that develop contingency management plans (such as discussing threat strategies) have fewer mismanaged threats.

SECTION A

Human factors knowledge and application

In this section:

This section is split into two parts:

Part A1 – The Individual

Chapters 1 – 12 contain knowledge areas that are most closely aligned with individual factors and performance and hence are applicable to everyone, including those operating as flight crew, cabin crew, and those operating small single pilot aircraft.

Part A2 – The Crew

Chapters 13 – 15 contain knowledge applicable to teams and crews, mostly applicable to multi-crew pilots and other teams such as cabin crew, but with concepts that single pilots can also benefit from. From a scientific perspective, much of this section draws from social psychology and group dynamics.

Chapter topics generally align with current EASA requirements in terms of areas covered. For more guidance on regulation see Section B, Part 5, Chapter 25 (CRM regulations).

This section (Section A) can be treated like a textbook of fifteen chapters. With the exception of Chapters 10 and 11 each chapter is divided into three distinct parts: basic theory, application to aviation operations, and relevance for CRM practice, as follows:

- Knowledge – A very brief theoretical introduction to the topic
- Application – How the knowledge applies in aviation operations
- Application to CRM – Assistance for the CRM trainer / instructor / examiner in putting across the knowledge

Use of Anecdotes

Throughout Section A, numerous anecdotes are used to illustrate theory. These are short stories that will help to add ‘colour’ and application to the narrative. The anecdotes come from all types of operation right across civil aviation, including air transport (fixed and rotary wing) and recreational flying of various types. Anecdotes have kindly been supplied by volunteers. Where those volunteers preferred not to be named in the document, the anecdote has no reference. Where volunteers were comfortable to be named, the anecdote is followed by a number referring to the list of contributors in the front of this document.

Limitations of Section A

Section A is not an exhaustive description of all CRM knowledge required by a CRM trainer. Each topic is covered with some basic theory that is then integrated into the flight operations domain (within the 'application' sub-sections) and finally discussed with relevance to CRM training. The focus has been on width rather than depth of coverage.

The scientific knowledge has been intentionally simplified and phrased in a non-ambiguous manner that may, on occasions, seem frustratingly imprecise to researchers and scientists. The chapters sometimes state scientific information as if simple fact, when usually the precision of the information is still debatable within science. This has been done in order to make the document more easily accessible, readable and more usable in the practical domain. For example, a statement might be used such as:

> *Startle is a reflex that automatically happens in response to a shocking event*

Scientists in the domain would not enjoy such a statement, because although not overtly incorrect, it does not reflect the precision of the evidential inferences or on going arguments. A more correct version of the above sentence would be:

> *Although still debated, 'startle' is usually considered to exhibit more characteristics of a reflex than an emotion by modern researchers. This is because the acoustic startle pathway is known to be relatively short, and that evidence from eye-blink amplitude measurements suggests the activation happens before full conscious awareness. Startle can therefore be argued to be an autonomous response to a stimulus, and the term 'reflex' can be justified in this context.*

The reader can see that if topics were approached in this way, this manual would be difficult to read, and less usable in the practical domain. Researchers are asked to treat this as a limitation to be considered if ever quoting from this manual in scientific research literature.

SECTION A, PART 1

The Individual

In this Part:

Chapter 1
Information Processing

Chapter 2
Perception

Chapter 3
Attention

Chapter 4
Vigilance and Monitoring

Chapter 5
Workload

Chapter 6
Surprise and Startle

Chapter 7
Situational Awareness

Chapter 8
Decision Making

Chapter 9
Error and skills

Chapter 10
Stress in Aviation, Stress Management

Chapter 11
Sleep and Fatigue

Chapter 12
Personality and Culture

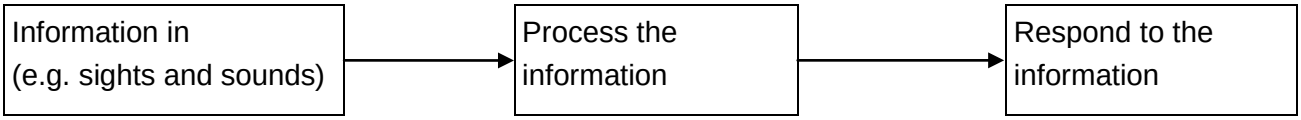
SECTION A, PART 1, CHAPTER 1

Information processing

Knowledge

This chapter gives a brief theoretical foundation for subsequent (more applied) chapters.

'Information Processing' attempts to explain how the human brain responds to incoming information. It is a general theory that can help to understand areas such as situational awareness and decision-making. There are three fundamental stages: 'information input', 'processing', and 'response' (input, process, output).



1. Input (information in)

When senses are stimulated (e.g. a sound or sight), the stimulus is remembered by a special 'sensory memory' just long enough for an unconscious interpretation 'perception' to determine whether the stimulus is important enough to draw the person's attention to. Hence for incoming information to be processed (thought about) it must be sensed, perceived and noticed.

2. Processing (process the information)

Processing compares incoming information to long-term memories in order to interpret it and decide what to do next. Processing takes mental effort (it creates and adds to mental workload). Operations such as hypothesising, assessing, calculating, decision-making, or any other thought process can be referred to as 'processing'.

Some well-learned perceptions can bypass this processing stage by triggering a skilled response automatically (even without seemingly catching our attention). Even complex tasks like driving a car can become automatic; many experienced car drivers 'find themselves' stopped at a red traffic light without remembering it happening.

Role of Memory

Previous experiences must be stored in long-term memory (LTM) for future scrutiny. Additionally, automatic routines such as speech and motor programs must be stored (in a long-term area called 'procedural memory'). Furthermore, during mental processing there is a need for the short-term buffering of information (like computer RAM) and this is done in an area called the 'working memory'.

Hence there are at least four types of memory that have been theorised:

- Sensory Memory
- Long-Term Memory (LTM).
- Working memory
- Procedural memory (similar to the colloquial phrase ‘muscle memory’)

There are other hypotheses of memory in information processing, and so trainers will encounter other terms in use, but they will usually parallel one of the four ‘types’ above.

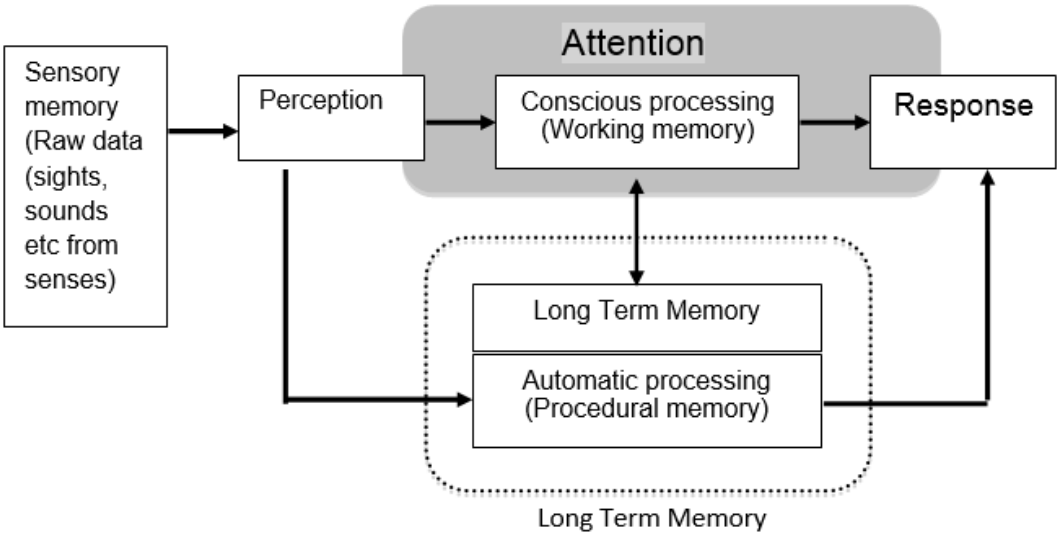


Figure 3. Simplified generic diagram of Information Processing (based on simplification and merger of many other authors' work

Figure 3 above is a simplified version of the overall theory. It works from left to right. Sensory memory remembers stimuli just long enough to allow perception, which passes the information to either conscious processing (working memory) or automatic processing (procedural routines). Much could be added, but one useful addition would be a feedback arrow from ‘response’ back to the start, since ongoing tasks such as flying are constantly being updated based on feedback.

Note the shaded area called ‘Attention’ in Figure 3. Attention will be discussed further in other sections because it is so fundamental to cognition and error. Attention is also aligned with mental effort (concentration, thinking, etc.). Conscious activities require attention and unconscious (automatic) activities do not. All central processing involves attention (hence it is within the shaded area). Long-term memories are generally agreed to be unconscious stores, therefore outside the ‘attention’ area.

3. Response

Responding usually takes a physical or verbal form (doing or saying) but there are other responses such as thoughts, eye movements, doing nothing, etc. Well-learned motor skills require almost no attention (i.e. 'fire and forget'). This is very effective and efficient but it can lead to a problem if the wrong skill is triggered and then continues unnoticed.

Application of Knowledge – information processing

Information processing theory can help practitioners articulate or understand a mental task. Consider a complex task such as making a divert decision (see the decision-making section for more specific analysis on this decision). It involves input, processing and actions. The information comes from many sources and causes heavy processing (in working memory). A problem at any stage of information processing could affect the outcome, for example:

- Sensing: Failing to hear an important radio call about the weather at the diversion, due to turning the volume down during a critical discussion.
- Perceiving: Misperception of the fuel gauges (selecting an airfield too far away).
- Processing: Miscalculating the crosswind vector at the diversion airfield.
- Responding: Accidentally selecting a speed of 140 knots rather than a heading of 140 degrees.

Almost all actions and operations can be analysed in this way, including quick and simple tasks. Identifying the problem stage can help inform solutions.

Application to CRM – information processing

A basic understanding of information processing can help articulate ideas and assessments of why people do what they do (e.g. for classroom case studies, diagnosing events in simulators, etc.).

The process of information acquisition means that the foundations for an accident can be laid before a crew ever make a decision or do any conscious mental processing. If information is not seen, noticed, or correctly perceived, then any subsequent action is more likely to look like an error.

In case studies, it is always important to attempt to establish (or hypothesise) what information an accident crew based their actions on, before determining if the actions themselves were erroneous. It is also important for trainers to remember that a 'failure' of processing (seemingly not responding appropriately, or at all, to a situation) could in fact stem from any part of the process. In a similar way, when observing an event in the simulator or on the line, the observer should consider the whole process equally, not just the part that is closest to the consequence, or the part that the crew vocalise the most. For example a crew may make a seemingly poor decision (e.g. choosing to continue the sector

after a simulated problem after take off) and the trainer notes ‘decision making’ down on their behavioural marker sheet. But the trainer should still be open to other possibilities such as information not having been perceived correctly (the decision might indeed have been good when considering the information as the crew perceived it). The trainer should therefore debrief in a way that allows a diagnoses of the whole task (input, processing and output) to pinpoint at what stage the problem occurred. Such a debrief might be called a ‘cognitive task analysis’ (CTA). In the most basic form, the instructor can start by asking the crew to break the whole process into just three or four stages, or draw a brief basic timeline (of what happened when). Questions can then be asked about the stages. The trainer should establish any differences between their own observation and the crew’s picture of the situation and ask questions that attempt to uncover where the issues occurred, and what they were.

Examples of such questions would be:

- “Which part of the task do you think worked well?
- “Did you find any part of the task difficult? Why?”
- “In hindsight, would you do anything differently? What/Why?”
- “What information were you basing the decision on?”
- “At [this stage] what information do you recall being most aware of?”
- “At this point, was there anything causing you concern?”
- “What information source would you have based the decision on, if that source was unavailable?”
- “Did the decision *feel* urgent?”

The aim of these sorts of questions would be to find out where the process went wrong. For example, it might have been that the response was appropriate given the information the crew perceived, but the information was incomplete or misperceived by the crew. The trainer then needs to focus on that element, not the decision making or response.

SECTION A, PART 1, CHAPTER 2

Perception

Knowledge

Incoming stimuli need to be quickly interpreted so as to know roughly what is being sensed. This process of perception is fast and effortless. Perception can be said to build 'mental models' of what the senses collect. For centuries, people have created optical Illusions that act to 'fool' the perceptual process (illusions are designed to create a misperception; i.e. there appears to be a difference between what you perceive and what is true).

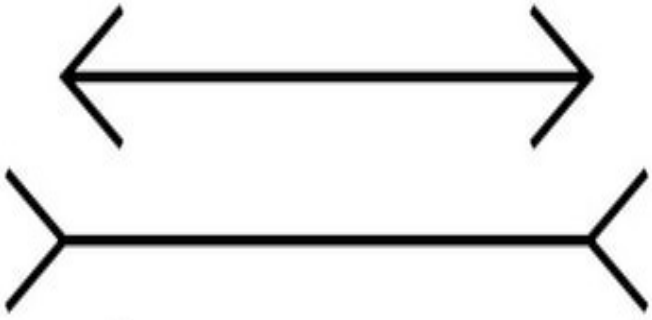


Figure 4. The Müller-Lyer Illusion by F.C. Müller-Lyer 1889. The two parallel lines are of equal length, but most people percieve the top one to be shorter. The exact reason for this is still debated.

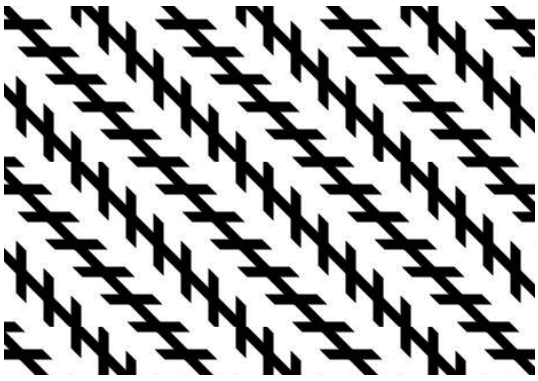


Figure 5. The Zöllner Illusion (Johann Karl Friedrich Zöllner, 1860). The diagonal lines are all parallel, but due to the short horizontal and vertical cross-lines, they do not appear so. The exact reason is also still debated.

The essence of the perceptual process is that it imposes knowledge and experience onto incoming sensory information in order to form a quick understanding of it. In other words the brain takes a very quick 'best guess' as to what the stimuli represent based on what it has learned of previously similar stimuli.

As well as the object being perceived, the context around the object also feeds the perceptual process of that object. A good example is a form of illusion created by the

suggestion of perspective in two-dimensional images, such as classic convergence illusions like the one in fig 6 below.

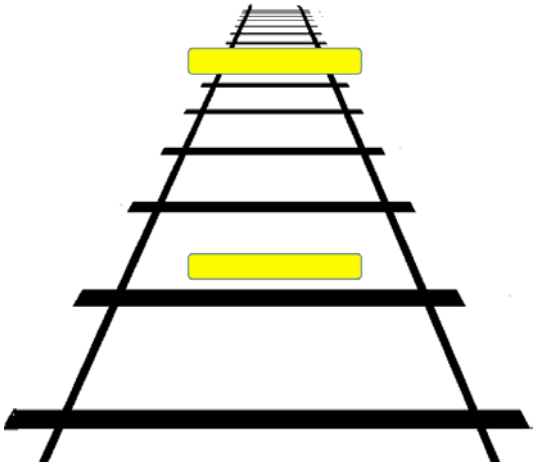


Figure 6. Classic Perspective Illusion

Sometimes called the Ponzo Illusion, putting two identically sized objects on a scene with suggested perspective causes one object to be perceived as larger than the other. This is because the brain naturally compensates for the perspective as it would in the real world (objects nearer the horizon or closer to the vanishing point are perceived as further away, and the size is unconsciously compensated for by the perceptual process).

Piloting an aircraft would be impossible without the use of perception, but on rare occasions the process will inevitably lead to the brain 'guessing' wrongly about the meaning (or properties) of an object.

Which comes first: noticing or perceiving?

In terms of information acquisition, there has long been a scientific debate about which comes first: the drawing of attention to a stimulus (noticing) or the perceiving of that stimulus (what is it?). To avoid a complex but fascinating indulgence into the science, it is practically useful (and generally correct) to consider that many things will get perceived (to an extent) whether they catch our attention or not, and that only some things that are perceived will draw our attention (either because of their physical characteristics or the meaning around them). Almost everything that catches our attention will be perceived. Hence we probably perceive more than we attend to.

Application of knowledge – Perception

This section explains common perceptual illusions in flying.

The single most important learning point regarding perceptual illusions is well established in aviation: pilots are rightly trained that unless obviously wrong, instrument readings should be prioritised over sensations (both vestibular and visual). It may be worth the CRM instructor recapping these illusions in order to reinforce that important point, and showing the number and breadth of situations to which it applies.

Glideslope

The need for VASIs and PAPIs stem from the difficulty that all pilots have (to varying extents at various times) in accurately judging the right glideslope angle using purely visual judgment. There are no reliable natural visual cues for glideslope angle.

The raw, uncorrected shape (a trapezium) that a runway presents to the eye during a final approach is one of the most important cues for the perceptual process (known as form-ratio). Because of this, one of the most common illusions is caused by a sloping runway surface. A runway that slopes downhill, away from the pilot is likely to generate a high approach (as the pilot attempts to maintain the normal perception of form-ratio). This could lead to a high-energy approach (to a downhill sloping runway) and the risk of an overrun. Equally, an upward sloping runway, as viewed from the pilot, may cause a low approach for the same reason. Hence it is important that whatever the runway shape seems to suggest about the glideslope, technical sources of glideslope information are carefully monitored (whether PAPI, ILS glideslope etc.) even on a visual approach. These illusions are unlikely to cause consequences in isolation, but can contribute to a situation.

As well as the sight of the runway, ground cues such as texture and horizon play an important role in maintaining the correct perception of the glideslope. The perceptual limitation inherent in judging approach path angle is particularly critical when there are no outside visual features other than the runway or helipad. Normally, when visual with a runway a pilot will also use ground cues some of which will become increasingly visible in their peripheral vision as they descend (such as ground texture). If these cues do not appear as normal, it can lead the pilot to unconsciously understand the reason for their absence as excess aircraft height. Hence in situations where there are no ground cues (such as night time approaches over desert or unlit water) the common and strong impression (perception) can be that the aircraft is high on the glideslope. This is dangerous because it leads the pilot to descend (i.e. depart from the glideslope). This specific illusion is often called the black-hole illusion, due to the apparent visual ‘black hole’ between the aircraft and the runway.

> *It was a dark but clear night with no horizon and our destination, a lone platform, could be easily seen with some distance to go. I briefed the approach and we commenced the descent. During the descent I was aware that something was not right. I understood that given my altitude and range from the platform I was too low, yet visually the approach appeared to be steep. I was aware of the black hole approach illusion having briefed it many times during CRM training, yet I was unprepared for the strength of the illusion I was now encountering. My co-pilot had fortunately been vigilantly monitoring the situation and re-orientated me with a command to climb.*

Height

Visual height illusions can be potentially dangerous in visual flight regimes such as military low flying, helicopter operations or general aviation, but even occasionally in commercial airline operations. An illusion might be innocuous by itself, but if workload is high due to other tasks then such illusions can cause problems, particularly below a thousand feet. Numerous factors feed the visual perception of height, including:

1. The visibility of texture and detail that can be seen on the ground, and the size of known objects (i.e. houses and animals).
2. The relative speed of ground texture flow (the slower that the ground seems to be moving relative to the viewer, the further away it is perceived to be).
3. Perspective and shape, e.g. of buildings, mountains, runways etc.
4. Known landmarks, distances and angles.

Miniaturised ground objects (miniature trees, small fields) can give the impression that the ground is further away than it is. Likewise, larger than expected objects can make the ground seem closer than it really is.

> *The commander (PF) was carrying out some SAR training approaches to a mountain peak at night using night vision goggles. The summit was strewn with large boulders and with no other object for reference the commander perceived the boulders to be smaller than they were. Several approaches were made and on each occasion the commander went around believing he had become too low.*

Poor visibility can also make ground objects seem further away (removing the colour and clarity associated with close objects). Flying very slowly and/or into a strong headwind can contribute to a perception that the aircraft is higher than it is and this can be exacerbated with ground lights at night. Night also removes many cues, particularly ground detail. Changes in the spacing and brightness of ground lights can feed illusions (roads, houses, etc.). Featureless terrain, water and glare remove several cues to height. Loss of perceptual cues will put a slightly heavier burden on the pilot to pay attention to height.

Speed

Humans have evolved ways of perceiving the speed of their movement, but for obvious reasons humans have not evolved a perceptual process for airspeed. A major natural cue for perceiving the speed of one's movement is texture flow, usually in peripheral vision. Other cues can also factor such as noise (volume and pitch change), perception of attitude (nose-low attitude can be mistaken for speed), buffeting and control response, and vestibular acceleration cues. Difference between speed and airspeed may be learned but even then, movement cues will feed airspeed perception. Aerobatic and post-stall accidents frequently occur when pilots apply too much back-pressure to the control column because the nose-down attitude gives the impression of sufficient airspeed before the

airspeed has built up in the dive, leading to a secondary stall or flick. This can be a fatal misperception of speed caused by use of an unreliable cue.

Substituting ground speed cues for airspeed indications is common. A disproportionate number of accidents are caused after turning downwind during pylon racing (Eshelby 1996) almost certainly for this reason. Another example occurs where gliders stall and 'flick' while rotating into the climb during winch launching, usually resulting in serious (often fatal) accidents. A disproportionate number of such accidents happen in calm conditions. Because pilots factor natural cues into their airspeed perception during the moments of launch (texture flow, acceleration and time elapsed) their timing of the rotation is skewed by ground speed, not airspeed. Due to this, calm conditions can cause launches to err towards early and steep rotations and high angles of attack, occasionally just enough to stall a high performance glider (which account for most such accidents despite accounting for a fraction of such launches).

Aerobatic and airshow pilots performing low rolls or other 'airspeed-critical' manoeuvres downwind are also vulnerable, as are general aviation aircraft after engine failure on climb out (i.e. turning back downwind for a landing). Although the message seems simple ("use the airspeed indicator") in practice this may not be easy in certain situations because perception is powerful and not under conscious control.

> *Late on in the approach my mind was focussed on the very short runway. Things seemed ok: the nose seemed higher than normal but there was no sensation of losing airspeed. I remember momentarily thinking that it must be to do with the airfield sloping (I had not landed here before). As I flared, the aircraft didn't seem to respond at all and just fell onto the runway very heavily (fortunately without damage). I later realised that I had landed with at least 15 knots of tailwind, and had probably run out of airspeed by the flare. The tailwind must have given me the impression of speed and I had clearly not properly monitored the airspeed indicator.*

The above anecdote is a good example of the power of ground cues to feed perception, particularly when under high workload. This effect has contributed to many serious accidents. In 2008, an Extra 300 aerobatic aircraft transiting an air display was destroyed and its passenger seriously injured after worsening weather led the pilot to make an emergency landing in a field. The tailwind component was between 10 and 15 knots. The following section is from a UK AAIB report:

> *In assessing speed at low level, pilots use a number of cues: primarily the airspeed indicator, but also the power setting and attitude, the feel of the controls and the impression of speed, sensed in the peripheral vision, by the rate at which the ground texture passes by. This last cue has been identified as being particularly powerful and difficult to ignore, and is known to have been a factor in the context of downwind landing accidents. It is possible that this impression of increasing ground speed as the aircraft turned downwind influenced the pilot inadvertently to allow the airspeed to reduce until the aircraft stalled, at which point there was insufficient height in which to recover control (AAIB 2009).*

Attitude and Bank angle

The inner ear has small receptors that pass information to the brain. Head orientation information is sensed using otoliths. These can be considered as little spirit levels (they have lots of little hairs with tiny weights on at the end, that bend whenever the head tilts). Head rotations (accelerations) are sensed in three dimensions by three semi-circular canals (fluid filled tubes in a circular shape).

The perception of gravity can be masked (indeed replaced) by aircraft bank angle or acceleration. This means that a pilot can have a perception of being upright when they are banked, and vice-versa. This does not usually fool visual perception and it is therefore useful that visual perception is prioritised naturally; except when there are insufficient natural visual cues of the outside world. An additional limitation with the vestibular system is that it requires a threshold of acceleration or displacement in order to be perceived. Hence, if orientation changes slowly, that change may be invisible to the perceptual process.

The classic problem is often called ‘the leans’ and occurs in IMC (or even on a dark night) as follows: a gradual increase in bank angle occurs unnoticed to the pilot. The pilot then notices the bank angle on the attitude indicator (e.g. artificial horizon) and rolls the aircraft back to level flight. The vestibular system only senses this second roll (returning the aircraft to level flight) but not the first roll that banked the aircraft gradually. The net vestibular perception therefore becomes that the aircraft is now banked, when it has in fact returned to level flight. This gives the pilot a feeling of being banked despite the attitude indicator showing proof that the wings are level. Because the attitude indicator is small (uses foveal vision) this illusion is not overcome by visual perception, and so the erroneous feeling of being banked remains. This is uncomfortable at best and dangerous at worst. If attention is distracted to a different task, then the pilot could unconsciously roll the aircraft without noticing in order to negate the uncomfortable sensation created by the feeling of being banked, and this might have consequences. Pilots must understand and accept that they must always control the bank angle of an aircraft with visual cues, whether external or internal (attitude director) and never use a sense of **orientation.**

Another well-known issue is that the hairs in the otoliths will be bent backwards by forward acceleration in exactly the same way as they get bent backwards by gravity when the head is tilted back. Therefore pitching upward and accelerating forward generate the same cue to the perceptual process, and hence the same perception, unless another sensory cue is factored in. This is a good reason why the attitude indicator should be used to establish pitch angle after take off on a dark night, or indeed any time when there is a lack of valid external cues.

Application to CRM – Perception

It is reasonable to ask whether there is any value in teaching pilots about perception.

The CRM trainer should be careful if discussing vulnerabilities around perception in a general way. Although a valid thing to do, the trainer must not imply that because perceptions can occasionally be wrong or even dangerous, pilots should treat them all with caution. It is an illusion caused by the benefit of hindsight (called hindsight bias) to point to a single misperception and suggest that the pilot should have questioned it at the time. Additionally, we have no choice in the way we perceive things and no matter how much we stare at misperceptions they will not change (consider the optical illusion, it does not suddenly become a non-illusion once you know it is wrong). If audience members infer that they are being told to be cautious of perceptions in general then they will be justified in moaning that CRM and human factors training does not apply to the real world.

Despite this there is value in teaching about perception and perceptual illusions: Firstly, as described in the previous section there are common perceptual illusions that apply to pilots. Knowledge of these can help to prepare for or avoid problems. Secondly (and less usefully) there may be some value in discussing what can happen (i.e. misperception) so that in rare cases individuals might consider a reappraisal or cross check if they are receiving contradictory information. However even this is subject to hindsight in the same way as before.

In terms of classroom teaching, optical illusions provide an easy and fun way to support the theory around perception. Asking the key question as the illusion appears is a good way to do it; e.g. “which line looks longest here?” Usually the audience will know that they are seeing an illusion, and some will second-guess the answer. That is fine. The trainer can ask those people whether that is what they see or what they know / guess. The trainer can point out that s/he sees line A as longest, no matter how many times s/he shows the slide. The trainer must never show any hint of trying to fool the audience with the illusion, and no hint of superiority. The trainer must remember that they only know the key to the illusion because they have seen it before, not because of their expertise or qualifications.

The simple objective is to show as clearly as possible that perception can occasionally be at odds with reality. For example the trainer can point out that:

> *When we look at the Müller-Lyer illusion we ‘see’ two lines of different lengths, and yet we know rationally that the lines are the same length.*

Hence in that specifically engineered case, perception does not match reality. Additionally, it is worth showing that no matter how hard we stare at the illusion, we still cannot help but be ‘fooled’ by it. Perception cannot be ‘over-ruled’. This leads to the question of ‘why learn about it? So what?’ There are several good reasons. Firstly, in order that pilots can be more prepared to counter common illusions if they recognise their possibility in specific context (vestibular illusions during instrument flying are the classic example). Secondly, if pilots know the context then they can use different cues or consciously cross-check during a specific period (e.g. approaching a runway on a dark night with no ground features).

In terms of common illusions, it can help to ask the audience for examples that have occurred to them, or ask them to find the specific applications for certain common modes of illusions (e.g. convergence and perspective). Importantly, most teaching of common perceptual illusions should be put into definite and highly specific context, because it is the context that will trigger the recall of the illusion's effects in the real world, not simply the knowledge of perception and illusions in general. Whereas we can work out the application of a real world illusion easily enough in hindsight, it is very difficult in foresight or at the time that it occurs.

SECTION A, PART 1, CHAPTER 3

Attention

Knowledge

To pay attention to something is to concentrate on it, whether that is a stimulus that has been sensed, a threat, a decision, a calculation, etc. Critically, attention is limited; if some attention is being used for one thing then it cannot be used for something else.

A person can choose to pay their attention wherever they deem it necessary (the visual scene, a conversation, thoughts, actions, etc.). That does not mean attention is required to do everything; e.g. autonomous actions can continue without attention such as in driving. It is generally accepted that we can only fully concentrate on (pay attention to) one thing at a time. As well as voluntarily controlling what and where to pay attention, attention can also be diverted or captured (e.g. by a flashing light).

Huge amounts of data hit the senses but only a small proportion ever catch attention and enter awareness. Therefore it must not be assumed that whenever something is sensed (e.g. seen by the eye) it has been noticed. A good example comes from excellent work of institutions such as the University of Illinois Visual Cognition Lab (such as the famous Gorilla in a Basketball game by Chabris and Simon). Sometimes things that would appear to be perfectly audible or visible do not catch our attention and do not receive any further processing. The brain only has the capacity to process a small amount of what is sensed, and it can be surprising what it can miss.

A whole field of science is dedicated to how and why we become aware of some stimuli but not others. The traditional theory is that of a filter, which passively prevents all but the most important sensory information from getting through to the working memory. When stimuli cause attention to be drawn (get through the filter) it is called attentional ‘breakthrough’. Critical information such as an alarm should breakthrough but irrelevant background ‘clutter’ (noise) should not. The physical properties of stimuli are an important clue for the brain as to whether a stimulus should attract its attention; bigger, louder, brighter stimuli and those with relative movement stand out from the background and are more likely to breakthrough (draw attention / get through the filter). Occasionally however, particularly during very high workload, even a very salient stimulus will fail to ‘breakthrough’. For example, in many of the classic passenger evacuation trials by the late Professor Helen Muir, participants reported a lack of noise during the evacuation, when in fact there had been a tremendous din. Clearly the sound had vibrated participants’ eardrums, but their brains had not consciously registered the noise. This could have been a lack of memory encoding due to the stress of the situation, but it seems more likely that the noise was ‘filtered out’ or not attended to because there were more important things to pay attention to and so the noise did not get noticed.

Whereas physical properties can help attentional breakthrough, the ‘meaning’ of a stimulus can also help. The classic ‘cocktail party effect’ describes how, with many conversations occurring all around, one conversation can suddenly breakthrough to attention because a word or phrase was particularly interesting (the classic example is the person’s own name being said by someone else). This suggests that there is at least some pre-processing of stimuli prior to attention being drawn, even if it is not realised or remembered.

Attention is aligned with capacity and resource because some difficult tasks need a lot of attention (sometimes too much) and there is only a limited supply. As such, attention is one of the most important hypothetical concepts when considering workload and multi-tasking.

Application of knowledge - attention

The sensory organs and their memory buffers (sensory memory) are not discerning; they will collect practically everything that they are able to physically sense. Hence much of the time pilots may not notice something when in fact they have physically sensed it.

The general issue of ‘not noticing something’ is often cited as the cause of accidents; e.g. VFR mid-air collisions (ineffective lookout), low speed events (failure to monitor airspeed), automation related events (failed to notice the autopilot disengage, or failed to monitor mode annunciators), lateral disorientation accidents (failed to cross-check the navigation), configuration related events (failed to notice the flaps were not set), and many others. Although a simplistic and selective point, it is true in hindsight that had these critical parameters caught the pilots’ attention then the particular accident would have been prevented (albeit perhaps as a substitution for a different accident). Hence it is fair to ask why they did not get noticed.

Eastern Flight 401 was perhaps the first documented major airline loss caused by a loss of automation mode awareness (1972). The autopilot changed mode (it stopped holding the altitude) but no one noticed. The audible chime did not ‘breakthrough’ the attention. There were no outside visual references because it was dark. The mode annunciators probably did not draw attention, and if they did their meaning was not perceived. Additionally all crew were involved in solving a problem, and so their attentional resources were utilised already (a CRM issue).

Humans have a limited pool of attention from which to draw; we cannot notice or pay attention to everything. Activities such as problem solving or communicating mean that other factors can get neglected (like in Flight 401). A more recent alternative to filter theory is to metaphorically consider attention as a spotlight. If the spotlight is on one thing, then it cannot be on another.

On many occasions, the need is greater than the resource available and so attention has to be carefully managed. For example, a manually flown final turn requires a pilot to share visual attention between at least three widely separated areas (the runway, the airspeed, and the attitude). This is an attentional compromise. Live flying experiments (using gliders)

show that pilots who pay less attention to attitude are more likely to over-use the rudder and fly skidding final turns (Jarvis and Harris 2007). However, correcting this by paying more attention to attitude risks misalignment of the final approach or mismanaged airspeed. Paying attention to one thing usually requires withdrawing attention from another thing, but without an obvious solution. Importantly therefore, trainers must avoid simply pointing out what a pilot was NOT doing enough of and suggesting they do more of it. Attention does not work like this. The trainer must consider why the attention was where it was, and what will happen if it is now artificially re-prioritised; has the trainer simply substituted one potential accident mode for another? The solution usually lies in better planning and managing of the workload (workload management) rather than simplistic feedback to pay more attention to something.

Occasionally attention can be distracted from the primary task because of low workload, particularly when the distraction has emotional relevance or interest. This is especially possible when everything is going well, or as planned.

> *Flying a visual approach to one of the thousand islands in the Med, I was fascinated by the perfect combination of blue sky, emerald sea and inviting landing strip glittering under the sun. I thought – "Why is everything is so right and perfect this morning?" Then the FO's voice came – "What you are aiming at is the taxiway Captain" It was only then, I acknowledged the beauty of the runway as well." [11]*

The discussion of attention theory is continued and expanded in the workload section.

Application to CRM – attention

Pilots will benefit from recognising that anyone can miss things, even when those things are very salient. They will feel more confident intervening when they think that a colleague has missed something if they know that (1) it is common to miss obvious things, and (2) the colleague also knows this to be true (perhaps because of the CRM training) and so knows that the intervention is nothing personal. It may also motivate crew to practice double-checking at specific important times, in the knowledge that they are also vulnerable.

Many CRM courses have used movies such as Simon's Basketball game (University of Illinois visual cognition lab) and other similar clips, in order to powerfully demonstrate this. This has been successful, and makes for a fun session. The CRM trainer should however follow through with an accurate explanation for their movie or game as well as to discuss application of this to flight operations, and suggestions of how and when such knowledge can help. Otherwise an important opportunity is missed.

SECTION A, PART 1, CHAPTER 4

Vigilance and monitoring

Knowledge

Vigilance refers to sustaining attention on something so as to notice when a non-ordinary event happens (e.g. monitoring a radar screen in case of incoming threats). In practice, and in the context of flying an automated airliner, this activity is often referred to as monitoring. The term vigilance is usually used to refer to tasks where the object of interest is independent of the person monitoring it and this is an important area in the operational oversight of modern automated systems.

Vigilance research has a long history. Researchers such as Norman Mackworth helped to firmly establish the concept of 'performance decrement' in valid vigilance tasks (see Mackworth, 1948). It was shown that vigilance performance dipped significantly within half an hour. It is now accepted that sustaining ones attention is difficult due to the way the attentional system works, and that performance will drop significantly over a short time. This drop is still known as the vigilance decrement. It is now agreed that most of it occurs within just 15 minutes of starting a vigilance task (Teichner, 1974) and can occur within a few minutes if the vigilance task is especially demanding.

The traditional view was that vigilance tasks were very undemanding and so users became bored, and it was this 'underload' that caused attention to be withdrawn leading to the decrement. However modern science suggests that vigilance tasks create high workload, frustration, fatigue and stress (Warm JS, Parasuraman R, Matthews G, 2008). It is now widely hypothesised that attention is withdrawn from the task because of its unrewarding workload and perceived relevance.

It has also been proposed that the performance decrement is due to fatigue. The relationship between fatigue and vigilance is not settled in science. It has been demonstrated that maintaining vigilance will add to fatigue and will be more difficult when fatigued. Fatigue and vigilance are nevertheless independent entities. To avoid participant confusion it is probably best that vigilance and fatigue are not discussed as if part of the same phenomenon in CRM training. It is better to teach vigilance primarily as part of attention, information processing, monitoring, situational awareness, workload or even automation. Fatigue impacts on most areas of human performance, and many factors increase fatigue. Vigilance does not appear to be a special case, although it may appear so to practitioners because it is very noticeable.

There is no 'silver bullet' for improving vigilance. The human brain is not set up to monitor unchanging or non-signalling independent parameters for long periods. No matter how much good intention or motivation someone has, they will still be subject to vigilance decrement.

Application of knowledge – vigilance and monitoring

> *Every time I ignored some of the flight instruments and didn't pay them the necessary timely attention, I learned a lesson. Looking at them again was like meeting one of those difficult people in life whose teachings you won't forget. So do respect them and give them this so needed attention through good scanning. [11]*

It is arguable that 'vigilance' is the foundation of the modern pilot's work, but equally it is easy to attribute 'vigilance decrement' whenever something goes unnoticed, or to attribute 'complacency'.

In modern automated aircraft, pilots are not expected to pay attention to a single specific item for an extended period of time, but to continually re-visit various parameters. Such checking may well decrease in frequency or attentiveness and although it is arguable whether this is the same thing as vigilance, there would appear to be read-across to vigilance research: Secondary checking increases workload and since it rarely leads to intervention or consequence (mainly due to technical reliability) it causes frustration and stress as described in vigilance research. It is clear that (in common with single primary vigilance tasks) withdrawal of attention from the vigilance task will lower workload.

Because pilots must scan numerous sources of information it can be unrealistic after an event to suggest a pilot suffered a lack of vigilance; it is just as likely that their attention was elsewhere, particularly when a lot was happening. When workload becomes high on a primary task such as manual flying or emergency actions, attention narrows to that task, and so monitoring of other sources degrades. This is not an effect of vigilance or fatigue; it is a matter of cognitive workload.

However, even when workload is low it is almost inevitable that high levels of vigilance are not maintained. Elements that are seemingly unchanging (reliably static), or have no direct feedback to the main task, or are rarely consequential, or are not easy to interpret, will often be dropped quickly. Unfortunately, modern automated flight decks contain a lot of information sources that fit these descriptions.

Because of this it can be tempting for pilots to stop monitoring, or to be distracted from the monitoring task, particularly when the autopilot is engaged.

> *The aircraft was in the cruise with the autopilot fully coupled when the commander (PM) became aware that the first officer (PF) was staring out of his side window and that something on the ground had drawn his attention. The commander decided to time how long it would take before the first officer's attention returned to scanning the instruments. His attention was diverted for over three minutes.*

When pilots drop sources from their scan, they often do not remember dropping those unless a reason arises. However, occasionally a pilot makes an effort or recalls the readings, and in these cases they recall monitoring that source. Hence pilots can gain a false impression of their own ability to monitor (while noticing the lack of monitoring in others).

> *The experienced training captain was becoming more and more passionate; "How many times do I have to tell these guys to monitor properly? They engage the autopilot and just stop monitoring! Perhaps they should all fly general aviation like I did, so that they learn not to be so complacent…." The training captain carried on while I wondered how to break the news to him that during the simulator experiment that he was now being debriefed about, he and his co pilot had missed the deliberately failed instrument that he was now referring to. It wasn't that he or his pilots were complacent, it was that they were human. [5]*

Pilots of all levels of experience are susceptible to this monitoring degradation and the brain is very quick to determine what is and is not worthy of attention in a scan (a matter of minutes).

It is generally recognised that closed loop monitoring tasks (such as control or tracking tasks) suffer far less from the effect of vigilance decrement. For example, when a pilot is flying an aircraft manually in IMC there is very little decrement in terms of vigilance towards the primary flight instruments. One hypothesis is that because the controlling task is more aligned with the brain's normal functioning there is no build up of stress or frustration, and so no urge to reduce attention on task. The use of procedural memory for manual controlling means that this task does not generate the workload associated with maintaining attention on an open-loop area of interest. This statement might appear slightly unintuitive, but it is probable that the slight workload caused by the perceptual motor control (closed loop control) is less than that caused by having to direct attention to an open loop task that is causing strain and frustration.

Application to CRM – vigilance and monitoring

Can vigilance be taught?

The bad news

Unfortunately the research work in the area of vigilance is mainly descriptive (describing vigilance) rather than prescriptive. There is no evidence that the vigilance decrement can be permanently reduced by training or instruction. People do not become generally more vigilant just because they understand the vigilance decrement or feel more motivated to be vigilant. This is chiefly because the vigilance decrement is not under voluntary control and is not a factor of motivation. There is therefore no 'easy win' for the CRM trainer in this respect.

Discussing the consequences and risks of the vigilance decrement will also have little direct effect, although it may provide some motivation to improve and cross-check. Accident reports, analyses and CRM courses sometimes imply or state that pilots must maintain constantly high levels of vigilance in order to avoid catastrophic consequences, and this also gets aligned with professionalism. However, whereas there is little doubt that greater crew vigilance would have prevented many accidents, such expectations are

usually unrealistic because they take no account of the reasons behind the vigilant decrement.

Of all people, the CRM trainer should account for human factors in any proposed solution that they recommend or imply. Vigilance (and automation) is one area where this does not always happen.

The good news

Learning about vigilance decrement could prepare a pilot to support their colleague, being more aware that a lack of vigilance is not something that only happens at night or when fatigued. They will then be less surprised and more confident to intervene if they recognise a lack of vigilance in a highly competent and fresh colleague. Additionally, the colleague will be more receptive and encouraging of the intervention if they understand the reality of the vigilance issue in themselves.

A vigilance or monitoring session should do more than teach theory. It should attempt to engage the participants in thinking of ways to help avoid as much of the natural decrement as possible or mitigate its effects, including sharing tasks where necessary. However it is not for the CRM trainer to change policy, procedure or technical training issues, and so the CRM trainer should avoid directly instructing pilots how to monitor (or what to pay more attention to) unless it is done in line with flight operations / technical training.

It is generally impractical to devise exercises that allow participants to experience and demonstrate vigilance decrement, due to the time required. However if time were available and an exercise was devised, then a competitive element could be introduced to show that despite motivation and effort, the vigilance decrement applies to all.

An example session might have the following objectives:

1. Participants understand that all people are subject to vigilance decrement (especially themselves)

   a) Discuss background and theory to vigilance decrement

   b) Extract several examples from the class if possible

2. Participants state for themselves (through facilitation) specific areas of risk around vigilance decrements:

   a) What elements are vulnerable to decrement?

   b) When is the decrement more likely to happen and be hazardous?

   c) What increases decrement (fatigue, workload on another task, etc.)?

3. Participants own the problem and discuss solutions

   a) e.g. What can you do to add resilience?

4. Participants understand why people withdraw attention during vigilance tasks

5. Participants have the opportunity to demonstrate and practice their understanding using case-studies

An exercise that can assist the above objectives is:

- Participants get into small groups (not absolutely necessary)
- A flight phase is described.
- They are asked to note the following:
    - What THREE specific pieces of information are the most important for a pilot to monitor in this phase (defined as specific informational elements, these would include airspeed tape, individual mode annunciator, altitude tape, radio altitude, attitude indicator, runway visual, etc)
    - What risk is associated with not monitoring each (of your three) effectively?
    - Rank those three by priority
    - How could you ensure the top ranked one was ALWAYS monitored?

Then debrief the class, make a class 'list' on a flip chart, from their separate lists. Do all the groups agree? Why / why not?

The idea is that the group accept the need to monitor carefully (and on particular items), consider the need to monitor certain elements, the risks associated with not doing so, and that it is not obvious what should be monitored (usually there is too much).

A further debriefing question to the class could be "what problems did YOU have doing this exercise?" This question should elicit some responses that demonstrate that the participants have thought more deeply about the issues of monitoring and vigilance, for example:

- How do you determine the 'importance' of something without hindsight?
    - Some elements need only be glanced at occasionally, whereas others should be scanned as often as possible.
    - Some elements are only important if they go wrong, others require active scanning (if controlling – e.g. manual flying).
    - It depends what is happening (is everything going ok?)
- Notice the problem of NOT having hindsight to fall back on (i.e. the real world)

All of these prompts and questions are designed to open discussion and facilitate a better understanding of the complexity of the issues and the need to consider the issue of monitoring in more detail.

Categorising Vigilance

The CRM trainer should treat vigilance as part of attention and cognition, not as part of fatigue. If vigilance is delivered as part of a fatigue lesson, then pilots could easily get the impression that feeling awake and fresh (fatigued) will make them vigilant. This is not true. Pilots should understand that vigilance decrement is a direct factor of the time and task, and whereas fatigue will make things worse it is not a necessary condition for the performance decrement.

SECTION A, PART 1, CHAPTER 5

Human error, skill, reliability, and error management

Knowledge

Skill acquisition

Prior to discussing human error, it is important to consider some basic points about acquiring skills. A skilled task is always much more difficult to achieve when one first starts to learn it, but somehow with repeated practice the skill becomes very easy to do. This applies to complex skills even more than simple skills. The universal example is driving a car; at first it seems impossible to master all the concurrent tasks required and the workload appears impossible to cope with. However, after several years those same tasks generate such a low workload that the driver switches on the radio to relieve the boredom. Indeed the driver may find herself at a red light in neutral gear, having achieved all the tasks that she found impossibly difficult two years before, but without even noticing herself doing them.

The common models of skill acquisition are continuums that describe this skill learning process. Perhaps the most well known is the Fitts & Posner three stage model (1967). This describes initial skill learning as the cognitive stage, that gives way to the associative stage, and finally the autonomous stage. These are not three completely separate and exclusive categories but just simply a way to describe a continuous process.

Clearly the more complex the skill is, the longer the process takes, but it is surprising how the most seemingly impossible tasks can eventually become automatic for someone who practices enough (such as riding a unicycle while juggling clubs).

Once a skill is autonomous then it requires little or no attention to carry out, and so the process of making repeated tasks into automatic routines is one of the human brain's most important strategies of reducing workload on known tasks, in order to release attention for use on other tasks.

This process does not just apply to motor skills, but many sets of procedures that are repeated reliably, arguably including decisions. Hence a new and novel problem requiring a decision will take a lot of effort and conscious thought, regardless how much of an expert someone is. Hence, an expert pilot faced with a completely novel problem is still effectively working at the cognitive stage of learning in terms of that particular situation. Later we will also call this 'knowledge-based performance'. If, having thought the problem through, the pilot comes to the wrong conclusion, then they are said to have made a 'knowledge-based mistake' (as will be discussed in the following section). On the other hand, if the same pilot carelessly selects Flaps 20 instead of arming the speed brake then they have made a skill-based error (as will be described) because the error occurred during a fully learned skill

due to the automated processing (the autonomous phase of learning was reached long ago). Error types depend upon the processing that caused them, and the processing tends to depend on the stage of learning that the person is at in terms of the task being done (or the ease of the task, which amounts to the same thing).

One can see instantly that experts are more vulnerable to certain errors than novices, and vice-versa, due to the processing of the task and therefore the stage on the learning continuum.

A final point on skill learning is that it is generally understood that skills cannot be improved without practice of some kind. At the very least, it seems that repetition is required to form the autonomous routines, improve them and maintain them.

Human Error

It has long been accepted that errors are inevitable; even the Roman Philosopher Cicero stated: “It is the nature of man to err”. That does not mean that the frequency of error cannot be reduced or the effects cannot be avoided or mitigated. CRM has long been part of the drive to reduce errors and their consequences.

Agreeing upon a definition of human error is problematic and surprisingly difficult. Some within academia argue that human error is a construction that only exists in hindsight. Although most people within industry do not share this view, the concept is instructive for those observing or analysing events. It can be very easy to pick out errors after an event, without noticing that the error was only identified by its consequences. This is fine, as long as it is appreciated that the flight crew who made the error did so without knowledge of those subsequent consequences. This sounds simple and obvious, but is challenging for the human to appreciate because once consequences occur the preceding events are then recalled as being more likely to have led to those consequences than they really were, or than they appeared to be at the time.

James Reason defines error as follows: “A generic term to encompass all those occasions in which a planned sequence of mental or physical activities fails to achieve its intended outcome, and when these failures cannot be attributed to the intervention of some chance agency” (Reason 1990). This definition is reasonably workable for a practitioner. Outside academia most people understand error to be a general (fairly loose) term referring to when humans get something wrong, such as an incorrect action, a forgotten check or a bad decision. Error is not therefore a particular mechanism of creating unsafe events, but a term used to denote any human factors process going wrong and having consequences. It therefore spans across all other areas of human factors (information processing, decision making, situational awareness, etc.). There are also underlying conditions under which humans are more likely to make errors such as circadian lows, stress, high workload and fatigue).

Dekker (2002) differentiates between two philosophies of human error, that he calls an old view and a new view. The old view is said to be where human error is seen as indicating a

human problem; meaning that an error is seen as having been caused by the human agent and it causes a problem to the safe running of the system (the ‘bad apple’ theory). In the modern view human error is seen as indicating a wider system problem and being a symptom of a non-ideal system. This so called ‘new view’ is a socio-technical approach whereby all elements of a system (design of interfaces, procedures, working practices and human vulnerabilities) are considered as being inextricably connected. Any ‘failure’ is therefore a failure of the whole system, and so the whole system requires looking at, not just the human agent who happened to make the error. Questions asked after a serious error would be ‘why did the system allow this error to occur? Why did the system cause this person to do what they did? Why did the system not block or mitigate the consequence of the error’. This is a challenging way of thinking about error not least because it can be misinterpreted as making excuses for negligent performance.

Clearly it is reasonable to consider error in many ways, which may include aspects of both views. Certain errors may appear to some observers to fit one view better than the other. Alfonse Chapanis (1951) differentiated between two important patterns of error using a metaphor of two expended rifle targets (Figure 7). One marksman (target A) has achieved a high numerical score but most bullet holes are scattered widely and randomly within the central portion of the target. The other marksman (target B) has a low score but all the bullet holes form a tight cluster (group) just outside the central portion. Most people would recognise that the difference between the scores is down to the sighting of the rifle, not the accuracy of the shooting, and that the second marksman has better aim despite scoring lower. The off-centre error was produced by the rifle sight not by the person’s aim. This can be metaphorically considered a system issue (set aside the fact that the sighting is part of the skill when firing a rifle).

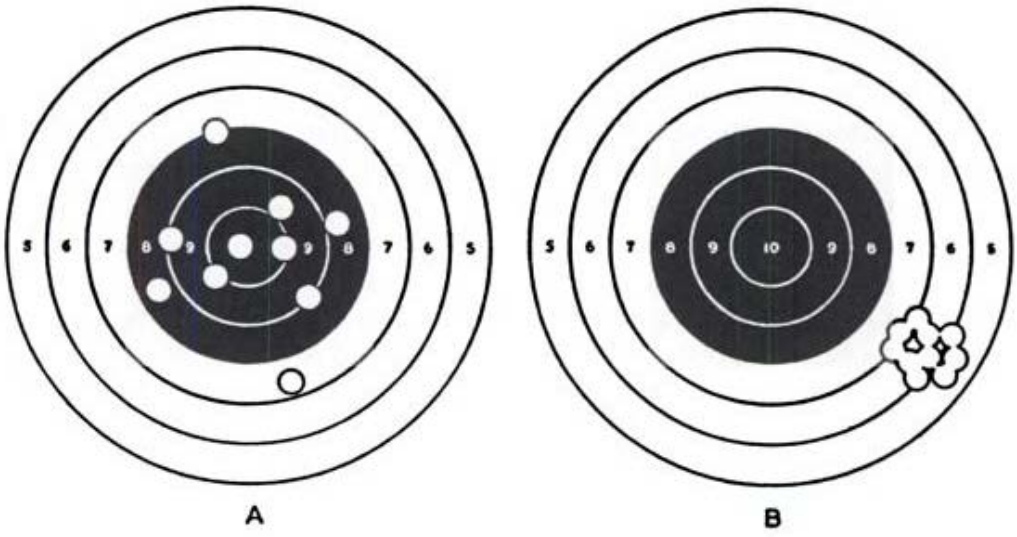


Figure 7.

The bullet holes are an excellent metaphor for error. Where lots of errors from different people are found in the same place within a system (i.e. lots of people are making identical errors) this is called ‘constant error’ and is almost always attributable to non-human

system elements (i.e. not the aiming of the rifle, but the sights). An adjustment within the system (setting the sights) is far more likely to eliminate the errors than trying to retrain each individual who makes them, or trying to change attitudes. This aligns easily with the 'new view' of human error. However, where errors are scattered around a system, much more diagnosis is required. It could be a common mode such as poor training, poor attitude or fatigue, but there could also be an element of individual human cause. It could equally be poor coding and identification of errors. However where the same individual continues to make the same mistakes, but others do not, then the solution should involve the individual.

Application of the 'old view' to all circumstances is common but can be unsafe because even where constant human error is recognised it is not used to steer solutions in the right direction. Instead, the old view tends to look at individual humans within the system (e.g. the pilot, controller, engineer) and attempt to 'fix' them (through retraining or sanctions) or remove them. The opportunity for systematic remedial action is therefore lost, as the opportunity to learn the cause of the problem.

Error types

Firstly, errors are categorised within the umbrella term 'unsafe acts', which includes all errors but also other issues. An unsafe act is an action (or inaction) that leads to a safety issue. Whereas an unsafe act can happen by accident (error) it can also happen intentionally (violation). There are many ways to categorise unsafe acts, but the most widely used is Rasmussen's SRK taxonomy (Rasmussen 1986) and an extension of it; Reason's generic error modelling system (GEMS). Although it is usually unimportant for the CRM trainer to be able to label and categorise unsafe acts, they should know the basic categorises for use when reading accident and incident reports, and other literature.

Unsafe acts are usually divided into three major types: errors (skill-based), mistakes (knowledge-based) and violations. The traditional way to understand this classification is to divide unsafe acts into those that are intended and those that are not. Skill based errors (called slips and lapses) are unintended actions or omissions, whereas mistakes and violations are intended acts or omissions, but mistaken. However perhaps a more useful method (loosely related to the framework) is to consider within which of the skill learning stages or which part of the information-processing system the unsafe act occurred.

Skill-based errors

If an unsafe act (including an omission) occurs as part of a learned skill or unconscious procedure then it is called a skill-based error. If this error occurred because the skilled action was inappropriate for the situation, this is called a slip (raising the flap lever while intending to have raised the gear lever). If on the other hand the error occurs because a skill or task step was omitted, or something was forgotten, this is a lapse (forgetting to raise the undercarriage). Lapses can be particularly insidious in aviation, due to the rule-based nature of many fundamental safety processes. The following extract shows how a

seemingly minor lapse can lead to a potentially fatal situation, with only a few chances to trap the error, and none to mitigate it:

> *I push the Pitts round the outside loop. I glance in to check the top-height – 900 feet, which surprises me. 900 feet is on the low side of lovely, but high enough and better than I expected – so I keep pushing. Landscape scrolls up the windscreens and then the Leicester runway fills the gap between cowling and top wing, swelling rapidly. I push on, past the down-vertical, past the point-of-no-return…*
>
> *And then, and only then, I remember that the altimeter was set for Farnborough, not for Leicester. I was simply 230 feet lower than I thought I was. Man! The runway! Just PUSH… I recorded a negative figure on the G-meter which prompted a major inspection of the airframe, and caused the Pitts factory to state that this was so far outside normal parameters that they could not offer comment.*
>
> *It was my fault. I deliberately miss-set the altimeter in the first place, failed to rectify it during my precious pre-aerobatic briefing, then topped it off by failing to notice over two whole manoeuvres that things were going altogether too well for a heavy S2-A with the front screen on. Mea definitely culpa. They told me my fin missed the runway by ten feet that morning. The most impressive low-level push-out anyone had ever seen; well would have been... [6]*
>
> Extract from ‘High Time’ (Lecomber 2013) with permission

One also hears the terms ‘error of commission’ and ‘error of omission’, which are effectively the same as slip and lapse. People make skill-based errors all the time. For example taking the wrong turn on a car journey because that is the turning they usually take on most other journeys (this would be called a slip, because it is an error of ‘doing’ something). An example of a lapse would be that the driver forgot to post a letter on the way to work, because usually her journey passes the post box without stopping. This is called a lapse because it is an error of not doing something. One can see that the situational drivers to slips and lapses are similar even though the labels are different. Skill-based errors are related to attention because with little or no attention the error can occur. The reason that attention is not paid is not a matter of complacency; it is that the skilled routine does not require attention. Skill-based errors are usually more likely when there are subtle differences between two situations or actions that get confused. The term ‘habit capture’ is sometimes used to describe these sorts of skill-based errors. The anecdote below, from commercial rotary wing operation, is a good example.

The standard departure required a climb to 3000ft, however, on this occasion the departure clearance was initially to not above 2000ft. Despite correctly acknowledging the clearance, the crew briefed and programmed the automation for a standard climb to 3000ft. Fortunately, as they approached 2000ft they were transferred to the departure controller and the error was corrected before a level bust occurred.

Knowledge based mistakes

If an unsafe act happens as part of a 'thinking' task such as making a decision, then it is called a mistake (also called a knowledge-based mistake) or a violation. The action was carried out as intended (there was no slip or lapse) but it turned out to be wrong. Where a decision or action requires an effortful conscious (knowledge-based) thought process then it would normally have involved some aspect of novelty and therefore would be approached in a similar way to the cognitive stage of skill learning.

Mistakes are unsafe acts where a person determines or decides their actions through thinking and carries them out correctly, but the actions do not have the desired consequences. In other words their actions were intentional but do not have the anticipated or hoped for effect. In the terminology of 'human error' all issues raised in part 1 of the decision-making chapter (Chapter 9, part 1) relate to knowledge based mistakes. The classic definition is that mistakes occur in the planning stage of an activity, such that the planned actions are correctly carried out, but the plan turns out to have been wrong.

Violations

It is worth looking at the difference between violations and mistakes or errors. Reason points out that violations differ from slips, lapses and mistakes because they are deliberate 'illegal' actions, i.e. somebody did something knowing it to be against the rules.

There are some important points to recognise about violations in aviation work. Firstly, most violations are 'well-intentioned'. The person carrying them out believes that they are necessary, or they are the best course of action. Secondly, violations are extremely common, and depending upon how the definition is applied, they are part of almost all tasks. Thirdly, most violations lead to positive or neutral results rather than adverse consequences. This is not to suggest that violations are good, but simply to state facts.

There are many reasons that violations occur. The main one is that personnel consider them necessary to get the job done. Violations can be roughly split into two types: routine violations and exceptional violations.

Routine Violations

Sometimes, procedures do not account for the cumulative time required to follow them and so personnel find ways of doing the tasks more quickly. These routine violations therefore save time and lower temporal workload. The result could be safer working and fewer incidents. Clearly, when violations have evolved within such a system, it can be dangerous simply to remove them all without allowing more time for the same tasks, because the workload will increase markedly and unintended consequences will result. The solution is to understand the violations, and attempt to change practices and procedures in a way that addresses the sorts of issues that the routine violations have evolved in response to. In these cases, no amount of enforcement, training or re-education will result in a violation-free environment that is as effective or as safe as previously. Hence the CRM trainer themselves can have little impact upon these sorts of situations. Tackling routine violations

that have evolved in response to task demand involves much more consideration than simply telling people to stop violating.

However, other routine violations occur when personnel do not understand, remember or agree with procedures. Again, these can quickly become part of normal working. These should be easier to resolve, by educating personnel in the reasons behind the procedures.

Exceptional violations

Some violations occur occasionally and have little precedent. These are known as exceptional violations. They are not necessarily extreme and most (not all) are intended for a good outcome. Whereas routine violations are normal ways of working, exceptional violations are acts that stand out as being different. They might be in response to unusual situations (where it is felt that SOPS are insufficient or not working), they might be an attempt to go beyond SOPs for even better performance (e.g. to catch up from a late departure), they might even stem from boredom (i.e. trying something different or being inquisitive) or rarely they may be deliberately harmful actions (sabotage).

Sometimes a violation will precede an incident or accident. In most cases it is too easy for an investigator or trainer to focus on the violation as the main cause, and fail to see that similar violations occur all the time, and do not cause these sorts of events. The danger is that the solution put forward is ‘follow the procedure’. This is almost always too simple and the trainer should try to see past the violation in order to look at all the interaction of other accident factors as well, so as to understand the complexity.

Error management

A key concept associated with error management is that of “defences in depth”, based on the premise that there are many stages in any system where errors can occur, and similarly many stages where defences can be built to prevent and trap errors.

Reason has highlighted the concept of ‘defences’ against human error within an organisation and has coined the notion of ‘defences in depth’. Examples of defences are pre-flight checks, automatic warnings, challenge-response procedures, etc. which help prevent and ‘trap’ human errors, reducing the likelihood of negative consequences. It is when these defences are weakened and breached that human errors can result in incidents or accidents. These defences have been portrayed diagrammatically, as several slices of Swiss cheese (and hence the model has become known as Professor Reason’s “Swiss cheese” model) (see Figure 8).

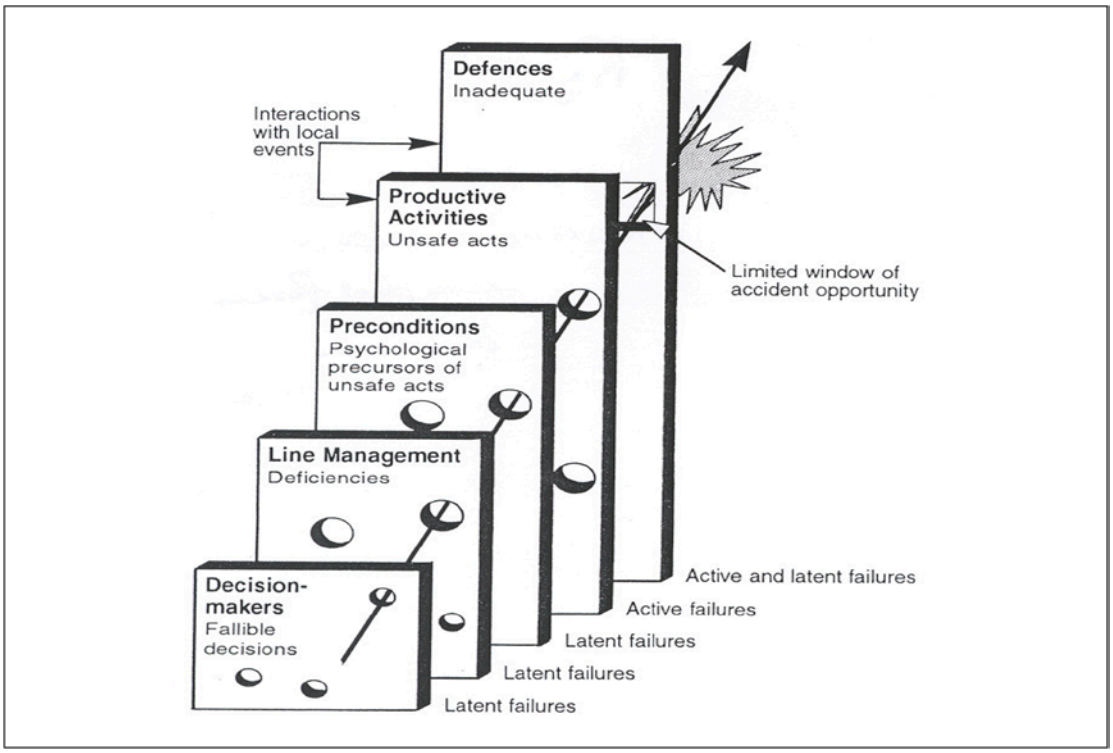


Figure 8. Reason's Swiss Cheese Accident Metaphor

Some failures are ‘latent’, meaning that they have been made at some point in the past and lay dormant. They may have been introduced at the time an aircraft was designed or may be associated with a management decision. Errors made by front line personnel such as flight crew are unsafe acts (‘active’ failures). The more holes in a system’s defences the more likely it is that errors result in incidents or accidents, but it is only in certain circumstances, when all holes ‘line up’, that these occur. Usually, if an error has breached the design or engineering defences it reaches the flight operations defences (e.g. in flight warning) and is detected and handled at this stage. However, occasionally in aviation, an error can breach all the defences (e.g. a pilot does not act upon an in flight warning, believing it to be a false alarm) and a catastrophic situation ensues.

Error detection and prevention

The concept of redundancy should be applied at all stages of the aviation system, never assuming that one single mechanism, especially if human, will detect and prevent an error. CRM provides a form of redundancy in that it emphasises the role of the second pilot to check what the first pilot has done. There is a potential danger with independent checks that the second person will trust the first person not to have done anything wrong, and therefore not to carry out the second check properly. CRM dual checking is one of the last lines of defence, especially if no automatic system checks and alerts are present. Pilots should try to be alert for the possibility that their colleague may have made an error, particularly in critical activities such as checklists. Pilots will be more open to being challenged if they have a good knowledge of error. Similarly, the pilot carrying out the first action should never become complacent and rely upon the other pilot detecting an error. (The same applies with pilot-ATC communications, and read-backs). It is essential to

remember that everyone is human and therefore everyone makes errors and mistakes from time to time.

Human Error, skill, reliability, and error management – Application

Knowledge-based mistakes are naturally covered within the decision-making chapter (Chapter 9), and therefore this chapter focuses mainly on skill based errors and violations.

Slips

Once a skill is learned to the point of being autonomous, it is reliable and robust. However it is also vulnerable to situational and contextual change. Skills literature (rather than error literature) uses terms such as ‘skill transfer’ or ‘transfer of training’ to denote a phenomenon whereby skills learned in one situation are applied to a different situation (rightly or wrongly). Usually this is positive; otherwise a pilot would have to learn each aircraft as if a completely new vehicle requiring a completely new skill set. However, where situations are quite similar, negative transfer can take place. This is where the skill for one situation is deployed in another with negative effects, “when a new response is needed for an old stimulus” (Magill 1989). A classic example of the risk is associated with a change of aircraft type. The autonomous skill has developed or been recently practiced on one aircraft and the ‘new’ aircraft is similar enough to lead to the ‘old’ skill being used in error. An example would be a pilot changing from a Cessna 172 light aircraft to a Robin DR400. The C172 has a plunger-type throttle control in the same location as a plunger-type mixture control of the Robin. If the pilot is concentrating on the approach, he/she could easily set some flap, return their hand to the throttle autonomously and retard it, only to find the engine cutting because the hand had located the mixture control of the Robin. Flare height could present the same problem in small and large aircraft, as can general handling and even stall recovery, particularly in aerobatic aircraft. Aircraft with common type ratings are particularly vulnerable particularly if the pilot has flown one type many times continuously and then suddenly flies the other.

> *I had just moved the throttle to taxi forward when the seat suddenly slid backwards and the aircraft lurched forward out of control. I grabbed and pulled on the handbrake between the seats……unfortunately my brain had decided I was in a car and the ‘handbrake’ was actually the flap lever.*

Error literature would refer to such errors as slips, and specifically ‘interference errors’ or ‘habit capture errors’. For the practical purposes of aviation professionals, it can be considered that the same phenomena are being referred to, just using different terminology. Skills and errors are closely related and their respective literature has many parallels but uses different terminology. This is not unusual for two sub-disciplines but it can be confusing for the CRM trainer trying to increase their knowledge across a number of areas. There are currently no resources that can easily answer whether a phenomenon found in one discipline is the same phenomenon described by another but under a

different label. Very often, since the phenomena are hypothetical even the scientists involved are not sure!

Just as the use of an old skill can be prompted by a new aircraft or situation, so subtly different tasks and controls within the same aircraft can also produce these kinds of errors. The following anecdote (from a commercial helicopter operation) shows a classic skill based error caused by two similar controls. It also shows how confusing the aftermath can be for a crew.

> *The aircraft parking brake and nose wheel lock are identical 'T handles' situated adjacent to each other. As the aircraft came to a stop to disembark the passengers the pilot monitoring reached out and applied what he believed was the parking brake. Having disembarked the passengers the crew ran through the pre-taxi checklist in order to reposition to a suitable parking spot for shutdown. As the checks were carried out the pilot flying highlighted that the parking brake was already off. The monitoring pilot felt confused as he was certain that he had applied the brake, however, as there was another aircraft waiting for them to move he didn't question the discrepancy. As they taxied they soon realised it was impossible to turn the aircraft. An engaged and now jammed nose wheel-locking pin was diagnosed which required the aircraft to be shut down in its current position.*

Although in the described event the error caused inconvenience, the same issue can lead to more hazardous outcomes (see reference AAIB 2008).

One particularly modern area of concern in automated aircraft is that of crew errors when programming the flight management computer (FMC). Serious incidents and accidents have been caused by simple but highly consequential errors, including slips, transposition errors and misreading data.

Lapses

A further common error type in aviation is the lapse. Human memory is not well suited to remembering all the tasks and order of steps required in all situations, or even in several common situations. The use of checklists has proved highly effective over many years in terms of preventing and mitigating these problems, and the error types discussed previously. Occasionally however, checklists are vulnerable to the way human skills work. The repeatable nature of checklist tasks means that the brain can turn checklist tasks into skills in the same way as any other tasks. The reason the brain does this is in order to save attention, which is the opposite of the intention. This can lead to pilots using checklists in the way that skills are performed; i.e. without paying attention to the items being checked. In CRM courses this issue is often taught through a concept labelled 'expectation bias'. This describes that people will see what they expect to see.

There are many examples where aircraft have attempted to take off without flaps correctly configured. In most cases the take-off configuration alert did not operate (the holes in the cheese lined up). In most cases the aircraft took off and the situation was resolved, but in

a number of well-known accidents the aircraft did not take off, or crashed shortly afterwards.

In 1989 a Delta Boeing 727 attempted to take off from Dallas Fort Worth but crashed with loss of life. The cockpit voice recorder captured the moment when the first officer replied to the challenge checklist item “flaps?” with “fifteen, fifteen, green light”. This reply would be the correct reply to the appropriate take-off flap setting, but the flaps were not set. One of the stated causes was that the flight deck environment was not sterile; the pilots were distracted by non-operation conversation.

More recently, in August 2008, the same accident occurred to a Spanair MD82 taking off from Madrid. During the ‘Final Items’ checklist, the first officer stated “… Eleven, Aligned, Eleven…” which would be the normal response to seeing flaps correctly set at eleven degrees. The flaps were not set.

In almost all cases where checklist items are bypassed or performed wrongly, such errors will be trapped by the individual at the time or immediately afterwards, or be trapped by the other crew-member. Distractions and parallel tasks in the flight deck are apparent in many cases where a checklist error is made and not trapped. These might be general distractors, or other tasks impinging or interrupting the checklist task.

Lapses can also occur when a situation that normally prompts an action does not occur, and so the crew do not take the action. The following anecdote is an extreme example from a commercial rotary wing crew.

> *It was a weekend; the crew had experienced multiple delays and were now tight against a departure time in order to beat forecast deteriorating conditions at their destination. It was normal practice to start engines, taxi to the gate, then complete the pre-take-off checks as the passengers boarded. On this occasion the task was to carry freight so there was no requirement to taxi to the gate. The freight seemed to take forever to load and the commander was very conscious of the need to make the departure time. The commander was aware they were rushing as they started engines, ran through the checks, and requested taxi. ATC were very co-operative and cleared them for an immediate departure. Shortly after take-off, ATC requested they re-cycle their Squawk. The pilot monitoring looked at the transponder and thought, “that's funny it's still set to standby”. ATC then provided a direct routing to their first en-route waypoint. The pilot monitoring looked at the FMS, it was blank. Then the penny dropped, they had omitted the pre-take off checks in their entirety!*

Defence against error

The first line of defence against error is the system designer. Work in the 1940s and 1950s by scientists such as Paul Fitts and Alphonse Chapanis helped to establish the idea that aviation design should account for human vulnerabilities. The classic example of that work is the placement and shapes of the gear and flap levers, intended to defend against the human error slip of selecting the wrong lever. Although established over seventy years ago

this work is still apparent in all modern air transport aircraft, and is driven by regulation. Other methods of preventing skill-based errors are control guards (e.g. over hydraulic cut off switches), interlocks (gear lever in ground-mode), different shapes and feel of controls (e.g. on autopilot control panels), making controls more difficult to operate (having to pull a switch before changing its selection) and putting controls out of reach where possible (e.g. the IRS mode selectors on an aft overhead panel). Despite such work errors can still occur, including on autopilot control panels (selecting the wrong parameter or mode) and systems controls on overhead panels (configuring the wrong system, or the wrong side of a system). For this reason, as well as attempting to prevent skill-based errors, designers put devices in place to mitigate or alert of consequences. These include alerts, warnings and automatic recovery functions such as reversionary modes.

However, designers cannot guard against everything nor provide barriers for every conceivable permutation of error. Therefore crew should never rely on the design to keep them safe.

Effective procedures are the next important stage (after effective design) and after that the crew themselves.

One clear defence against the problems of checklist usage (e.g. failing to set take-off flap) is to keep the cockpit and the tasks sterile. Compliance with requirements for sterile cockpits is helpful, but usually not sufficient in itself. A sterile cockpit can exist in which pilots are distracted by each other or otherwise occupied during checklist usage.

Although the use of checklists is an obvious and important example, skill based errors occur in many areas of pilots' work. Some other important areas are configuring, programming flight management computers, autopilot panel and bug selections, emergency actions, monitoring lapses and system settings.

Operating procedures often provide a framework of steps for actions or tasks (whether written or memorised). Following such procedures alleviates the need for heavy knowledge-based processing (decision making) but on the other hand the steps may be too complex or insufficiently repeatable to become skills. The result is to support 'rule-based performance'. Following a set of directions or instructions is a good example of rule-based performance. An error occurring due to a misapplied rule, omitted a rule or repeating a rule is called a rule-based mistake. Simple processes such as checklists can suffer from rule-based mistakes as well as skill-based errors; for example if a checklist is interrupted and the pilot returns to the wrong place. This has occurred in many accidents.

Due to the infinite number of situations that can occur, there cannot always be an operating procedure to protect against every potential error. One reason for crews to learn about error theory in CRM is in order for them to appreciate their vulnerability and then to become used to spotting the potential for them to commit error, so that they might find a way of successfully defending against it. One good rule of thumb is that if any doubt surfaces, pilots should re-check or pause to review the situation. Good crews often do this and the following anecdotes show some good examples.

I was a new ex-military F/O flying B747s with Cathay. There was a strict curfew at Kai Tak and, after frantic activity, we had made it to the holding point with 2 minutes to spare. We were cleared "Immediate Take-off" and entered the runway. The captain applied the parking brake, started his stop watch and folded his arms. The F/E and I started to look at everything we had done thinking we'd missed something. After 1 minute, the captain said "All set?" we said "Yes" and he took off. In the cruise I asked what that was all about and he said that we were all tense and rushed and about to take off through the Lei Yu Mun gap into a rainy night and he thought the one minute left to curfew was best spent calming down. Brilliant!

Taxiing out after a lot of pressure to get the aircraft away from the stand on time, the captain said 'OK we had a lot of hassle and interruptions at the gate - the main thing is to make sure we don't keep on hurrying. Let's take a minute to do a review and get our heads back in flying mode. Does that make sense?' [1]

In the two examples, the captains intuitively recognised the relationship between feeling hurried and the potential for error (particularly lapses), and used that feeling as a cue to stop, slow down and re-check. Although it is not possible to know for sure, such behaviour has almost certainly prevented accidents in the past, and does not apply only to large or multi-crew aircraft:

The glider before me in the launch queue was suddenly pushed out of the way. I jumped into my glider so as not to hold things up. The rope was attached to my glider and the tug aircraft taxied forward. I had had to rush my checks and did not feel ready, so I decided to release the rope and open my canopy. I was relieved that I had done so when it was noticed that I had left the heavy wheel dolly (for ground manoeuvring) attached to the tail of the glider!

Sometimes situations occur where a specific error is predictable in a given situation. A common example is where a pilot recognises that a crucial action must be taken, but not for five minutes, and therefore there is a serious risk of forgetting it. Crews who understand their vulnerability to error are more likely to recognise these sorts of risks, are likely to develop their own ways of guarding against such potential errors. The following anecdote from rotary wing operation is a good example.

As a condition of the daily engine power checks, all bleed air consumers are switched off, then after three minutes at maximum continuous power the automated power check is conducted. Once the check is complete the crew make a note of the various engine parameters and the displayed check results. At this point crews were often making a premature exit error: with the check results recorded, they were omitting to select the bleed air consumers back on. One enterprising co-pilot I flew with switched the ice detector off (a bleed air consumer) then hooked one of the aircraft blanks over the switch and trailed the tail of the blank across the FMS. The presence of the blank made it very obvious that the ice detector and other bleed air consumers were switched off.

This anecdote is a personal solution that worked for the individual. It is used here as an informational anecdote only, to illustrate the general principle, not as a suggestion or an example to be necessarily followed.

Violations

It is usually unimportant to precisely define labels, but a huge amount of effort is expended around defining the term ‘violation’ and the need to be able to apply that label to an unsafe act. Indeed in some cases a person’s entire career can depend on this labelling process. In general ‘just cultures’ tend to be more accepting of mistakes and errors than of violations. One must not confuse an intention to violate with an intention to do harm.

Many errors violate rules and procedures, but are not classed as violations because there was no intention to violate. Hence the defining characteristic of a violation as opposed to a mistake or error is the intention to violate. The following is an example of an event that would normally be categorised as a violation, for all the reasons given.

> *The commander was in his first job as a commercial pilot and was tasked to a wedding to fly a newly married couple from the church to their wedding reception. As the couple emerged from the church it became apparent that the bride was of a somewhat fuller figure than the commander had anticipated and would likely put the aircraft above its restricted take off mass for the confined area departure. Faced with informing the bride versus giving the task a go he conducted the latter. As he neared the obstacles in his take off path, he realised his mistake, avoiding them by only a small margin.*

It follows that the person must be aware of the rules (at least to an extent) otherwise their action would be classed as a mistake rather than a violation because they did not understand what was permitted.

Clusters of violations can be thought of in the same way as clusters of errors. Where many people make identical violations, there is usually a systematic issue. Where individuals make different exceptional violations, these can usually be effectively dealt with at an individual level.

CRM and human factors professionals are concerned with the drivers behind violations even more than the actions themselves. Routine violations can be an indicator that procedures are not adequately aligned with the human task (often requiring too much time) or the culture is inadequate. Even exceptional violations (like the anecdote above) are usually done for reasons that appear justifiable to the crew at the time.

Human error, skill, reliability, and error management - Application for CRM

It is important for both students and facilitators to accept that human error is inevitable to some extent, and move towards a motivation to reduce, detect and manage error through systems such as error management or even by improved performance.

An underlying aim of some CRM training appears to be to teach the audience how to categorise different kinds of errors. This is unimportant in itself. It is much more important for the participants to understand routes to error. This may include categorization as a step, but it is not a means in itself.

There is a great deal of terminology in use around types of errors, much of which is synonymous. Because some errors and consequences are related to attention being distracted from the task, they are often referred to as ‘attention capture’ or ‘environmental capture’ errors. They are also said to be caused by ‘expectation bias’, which is a term used to refer to a situation whereby a skill will be triggered by an ‘expected cue’ rather than a real cue. The term ‘skill-based’ error is a more generic term for an error occurring as part of a skilled routine. All the terminology can be confusing, and although the terms are not precise synonyms, at a practical level they describe very similar things. It is therefore important that CRM trainers within the same operator decide upon consistent terminology. The actual terminology used is less important than consistency and understanding; using multiple synonyms can cause confusion at many levels.

It is important for participants to understand how errors and mistakes come about, so that they can guard against them. Areas that are ‘error prone’ should be discussed, along with the types of errors that occur. For example, skill-based errors will tend to occur in areas of the operation that are easy but ought to be paid attention to, particularly where there are other tasks and interruptions occurring.

Example of running an error session in a classroom

The objectives of this session will be for participants to understand the root of errors and mistakes, understand them in the operational context, look at solutions and feel motivation and ownership in attempts to manage them.

1. To begin an error session in a classroom, a trainer could ask each person to write down one/two errors that they have seen occur recently on the flight deck (it is a good idea for the trainer to have a number of prepared errors written down in case the audience does not provide many good examples). The trainer can write them up on a large white board (or present them one by one on a slide if pre-prepared) to promote brief discussion. The trainer has several alternatives in this process; one might be to write each anecdote on the board with no pre-organisation, circle and number each, then when finished ask the participants to group them into events that have the same “mental-mechanism” or other colloquial term for cognitive root. Alternatively, the skilled trainer might categorise the anecdotes as they collect them, and then ask the participants to explain why the trainer has grouped them in these sets. The trainer must recall that the purpose is to understand cause, not to categorise. The categories emerge as a way of showing and discussing various routes to error.

2. After facilitating the discussion, the trainer could show some examples from accidents or incidents to further contextualise understanding. Use of flight data or recent incidents in the airline will be powerful here.

3. After this the trainer can ask the class to come up with preventions and mitigations. This would be done in groups. Usually, this is best done with single examples, rather than asking people to solve ‘error’ generally. One purpose of doing this is to achieve ‘buy-in’ from the audience into the concept. If the audience generate solutions then they will have accepted that the area is applicable.

4. Discuss these ideas and show the interventions or initiatives that the company is championing. A skilled facilitator can listen while the groups are working on solutions, and should be able to find a way to align the solutions being put forward with company solutions. This is a very powerful way to gain acceptance of company proposals, because the participants perceive some ownership of the solution. Solutions may include sterile tasking, threat and error management practices, highlighting of error prone procedures or practices, and many others.

It may be useful to link the teaching of error with information about the company’s occurrence reporting scheme, stressing the importance of open and frank reporting of errors in order that lessons can be learned from them. However, this can be a sensitive area, and care should be taken not to jeopardise any confidentiality agreements if using real examples of errors from the occurrence database.

CRM sessions should have the objective of minimising violations in isolation from fostering increased understanding and awareness of the issues in more depth. Spotting and labelling violations is an insufficient activity for a classroom lesson. The CRM trainer should seek to facilitate discussion around why violations occur, what solutions are available, what causes the violations and whether the solutions address the problem. Solutions that simply aim to prevent all violations occurring, without any other adjustments, are usually insufficient and in some cases can be dangerous.

In the simulator, pilots should be encouraged to spot their own and others’ errors as well as routine violations. Instructors should allow and facilitate such practice, in order to foster greater understanding of how the errors came about, and their predictability. Instructors should try to avoid considering errors as a sign of poor performance in themselves.

SECTION A, PART 1, CHAPTER 6

Workload

Knowledge

Workload can be loosely and simply thought of as the amount of mental effort needed (and expended) to process information. This chapter discusses cognitive (or mental) workload, as opposed to physical workload. Workload is a deeply complex (and contended) area within science, with many competing interpretations and definitions. It is linked to almost all other areas within cognition and performance, particularly attention, vigilance, fatigue, skills and multi-tasking. This section uses hypotheses and explanations designed to be usable whilst approximating, and occasionally being selective with, scientific knowledge. In general, high workload is associated with increased errors, fatigue, task degradation and poor performance.

All conscious operations (problem solving, decision making, thinking, etc.) cause workload. The hypothetical area of the brain that deals with all such activity is the working memory (Chapter 1 – 'Information Processing') and specifically a part called the 'central executive', which requires attention to perform the tasks. Hence attention and working memory are the keys to understanding workload. The more attention is required and used, the higher the workload is said to be. Hence workload can be approximately expressed as the amount of attentional demand.

From Chapter 5 (Human error, skill, reliability, and error management) it should be recalled that skilled tasks require attention to learn (high workload), but once learned use very little (or no) attention. This is the brain's main strategy of workload reduction: to turn repeated tasks into skilled routines, so that they can be performed in the future without demanding attention, and therefore generating workload. Without this strategy and capability, everyday life tasks would be impossible.

Task causes of high workload

In practice, workload is *directly* affected by four general task factors (Jarvis 2010).

1. 'Difficulty' of the task
2. Number of tasks running in parallel (concurrently)
3. Number of tasks in a series (switching from task to task
4. The time available for the task (speed of task)

It is worth nothing that there are other indirect factors such as durations of task, fatigue and level of arousal. However, the direct factors (listed) will be discussed at more length.

1. Task Difficulty

Task difficulty is the most obvious factor, and is easy to appreciate. Putting aside factors such as time constraints and parallel tasks, mentally adding 2 and 2 together is a low workload task while mentally multiplying 236 by 37 is a high workload task. As tasks become more difficult the central executive has to do heavier processing, more buffering and recalling of data at various stages, and more interrogation of long term memory and learned rules.

2. Multi-tasking

This is a complex area, but a highly simplified merger of the main theories will be used to demonstrate the basic science behind 'multi-tasking'. The main theory of 'working memory' must be looked at (introduced in Chapter 1, information processing).

Serving the central executive (the brain's single central processor) are two short-term memory buffers called the 'phonological loop' and the 'visual-spatial sketchpad' (Figure 9). These are small active stores that act to buffer sounds and pictures respectively. These sounds and pictures may be sourced from the senses or from the long-term memory. The visual spatial sketchpad is like the 'mind's eye'. The phonological loop is a 'mental ear' that sounds out short clips of audible information.

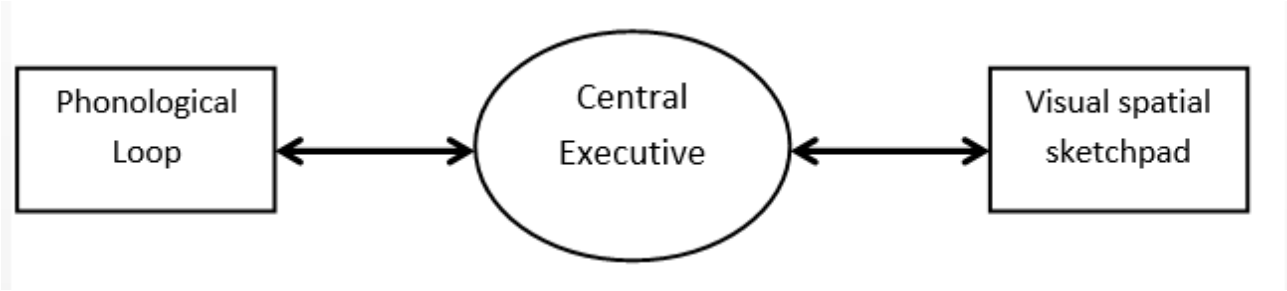


Figure 9. Working memory, simplified from Baddeley and Hitch 1974, see Baddeley (1990).

If a task requires continual visual information input (such as flying an aircraft manually) then the visual spatial sketchpad will be in constant use, picturing what comes from the eyes. The same is true of the phonological loop during verbal processing tasks (such as communicating with ATC). Ideal multi-tasking is possible when one task uses just the visual spatial sketchpad, and the other uses just the phonological loop. Additionally, because there is only one central executive, only one of the tasks can fully use it. Hence ultimate task sharing happens when a visual/spatial/manual task is being performed concurrently with a verbal/auditory task AND at least one is a well-learned skill (hence not requiring the central executive). Furthermore the two tasks should use separate sense organs for input (eye and ear) and separate forms of output (e.g. physical arm movements and vocal sounds) in order for ideal task sharing.

Figure 10 shows all this in the form of a highly simplified model that combines aspects of multiple resource theory with Baddeley's working memory model. From top to bottom it follows the basic input-processing-output model introduced in Chapter 1. However there

are clearly two sides (left and right): one auditory and one visual/spatial. The arrows do not join the boxes because the theory is not defined in this level of detail.

To demonstrate the model: manually flying an aircraft requires visual input (eyes) feeding into the visual spatial sketch-pad and requiring a manual response (physical handling). All of this involves the right-hand side of the model. Communication requires audible input (ears) feeding the phonological loop and requiring a verbal output (talking), and hence consumes the left hand side of the model. In theory therefore pilots should be able to fly and communicate at the same time, but it depends on the need that either task has for conscious control and attention - the central executive).

If both the tasks discussed are autonomous (skills that require little attention) then they require little central executive control, and after a little practice should be able to be shared without interfering with each other.

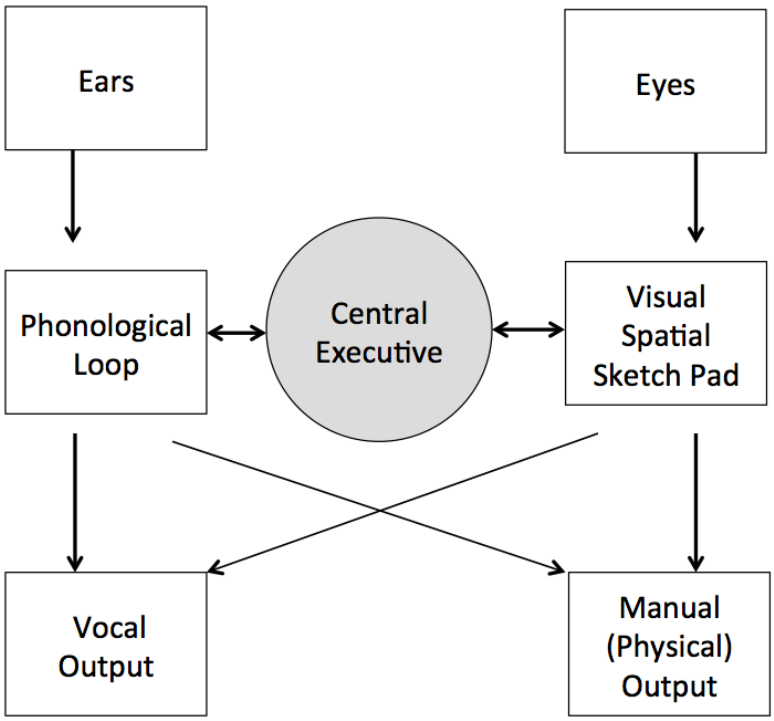


Figure 10. Simplified version of multi-tasking theory (by Jarvis 2014, based on merging Baddeley 1990 and Wickens 1999).

The usual problem in multi tasking is the competition between tasks for the central executive. Communicating and manual flying are good examples of two tasks that may appear to be easy and autonomous as well as sufficiently resource independent, but that often clash in practice, leading to decrement of one, the other, or both. This is because both these tasks are likely to compete for executive control (attention) on a regular basis (the communication task in order to work out what is being said, and the flying task if more attention is needed to strive for accuracy). Occasionally, each task may even demand the working memory buffer of the other (for example if talking about directions then the visual spatial sketch pad will be required to imagine the route).

It has been shown that flying an accurate ILS approach is adversely affected by mentally processing crosswind information (Ebbatson, Jarvis, Harris 2007). This is because although the crosswind information is presented verbally, the calculation of the wind vector requires heavy executive functioning and some spatial visual resource. Hence the mental process of the wind calculation task competes for attention (central executive) with the concentration being paid to the manual flying task to keep it accurate.

In Figure 10 the two diagonal 'crossover' arrows represent tasks where the input is on one side but the response is on the other, such as reading aloud (visual input to the visual special sketch pad, but vocal output) or writing dictated words (auditory input, manual output). These can be shared in the same way as tasks that occupy only one side of the model.

These sorts of theories help to predict which tasks can be potentially executed concurrently and which cannot. For further or deeper information on multiple resource theory see Wickens (1999).

3. Tasks in Series (Attention Switching)

Knowing that in most cases concurrent tasks will compete for resources to some extent, doing one task at a time may appear to be the ultimate solution if time allows. However the very act of switching tasks is almost always expensive in terms of attention and is therefore intuitively avoided if at all possible.

The reason for this can be explained with a metaphor of RAM in a computer: Information and routines required by a running computer program are held in the RAM. If that program is closed and another is opened, then new routines and information must be loaded into RAM and this takes time. While humans are engaged in a task, everything needed is aligned and accessible for the working memory, but if the task changes then this set up must be changed, and that change itself adds to workload and takes time.

4. Time available for task (Speed of task)

Obviously, attempting to process a task more rapidly than one would prefer adds difficulty to the task, and potentially induces error. Additionally, the very awareness of reduced time can itself add an extra attentional demand (the pilot gives some attention to the considerations and awareness of the time criticality). There is clearly a danger of a vicious workload circle beginning.

Effects of high workload

From a practical perspective, increasing workload has the following symptoms, each of which will be discussed:

- Attentional and task focusing
- Task shedding and reprioritisation
- Implications for situational awareness

- Increased use of decision short cuts and less scrutiny or review.
- Increased fatigue and chance of error

Sustained workload contributes to fatigue. Very high workload (particularly fast onset) and feelings of not coping with the workload can cause high arousal or stress. All these things make error more likely.

A direct effect that occurs with high workload, is the focusing of attention (also called attentional narrowing, coning or funnelling). There is some scientific debate about whether this effect is primarily associated with arousal but because of the approximate commonality between symptoms of high arousal and high workload, for practical purposes this is unimportant. Attentional focusing is a very effective strategy that appears to have evolved in order to maximise concentration on a problem or threat (e.g. the object that is creating the workload or arousal). Additionally because the attention is narrowly focused, other events and stimuli that would normally draw attention, fail to do so. Hence information outside the task can be missed. Although often a positive effect (minimising distraction) this can lead to important signals being missed, even signals that are seemingly highly salient (loud, bright etc.) There are many repeated stories of pilots landing despite continual loud alerts sounding all the way down the approach because the gear was up.

Under a high workload task, a pilot may not have the capacity to search and assess other areas, problems and alternatives. This is one reason for the insidious nature of an apparent bias that leads pilots to stick to courses of action that, in hindsight, appear to be flawed. In order to do something other than continue a mentally planned action (such as continuing an approach) attention will have to be diverted from the primary task in order to make other assessments. As well as the reluctance to remove attention, this would also represent a switch of attention that has a cost all of itself.

When all attention is focused on one element of the operation (such as an emergency) then situational awareness of other aspects and the wider picture will suffer as a consequence. The process of maintaining high awareness requires attention and hence workload and it follows that situational awareness around the area of focus can be high even when overall situational awareness might decrease. Maintaining situational awareness requires attention, and situational awareness is therefore as likely to be lost under very low workload, as it is under high workload. Hence the relationship between high workload and situational awareness is far from simple.

If the cause of excessive workload is several concurrent or serial tasks then the unconscious urge is to shed one or several tasks, and to avoid continual switching (Jarvis 2010). If some of those tasks are autonomous then the skill may continue unchecked. In the case of executive control tasks, one or more tasks might effectively be dropped but this will not always be noticed due to the concentration on other tasks. Unfortunately there is no general rule to predict which tasks may suffer and which will be prioritised; situations and combinations of tasks are extremely varied and so it will depend on many factors.

A poorly planned glider flight under a low cloud base developed into a very low level circuit. With the increasing workload and considerable anxiety, I became fixated on the landing area. The low height and strong tailwind exacerbated the sense of speed to such an extent that I ceased to monitor the ASI. I was very lucky to survive the stall and spin accident that destroyed the glider.

In the above anecdote, the pilot's attention has narrowed to the critical area of concern: the landing area (the pilot was unsure whether he could make the circuit work). Under high workload the scan of the ASI was dropped because powerful (but unreliable) speed cues were available from the peripheral texture flow that falsely reassured him of the airspeed (see Chapter 2, 'Perception'). The workload and anxiety were strong enough to overcome all the pilot's experience and training in this respect.

When assessing information and making decisions, high workload can lead to complex decisions being taken more rapidly than normal, possibly without considering some factors, options or complexities. Whether a decision is itself the creator of high workload or whether it must happen alongside a different high workload task, similar issues apply. The temptation can be to base that decision on just a few (or a single) criteria rather than considering how factors interact (non-compensatory decision making, see Chapter 9, 'Decision making'). Heuristics and biases could be used with little scrutiny or review. A temptation will be to get the decision made and shed that decision task (lowering workload and returning to the primary task of operating the aircraft).

An increased chance of error comes from all the above factors. High workload on a particular task makes errors on other tasks more likely to happen and less likely to be noticed, particularly autonomous routines or checking tasks that have been under-prioritised. There can be benefits from high workload; task engagement and concentration on a single task are some.

Application of knowledge – Workload

Processes that primarily require executive control will add considerably to workload. These might include concentrating, paying attention, calculating, trying to remember something, being careful, maintaining awareness, doing an unfamiliar or novel task, doing a new or unlearned task, doing a challenging task, making a decision, assessing evidence, reviewing a situation, looking for something, listening to something or someone, managing a set of tasks, etc. Although most of these things happen regularly on a flight deck, excessive workload is not usually caused. But when they are required to be managed in addition to existing tasks, or are particularly challenging or time limited, there is a danger of excessive workload and problems associated with it.

Lowering of workload can be discussed in the light of the four workload drivers discussed earlier (from Jarvis 2010). Task difficulty is the driver that is least likely to be able to be reduced at the time; there is often no quick way to make a task less difficult.

Time limitation (speed of task) is the most obvious variable that a pilot can change in order to affect workload. When possible, allowing more time for a task lowers the workload and helps to avoid a vicious cycle of workload from building up.

> *A captain on a line check needed to return to land after a technical snag, meaning they could not dispatch for the next sector. After the decision had been made he said to the F/O 'Let's not hurry, keep flying away from the airfield whilst we make a plan and set up the FMS - that way we will have time to fly a normal descent and approach' [1]*

Parallel tasks usually require effective CRM practices; relieving a colleague of one task for a short time, or asking a colleague to take over a task can bring back sufficient capacity for normal functioning.

With serial tasks, the issue is not the tasks themselves, but the switching. The brain naturally tries to avoid continual attention switches that are costly and difficult, but when two non-sharable tasks must be completed the strategy used for parallel tasks applies (CRM, re-arranging flight deck tasks).

Unfortunately, there are situations that occur on the flight deck that have aspects of all the four workload drivers, particularly emergency situations. In such cases, if time can be created it lowers the workload as well as facilitating better management of tasks between crew-members.

Dealing with high workload is problematic for an individual once they are in a high workload situation. This is not because people do not recognise high workload: individuals are good at self-reporting their workload. However several other effects mean that high workload may not be recognised for what it is, at the time. Firstly, the perception of the time changes so that it feels like less time has passed; hence the higher speed of tasks is less obvious. Secondly, high workload tasks are so absorbing that the individual may not consider the workload that they are under (in effect they do not have the time and capacity to step outside the situation briefly to consider their own effectiveness). Because of these issues, relying on individuals to recognise and then manage their own workload can be unreliable unless specific training or practice is given. More realistic triggers for initiating workload management are recognition of the changing situation before the workload elevates (avoidance), recognition of high workload in a different crew member, or recognition of the task characteristics and types of situations (rather than recognising the effects of them).

> *A new Captain experienced his first emergency and was returning to the airfield having had an engine shutdown a few minutes in to the flight. Whilst the QRH was being completed, ATC turned the aircraft downwind while the crew prepared for the approach. On being given a closing heading, even though everything was done, the Captain recognised he was not feeling comfortable and felt rushed. He instructed the F/O to tell ATC to extend downwind for another minute, extended the flaps and took a moment to review prior to turning in. [1]*

Application of knowledge for CRM - Workload

In the classroom

In a classroom environment, many activities can be used to replicate workload. These do not have to be within an emulated flight deck, but the types and elements of the tasks should match those in a flight situation. For example, a time-forced physical manipulation task that requires visual and spatial processing resource can be chosen to use the same resources as a challenging manual flying task. A verbal task such as answering questions aloud can emulate communication tasks. However it is no good simply getting pilots to do such tasks, unless there is an objective relating to the pilots' roles and some consideration of how such tasks feed into the learning experience.

Example: the trainer might decide to facilitate thought about task type and 'effective' workload management by giving one manual and two verbal tasks that must be maintained at all times by two pilots who must decide how to share them. To add challenge, the least challenging verbal task might in fact compete for some visual/spatial resource and hence be unable to share with the spatial task, while the harder verbal task competes less. This might lead to a discussion about why the two seemingly most challenging tasks would be better off being done by one person, while the other 'easy' verbal task is picked up by the other. Clearly there are a myriad of ideas around such themes.

Case studies can be used and the participants asked how the crew in the case study could realistically have managed a specific part of the situation differently? Discuss whether there are any general lessons from that exercise, in terms of approaching any high workload situation.

In the simulator

The simulator instructor or evaluator who identifies high workload (probably predicts it based on the task) should ask themselves what drivers are creating the workload and whether the crew are actively dealing with the workload. Here are some questions that the trainer should ask themselves;

- Did the crew recognise the workload (before, during, etc.)?
- Did the crew attempt to reduce the workload? How?
- Did the crew work together to balance or shift workload appropriately, or did they try to unsuccessfully multi-task by themselves when the other crew-member could have alleviated the problem?
- Did one crew-member recognise and proactively re-task to reduce the other's workload?
- Did the crew make any attempt to assess or extend the time available?

As the situation is on going, the trainer should consider what is being done and what has to be done (i.e. tasks) and how those tasks are being distributed and swapped. They should also look for signals that the crew have recognised the workload problem (existing or pending) and signs that they are attempting to deal with it. There is a difference between a crew attempting to deal with the situation and attempting to deal with the workload. Although both may be related and both may happen, one should not be mistaken for the other; a crew can work very well to sort a situation out, while failing to manage workload. Such an approach may have consequences on other aspects of the overall detail.

After a very high workload situation in which the crew could have managed better, it is a good idea to repeat it, but this time position-freeze the simulator at a critical point and allow the crew as much time as they like to sort it out, assess, plan and even prepare things before unfreezing and continuing. Some examples of questions and prompts for the trainer would be:

- What did the crew do differently the second time?
- How did it feel compared to the first attempt?
- How much extra time did they use?
- How could they have generated that the first time (without position freeze)?
- How could the crew have done an overall better job on the first attempt?

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- How could they have generated that the first time (without position freeze)?

- How could the crew have done an overall better job on the first attempt?

SECTION A, PART 1, CHAPTER 7

Surprise and startle

Knowledge

Startle reflex

The human startle reflex was famously investigated by Landis and Hunt (1939) who filmed the reactions of people to an unexpected pistol shot occurring just behind them. It is now well established that there is a reflex-like event (startle reflex) that blinks the eyes and causes a whole body 'jerk' to occur (similar to that sometimes caused in sleep). This reflex has a relatively basic neural pathway from the sense organ. Many things can cause (or contribute to) a startle reflex, including sudden noises, unexpected tactile sensations, abrupt shocking perceptions, the sensation of falling or an abrupt visual stimulus.

There is little evidence that a startle reflex alone creates much of a sustained or lasting impact on cognitive functions (although there are some minor and short lived physiological changes such as raised heart rate). A skilled motor task will be momentarily disrupted by a startle reflex but return to normal within five to ten seconds. For more details see Thackray & Touchstone (1970).

For pilots, the main effects of the startle reflex are the interruption of the on going process and distraction of attention towards the stimulus. These happen almost immediately, and can be quickly dealt with if the cause is found to be non-threatening; for more detail see Graham (1979), Herbert, Kissler, Junghöfer, Peyk & Rockstroh (2006) or Schupp, Cuthbert, Bradley, Birbaumer & Lang (1997). A further possibility is that any 'primed' motor action may be triggered. For more detail see Valls-Sole, Kumru, Kofler (2008).

Reaction to Fear

A perception of fear can cause a startle reflex to be potentiated (more pronounced) should it occur and attention to become more focused. In a state of fear, very little is required to trigger a full 'fight or flight' response (a startle will probably be sufficient at this point).

Fight or Flight

When we perceive a serious and imminent threat (whether we are already in a high state of fear or not) the hypothalamus initiates a cascade of events (nervous and hormonal) such as increased heart rate and breathing, secretion of adrenaline, and increased sweating. This is called the alarm reaction and is part of 'fight or flight' (see Chapter 10, Stress). These changes immediately prepare the body for action to maximise the chances of survival in the anticipated imminent encounter. No startle is required to activate the fight or flight response, although a startling stimulus may be part of, or coincident with, the same threat.

Importantly the alarm element of the fight or flight response also appears to have an immediate and sustained impact on our cognition. All mental capacity becomes focussed on the threat and/or the escape from it. As long as the required response to the threat is to engage in a single basic task (i.e. a single learned skill or set of easy steps) then this focussing of attentional resource can be beneficial. The senses can appear heightened to the threat and the level of attention is very high but very focussed. The following anecdote is from a non-IMC rated, general aviation pilot.

> *Having descended to avoid infringement, we had to deviate from our track and fly through the visible VFR trenches between increasing cloud and rising ground. I could not believe how quickly the weather had changed from the time it took us to venture the 46 nm from the Sunny Cotswolds to the rural high Welsh terrain. Before we could execute a 180 turn, cloud in our 9 o'clock position rapidly engulfed us. A heightened sense of hearing coupled with adrenaline amplified some disturbing rattles in the cabin, including the sound of pelting rain, and startled us into the most alert state of mind that we have ever been in. After invaluable guidance from London Radar, we emerged into VMC after the longest 6 minutes of our lives!*

The anecdote describes the heightened attention to the threat. ATC involvement was crucial, because it meant problem solving tasks and ambiguity were lifted off the pilot who could simply concentrate all attention on carrying out that single basic flying task. Although not experienced at this task, it was sufficiently bounded that with the heightened and focussed attention, the pilot managed it. It will be seen that without ATC removing the ambiguity, the pilot would probably not have managed the fight or flight response.

Some experimental evidence has suggested a decrease in memory performance of recently learned information (using memory tests) during fight or flight. But there is little evidence that long-term memory or skills are negatively affected, except in terms of manipulation issues (coordinating the skill, e.g. with tremor). So it is probable that old established learning and innate knowledge trumps new learning during fight or flight. This may be part of the explanation for an effect often called 'primacy' whereby individuals report that in difficult situations they reverted to early (or previous) learning, even when it was inappropriate to do so (for example reverting to the handling characteristics of a previous aircraft type).

A vicious circle

Hypothetically and anecdotally, during fight or flight pilots can get mentally 'stuck' within a situation (unable to interpret or resolve a situation, and unable to move on, even if that situation would present no problems under normal circumstances). This usually happens when, unlike the above anecdote, the situation is ambiguous or requires problem solving. For practical purposes, let us try to generate a hypothetical way of understanding this issue that takes reasonable account of the scientific knowledge.

In a fight or flight state, time is key to survival. In modern humans, the fight or flight response is accompanied by an urge to be engaged in the active solution (like in the

above anecdote – where the pilot is simply concentrating all their attention on one task, in line with the natural fight or flight response). But to do this the person must know (or be told) what response to take. In ambiguous cases this might not be obvious, and might require problem solving or complex thinking to assess the situation or response required. But in fight or flight, the brain wants to quickly establish a very basic mental model then drop any assessment process in order to concentrate all attention to the response. But if resources are not given to assessment and problem solving then the person cannot decide the best response. This situation would be best described as a vicious circle. As part of this, during the fight or flight response the brain favours sources of information that require the minimum of processing. This means simple 'real-world' cues or conditioned cues and responses.

All this worked well in nature, over millennia. However it is a problematic strategy when dealing with new technology (within which humans have not evolved). Human processes are not perfectly adapted to perceive the cues and information from modern interfaces. Such information requires more mental processing than does 'real world' information, particularly in new situations.

Taking all the above into account, it can be helpful to hypothesise a vicious circle occurring during ambiguous situations on modern flight decks, as follows: The brain requires a basic and quick understanding of the problem in order to act at once. But because flight deck information is often abstract and unnatural, the pilot requires more time to work out the problem than they would if the cues were natural real-world ones; time that they are unconsciously not willing to allow. Unless this conflict is resolved, the pilot becomes mentally 'stuck' (the start of the vicious circle).

Let us take a simple example: an unusual attitude. While easy enough normally, when experiencing extreme fight or flight, a pilot may glance at the attitude indicator but be unable to make sense of it (particularly an unusual and unfamiliar attitude) because the brain does not want to dwell on assessment, but wants to be engaged in the task resolution. The pilot (consciously) does not know the attitude and needs a little more resource and time before acting or responding. The pilot is stuck. Anecdotally, this feels like a mental blank. There is no easy solution:

1. If the pilot yields to the unconscious urge and breaks the vicious circle by making a spurious or guessed response then this could solve the situation by lucky chance (an action was effective) but also risks disaster (such as a fatally wrong control input). In any case, if the action does not solve the situation (or leads to a further threatening situation) the fight or flight continues, and nothing is resolved.

2. Alternatively, if the pilot continues trying to process the information then they may not receive the resource to process it while in that state, and so remain stuck.

While flying straight and level in the cruise during an early instrument flying detail, the increasing pressure (levels of concentration and air traffic input) eventually became too much. Loss of situational awareness and orientation was sudden with no obvious warning precursor. Despite staring at the instruments, nothing made sense. At this point the only option appeared to be to eject. However this was an instructional detail, and the reassuring words 'I have control' were sufficient to completely negate the workload pressure. As quickly as the mental picture was lost, it was regained. The experience was frightening and unforgettable. [10]

In the above anecdote, it is likely that the increasing pressure and workload narrowed attention causing difficulty in managing the various tasks, and ended in a fight or flight response (perhaps in response to the realisation of being overloaded). This led to the pilot feeling the need to escape the situation. The action of the instructor taking control resolved the threat. From that point mental resources and time were no longer quite so focussed on the perceived threat, and interpretation quickly occurred.

Application of knowledge – Surprise and Startle

Startle Reflex

The startle reflex should not cause serious sustained problems for pilots in most circumstances. One recent possibility however is that due to the industry focus on 'startle effect' or 'startle factor' and the linking of it to disturbing accidents (often inaccurately or through conjecture) some less confident pilots could mistakenly infer that a startle itself may seriously affect their ability, generating a fight or flight response. Aviation commentators, trainers, conferences and publications must be careful not to generate a self-fulfilling prophecy.

Without continual exposure to all possible startle stimuli, we cannot avoid the startle reflex, and cannot control it as it occurs. A particularly intense startle will be caused either by the magnitude and onset of the stimulus, or by a person's underlying feeling at the time, particularly of fear or anticipation.

Fight or flight

This appears to be the closest effect to the 'startle effect/factor' colloquialism used often in aviation, and so it is reasonable to consider how it applies and whether anything can be done about it.

The flight or fight response is an innate reaction (i.e. hard-wired), but there is also generally agreed to be an overall element of learned emotional response. General changes in the emotional response would require overall behavioural change, as opposed to specific pilot-related training.

However, the fight or flight response is a reaction to a set of perceptions. Recall that it is the perception of the situation (not the situation itself) that the body reacts to. This is one reason why people will react differently to the same set of circumstances; some with

elevated flight or fright responses, and some without. A realistic (but not particularly practical) way to reduce the effect is to reduce the perception of fear caused by exposure to the situation. Usually this would be through exposure to the situation and/or solution so that it begins to feel non-threatening. The obvious difficulty being that there may be many thousands of situations to gain exposure to, and often it is the unusual and unpredictable ones that are of concern. However reduced fear of a perception can happen at a slightly more general level (for example becoming more confident in one's ability to cope with emergencies, more familiar with an aircraft type or more familiar with unusual situations or upsets). All these are still impractical for the CRM trainer however.

The most realistic counter-measure is not to attempt to reduce or fight the effect, but to align the task expectation with it in a way that recognises the cognitive response. This points towards the need for the simplest assessment or solution possible to remain safe.

Recall that in a fight or flight state the brain likes to respond as quickly as possible (or at least get closure of the assessment process) and does not like to engage in difficult processing or thinking about what action might be best. Well learned, easy, rule-based tasks will be very attractive, and preferred in such situations.

> *We had to 'de-plane' due to an APU fire. The air-bridge was still connected to the front left door so all passengers would go that route back to the terminal. There was some confusion among cabin crew and passengers. I had no clear role (my door was not in use) and I felt rising panic as I wondered what to do. However as the evacuation started I found myself counting the exiting passengers, so that we would know when it was complete and could exit ourselves. This felt like an important thing to do and although challenging in that situation, it was a task that I could achieve. I suddenly felt calm and in control. All the panic disappeared and I was able to say for sure when we had definitely evacuated all 139 passengers. I think doing that task kept me calm and focused [8]*

In the above anecdote, after a probable fight or flight response, the crew-member defaulted to a clear rule-based task that was within her capability when in a fight or flight state (counting is learned early in life). At that point, she broke the cycle and could function clearly again. Rule based, well-learned tasks (in this case simply counting people) are very attractive in such situations. Because the task felt useful and achievable, it calmed her and lifted the fight of flight response from her, allowing her to perform extremely well in that task (which was probably not as simple as it sounds when people are trying to de-plane in a hurry).

This explains why running QRH drills or checklists is both effective and calming. It is very comforting for pilots to be able to run through a set of well-defined rule based-steps, and doing this can help to maintain a functional flight deck. Each easy, rule-based task, gives that pilot perceived control of a task and with it the possibility to break out of any vicious fight or flight circle. These tasks act to distract from the threat and so calm the perception of threat that is causing fight or flight. Completing the task successfully can also help to give the impression that the threat is being dealt with. The more that any task is perceived

by the crew to resolve part of the situation (whether it has done so or not) the more positive its effect will be in terms of countering the cognitive symptoms caused by fight or flight.

The best solution therefore to the elements that form 'the startle effect/factor' is a prepared linear, simple, rule-based response (whether actions, words or thoughts). The classic rule of 'aviate, navigate, communicate' is a very good starting point in most cases, but in severe and heightened cases with fight or flight, it may not be simple enough. Aviating (prioritising on flying) may not bring relief, and may not resolve the situation. For example in a severe upset situation or with a primary control or display problem, the 'aviate' task may not be resolvable when in the fight or flight state, and the pilot(s) could get stuck trying to 'aviate'. The Air France Flt 447 accident may be an example of this, although it will never be known for sure. The 'aviate' task is in fact complex (more so for some pilots than others) and is not a simple rule-based task. A simple rule based task would be 'airspeed reading?' (i.e. assessment) or 'control column central' (i.e. action). A simple well-learned (conditioned) act would be 'airspeed too low – control column forward'. However the recognition of a stall is more complex, relying on multiple cues, and in some cases may be difficult in a fight or flight state. One can instantly see the difficulty in generating simple rule-based tasks to solve complex situations. Sometimes, such solutions can be quite specific and individualised.

> *I was usually the cabin crew member 'volunteered' to deal with medical emergencies. The first few times I found it difficult to get my thoughts clear due to 'internal panic' as I first arrived at the casualty and everyone else stood looking over me expectantly. One day I accidentally stumbled on a solution that worked well for me personally from then on; it was that no matter what the emergency was, I would take the heart rate first. While counting the heart rate for 15 seconds or so, I had time to collect my thoughts, onlookers calmed-down as they perceived I was in control, I felt in control, and the situation quickly became clear in my mind. After taking the heart rate, I always felt able to think clearly and deal with the situation. It didn't matter that the heart rate was sometimes irrelevant! [8]*

The above anecdote is a personal solution that worked for the individual. It is used here as an informational anecdote only, to illustrate the general principle, not as a suggestion or an example to be necessarily followed.

Application to CRM (classroom) - Surprise and Startle

After a classroom session, participants should understand the difference between the startle reflex and other responses to fear or threat, specifically the flight and fight response. The startle reflex does not necessarily lead to degraded cognition. Under most circumstances, a pilot will regain almost full cognition before having time to think about what happened. Air France Flt 447 was a complex accident; the event was probably not contributed to by a simple startle 'reflex'.

Suggested resolutions for training the fight and flight element of surprise and startle are:

- Avoid taking any action unless obvious (the urge will be to act).
- Act simply. Do only the simplest safe actions.
- If stuck trying to unsuccessfully assess one thing, acknowledge it and actively switch attention to something else.
- Consider hand over or swap of control or of tasks (to break the vicious circle)
- If someone else appears stuck, assess their task and then consider offering to take it from them in a confident manner (albeit perhaps for a short time).
- If the feeling arises (and it is recognisable) simply vocalising the fact can help alert the other pilot so that they can help.

SECTION A, PART 1, CHAPTER 8

Situational Awareness (SA)

Knowledge

The general concept of situation awareness (SA) emerged from colloquial consensus. Arguably (and anecdotally) the term has been used for over half a century but SA is generally agreed to have become part of established aviation science and academia in the 1990s. Certainly from that time the scientific interest in the term ‘situational awareness’ grew.

Whereas situational awareness is very easily understood as a colloquial generality, it is surprisingly difficult to define or measure objectively. Criticism towards the concept of situational awareness has been attracted by this problem. However as a vehicle of general understanding among flight crew, situational awareness appears to have merit. This is unsurprising given its roots; it almost certainly emerged as one of many terms used to express an idea in the real world. Flight crews are not usually concerned about definitions and measurements, but about understanding and communication of general ideas. From this perspective, situational awareness appears to have proven useful. A colloquial definition of situational awareness is “knowing what is going on”. It also appears synonymous with the colloquial idea of ‘mental models’. Situational awareness is deemed to be at its highest when the person is able to anticipate how a situation is likely to continue into the immediate future.

Situational awareness therefore appears to be a hypothetical state of the individual that continually changes (by the minute and even second). If so, it must relate to information processing models because it relies on information being properly sensed, perceived and interpreted. There must also be an element of attention because high situational awareness does not appear to be something that happens passively. Research is generally agreed that maintenance of high levels of situational awareness increases workload, and hence uses attention. It follows that situational awareness is associated with working memory, and this is also generally agreed amongst theorists. Because it is a process reliant on working memory, the quality and quantity of situational awareness are necessarily limited. The process by which SA is actively updated is usually called situational assessment and is also associated with working memory. It is generally uncontended that a low level of assessment normally happens naturally and passively in a conscious human but that higher levels of attention are required to assess actively in order to maintain high levels of awareness.

Classically, situational awareness is spoken about as having three levels: perceiving the situation (equivalent to recognising what is happening at the time), understanding the situation (understanding fully what is happening) and projecting the situation (equivalent to being able to project ahead to predict what is likely to happen next). These are known as

levels 1, 2 and 3 respectively. Each stage is reliant on the one below it. Level 1 is said to be the foundation of SA because without perceiving the situation one cannot establish understanding of it (level 2), or project it forward (level 3). Similarly, level 2 (understanding) is vital to be able to project ahead (establish level 3 SA).

It is said that numerous types of failures can occur at each level, as shown in table 1 below (the types of failures are in the right hand column). It can be seen that 'level 1' failures are mostly during the early stage of information processing (sensing, perceiving, etc.) This aligns with the earlier narrative (Chapter 1 – information processing), in that information wrongly sensed, perceived or not available will make processing ineffective. Level 2 and 3 failures are associated with problems further into the information processing process, mostly in the working memory.

Level 1 SA: failure to correctly perceive the situation	A: Data not available B: Data difficult to detect/perceive C: Failure to scan or observe data 1. Omission 2. Attentional narrowing / distraction 3. High taskload D. Misperception of data E. Memory failure
Level 2 SA: Failure to comprehend situation	A: Lack of/poor mental model B: Use of incorrect mental model C: Over-reliance on default values in model D: Memory failure E: Other
Level 3 SA: Failure to project situation into the future	A: Lack of/poor mental model B: Other

Table 1. SA Error Taxonomy (Endsley, 1995)

The three levels of SA above are approximately aligned with the central tenant of threat and error management (TEM). In order to avoid a threat one must be able to project ahead. In order to trap a threat or error one must understand the situation. If someone does not understand the situation then they are more likely to make an error requiring mitigation.

Situational awareness and information processing theory seem to have a lot in common and certainly large parts of them are, to an extent, interchangeable. Some trainers prefer to discuss issues using an SA-based model rather than an information-processing model and vice versa, and so it may be comforting to note that they are effectively overlapping phenomena.

Information processing started out as a theoretical framework to explain cognitive phenomenon such as memory and perception whereas SA 'theory' was very probably started by practitioners trying to articulate and encapsulate the process of assessing and

understanding situations in the real world, and was then described and expanded by scientists later.

For these reasons, some people have found situation awareness to be a useful vehicle for articulating the initial general process that occurs in most tasks (such as decisions and skilled performances). Indeed some CRM trainers substitute the early stages of information processing for situational awareness, and substitute the later parts for 'decision making' creating a simple information-processing model for articulating the process of making decisions based on good situational awareness. Ideas such as these can allow the trainer and trainees to articulate, understand and apply basic processes, and move towards forming safe practices. It is important that trainers recognise that all theoretical ideas (even scientifically supportable ones) are not hard facts, but are vehicles to assist understanding (whether scientific or colloquial). Hence, trainers should not become overly focussed on the exact nature of the various theoretical models, but simply use them to support and explain practical applications as they see fit.

More recent extensions of the SA theory include shared SA and distributed SA. Shared SA (or crew SA) refers to how situational awareness is shared and divided across the crew. Distributed SA refers to how SA is distributed across the system, including the crew, interfaces, system and all components. The latter can only be modelled; there is no way to measure it. Both these theories tend to be descriptive rather than prescriptive.

Application of knowledge – Situational Awareness

Situation awareness is said to describe a pilot's awareness of what is going on around him or her, e.g. where they are geographically, his/her orientation in space, what mode the aircraft is in, etc. Under Mica Endley's three levels, SA refers to:

1. The perception of important elements, e.g. seeing a low oil pressure indication.
2. The comprehension of their meaning, e.g. Is there a leak? Is it a faulty indication?
3. The projection of their status into the future, e.g. Does this require a diversion?

Almost any case study can be found to have elements within in that could be described as 'loss of SA' or can be attributed to degraded SA. When studying an accident it can be tempting to attribute the cause to 'loss of SA' or insufficient level of SA but it is important go beyond this. 'Lost/reduced situational awareness' is a term that sometimes gets used very generally, often without much analysis. It is easy to identify in hindsight that the crew did not know something important but much more challenging to discover why, and determine whether the circumstances could have been reasonably foreseen and can be generalised to other situations. Often a crew 'lose situational awareness' due to concentrating on other things so it is crucial to analyse whether they took a reasonable course of action in foresight, not in hindsight. Also recall that if crews are distracted by

other important events, the time and effort they have to spend on SA processes is low. That explains the loss, but it does not explain why they prioritised the way that they did. Such analysis should at least be seriously attempted.

In terms of maintaining and updating overall situational awareness (i.e. related to navigation – one's position in space), it is important to use multiple sources of information whenever possible (not just in order to triangulate one's position but to avoid problems caused by single unreliable sources or errors in interpretation of the source). Problems often occur when crews become reliant on only one source, making their situational awareness vulnerable. The anecdote below aptly illustrates the problem; the pilot relied solely on the VOR needle (which he had set wrongly) and did not use other sources of SA updating, such as the map.

> *To get back before dark I decided to follow a VOR radial approximately South East to Bovingdon rather than messing about with dead reckoning. But then I accidently selected the frequency for Heathrow's VOR! Why I didn't check the frequency on the box I'll never know. My next error was relying totally on the VOR (I had no DME, so was just waiting for the VOR needle to flip). I must have looked at the ground often but somehow didn't compute a problem; probably I was focussed on doing a good job of tracking the radial (not being IMC rated). Had I checked on the map I would have noticed something wrong. Luckily, before getting too close to Heathrow a bit of weather got in my way and while having to re-orientate myself I fortunately recognised Wycombe Air Park below and realised I'd messed up! I managed to sort it out ok after that and get in before dark… just. Many lessons learned and no harm done – thanks to a cloud.*

In the following anecdote, the crew maintained general situational awareness but the single source of information about the destination turned out to be erroneous.

> *With some twenty minutes to run until landing we managed to establish contact with our destination, a vessel. Radio communication with the vessel was difficult; however, we had a good radar contact in the vessels reported position and elected to conduct an Airborne Radar Approach. As we broke from cloud close to approach minima we discovered the radar contact was not the vessel that we believed. We went around from the approach and contacted the vessel again. They had omitted to inform us they were making way and were now some 20nm from their last reported position! Fortunately we had added contingency fuel to cope with such a situation.*

Application to CRM– Situational Awareness

Initial training (in the classroom) could introduce the concept of SA and illustrate the dangers of poor SA (possibly using well-known incidents and accidents). Factors contributing to good and bad SA should be covered.

'Loss of SA' should not be deemed to be the cause of the accident. Much more depth is required in analysing the case study. Questions should be asked such as:

- What did the crew become unaware of?
- When did they stop noticing the critical element?
- WHY have they lost awareness of that aspect?
- What WERE they aware of?
- How could you use this knowledge to help you generally, in the future?

It is obvious to state that pilots must maintain high levels of SA at all times, in order to achieve safe flight and effective threat and error management. However, such a statement is simplistic. Maintaining high SA takes some effort and requires resources. In many situations a pilot has no easy way of knowing how to direct their effort or resource in order to achieve SA. SA is not something that one can easily interrogate. It is not possible to be certain of the level of SA that one has at any given time, although a pilot may have a feeling about their awareness levels. A pilot with a very different mental model to reality is often said to have lost SA but may have no idea that they have lost it, and indeed may feel perfectly normal. Because of this, it is not easy for pilots to determine the amount or type of assessment that they need to do in order to maintain or increase SA.

Also under difficult conditions attention is taken away from the situational assessment task and so SA will degrade. It is established good practice (and worth reinforcement) that after an intense period of dealing with a specific situation, pilots make a wider review of their overall situation (partly in order to regain SA). It is however not simple for the pilots to know the extent that they may have lost SA, or to what extent they have regained it. SA involves awareness of many factors and so pilots can be under the firm impression that they have high SA, when in fact they may have a critical loss of SA in a single area. For these reasons, CRM trainers should be open to the limitations inherent in discussing situational awareness as if it is a ‘method’ for maintaining safe operation. Additionally, despite tips and tools developed to assist in diagnosing SA (such as those below or those within behavioural marker schemes) the CRM trainer must be careful not to give the impression that this is an exact science.

Situation awareness may be a worthy principle and a good vehicle for a common articulation of a general phenomenon, as well as a way of helping pilots understand their limitations. However it is not a ‘silver bullet’ and CRM must not give pilots that impression or any idea that maintaining high SA is simply a factor of effort or ‘professionalism’. The CRM trainer should be able to balance the debate with realistic expectations and knowledge.

When operating, recognition of reduced SA is understood to be important, although very difficult (as explained). It is unlikely that a pilot who has lost SA will passively recognise it without a clear signal or consequence. It is quite possible that SA will be regained on its own without the pilot ever realising that they had an inaccurate mental model of the situation.

Many trainers find LOFT exercises and debriefs to be a useful way to improve the recognition of reduced SA with regard to both individuals and crew. The use of distractors to remove crew attention from an important but usually reliable parameter is one way to make the point. Mica Endsley advocates a training method whereby LOFT exercises are stopped midway through, in order to test individuals on their SA, and make them aware of their actual levels of SA, rather than their perceived levels, particularly at the end of an exercise.

Cues to recognition of 'loss of SA' have been proposed. The following list is adapted from Bovier 1997. It is claimed that most accidents involving human error include at least four of these cues, although such statements should be treated with caution because they imply causation and extrapolation without support.

- Ambiguity – information from two or more sources does not agree
- Fixation – focusing on one thing (i.e. attentional focus / tunnelling)
- Confusion – uncertainty or bafflement about a situation (often accompanied by anxiety or psychological discomfort)
- Not prioritising the flying task – everyone is focused on non-flying activities
- Everyone heads down
- Not meeting expected checkpoint on flight plan or profile ETA, fuel burn, etc.
- Skipping or not complying with SOPs
- Busting limitations, minimums, regulatory requirements, etc.
- Cannot resolve discrepancies – contradictory data or personal conflicts
- Not communicating fully and effectively – vague or incomplete statements

This list can be useful for a crew or trainer / checker. An item might suggest a problem with SA but it cannot confirm reduced SA. Hence pilots may need to assume reduced SA based on a few cues, and attempt to regain it if they have the capacity.

Regaining SA can be problematic for the reasons previously given (one will not know when it has been regained or what aspects may have reduced and when). Hence, regaining SA is effectively a blind process that is much the same as for normal management of the flight. Crews can prioritise their situational updating using the aviate, navigate, communicate model or any other systematic process. Tips for Good SA Management (Bovier, 1997) are as follows:

- Predetermine crew roles for high-workload phases of flight
- Develop a plan and assign responsibilities for handling problems and distractions
- Solicit input from other agencies, including cabin, ATC, etc.

- Rotate attention from plane to path to people (aviate, navigate, communicate)
- Monitor and evaluate current status relative to your plan
- Project ahead and consider contingencies
- Focus on the details and scan the big picture
- Create visual and/or aural reminders of interrupted tasks
- Watch for clues of degraded SA
- Speak up when you see SA breaking down

The following text is from JARTEL (2002), and gives examples of good and bad practices that could indicate clues to situational awareness.

1. Crews need to be constantly aware of the state of different aircraft systems.
    a) Examples of poor practice:
        i. Does not ask for updates
        ii. Does not signal awareness of changing systems
    b) Examples of good practice:
        i. Monitors and reports changes in system states
        ii. Acknowledges entries and changes to systems
2. Crews need to be aware of their environment (position, weather, air traffic, terrain).
    a) Examples of poor practice:
        i. Does not acknowledge / repeat ATC directions
        ii. Does not enquire about environmental changes
        iii. Does not comment on relevant environmental factors, or is surprised by them
    b) Examples of good practice:
        i. Collects information about the environment
        ii. Contacts outside resources when necessary
        iii. Shares information about the environment with others

3. Crews need not only to be aware of the present state of the aircraft systems and environment, but must also be able to predict future states in order to anticipate future events.

   a) Examples of poor practice:

      i. Does not set priorities with respect to time limits

      ii. Does not discuss relationship between past events and present – future

      iii. Is surprised by outcomes of past events.

   b) Examples of good practice:

      i. Discusses contingency strategies

      ii. Identifies possible – future problems

SECTION A, PART 1, CHAPTER 9

Decision Making

Introduction

Consider a simple continuum of different decision processes (fig 11). From left to right, less time is used and less attention is required (less mental effort) overall. Most types of decision-making sit on this line. The brain tries to shorten decisions whenever possible.

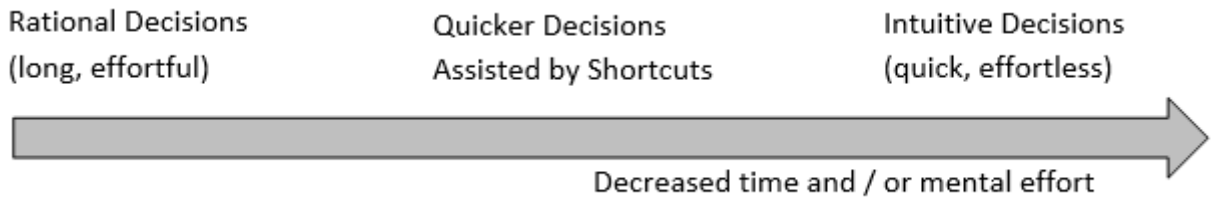


Figure 11. Simple continuum for decision types

On the far left: Rational decision-making is an effortful logical process. In the middle: time and effort are saved by using various shortening mechanisms and on the far right decisions are made by what 'feels' right at that moment.

This chapter will treat each of the three aspects of the decision continuum separately (as three separate sub-chapters) going through knowledge, application and application to CRM for each of the three in turn. It must be stressed that the continuum is not a scientific finding, but a highly simplified overview of the enormous field of decision-making theory, created for the practitioner.

SECTION A, PART 1, CHAPTER 9, SUB-CHAPTER 1

Rational (classical) decision making

Knowledge – rational decision making

When a person applies reasoning and logic to make the most ideal choice, it is known as 'rational decision-making' or 'classical decision making'. This process takes time and effort, and is therefore similar to complex decisions such as buying a house or car.

To illustrate using a non-aviation context: Anne has three potential suitors: Alan, Bill and Chris. All have requested a date this Saturday night and Anne cannot decide whom to go with; each seems to have good and bad points. She resolves to make a 'rational' choice. She considers the good and bad points of each alternative and lists them (Figure 12). There are a number of possible scoring methods, for example she could score each man by subtracting the number of negative points each has from the number of positive points, in which case she will date Bill.

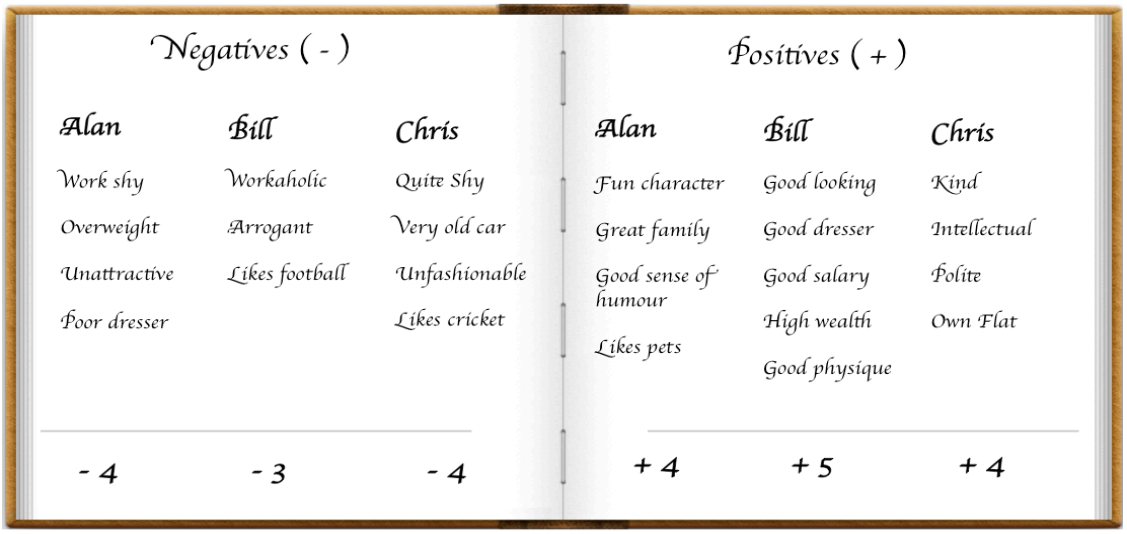


Figure 12. Anne's rational decision matrix

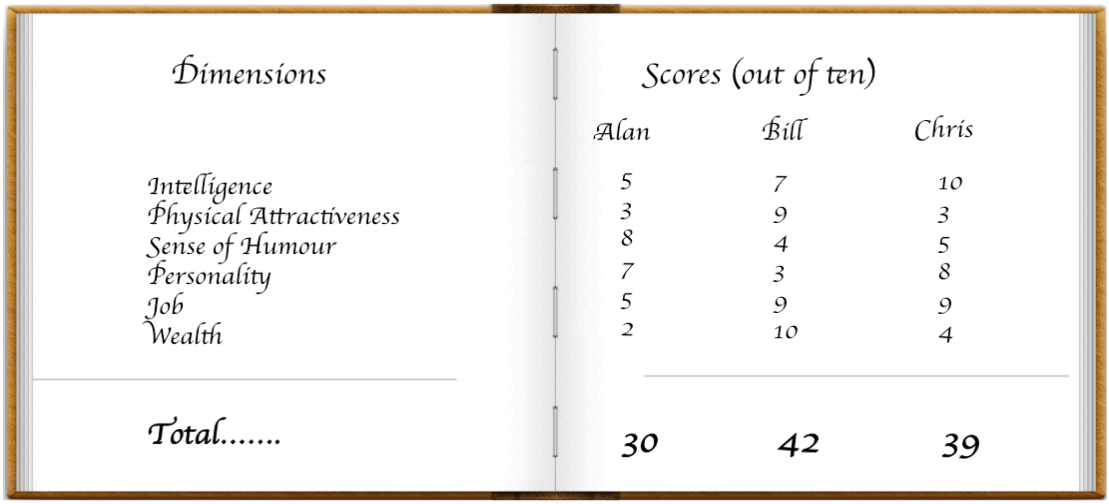
Rational decisions are not usually written down, and are therefore effortful (high workload).

They take the form of recognising and considering the problem, generating options, comparing the various aspects (called 'decision dimensions') of each option and choosing the best option overall.

Having generated options, the analysis task can take many forms but the ultimate aim is to consider all possible permutations of a situation in order to choose the optimal option. Such processes have shown some limited success in laboratory experiments, and are probably effective in certain limited situations.

However because rational decision-making requires complex analysis, it is usually incomplete. To explain, let us return to Anne. All three alternatives have good and bad points (Figure 12). Anne chose to sum the number of positive statements about each man and subtract the number of negative ones (call this method 1). The most obvious problem with this method is that it fails to account for the scale of each element; e.g. is Alan's poor dress-sense worse than Chris's unfashionable clothes, and by how much?

Having noticed the problem, Anne decides on a second method; to score each man across all dimensions and compare each man's total (Figure 13).



Dimensions	Scores (out of ten)		
	Alan	Bill	Chris
Intelligence	5	7	10
Physical Attractiveness	3	9	3
Sense of Humour	8	4	5
Personality	7	3	8
Job	5	9	9
Wealth	2	10	4
Total.....	30	42	39

Figure 13. Method 2: determining dimensions to compare each man on, and scoring them. This accounts for the *amount* of each element.

Anne still suspects this method is not optimal; she values a 'sense of humour' more than wealth and yet this method values them equally (i.e. a score of 10 for wealth adds as much weight to the outcome as a score of 10 for 'sense of humour'). To account for this problem, Anne assigns a general weighting to each dimension, by which to multiply each score (Figure 14). Notice that 'wealth' receives a weighing of 0.2 showing that Anne feels this is not important to her, but 'intelligence' is weighted 1, meaning that it is five times more important to Ann than wealth. Using method three, Chris wins for the first time because he scores well on dimensions that Anne values (weights) as important. Doing this method mentally would clearly be hard work and error prone, but it has been proposed that this is what our brains roughly attempt. It is clear that the burden on working memory would be considerable.

Dimension	Weighting (importance)	Score X weighting		
		Alan	Bill	Chris
Intelligence	1	5	7	10
Physical Attractiveness	0.6	1.8	5.4	1.8
Sense of Humour	1	8	4	5
Personality	0.9	6.3	2.7	7.2
Job	0.2	1	1.8	1.8
Wealth	0.2	0.4	2	0.8
Total.....		23	23	27

Figure 14. Method 3: all dimensions weighted, and summed.

Just before she telephones Chris, Ann quickly reviews her decision and realises that her analysis method is still yet insufficient. Anne's current life objective is to settle down and have a family, and so the same desire in a potential partner is critical. The way that she generated her dimensions risked missing this most important factor (and perhaps others).

Application of knowledge – rational decision making

In aviation, the most likely occasions when rational decision processes are attempted are novel and/or complex situations, and when time is available. Predictable circumstances are usually trained for and/or proceduralised, so most inflight decisions are rule-based or well practiced. Hence rationale types of decisions are only used in flight in response to an unexpected, unusual, ongoing or emergency situations.

The diversion decision (if and where to divert) is the most obvious set of inflight circumstances requiring rational decision processes because most situations requiring diversions are varied and novel (there is no easy rule or response). The combination of circumstances and options (often accompanied by an emergency) are unlikely to be the same as previously practiced due to situational complexity. Hence, although expertise can be factored in to such circumstances, large elements are effectively new and unpracticed on every occasion. Because of the inevitable novelty and complexity of divert decisions it is generally agreed that it is better for crews to consider and discuss them carefully, rather than simply act upon them intuitively. This means a process close to rational decision-making. Other situations requiring rational decision processes occur on the ground. Usually, these situations also involve novel complexities around unpredictable factors such as weather and changes to flight plans.

On most occasions where the classic kinds of rational decision making processes are used, the crew will be facing a situation that is undesirable and unanticipated. Such circumstances are not ideal in terms of clarity of thought, and this is why decision acronyms (decision aids) are said to assist. Decision acronyms are as close as the industry has got to proceduralising rational decision processes.

There are many aviation decision aids (all in the form of acronyms) such as GRADE, DODAR, DESIDE, FOR-DEC and SHOR. Each letter stands for a step in the decision process, e.g. DESIDE: Detect, Estimate, Set Safe Objectives, Identify, Do, Evaluate. Such aids work by giving a structure to a decision process, encouraging pilots to use a systematic decision process and avoid shortcuts that can lead to error. It is important to recognise that such tools structure the decision process but do not make the decision.

Research evidence by Li and Harris (2006, 2008) found improvement in the quality of pilots' situational assessment and risk management when using aids, but at the expense of speed (Harris 2011). Jarvis (2007) found no strong evidence that using decision aids (specifically FORDEC and DESIDE) made a positive impact upon general aviation pilots' decision outcomes when continuing towards unplanned IMC conditions. The most likely reason for this was that pilot decision-making during this situation was found to be more aligned with a process of trade-offs than the consideration of options and choices (Jarvis 2007).

Decision aids are most suitable for novel situations where time and information are clear. In general, rational decision methods are unsuited to situations where there is insufficient time to make full use of them. In some situations, using rational decision processes may even be worse than allowing the brain to deploy its normal shortcut tactics or rely on intuition. Hence the key point for operators to note is that rational or acronym-aided decisions should only be attempted if time allows, or if the crew needs a structure or rule-base to revert to normal functioning in times of stress or high workload around unexpected events.

For these reasons, available time should be a major consideration for pilots when determining decision-making tactics. British Airways has led the way in this respect by adding a 'T' prefix to their decision acronym (T-DODAR). The T stands for 'time' and reminds pilots to consider time-criticality and time available before running the decision process. In rare time-critical cases, this can usefully support rejection of an aided decision process (e.g. where it becomes clear that the time spent running the process would be likely to worsen the situation regardless of the outcome). At other times it can help to set boundaries on the decision time (e.g. where there is fuel criticality or worsening weather). An early consideration of available time is a useful addition to a dynamic decision process because there are situations in which spending ten minutes making a decision is itself the worse possible option. Equally, it is best not to rush things when time is available. Hence, encouraging pilots to briefly consider the time available to them before determining how best to proceed is usually time well spent.

It is important for trainers to note that in most everyday situations humans do not use classical methods of decision making, and nor could they. A pilot may make several decisions every minute in normal operation (and many more depending upon the definition of 'decision'). The definition of decision-making could include choices such as whether to put the seat belt sign on, make a radio call, or even check a particular display. Repeatable

decisions of this kind do not require the depth of analysis given to rational classic decision techniques, and tend to happen effortless or even autonomously like skills.

With or without the support of decision aids, rational decision-making processes can be poorly used even when the situation is optimal for their use. One common problem is option generation. In most situations there is no way for crews to systematically generate options and no way of knowing whether they have exhausted the possible alternatives. Beyond option generation lie a number of other problems for flight crew. These are illustrated in the example of Anne, where each analysis method was flawed in some way. These problems can be generalised as follows:

1. Unsystematic consideration of the options (plucking positives and negatives out of the air in response to each option) can lead to missing important dimensions that will appear obvious in hindsight. This is very common when applying rational methods to unexpected situations.

2. Being influenced by the 'amount' of good and bad points is misleading, hence the need to 'score' the alternatives (i.e. consider the amount of 'good or bad' not just if it is good or bad).

3. The amount of 'good or bad' still fails to account for the importance of each dimension. Good scores on important dimensions should give more influence to the choice. Hence there should be some consideration of what is required of the options prior to option assessment, or at least afterwards (as a review).

Use of decision acronyms would not necessarily avoid or mitigate these problems. To demonstrate why not, consider a night time diversion decision with three options (A, B or C). The method that some crews use will sound like Ann's first method (and probably fit with a decision acronym). The crew goes through the options in turn, considering the positive and negative points of each. There may be no systematic consideration of what dimensions should be considered, with the risk of missing important dimensions such as runway length, weather, or airport opening times (because these were not triggered by any particular option). When crews start their decision from the options rather than the objectives or dimensions they risk missing important aspects of the problem.

Notice that a crew needs technical expertise in order to generate the important factors (dimensions), weigh them, generate the options, assess them, and decide the best to choose. Such expertise is not part of CRM training but is gained through experience and technical training. Hence CRM can solve some parts of some decision-making issues, but must rely on good technical training and pilot expertise to be fully realised.

Here is where CRM integration has some way to go. To teach people 'decision-making' in a CRM classroom is good but insufficient. Telling pilots to consider options does not help them identify the options, nor how to go about evaluating and comparing them. These things require specific technical knowledge.

Finally, Anne's example did bring out a particularly important aspect of good decision-making: the review. There are two main reasons to review decisions after making or executing them. Firstly, when caught up in the decision process, the sheer workload means that there is a chance that even quite obvious issues (e.g. options or requirements) will be missed, and hence not factored in. Secondly, if a decision is reviewed after the action has been taken then the immediate effect of the decision can be factored into a review, and other important information may come to light.

Application to CRM – rational decision making

The integrated solution is to teach decision methods in parallel to teaching the main decision elements required for that general class of decision. In the case of diversions this might mean (after establishing time available) pilots identifying the important requirements (e.g. runway length, weather, range, etc.) and using them to reach the best option. Equally however, in the real world the crew might use the options to generate requirements. This will also work as long as important requirements that are not cued by the options (such as weather) are still considered or reviewed. The exact order or technique used is unimportant as long as the process is sound (i.e. options are considered with requirements). Clearly to teach or evaluate this, the CRM trainer must be skilled in decision processes and assessment, have good facilitation skills, and technical domain knowledge.

Example exercise for integrated rational decision-making

Classroom exercise example (allow at least one hour)

Aim – Improve the rational decision process: crews generate and consider requirements as well as options.

Objectives

- Demonstrate the temptation as well as the problem of driving a decision from the options alone.
- Show the inherent risks involved.
- Make crews consider the critical option requirements.
- Allow them to practice the process, and demonstrate the worth.

Exercise steps

1. Put the pilots into groups (2 to 4).
2. Explain a night time divert decision scenario (Airports A, B, C) and give them a summary sheet with airport plan but leave out some less obvious dimensions, (e.g. information on runway lighting). Make 'Airport A' the best choice (in the absence of the omitted information).

3. Tell the groups to call you across to them if they require any further information about any of the options.

4. Tell them they have five minutes to decide an option (a clock on a computer generated slide would help focus the time element).

5. Ask for then write down their preferred option.

6. Facilitate a debrief;

a) Ask each group what airport they chose

b) Ask what process each group went through.

c) Ask whether they considered the time available to them first, and how that affected the process

d) Make a note of whether they drove the process from the options or the decision dimensions (you can call them factors, requirements, aspects, etc. It does not matter what you call the dimensions, as long as it is consistent).

e) Point out the critical information left out about Airport A (e.g. it does not have runway lights).

f) Did any group miss that consideration – e.g. runway lights? If not, when did they realise that they needed to know? Why? Did they drive the decision process from the options available, rather than considering the requirements for a night time diversion (the dimensions) first? Humans are very bad at considering information that is not immediately to hand.

g) Talk through an effective process (e.g. consider time available for decision then consider the important things required, compare those across the options, consider other information around the options, select the option and review the decision).

7. At this point (or earlier; before the debrief if you are a confident facilitator), ask the groups to step outside the scenario, and simply list all the factors that they would need to consider for any option (airport) in a night time diversion and how important each is (use the term ‘requirements’ if preferred). This will force them to consider the critical decision dimensions in a bottom-up manner, rather than cueing them from the options themselves.

8. Did the groups come up with any factors/requirements (decision dimensions) that they did not consider in the A, B, C exercise? Why did they not miss these previously? e.g. was it because they were driven by the options?

9. Give groups a similar but different diversion scenario to try, but this time allow them to use their newly constructed list of night time diversion decision dimensions in order to drive the comparison of options.

10. Now give them a completely different rational decision (not a divert) and see if there is an attempt to take the critical requirements into account.

This lesson can subsequently transfer directly to the simulator (or be modified as a simulator exercise itself).

Note: This exercise should be facilitated by a person who is a confident in both facilitation AND technical expertise (preferably an experienced airline pilot with examples and anecdotes to hand).

SECTION A, PART 1, CHAPTER 9, SUB-CHAPTER 2

Quicker decision making mechanisms and shortcuts

Knowledge – quicker decision making mechanisms and shortcuts

Humans use *shortcuts* all the time. For example if asked the answer to 70 x 10, most people would not use the process of adding 10 together 70 times, they either retrieve the answer from long-term memory or use a shortcut such as putting a zero behind the 70.

In the same way, many scientists have long believed that humans very rarely, if ever, make decisions in the way that classical models suggest. Simon (1957) used the term 'bounded rationality' to suggest that humans do not have the 'mental capacity' to make perfectly rational decisions. Scientists began to find evidence that the human brain appeared to use various mechanisms and shortcuts that did not fit the rational model (e.g. Simon, Kahneman and Tversky).

Many ways of shortcutting the rational process have been described and studied. Understanding some of these methods will enable a trainer to better understand why a crew did what they did (useful in exploring a case study or observing a crew). It is important for trainers to understand that these decision mechanisms are both inevitable and usually necessary. Trainers should not simply criticise any shortcut that they notice, or crudely draw a causal link between any observed mechanism and a poor outcome.

With rational decision tasks there is a complex mesh of information that the brain must make sense of in order to form a hypothesis on which to base a decision. Selecting and combining information to build a hypothesis is a highly complex task and so the brain usually uses mechanisms that might be considered as 'shortcuts' to construct understanding (and then almost always a partial understanding, no matter how it is done). The trainer should have a basic understanding of common mechanisms in order to assess to what extent those mechanisms may have contributed to an outcome, whilst also appreciating their necessity.

The rational process described previously usually involves having to compare and compensate for numerous different elements. Such compensatory processes demand a lot of mental effort and generate mental conflict (i.e. the various elements make the decision difficult to resolve). It is much quicker and easier to use non-compensatory processes. These are not specific techniques, but processes whereby decision makers only use a small number of factors and simple criteria. For example, when making a diversion decision, rather than weighing up runway length, weather, distance, available approach type, passenger convenience, time, etc, the crew may simply decide to go to the nearest airport with sufficient runway length and weather minima. In that case only three factors were considered, and all were binary choices (yes/no) requiring no optimising of

comparisons and compensations within a mesh of interacting variables. Clearly such decisions risk choosing a non-optimal option, but they are far easier to make and save time. Under high workload, and in emergencies, rational decision processes tend to become more non-compensatory. It can be argued that all rational decisions contain some elements that have been considered in a non-compensatory manner.

Most decisions can be crudely broken down into two parts: the assessment of the incoming information and the processing of that information (including what action to take if any). The first part (assessment) is roughly equivalent to SA (but requires more internal construction of hypotheses) and the second part is what is popularly understood to be the decision. The following description of decision mechanisms is split into two parts accordingly.

Mechanisms for shortening information assessment

Many shortcut mechanisms occur at the stage where information is being assessed prior to generating options, determining responses etc. This must be expected given the huge amount of information that accompanies most big decisions. Working memory cannot hold all the details and complexities associated with all the sources of information, and must therefore find ways to make a decision possible. Here are examples of five important mechanisms (biases & shortcuts) associated with information assessment.

Recency

For good reason, when forming a hypothesis, the brain allows itself to be heavily influenced by information that it perceived most recently. This could also be considered to be an ‘up-to-date bias’, which is probably the reason that natural selection maintained it. One can see that this bias usually has unseen and effortless benefits. Occasionally however it may lead to a more important piece of information being ignored (although this may only be obvious in hindsight).

Neglect of underlying information

It is easy to overlook information, even though it would explain the evidence more reliably. For example, if flight data reveal that visual approaches produce ten times more safety concerns each year than go-arounds, our first reaction is to think that visual approaches are more likely to produce events than go-arounds, and are therefore in more need of intervention. Only when we think a little harder will we recognise that the situation is almost certainly the reverse, because more than ten times the number of visual approaches are flown than go-arounds.

Availability

All things being otherwise equal, information that comes to mind easily (for whatever reason) is much more likely to influence the hypothesis than other information. It is well established that when assessing risk we are influenced by the information that comes easily to mind. This is often said to be why people are unreasonably scared of flying,

because air accidents have a high profile in the media, whereas safe flights are not discussed. The most available information about commercial flying in the mind of a non-flyer may be the memory of seeing the aftermath of a big accident on the news.

Accepting small samples

Humans are quick to extrapolate general hypotheses from only one or two repeated events or experiences. Often this is correct, but it does not account for random chance.

Mechanisms for shortening decision choices

As well as using shortcuts to assess information, humans use various processes to assist in determining answers and responses. Simon (1957) described how in most situations people do not seek the optimal solution, just a satisfactory one (known as satisfycing). Optimising obviously takes a lot more time and effort, but importantly it may be beyond the capabilities of people in most complex situations. Satisfycing can be thought of as a type of short cut, but some academics would not consider it as such; it is often thought of as a normal and natural part of decision processes.

Two other applicable mechanisms that have been well described in scientific literature are as follows:

Anchoring and adjustment

When the human brain has no easy frame of reference to provide an answer or solution it will allow itself to be influenced by anchors that it ‘knows’ rationally are abstract, independent or have no relationship to the situation under consideration. It is as if the brain always requires a starting point from which to adjust its answer, rather than being able to simply generate an answer based on the information it knows. This effect was classically shown by Kahneman and Tversky in the following way: Participants saw a random number generated by a spinning wheel. They were then asked whether they thought the percentage of African nations in the UN was smaller or larger than that number. They were then asked to guess the percentage of African nations in the United Nations. Those who had witnessed a high random number being generated gave significantly higher answers than those who had seen a low number. In fact the ‘random’ numbers were fixed for experimental and analytical reasons, but the participants were not aware of this. This experiment, and others, gave convincing evidence for anchoring and adjustment. For more information, see the extensive and classic work of Kahneman and Tversky.

Confirmation bias

Once humans have an answer, hypothesis, or have decided upon a response, the natural tendency is to give more weight to subsequent evidence that confirms the hypothesis, and to give less weight to evidence that conflicts with the hypothesis. The effect might be so strong as to accept confirmatory evidence and reject contrary evidence. In experiments, when asked to question their own hypothesis, it is regularly found that people ask questions that attempt to confirm it.

Uncertainty

Theoretically, the aim of most decisions is to achieve the maximum utility. Utility is the worth of an option to the decision maker, which may be different for different people. For example; £1,000 is the same regardless of who gets it, but the utility of £1,000 is greater for a poor person than a rich one. The former would go to much greater lengths to obtain the £1,000 than the latter. Utility drives decision making more than the absolute value of the options. The modern view of utility is that it a relative concept.

Usually making a choice involves considering future states that are uncertain, so the decision maker must factor in the chance of an option being successful. This 'likelihood' of success also affects the utility (a near-zero chance of winning a million pounds represents a low utility, despite a million pounds being highly valued by most people).

Use of these mechanisms in general

It is useful to consider these sorts of decision mechanisms as part of otherwise rational processes. There are occasions when a decision will be based solely on a short cut without further consideration of circumstances or options, but usually such processes form a smaller part of a situational assessment or decision choice.

The obvious advantage of these mechanisms is that they save time and effort. However the effectiveness has probably been underestimated in the past, and without doubt these processes are relatively reliable (otherwise they would not have been naturally selected). Some recent research has even suggested that ignoring part of the decision information can lead to more accurate judgments than weighting and adding together all information (Gigerenzer and Gaissmaier 2011). Occasionally however, shortcut processes are followed by the selection of a course of action (or decision option) that was not the best available, even in foresight. The use of decision shortening mechanisms must not be seen as a failure of process regardless of the occasion; such an analysis would be crude and incomplete; most (or arguably all) decisions use shortcuts. It is important that the trainer or instructor identifies the technique that contributed to the problem and determines whether there was any reasonable way of doing it differently at the time (i.e. against the background of other workload and current knowledge).

Application of Knowledge – Quicker decision mechanisms and shortcuts

Shortcuts affect flight crews all of the time. Usually they cause no problems, and combined with intuitively dispensed experience and effortful rational processes, most decisions are safe enough. Occasionally however, such processes create decision errors.

Shortcut mechanisms will become more prevalent as general task load increases, when the time and attention required for rational decision processes is limited. Additionally they may happen more frequently when the decision does not appear so critical, due to lower

prioritisation of attention. Nevertheless In all cases the ability to use shortening mechanisms is important in order to prioritise resources elsewhere.

A recent example occurred where crew actions led to a situation that looked like a technical failure, but unbeknown to the crew was solvable if they ran the appropriate QRH checklist. However recent and available information impacted the assessment of the problem. The captain had experienced several failures on other aircraft (increasing availability of that diagnosis) and the current aircraft had suffered a track error earlier in the sector (increasing recency of that diagnosis). This predisposed the crew to conclude that the result of a later error was a technical failure, which led to incorrect diagnoses and a subsequent incident. The colloquialism that would be applied in hindsight is 'the crew jumped to a conclusion'. However such a conclusion was predictable given the natural decision making process and the workload at hand.

There is no evidence that problems caused by shortcuts and biases are overcome just by a greater understanding that such shortcuts occur. More recent and available information will feel more important even if a person knows why.

Biases and heuristics such as recency and availability can lead to an incorrect diagnosis of a situation and confirmation biases can work against the trapping of the problem. This is why the use of frameworks, reminders and decision aids can help. The decision review is probably the most realistic countermeasure.

A stark illustration of confirmation bias comes from the PSA Boeing 727 that collided with a Cessna 172 at San Diego in 1978. On the downwind leg in visual conditions, the flight crew was visually searching for a Cessna 172 that they had previously had visual contact with. The captains asked: "are we clear of that Cessna?" The replies implied that no one knew for sure, but everyone considered they should be clear, e.g. "supposed to be". The captain then said the following:

> *I guess… Yeah; before we turned downwind, I saw him about one o' clock…probably behind us now*

The first part of the communication indicates that the captain was unsure but then found a small piece of evidence to provide some confirmatory support for this preferred consensus, as opposed to challenging it. One might expect (particularly in hindsight) that the non-sighting of the Cessna 172 at this point would cause the crew concern and lead to seeking evidence of its whereabouts (e.g. using ATC or prioritising the visual lookout). But the very fact that they cannot see it becomes evidence supporting the idea that it is behind them. The captain's statement shows a rationalisation of this position using further aspects such as the earlier sighted position at one o' clock. This is entirely normal and natural, even though in hindsight it might appear to some to be reckless.

Application to CRM – Quicker decision mechanisms and shortcuts

Decision making training in the classroom

As with many areas of CRM, knowledge of human issues is important in terms of motivating individuals to attempt to make small changes to the way they do things.

In terms of classroom CRM, decision-making shortcuts and other mechanisms can be taught through examples of research or abstract situations. The trainer should quickly move to putting these into reasonable context, rather than producing slides and narrative based on textbooks. If the trainer is confident, knowledgeable and able to apply theory quickly to examples, then extracting examples from delegates can be more fruitful than spending time on case studies. If the trainer is less confident than preparing some small examples from accident reports will prove useful. Discussion of examples should lead to discussion of what things can help. Despite this the trainer must not give the impression that the various mechanisms that have been developed by evolution can be easily optimised by education or training. It is also important to avoid giving the impression that decision shortcuts are always problematic.

There is very little valid evidence that teaching decision-making in general improves decision-making in real world environments. Whereas it is probable that certain situations and accompanying decisions can be optimised, the overall phenomenon of decision-making is too wide and complex for general rules to be applied for improvement (so called ‘silver-bullets’). The classroom CRM trainer should therefore attempt to contextualise theory quickly and facilitate discussion of how decision-making applies to certain common situations on the flight deck.

Assessing and observing decisions in the simulator or on line

There is always a reason behind the process of shortening a decision, and where the mechanism seems inappropriate the trainer must explore why it was used.

If a trainer identifies a shortcut as part of problem, then they must first establish whether that shortcut is routinely used in similar situations. If so then the trainer must uncover why it failed in that case. The shortcut may be generally inappropriate, and the training scenario may expose the reason to the crew. However it is likely that the situation was not exactly as perceived by the crew, and the trainer can facilitate some learning about why that shortcut did not work in that situation. The trainer may also discuss ways to add resilience to an inevitable shortcut situation. For example if a crew make a shortcut to allow time to prioritise something else, then putting in place a review or a barrier to error may be appropriate. One can see that a trainer who simply states that using the shortcut was inappropriate is at best missing a good learning opportunity, and at worst re-directing crew resources artificially without considering the unintended consequences.

If a crew makes a choice that appears unwise, they have usually done so because they assessed their chosen option as having greater utility than the other options. The trainer must find out why that option had higher perceived utility for the crew, not why the crew made the wrong choice. There is a subtle difference in approach.

When debriefing such an event it is worth recalling that the utility of a choice is formed of both probability of success and the worth of the choice. The crew may have assessed an option as being likely to work, but it did not work. A common underlying assumption is that because a chosen option did not work, the crew could have known that at the time, or have been able to work it out. This is not always true. Once a scenario has played out, and the consequences of taking a particular option become apparent, the perception of utility will unconsciously change due to hindsight bias (in both the trainer and the crew). If the option worked, the utility will be perceived as higher than it was at the time, whereas if it fails the utility will be viewed as lower than it really was. The trainer needs to be aware of this bias in themselves and not treat the situation as having been more obvious than it was at the time, or the crew's choice as being more correct or more incorrect than it was at the time. A 90% probability will fail 10% of the time. The trainer must recognise this rather than assuming that if something failed then it had been unlikely to work to begin with. Sometimes the right option (at the time) can subsequently fail. The trainer should avoid the temptation of assessing the decision purely on its consequences later on.

Many risk-based decisions taken in flight have an unfortunate characteristic when looked at from the perspective of someone outside the process, or in hindsight. Sometime the chosen option appeared to the crew to represent the least risky choice at the time, but appears to the observer to have been a risky choice in hindsight. The trainer or observer can overcome this natural hindsight bias to try to establish whether the crew felt the decision to be a relatively low risk choice at the time, and why. The level of risk accepted by a crew is not necessarily correlated with the level of risk as seen from outside the decision. Asking what made an option appear less risky than others is usually a more fruitful approach than asking the crew why they took a risk. As a bonus, this approach shows the crew that the trainer is trying to understand the process.

The session debrief is usually the best time to dig into a decision, with the obvious disadvantage of memory limitations, given everything else that may have happened in the meantime. Scientists use various techniques to attempt to illicit information about decisions, and the trainer can learn from these. Some effective questions to try to break into a decision process after the event are:

- What made the decision appear to be right at that time?
    - This type of question aligns the questioner and the crew, as opposed to creating conflict. It shows the crew that the trainer understands implicitly that the decision was made for a good reason in terms of informational assessment.
- How was the situation expected to pan out after the decision?

- This type of question tries to discover what the future assessment was, and why it appeared to be the right choice of action.

- How confident were you that the decision was good at the time?
  - This gives a clue as to the nature of risk in the decision. The decision may look risky to the trainer, but may have appeared to the crew to be low risk at the time.
- After the decision was taken, what else occurred that made things go wrong?
  - This type of question helps the trainer and the crew to align their perceptions of the situational variables that impacted upon the decision. The trainer can then decide to what extent those factors were reasonably predictable, or linked to the decision process.
- What would happen to a crew in your position who chose to do [a different option]?
  - This gives the crew an opportunity to explain why they did not choose other specific options, and may enlighten the trainer to their decision making process. It is too easy to make the assumption that alternatives would have worked better, without testing them or considering them fully. Having discovered why the crew assessed the situation in the way they did, chose the action they chose, and rejected the alternatives that they rejected, the trainer will be in a strong position to give realistic feedback and assessment of what occurred.

SECTION A, PART 1, CHAPTER 9, SUB-CHAPTER 3

Very fast (intuitive) decision-making

Knowledge – very fast decision making

It has long been known that some seemingly complex decisions appear to be made without the effortful process of considering options or even using shortcuts. This is different to a reflex action (i.e. ducking to avoid a thrown object). It seems that there are times when despite a situation being seemingly ambiguous or complicated an answer 'comes to the mind'.

There are a number of scientific schools of thought around such decisions, such as the process being emotionally driven, being driven by common unconscious decision biases or the process being primed by deeply learned but 'non-declarable' expertise. The latter school of thought will be considered for the purposes of this section. The scientist best known for his extensive work on this area in the last few decades is Gary Klein. Klein termed this process 'recognition-primed decision making' (RPD, Klein 1998) after his research in naturalistic decision making situations. His work is well known for being carried out within real world contexts. This means that it is not concerned with clinical laboratory tasks, but with understanding how real people (particularly experts) make critical choices in their real environments (i.e. on the job). Klein spent many years studying and observing various experts in order to describe the process.

In general (and at its most basic level) RPD is a process whereby typical situations are recognised from previous experience. The decision maker then quickly simulates the first option that comes to their mind and as long as it seems like a satisfactory response, they carry it out. If that first option is not satisfactory, then they move to another. Hence, one fundamental part of recognition-primed decisions is the serial processing of options. This means that a single option is generated and then tested (mentally simulated) before any other options are generated. If the option is satisfactory (if it seems likely to fulfil the objective) then it is acted upon, but this means that there may have been better options that were never considered. However RPDs are all about speed and workload, not optimisation. This therefore has a strong theoretical similarity to the theory of satisfycing (Simon 1950) that was discussed earlier.

Application of Knowledge - Very fast decision-making

It is arguable that most decisions made on the flight deck could fall into the category of recognition-primed decisions. This is because both crew-members are experienced enough to base choices on past experience.

Very rarely, crew take RPD decisions that are inappropriate in the circumstances. The Tenerife 1977 runway collision is a probable example (although it will never be known for

sure). The captain's decision to take off was not discussed or analysed, and appears to have surprised the other crew-members. It appears to have been taken very quickly without consideration. But there are many reasons why the captain would have felt that the situation was typical of one where the decision to take off was appropriate. He had spent most of his time in simulators where RT practices were often not fully adhered to, or were of secondary importance. In the captain's mind, the communications (departure clearance) probably did not feel different to a typical take off clearance, and did not therefore flag a problem. Indeed the communication using the term 'clearance' was probably enough to cue the captain to take off given his recent simulator experience. He could not see the other aircraft and probably felt that it had cleared the runway, perhaps because he heard the previous conversation that he perceived as indicating that the American 'clipper' would leave the runway. His mental model was that the runway was clear. With the perception of a clear runway and the perception that clearance had been given, he made a decision that he had made thousands of times before: to take off. It can be seen that the situational assessment (that of situational 'typicality') was the critical issue in terms of the decision error, not the decision choice itself (the choice was a 'symptom' of the situational understanding).

A real world situation can often generate a feeling (in the moment) that it should be safe enough to 'bend the rules' in this case. This happens when a situation has many typical features and the expert does not have the time or capacity to consider everything at that moment. If there is motive or pressure then a decision to go further than agreed becomes more likely and will appear reckless in hindsight but feel acceptable at the time. Specifically the busting of minima or agreed bottom lines can feel acceptable at the time but may be based on partial information. For this reason it is important that pilots are very cautious about allowing themselves to break planned safety limits when under pressure, or even when in seemingly normal circumstances. The following anecdote is a good demonstration of this.

> *As a very new commander, I taxied out at Rome with a large thunderstorm cell approaching the airfield on an otherwise clear evening. The departure queue was long and there were no reports of any wind shear. Myself and the FO agreed that if the approaching rain shafts from the very active CB were anywhere close to airfield boundary we wouldn't go. Murphy's law dictated that just as we became number one for departure, the rain appeared at the boundary. We declined the take-off clearance. The traffic behind was offered take off which they accepted and taxied past, along with another aircraft. I was now on PA explaining why I was unwilling to take off despite the obvious departures occurring beside us and in full view of our pax. The aircraft rolling on the runway disappeared into heavy rain. It then reappeared at about 50' over the grass! A very shaken crew reported severe wind shear at lift off and the tower commented that wind was now 50kts across the runway! They were lucky. Set bottom lines and stick to them. [9]*

Application to CRM - Very fast decision-making

Fast intuitive decisions may not be open to conscious scrutiny at the time. The process is deeply rooted and cannot simply be improved or made error-free by putting in more effort or employing various techniques or decision aids at the time. It is accepted that recognition primed decision making theory (along with all such intuitive decision theory) is largely descriptive, but not prescriptive.

However, this does not mean that knowledge of intuitive decision-making is of no use. Most people are familiar with a feeling about a certain option, or confidence in a choice that they are making, without knowing why (without being able to 'put their finger on it'). It is worth knowing that in many cases such feelings have grounding, even if consciously the reasons cannot be unpacked. This does not mean pilots should always opt for the option that 'feels' better, but that if they feel that one option is better than another, it is worth at least scrutinising why that is the case.

Another learning point is that when there is a strong feeling towards a certain option, a pilot should consider whether there are any particularly untypical circumstances. Intuitive decisions are based on typical situations, and so will be less reliable when the situation has certain atypical features (such as in the Tenerife Airport accident example). These atypical features may require more scrutiny because they can easily cause error in intuitive decisions. It follows that decision reviews are equally if not more important, after a big decision influenced by any form of RPD.

Intuitive forms of decision-making can easily be examined in the classroom, and case studies can be used to show them. Gary Klein's books and papers relate compelling examples of RPD in action. As with other decision making instruction, generating examples from the audience is an effective way to get the point across, as long as the audience participate and the trainer is able to facilitate. However the trainer must also realise the limitations of teaching about intuitive decision making in the classroom, and that just teaching people about the topic will not necessarily be of any use to them in real world situations.

In terms of instructors / examiners, knowledge of intuitive processes as one part of overall decision-making area is very useful. It can help the instructor to understand why a crew did what they did, especially when there was little communication around a decision they made. Without overt communication or discussion, a decision can sometimes appear to be unfounded or rushed, when in fact it was soundly based. If the decision leads to an undesirable consequence, then the trainer should not simply state that the crew ought to have spent more time on the decision, without considering whether extra time would have helped (or even been possible), and should try to resolve whether the decision was in fact better than the subsequent situation made it look in hindsight.

Hence there are several ways that learning about intuitive decisions can help. Firstly, it can help pilots appreciate that their general liking or disliking of an option is often worth further

examination, and secondly it can help instructors or examiners to understand what they observe, and to de-brief appropriately.

In general

It is useful for trainers to learn about different types and mechanisms of decision-making. A common flaw in the assessing of decision-making is to conclude that any undesirable outcome following a decision could have been prevented by spending more time and effort on the decision. Because of the use of decision aids, good decision-making is often thought to be that which appears to be performed in the manner of a decision acronym, regardless of the circumstances. A poor choice is then said to stem from a decision process (of 'rational decision making') that was not carried out properly. Decision aids force rational decisions, and so if a rational decision is inappropriate in such circumstances, so is a decision aid. It is important to note that pilots rarely use rational decision making approaches in the manner that trainers might deem appropriate and in most situations it would not be a good idea to make decisions in that way. A further cautionary note is that behavioural marker systems tend to assume rational/classical modes of decision-making. Hence there is a danger that where decisions were not made in classic/rational ways, trainers will deem them to have been poor whenever the situation subsequently deteriorates, regardless of circumstance, or whether it was realistic to expect the crew to implement a rational, acronym-aided, decision process at the time.

SECTION A, PART 1, CHAPTER 10

Stress in Aviation

Stress is the response to unfavourable environmental conditions, referred to as stressors, and describes how a body reacts to demands placed upon it. Stress applied to an airframe or power plant that exceeds the designed load factor leads to weakening or failure of the component affected. In the same way if excessive demands are placed on an individual, it is possible to exceed the individual's capacity to meet them. This results in deterioration in the individual's ability to cope with the situation.

Stress can develop when an individual's perceived ability to perform a given task does not meet the demand. This gives rise to physiological (physical) and psychological (mental) responses that can affect the individual's performance.

Physical stress occurs when external conditions either put a strain on the homeostatic mechanisms of the body or are so extreme as to nullify them. Mental stress occurs when the perceived demand exceeds the perceived ability.

An individual can be likened in some ways to a bucket in that he or she has only a certain capacity. Once that capacity is exceeded, the bucket will overflow and will hold no more. Just as buckets come in different shapes and sizes, so different individuals have different capacities and abilities to cope.

Stress on a human being can be defined as:

- The body's non-specific response to demands placed up on it, whether these demands are pleasant or unpleasant;
- An unresolved pressure, strain or force acting upon the individual's mental or physical systems which, if continued, will cause damage to those systems.

Thus continued stress can create physical symptoms such as insomnia, loss of appetite, headache, irritability etc. The stimulus for stress is known as a stressor which is the force producing a change in the self-regulating balance between the individual's internal and external environment.

This stimulus will demand a response, which may be psychological or physiological. Thus a stressor is the stimulus and the stress is the response to it.

Stress is an inescapable part of human life. It is impossible to live without experiencing some degree of stress, whether at home, during a work role or at leisure. Further, an optimum amount of stress is necessary for an individual to function efficiently and perform a given task such as flying an aeroplane.

Selye described two forms of stress. The first is 'eustress', which is associated with a feeling of increased energy and ability to deal with the stressor. It can be considered to be

'good stress' which stimulates and adapts the body. The second is 'distress', when the individual feels that events are out of control and there is an inability to cope. This is 'bad stress'.

Stress can be acute or chronic:

- Acute stress is something sudden and unexpected such as an engine fire or losing one's wallet;
- Chronic stress is something that continues for a long period of time such as financial difficulties or inter-personal relationship problems.

The response to acute stress takes three stages, known as Selye's general adaptation syndrome (GAS):

1. Alarm reaction

   In the alarm stage the body recognises the stressor and prepares for fight or flight by the release of hormones (adrenaline and corticosteroids). These hormones increase the heartbeat and the rate of breathing, raise the blood sugar level, increase perspiration, and slow digestion. Depending on the degree of danger recognised, the alarm reaction may result in a burst of energy, greater muscular strength, heightened hearing and vision. For more about the effects of the alarm reaction on cognition see Chapter 7 ('Surprise and Startle').

2. Resistance

   In the resistance stage the body attempts to repair any damage caused by the stress, enabling it to adapt to sustained or chronic stressors such as extreme cold, hard physical labour or personal worries. If the stress continues over a long period, the body will attempt to maintain its arousal state of readiness.

3. Exhaustion

   Exhaustion is short lived and affects those parts of the body that have been involved in the resistance stage. If the combination of resistance and exhaustion continues without relief over a long period, physical symptoms may develop such as raised blood pressure, headaches or indigestion.

Stressors

The total stress that can be imposed on the individual can be considered to come from four sources:

1. Environmental (physical)

These stressors are related to normal events that may occur during flying operations.

They may occur singly or collectively, and can be created by noise, vibration, heat, lack of oxygen, presence of carbon monoxide, the onset of fatigue etc. Others are directly related to the tasks involved in flying and the degree of stress will vary from flight to flight, and for different stages of the flight.

The potential main environmental sources of stress on the flight deck are:

- Temperature: 20 deg C is considered a comfortable temperature for most people in normal clothing. Greater than 30 deg C leads to increased heart rate, blood pressure and sweating whereas less than 15 deg C leads to discomfort, loss of feeling in the hands and poor control of fine muscle movement.
- Vibration: Different parts of the body show a natural resonance at different periods of vibration. For example, the natural resonance of the eyeball is 30-40 Hz, and the skull is 1-4 Hz. Effects of vibration include:
  - 1-4 Hz Interference with breathing, neck pain
  - 4-10 Hz Chest and abdominal pain
  - 8-12 Hz Backache
  - 10-20 Hz Headache, eyestrain, throat pain, speech difficulty and muscle tension
  - 30-40Hz Interference with vision
- Noise: Sound over 80 dB can impair task performance and over 90 dB there is measurable impairment of the task. However, it has been shown that in some situations performance of vigilance tasks can actually be better in high noise levels than in low levels because noise can increase arousal levels.
- Humidity: Normal humidity is between 40-60%. Minor discomfort is experienced above 70%. There is also mild discomfort below about 20% caused by skin, eye, nose, and throat dryness
- Glare: UV radiation from sunlight can cause visual fatigue

2. Life (psychological).

Life stressors are associated with events in everyday life. They are wide ranged and may include such factors as domestic, social, emotional or financial pressures which most people face on a recurring basis. Family arguments, death of a close relative, inability to pay bills, lifestyle and personal activities, smoking or drinking to excess and other factors which may affect physical and mental health, all contribute to life stress which is part of everyday living. These can add significantly to the operational stressors, which are part of flying activities. Stress can also arise from physiological factors such as hunger, thirst, pain, lack of sleep and fatigue.

There have been many attempts to quantify the stress effect of life or domestic events. One such scheme scores stress by totalling points, as follows:

Death of a spouse or partner	100
Divorce	73
Marital separation	65
Death of a close family member	63
Personal injury or illness	53
Loss of job	47
Retirement	45
Pregnancy	40
Sexual problems	40
Son or daughter leaving home	29
Change of residence	20
Bank loan or credit card debt	17
Vacation	13
Minor law violation	11

The cumulative points score gives an indication of life stress, but such schemes need to be treated with caution because of wide individual variability.

<60	Free of life stress
60-80	Normal life stress
80-100	High life stress
>100	Under serious life stress

3. Reactive

These stressors are the body's physical or mental response to situations that arise in everyday life, as well as those that arise when operating an aircraft. They stem from the body's reaction to specific events. Examples in aviation are encountering wind shear on finals or running short of fuel. These are the types of stressors that can cause startles, alarm reactions and fight or flight responses.

4. Organisational

Stress can arise from within the company or organisation for which an individual works. Certain organisational conditions have been identified as potential stressors. These include:

- Poor communication
- Role conflict or ambiguity
- Workload and autonomy

- Relationships with others
- Lack of career development
- Pay inequality
- Bureaucratic processes

Organisational stress in the aviation industry can affect flight safety. It can be avoided when the company is proactive in giving attention to the listed factors, and provides support for employees.

Stress Overload

Stress factors (or stressors) are cumulative and additive. Each individual has a personal stress limit and if this is exceeded, stress overload occurs which can result in an inability to handle even moderate workload. This personal stress limit varies with different people, as it is affected by an individual's physiological and psychological characteristics. For example, some individuals have the ability to switch off and relax, thus reducing the effects of stressors. Others are not so well equipped and the stress level increases to an unacceptable degree. When it happens to individuals working in a safety related environment, such as flight crew, air traffic controllers or aircraft engineers, it can have serious effects in terms of flight safety.

It is common for an individual to believe that admitting to suffering from pressure is an admission of failure of ability to meet the demands of the job. It has long been an accepted culture in aviation that flight crew and others should be able to cope with any pressure or any situation, and training is directed at developing this capability in the individual - the 'can do' attitude.

Sometimes an individual, or his or her managers, will fail to recognise or accept the emerging existence of stress-related symptoms. Denial is common, in an attempt to maintain self-esteem. Once the symptoms are apparent, behavioural changes such as aggression or alcohol dependence may become established. Such behaviour may lead to disciplinary action, which could have been avoided by early recognition of the developing situation and appropriate intervention and support.

Anxiety and its Relationship to Stress

Anxiety creates worry, and in turn any form of worry may lead to stress. Anxiety can be produced when an individual knows that they have no control over events or lack the knowledge to handle them. It is particularly prevalent in people who, for one reason or another, are lacking in self-confidence. This can be changed by increasing knowledge and gaining greater proficiency in operating an aircraft, requiring more time devoted to study and flight training.

Attitudes and general mental state have a direct influence on an individual's wellbeing. Psychological and emotional factors such as fear, anger, frustration, worry and anxiety

may, over a long period of time, begin to affect the physical aspects of an individual's state of wellbeing.

Stress and anxiety are an inevitable part of human life and in small quantities they are necessary to achieve optimum performance. It is nature's way of keeping an individual keyed up for a task, by helping concentration and making recognition of danger easier. On the other hand excessive stress levels lead to excessive anxiety and it is important that individuals are able to recognise this.

Effects of Stress

Individuals respond in different ways to high stress loads. Apart from the effects on behaviour, such as aggression, irritability, dogmatism and frustration, various psychological mechanisms may come into play in an attempt to cope with the situation. These make many of the human vulnerabilities discussed in other sections more likely, and include the following:

Omission

Omitting a particular action, such as failing to lower the landing gear during an approach with high workload and additional distractions;

Error

Incorrect response to a given stimulus, such as switching off the anti-collision beacon instead of the electric fuel pump;

Queuing

Sequentially delaying necessary actions in an inappropriate order of attention priority, such as failing to action a check list while dealing with complicated air traffic control instructions;

Filtering

Rejection of certain tasks because of overload, such as not identifying the navigation aids when setting up for an instrument approach, or failing to consciously hear R/T transmissions;

Approximation

Making approximations in technique in an attempt to cope with all the tasks required in a short-term interval, such as accepting inaccuracies while flying an instrument approach;

Coning of attention

With increasing stress, the attention scan closes in to a smaller field of awareness. This can lead to inability to integrate the available information, and may be seen in the breakdown of the instrument scan during high workload activity in instrument flying conditions;

Regression

Under stress, behaviour may regress to the earliest learnt, such as operating a control or selector in a manner which would have been appropriate to the previous type of aircraft flown but not the current one;

Escape

The ultimate response to extreme levels of stress is to give up or freeze.

It can be seen that many of the above relate to other areas of human factors such as workload, decision-making or error.

In addition to the psychological effects of stress, physical effects may occur which vary from one individual to another. Stress is often interpreted by the brain as some form of threat, and indeed if being chased by a hungry sabre-toothed tiger it is a reasonable assumption.

The 'fight or flight' response is when the primitive automatic responses for handling threatening situations come into play. The hormone adrenaline (epinephrine) is released, causing a rise in blood pressure, an increase in heart rate, deeper and more rapid breathing and an increase in tone of the larger muscle groups. Hormones known as corticosteroids are also released, making available stored sugars for increased energy use. The body is now ready for fight or flight (escape). Unfortunately this is often an inappropriate response because the situation has to be handled by mental rather than physical effort. See Chapter 7 for more details.

Stress Management

A certain amount of stress is unavoidable and indeed in certain conditions, it may be beneficial in raising arousal and hence improving performance. However, stress overload can reduce performance and it is helpful to consider ways of dealing with stress and reducing its effects.

The first step in reducing stress is to recognise when one is approaching the normal stress limit; inevitably this is a personal evaluation based on an understanding of one's own personality and capacity.

In determining fitness to fly, the psychological and emotional part of wellbeing must be considered in addition to the physical. Flying training engenders self-confidence and a strong desire to complete the task in hand. It can be difficult therefore to recognise and admit that one may be approaching the limit.

The maintenance of physical wellbeing can assist in developing resistance to stress.

Actions to deal with stress include:

- Recognise the factors that are combining to cause the stress. Assess one's own situation to see which of these factors is present;

- Deal with those factors that can be removed. Some can be handled just by recognising them by what they are and mentally putting them aside;
- If stress is being produced by overload, pause to organise a list of priorities. Do not allow low priority problems to influence when not intending to deal with them. In flight, follow standard operating procedures and use check lists;
- Manage one's time. Apportioning time to each item helps to develop a cycle of activity;
- When appropriate delegate duties and learn to off load;
- Involve other people. Communicating and avoiding isolation is an effective way of lowering the level of stressors;
- In situations of acute stress, learn to recognise what is occurring. Learn to "let go" and to mentally and physically relax. It may help to consciously relax one's muscles whenever feeling tense or stressed;
- If the situation allows, take a short break for refreshment or relaxation. In flight, hand over control to another crew member when this is possible;
- Physical fitness seems to make some people more stress resistant. Eating regular balanced meals and indulging in physical activity several times a week promotes general health;
- Be positive and tackle responsibilities and problems as they occur. Avoid the tendency to put things off in the hope they will go away;
- Recognise own limitations and avoid over commitment.

Finally, remember that clear thinking, free from emotional or physical worries, is essential for flight planning and the safe conduct of a flight. Accidents and incidents in flight may occur because the requirements of the task exceed the pilot's capabilities, and this is more likely to occur when the effects of life stresses reduce the capacity to cope.

Coping Strategies

Coping is the process in which the individual either adjusts to the perceived demands of a situation or changes the situation itself. Some of the strategies appear to be carried out subconsciously, and it is only when they are unsuccessful that the stressor is noticed. Individuals vary in their ability to cope.

Three coping strategies can be defined:

Action Coping.

In this strategy the individual takes some action to reduce the stress either by removing the problem or altering the situation so that it becomes less demanding. The extreme is

when the individual removes himself from the situation, for example by changing jobs or getting divorced.

Cognitive Coping.

This coping strategy is used when the situation cannot be changed. It involves reducing the emotional and physiological impact of the stress. This may be done by rationalisation or emotional and intellectual detachment from the situation. The effect is to change the perception of the problem even if the demand itself is no different.

System Directing Coping

This is a means of removing the symptoms of the stress by taking physical exercise, using drugs such as tobacco and alcohol or utilising other stress management techniques.

Stress management is the process in which an individual will adopt systems to assist the coping strategies. Stress management techniques include:

Health and fitness programmes

Regular physical exercise assists some people with cognitive coping;

Relaxation techniques

There are many forms of relaxation frequently involving progressive muscle relaxation and the use of mental imagery. Examples include meditation, self-hypnosis, biofeedback techniques and autogenics. Some or all of these can be helpful in enabling individuals to reduce anxiety and control tension;

Counselling techniques

Counselling can assist both cognitive coping and action coping by modifying the way a situation is perceived leading to appropriate behavioural change. It may involve anything from regular sessions with a professional counsellor to simply taking about a stress problem with a supportive friend or colleague.

As in all aspects of human factors, there is much variation between individuals and within the same individual. An understanding of the human response to stressors should assist in developing individual coping strategies.

SECTION A, PART 1, CHAPTER 11

Sleep and fatigue

Sleep

Sleep is essential for restoring the normal balance between the different parts of the central nervous system. It may be thought of as being analogous to the way a computer might work: transferring the day's experiences (from the preceding period of wakefulness) from RAM (random access memory – the type of memory used in the moment) onto the hard disk. This frees up the RAM for use during the next period of work (wakefulness).

Also during sleep, the body's physical functions are rested and some renewal takes place. During sleep, sympathetic nervous activity decreases and the muscular tone becomes almost nil. The arterial blood pressure falls, the pulse rate decreases, the blood vessels in the skin dilate and the overall basal metabolic rate of the body falls by up to 20%.

On average, most humans physiologically need about 8 hours of sleep per night. However, in modern society most adults report an average of 7 and 7.5 hours sleep per night. Studies have shown that up to 75% of adults report day time sleepiness, with nearly a third of them reporting severe levels which interfered with activities.

Sleep loss can be acute or cumulative. In an acute situation, sleep loss can occur either totally or as a partial loss. It can accumulate over time into what is referred to as "sleep debt". As little as 2 hours of sleep loss can result in impairment of performance and levels of alertness. Sleep loss leads to increased reaction time, reduced vigilance, cognitive slowing, memory problems, time-on-task decrements and optimum response decrements. It has also been shown that performance variability increases with sleep loss.

The normal sleep requirement is 8 hours in every 24-hour period, and it is possible to perform a simple calculation of sleep debt when this is not achieved. As the sleep requirement is 8 hours, within a 24 hour period this leaves 16 hours available for activity. Alternatively, this can be expressed as one sleep hour being good for two hours of wakeful activity. The maximum possible credit to offset against sleep debt is 8 sleep hours, meaning that no matter how long is spent sleeping, sleep debt will still begin occur after about 16 hours of continual wakefulness. It is not necessary to sleep for the exact number of hours in deficit to recover sleep debt. Most people find that a 'catch-up' sleep of around one third of the deficit is sufficient. Sleep debt can become cumulative, leading to a decrement in alertness and performance if the deficit is not recovered within a reasonable time.

Stages of sleep

Sleep can be divided into five stages - stages 1 to 4 and rapid eye movement (REM) sleep.

Stage 1 is a transitional phase between waking and sleeping and this normally takes around 10 minutes as a person falls asleep. Sleep then becomes deeper with 15 minutes in stage 2 sleep and a further 15 minutes in stage 3 sleep before moving on to stage 4. Approximately 90 minutes after sleep onset, REM sleep will occur. The cycle of REM sleep and stage 1 to 4 sleep repeats during the course of the night in 90 minute cycles, each succeeding cycle containing greater amounts of REM sleep. An 8 hour sleep period will typically contain about four or five bouts of REM sleep. Most stage 4 sleep happens early in the night, as can be seen in the hypnogram (figure 15) in which the solid bars represent REM sleep.

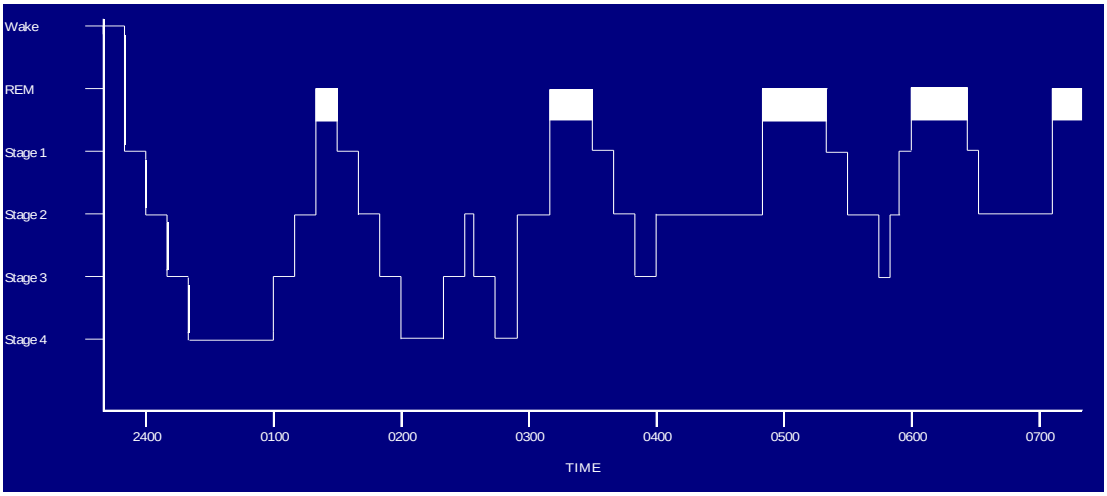


Figure 15. Hypnogram

The stages of sleep can be shown by examination of the electroencephalogram (EEG), which measures electrical activity in the brain. The pattern changes for each stage, and stages 3 and 4 are referred to as ‘slow wave’ sleep from the shape of the EEG tracing. During an eight-hour period of sleep, 50% is usually made up of stage 2.

It is thought that the stage 1 to 4 sleep is related to body restoration whereas as the REM sleep may be related to strengthening and organising memory. When learning new tasks, an increased proportion of REM sleep is seen. REM sleep is sometimes referred to as ‘paradoxic sleep’.

Performance and alertness

Besides sleep, the other major influence on waking performance and alertness is the internal circadian clock. Circadian rhythms fluctuate on a regular cycle which lasts something over 24 hours when allowed to ‘free run’. The circadian rhythms are controlled by the suprachiasmatic nucleus of the hypothalamus situated in the brain which is the time keeper for a wide range of human functions, including physiological performance, behavioural mood and sleepiness/alertness. Many body functions have their own circadian rhythm and they are synchronised to a 24 hour pattern by ‘zeitgebers’ (time givers). Light has been demonstrated as being the most powerful zeitgeber to synchronise the circadian pacemaker.

The mean normal body temperature is 37 degrees Celsius, but it has a natural cycle of less than one degree over the 24 hour period with a minimum at 06:00 hours, rising during the day to a maximum at 20:00 hours. In the normal rhythm, sleep would occur between 24:00 and 08:00 hours when body temperature is falling and reaching its low point. Therefore it is most difficult to work when body temperature is falling, and hardest to sleep when the body temperature is rising.

Moving to a new light/dark schedule (e.g. shift work or time zone changes) can create internal and external desynchronosis. This leads to a discrepancy between internal suprachiasmatic nucleus timing and external environmental cues. The internal clock can take days or weeks to readjust, but generally requires one day for each time zone crossed or one day for every 90 minutes of jet lag.

Crossing time zones is a way of life for long-haul flight crew, and constant time zone shifts can lead to cumulative sleep deprivation due to disruption of the body cycles known as circadian desynchronosis. This is also known as ‘situational insomnia’. However, sleep debt and fatigue can also be problems for short-haul crew as a result of regular early morning starts and long multi-sector days.

Long-haul crew have to constantly adjust and readjust circadian rhythms, and the various intrinsic rhythms for temperature, digestion and excretion get out of phase with the rhythm for sleep. This leads to jet lag or circadian dysrhythmia.

Resynchronisation on westbound flights is aided by the body’s normal circadian rhythm being nearer 25 hours, thus assisting the day to be ‘stretched’, whereas eastbound flights are more difficult due to the day being ‘compressed’. Resynchronisation is easier when local time on landing is behind that at the airport of departure, whereas it is difficult when local time is ahead.

Factors affecting sleepiness include:

- Prior sleep and wakefulness;
- Circadian phase leading to –
  - Increased sleepiness in the early hours of the morning and during the afternoon;
  - Decreased performance in the early hours of the morning.
- Age (the amount of nocturnal sleep required reduces after the age of 50);
- Alcohol (reduces the quality of sleep);
- Work and environmental conditions.

It is vital that pilots and crew-members identify any sleep threat early on, because once sleepiness takes hold it can go unnoticed until too late. The following two anecdotes are not unusual.

1. An ex-military pilot recounted that he had been on task in a prolonged auto hover at 40ft over the sea. It was the early hours of the morning when suddenly he awoke with a startle. He quickly looked around to see if anyone had noticed his slumber and to his horror he realised that the entire crew were sound asleep.

2. It was late at night and the crew were on a prolonged surveillance task which involved hovering at altitude over a city. The commander recalled that after some time on task he had a sensation of falling and realised he had fallen asleep momentarily and lost control. In his startled state he stared at the attitude indicator but could make no sense of it or any of the other instruments to affect a recovery. This disorientation probably only lasted for a second or so but it felt like an age. Once control was regained it took more concentration than normal to maintain. The remainder of the crew, who had been focussed on the surveillance task throughout, were oblivious to the situation and calmly asked if they had encountered some turbulence.

Fatigue

Fatigue can be defined as the likelihood of falling asleep. Therefore, in practical terms, there is little difference between chronic fatigue and acute tiredness. However, the state of fatigue is more complex than simple sleepiness. When experiencing fatigue, the individual's sleep is affected, taking longer to fall asleep, sleeping for a shorter period and having a reduced sleep quality. Increasing fatigue is associated with deterioration in mood ratings. Fatigue can be caused by sleep loss and circadian desynchronosis, but it can also result from low motivation and low levels of external stimulation. In aviation, fatigue becomes important when it reduces efficiency and impairs performance.

In commercial aviation, fatigue is controlled by the imposition of flight time limitations, which are complex and take account of work rest schedules and previous flight duty periods. These do not apply in non-commercial flying but it is important to recognise the effect that fatigue or sleepiness can have on an individual's performance and limit flying time accordingly.

Factors leading to the development of fatigue include early starts, night flying, a high number of sectors and long duty days for short-haul flight crew. For long-haul flight crew there is the additional problem of long flight duration and regular crossing of time zones.

There are two principal components of sleepiness or fatigue:

- Physiological sleepiness - this is a requirement like hunger or thirst and can only be reversed by sleep;
- Subjective sleepiness - this is an individual's perception of his or her sleepiness but it may be affected by other factors. It may be difficult for an individual to subjectively assess his or her own alertness. In general, individuals over-estimate the time taken to fall asleep and under-estimate the total sleep time. Individuals tend to report a greater level of alertness than is actually the case.

Management of Fatigue

Fatigue can be either short-term acute physiological or long-term chronic fatigue.

Short-term fatigue is akin to tiredness and is usually a result of lack of sleep, hard physical or mental exertion, long duty period or jet lag.

Chronic fatigue is much more difficult to recognise and quantify. It may be a result of lack of physical or mental fitness, domestic or work stress, financial problems and/or a high workload. It is subjective, with one individual being able to tolerate a greater level of stress than another before the onset of fatigue.

Fatigue gives rise to impaired performance and reduced levels of awareness.

Symptoms of fatigue

- tiredness
- slow reactions
- diminished motor skills
- diminished visual acuity
- reduced short term memory capacity
- channelled or tunnelled concentration

Effects of fatigue

- reduced awareness
- easy distraction
- poor instrument flying
- increased slips and mistakes
- abnormal mood swings

Individuals have different needs and react differently to sleep loss. Therefore each individual must apply recommendations to suit his or her own particular circumstances.

Preventative Measures

Coping strategies for jet lag

Stop-over less than 24 hours

Maintain eating and sleeping cycle on home time.

Stop-over of 24 hours

This is a difficult time interval to cope with. It does not allow time for two good eight-hour sleep periods, but is too long to cover with a single sleep session. The coping strategy may involve taking a limited rest period on arrival, and then a later longer period of sleep before call for duty.

Stop-over greater than 24 hours

It is important to gain sufficient sleep credit to complete the planned schedule, with an allowance for possible delays.

Sleep scheduling:

- At home the best possible sleep should be obtained before a trip;
- On a trip, as much sleep per 24 hours should be obtained as would be at home;
- Feelings should be trusted - if the individual feels sleepy and circumstances permit, then he or she should sleep. However, if the individual wakes spontaneously and cannot get to back to sleep in about 15-30 minutes, then he or she should get up out of bed.

Good Sleep Habits:

- A regular pre-sleep routine should be developed;
- Sleep time should be kept protected;
- The individual should avoid going to bed hungry, but should not eat or drink heavily directly before going to bed;
- Alcohol or caffeine should be avoided before bedtime.

If necessary, physical and mental relaxation techniques can be tried to aid falling asleep. If unable to go to sleep within 30 minutes, the individual should get up. An optimum dark, quiet and comfortable sleep environment is important. A healthy lifestyle with regular exercise should be maintained, which seems to help with the first stages of sleep.

Decreased wakefulness leads to a state of hypovigilance, which helps to control energy consumption by reducing activity of the central nervous system. Its total prevention in flight is not possible.

Strategies for delaying the onset of hypovigilance during flight include:

- Maintain sleep credit - always plan sleep patterns whenever possible
- Be aware of the symptoms - drowsiness, slower sensory perception, preoccupation with an out of context problem, moodiness, reluctance to communicate

- Alternate periods of activity and relaxation
- Engage in social conversation
- Engage in physical activity such as arm and leg stretching
- In a multi-crew operation, it is possible for crew-members to take planned naps during the flight - these should not exceed 30-45 minutes, and recovery from a nap takes a period of five minutes.

Strategies for delaying or preventing the onset of fatigue include:

- Keep fit
- Eat regular balanced meals
- Avoid regular use of alcohol
- Ensure control of emotional and psychological aspects of life
- Ensure adequate preparation for flight, including flight planning and flight deck comfort.

During flight it is helpful to alternate periods of activity and relaxation. Engaging in social conversation and physical activity such as arm and leg stretching may also assist in maintaining wakefulness.

Caffeine consumption may be used to increase alertness. A cup of coffee usually takes about 15 and 30 minutes to become effective, and the effect lasts for between three and four hours, although this is less effective for those who consume regular large quantities of coffee. A balanced diet including drinking plenty of fluids can also help to prevent the onset of fatigue.

Bright light (more than 2,500 lux), used at the appropriate time in the circadian cycle, can help to reset the circadian clock.

After flying east, the traveller should be exposed to evening light with respect to body time, but morning light should be avoided. Conversely, when travelling west, morning light should be sought and evening light avoided. This makes the best use of the natural zeitgebers in resetting the body clock.

When used appropriately, certain drugs can help in the short-term to resynchronise the sleep cycle after time zone crossing.

Temazepam is a short acting benzodiazepine which is rapidly cleared from the body. Many people find this drug helpful in promoting sleep and used for two or three days after travel, it can assist in resetting the sleep cycle. However, it should only be used under medical supervision and should never be taken within 8 hours of flying as a member of crew.

Melatonin is a substance secreted by the pineal gland with a rhythm that is linked to the light/short cycle through the suprachiasmatic nucleus. It is available in tablet form and has been used by many people to assist sleep. However, despite being a natural substance, the long-term side effects are not fully understood, particularly those affecting reproductive function and heart activity. It therefore does not have a pharmaceutical licence for general use.

Although alcohol is used by some aircrews as an aid to sleep, it is a non-selective nervous system depressant and is effectively a drug. Although it may induce sleep, REM sleep is considerably reduced and early waking is likely. It is important to remember the decrement in cognitive performance and the after effects on the vestibular system of even small amounts of alcohol. It is therefore not appropriate to use alcohol in this manner.

Finally, it should be remembered that there is no simple or single solution for combating the effects of sleep loss and jet lag. The individual has to discover what helps him or her to cope.

SECTION A, PART 1, CHAPTER 12

Personality and cultural differences

Knowledge

It is obvious to point out that everyone is different; some people seem to behave or perform in different ways to others. Although some observable differences are due to situations that people find themselves in rather than personal traits, there are still clearly more stable and permanent differences that exist between people. What is sometimes not obvious is how much of these differences are due to individual personality traits and how much are inherited from the culture that the person developed in. Hence, the easiest way to consider the difference between personality and culture is to appreciate that personality differences are the characteristics of an individual within their own national group, whereas cultural factors are the characteristics of people that are common to their national culture (but may be quite different from people of other cultures). It is clear that complete separation of personality and cultural factors is impossible; personalities are almost certainly influenced by culture, and vice-versa. However the two phenomena are usually treated as different areas within human factors science and research, and so will be discussed as such here.

Personality

Eysenck (1970) developed an approach to personality involving two major factors: neuroticism-stable (denoted by the letter N), and the introversion-extraversion continuum, (known by the letter E). Extraverts are said to be impulsive and sociable, introverts are more withdrawn and cautious. A low neuroticism personality is one of an emotionally stable person, whereas a high-neuroticism person will worry and to get upset easily. High neuroticism is also called high trait anxiety, meaning that high anxiety is a personal trait of that person, as opposed to state anxiety, which is a transient state of anxiety present in anyone at any time. Eysenck deemed the two factors (E and N) to be unrelated (independent). The Eysenck personality inventory (EPI) produces a score on these factors and is widely used even today.

In addition to these two main factors, three others are commonly added to create ‘the big five’. These are agreeableness (A), conscientiousness (C), and openness to experience (O). In order to obtain a measure on these five dimensions, tests such as OCEAN (openness to experience, conscientiousness, extraversion, agreeableness and neuroticism; Collis 1997) are used. The ‘big-five’ personality factors are seen across most modern approaches to personality, even if not specifically labelled as such.

Many other approaches to personality exist, and many other personality inventories are in use. Two well-known examples are Cattell’s 16 PF (16 personality factors) and the Myers Briggs Type Indicator (MBTI). Both are used often in selection and job-related personality

assessments. All such tests rely on participant self-reporting or answering of questions. The use of personality tests is debated.

A note of information: Personality inventories and ‘metrics’ provide one of the most effective vehicles for academics and consultants to productise their services and should be considered in this light along with the underlying scientific publications that underpin them.

Cultural differences

Cultural differences probably feel more subtle than personality differences. The way that people behave, think and interact towards each other generally, as well as what motivates them, will be partly a factor of their national and cultural background. People who have grown up in different countries will have experienced different general ways of acting and behaving, particularly in social situations. They will also have developed different values. A person from one country might act in a way that seems polite, but a person from a different country might perceive that way of acting as rude. One culture may value subordinates speaking up, whereas another culture may value subordinates who obey their superiors unquestioningly. The latter might perceive a subordinate who points out a concern as being impolite, aggressive or disruptive.

Culture of any kind is notoriously difficult to define, or even to explain. Perhaps the best known figure in the area, Professor Geert Hofstede, defines it as “the collective programming of the mind distinguishing the members of one group or category of people from others” (Hofstede 2014). One can see the difficulty of producing a simple definition. Describing cultural differences in more detail has long been an area of debate and study.

The classic Hofstede model describes four major cultural elements (dimensions) that can vary between different cultures:

1. Power Distance (PDI) -This is the acceptance (by less powerful members of the society) of the amount of power held by higher group individuals, and hence society’s acceptance and expectation of differences in power between group members. In other words, some societies are comfortable with large inequalities of power between individuals, whereas others are not.

2. Individualism versus Collectivism (IDV) – This is the difference between the value put on individual needs and the value put on group (team) needs. Western societies are often observed to be high in terms of individualism.

3. Masculinity versus Femininity (MAS) – Societies can reflect more ‘masculine’ or more ‘feminine’ traits. A masculine society is one that values factors such as assertive and materialism, whereas feminine societies are more submissive and cooperative.

4. Uncertainty Avoidance (UAI) – This is the extent to which people avoid uncertain and ambiguous situations.

Hofstede accepts two further dimensions added later by Michael Bond and Michael Minkov respectively;

1. Long term Orientation (LTO) – The propensity for a society to think in long-term or short-term ways. Short term thinking values tradition and current norms, whereas long term thinking adapts tradition and is concerned with thrift, saving and investment.

2. Indulgence V Restraint (IND) – This is how much a society accepts free gratification, or suppresses such gratification for wider or longer term aims.

(Source: Hofstede 2014)

It is not easy for people to recognise their own cultural traits because those traits are such an integral part of their personalities, and unlike personality traits they are reflected in most people around them (i.e. from a similar culture or country) and therefore do not stand out.

Personality and cultural differences – Application of knowledge

Early CRM training often focused upon pilots' personalities. Because many trainers were brought in from management disciplines, the content was often borrowed from management training. The main idea was that by recognising personality traits (themselves and others) crews could work better as teams, and social skills such as communication and leadership could account for the personalities of the crewmembers.

Tests like those mentioned above were sometimes administered to pilots, either as demonstrations and learning exercises, or in attempts to train and educate people around their own strengths and weaknesses. This practice appears to have reduced markedly over the last decade or so, which is probably a positive step for three main reasons; firstly, pilots (like many other people) were not always comfortable openly discussing their apparent personality traits and the relationship of these to their professional duties. Secondly, pilots often inferred (sometimes rightly) that the implication in the training was that some of them had the wrong personality and should change it. Thirdly, evidence that personality relates to accidents is not strong, regardless of the field of study.

A meta-analysis of personality and accidents in high-risk occupations by Robertson and Clarke (2002) concluded that accidents were slightly associated with personality traits such as openness, low agreeableness and low conscientiousness. However Cellar et al. (2000) had found only limited evidence that agreeableness was associated negatively with vehicular accidents, and Salgado (2002) found no reliable association between any personality factors and accident rates. A study of accident involvement in US Navy (Levine et al. 1976) found those with a history of accident involvement to be more risk-taking and more adventurous.

Sanders et al. (1976) attempted to cross-validate previous findings that three factors from the Cattell 16PF (personality factors) personality test were predictive of pilot-error accident

involvement. They found that individual differences in personality characteristics of the aviators prevent consistent identification of traits associated with pilot-error groups. Although there does appear to be some association between personality and accidents, it is unlikely that a single 'accident-prone' personality exists (Sümer 2003; Farmer 1984).

Various scientific studies have found various debatable correlations between personality factors and pilot performance, or cultural differences and pilot performance. One of the biggest problems is defining pilot performance in a way that can be measured and statistically compared to personality or cultural factors. In general, it is agreed that commercial pilots' personalities should be emotionally stable, non-impulsive, agreeable but assertive, and that cultural differences should be appreciated by all crew-members, and where possible substituted for a professional culture.

The emphasis on operational safety culture can be seen as an attempt to supersede the problems of other forms of culture and personality traits with an optimal culture that applies to aviation professionals.

Whereas it is clear that accident rates vary among nations (particularly between the developed and developing world) it is not obvious to what extent, if any, those accident rates are influenced by cultural differences (e.g. between developed and developing nations). Nevertheless some researchers have made convincing arguments attributing cultural dimensions to accidents. One example is argued by Helmrich (1994) to be the Avianca Boeing 707 (flight 52) that ran out of fuel approaching John F Kennedy Airport (the criticality of the fuel emergency was not communicated). Another, argued by Westrum and Adamski (1999) is the runway overrun of Korean Air 1533 in which there was disagreement between the Korean and Canadian pilots.

A large part of CRM training attempts to redefine the operating culture, and where this directly clashes with national culture, CRM has been slow to gain acceptance, or has been rejected. An obvious example is assertiveness of junior flight crew regarding safety critical information. This was accepted relatively easily by Western cultures because it was quite closely aligned to elements within their national culture (e.g. more 'individualistic' and lower 'power-distance'). However the idea of assertive junior pilots directly clashes with some Eastern cultures, where it is seen as anything from impolite to dangerous. It can be difficult for individuals brought up with Western values to appreciate the problem of calling for such activity on an Eastern flight deck; to go against cultural norms can be very damaging to a working dynamic, and lead to a less functional (and possibly less safe) environment.

Personality and cultural differences – Application to CRM

CRM that attempts to improve safety by identifying pilot personality traits associated with safety risk is controversial. Doing so could be seen as another way of expressing the old view of human error (the bad apple theory, that certain people cause errors and accidents and so the solution is to root out those people). A more effective focus might be the way people behave and act in a group and a culture, not what personality people have.

Humans tend to be very quick to perceive differences between themselves and others, and attribute those differences to personal predispositions. Usually, showing why certain types of behaviour or interactions are unhelpful is more powerful in driving change than to focus on pilot personalities. If assertiveness is a good thing, then assertiveness should be encouraged for everyone. It is unnecessary to make this a personality issue, and could distract from the message.

If one is to look at ‘personality’ or ‘culture’ as part of CRM, then rather than attempting to use labels and scientific notions, it would perhaps be more realistic and useful to discuss the sorts of common traits and behaviours that pilots perceive in others they work with (and themselves), what effects and challenges these cause, and what can be done. If this is done, specific personality types need not be analysed. It does not matter what label is given to the various types of behaviour (or perceived traits) that emerge from the participants’ anecdotes during a session (e.g. impatient, supportive, argumentative, cold, etc.). What matters is that the group discusses coping strategies and helpful suggestions from their own experience, in order to maintain effective crew performance. The underlying objective of doing this would be to get peer-influenced buy-in in terms of helpful and unhelpful behaviours.

Discussing culture is usually less controversial among pilots than discussing personality. If pilots of various cultures are in the classroom, then a sensitive CRM trainer can use this to make the sessions more realistic and interesting. They might, for example, ask various pilots how a pilot from their culture may react or behave in given situations. The basic aim is the acceptance and understanding that colleagues who act and behave in ways that seem alien, unhelpful, confrontational, etc are often not necessarily intending to come across in those ways. A pilot perceiving a colleague as doing so should not react in a way that will aggravate the situation, but appreciate that it may be a cultural difference. Emphasis should be on a standard and safe operating culture as the ultimate redress for cross-cultural issues.

SECTION A, PART 2

The Crew

In this Part:

Chapter 13

Effects of groups and teams (Coordination, Teamwork, Roles and Group decisions)

Chapter 14

Leadership

Chapter 15

Communication, Shared Mental Models, Assertiveness and Intervention

SECTION A, PART 2, CHAPTER 13

Effects of groups and teams (coordination, teamwork, roles and group decisions)

Knowledge

Having a crew means having spare capacity, redundancy and safety. Really effective teamwork can go further; providing synergy. Synergy is the concept that the product of the crew is more than the sum of the two pilots combined. In other words the team aspect adds something extra. Examples would be the ability to generate the best solutions or the ability to understand situations through team discussion. In poor cases, having two individuals can be worse than one. For example if the group becomes disruptive, political, argumentative, etc. Hence, it is important to make sure that flight crews can work together in specific roles within the operation, and contribute to the overall team.

The study of groups of people is known as group dynamics. When a number of people interact with a shared aim or experience, they are called a group. A strong group is said to be cohesive. Cohesion is the subtle bonds between group / team members at any time, caused by liking, dependence, trust, etc. Cohesive groups are more functional, but also more inward looking.

The way that people act and behave is usually quite different when they are part of a group or team, compared to when they are alone. That difference may be difficult for the individual to recognise at the time.

The essence of group behaviour (the behaviour change between ‘individual on their own’ and ‘individual in a group’) is the role that the individual takes on when in a particular social or professional context. Taking on a role usually involves taking on a subtly different identity (sometimes called a social identity or group identity) and is a bit like temporarily changing one’s personality. This can be informal or formal. In an informal group situation such as a group of friends, a person may take on a fairly permanent role, for example becoming the leader, the counsellor, the arbitrator, the antagonist, the joker, etc. These roles can become internalised and drive the way that that person acts whenever they are amongst that particular group of people. Such behaviour may be quite different to the way the person seems to act at other times (i.e. when with their family). The person may feel like a ‘different person’ in certain company, compared to other company, due to the role they take on. Roles can also be formal, such as an appointed captain and first officer. The internal expectations associated with a role predict the types of behaviour that people exhibit when in those roles. This is the essence of good role modelling: so that when newcomers take on a role, they have a good model from which to anchor their behaviour.

The most famous psychological observation demonstrating the power of roles was carried out by Professor Philip Zimbardo at Stanford University in the 1970s. A fake but realistic

prison was set up in the university. After agreeing to take part in 'an experiment' student volunteers were unknowingly and randomly assigned to two groups; prisoners or guards. Guards were given sunglasses and uniforms, and told to guard the prisoners, but there was no detailed instruction of how to do so. The prisoners were realistically 'arrested' at their homes and taken to the prison. The plan was for Zimbardo's team to subtly observe what happened for the next two weeks, but not to interfere. Rather than the student volunteers deciding to walk away from the bizarre experiment, they became immersed in it, taking on their roles. After a minor revolt, prisoners fell into the role of prisoners, being subordinate and accepting all sorts of real punishments and bad treatment. Guards became abusive and devised such unpleasant and unnecessary treatments that Zimbardo had no choice but to call off the experiment after just four days. Afterwards (even many years later), the students who were assigned as guards were shocked by the way they had acted, and felt that their behaviour went against their normal values. They had become immersed in the role of prison guards, their actions seemingly being driven by what they felt the role of a prison guard was. In the same way, individuals' behaviour and actions are driven by their perception of what people normally act like in those roles (called norms). It is worth considering what pilots consider the norms of their own roles to be.

Even where a social group is absent, it is possible for the simple presence or attention of others to change one's way of behaving. In aviation, a classic example is airshow flying, where a crowd of passive spectators can influence an individual to behave in a way that seems out of character (even to themselves). Research by Papdakis and Jarvis (2008) showed that despite airshow pilots performing more practice flights than flights in front of an audience, they were more likely to crash when flying at an audience event. With responses from pilots right across the world, the same research project found evidence to support a view that many pilots hold seemingly inconsistent values towards their own safety. This is a common and natural effect of social behaviour. Evidence suggests that the values held by many airshow pilots towards safety, subtly changes in the presence of an audience, when their role appears to shift towards their airshow-pilot "persona" (Jarvis 2010).

> *Our multi-aircraft display team was due to open the show before transiting to another display. The wind was gusty and the cloudbase was low and grey, and not particularly inviting. Frankly I didn't want to fly but none of my team-mates seemed concerned so I thought I was having an off-morning. We taxied out past the expectant crowd line and this probably presented an implicit demand on us to fly when we really should have stayed in the pilot tent for another hour and waited for conditions to improve.*

Within groups, roles usually demonstrate some hierarchical elements. A common characteristic of groups is the tendency of members (particularly those lower down in the social hierarchy) to follow group practices and norms. This is known as group compliance. The classic experiments of Stanley Milgram carried out at Yale in the 1960s, and repeated many times since, show an extreme aspect of compliance called obedience that is important for leaders and follows to understand. Milgram set up a fake laboratory where volunteer participants had to ask questions to another person (whom they perceived to be

another volunteer, but was in fact an actor) who was strapped into a chair with fake electrodes attached. The volunteer was instructed by the experimenter (another actor) to administer increasingly large electric shocks to the person in the chair, whenever that person answered a question wrongly. Some verbal pressure was put on the volunteer, but nevertheless almost all volunteers administered a shock and over half of volunteers administered a lethal shock despite clear labelling to that effect and the respondent apparently being in serious distress (indeed ultimately pretending to have died). Repeated trials with many variations by many scientists have shown similar results since, and the general effect is undeniable. In essence, the effect of being in a subtly subordinate role (taking instructions from a perceived figure of authority) can lead people to take actions that they would normally not take.

Group decision-making

Group decision-making is a complex and well-researched area. Processes similar to individual biases can occur, as individuals consider the situation and generate options. However, on top of this, there are effects unique to groups. One of the best known is called group-think. This is where members of a group are reluctant to challenge the decision of a leader (or the group) and instead overtly agree, even when in doubt. There are a number of reasons why people do this. One is to maintain their own position in the group (be favoured by the leader and others), another is to maintain good group relationships. The members often recognise that group issues are more important to them than the decision (the task is sacrificed for the relationships or politics). These effects have been well researched and expertly described in some famous case studies, perhaps the two best known being the J F Kennedy ‘Bay of Pigs incident’, and the space shuttle Challenger (see Janis and Irving 1982, and Moorhead, Ference and Neck 1991).

A related effect (arguably a symptom of the group-think phenomenon) is risk-polarisation. This is the tendency for group decisions to err towards extremely high or extremely low risk strategies, rather than moderate risk strategies which individuals are more likely to make alone. Risky-shift is perhaps the most applicable effect for flight decks, which is simply the high-risk side of group polarisation. This occurs because an individual’s doubts about a strategy can disappear as others show agreement. Confidence in the decision grows as agreement is perceived. The original decision then appears less risky than it did, and so further discussions that generate even more risky choices appear less risky than they otherwise would have. This effect is accompanied by a diffusion of responsibility, meaning that each group member feels only partly responsible for the decision and is therefore able to accept an overall higher level of decision risk than they would alone.

Application of knowledge - Effects of groups and teams

Flight crews are usually temporary teams; pilots may not even have met until the briefing, so there is no time to develop as a crew before entering an effective working relationship. A common understanding of how the crew will work together is therefore important. Company operating procedures cover functions and actions, but CRM training can show

what behaviours and attitudes are expected, and help to standardise these across the company.

Given human tendencies such role taking, anchoring, adjustment, and confirmation bias, it is important that crewmembers set the right tone straight away (to take on appropriate roles) otherwise small relationship problems can become engrained and reinforced. Good ‘first impressions’ are important for establishing the right authority gradient (the leader and follower roles), including trust and confidence in one’s colleague. It is important to use standard practices and procedures and to act within the accepted norms. This is particularly important when dealing with people from other cultures. Importantly, as well as setting the right task climate, doing this will act to make the situation familiar to everyone. Familiarity makes people feel comfortable, and so pilots that act in standard, predictable ways are more likely to build confidence and trust in others, and begin the process of forming a cohesive and effective team.

Simple acts (e.g. within a Western-Centric Culture, smiling, shaking someone’s hand or using a little humour) are surprisingly powerful ways to set a good initial climate and put people at ease. These small things help to show acceptance of other group members and of the team as a group. Additionally, a captain who shows acceptance of his own natural vulnerability and empowers the first officer by inviting their input usually sets a mutually supportive climate (as long as the first officer understands the message). Some examples follow;

> *Carrying out line flying duties with Police units every month involves stepping in as the duty pilot with the resident crew for 2 shifts. I am acutely aware that whilst being fully qualified and current, I am not as familiar as one of their regular pilots would be with their operation. In an effort to 'highlight' and 'address' this potential problem, I always mention this at the end of the crew brief and encourage the crew to not feel shy about pointing out anything if they see me try to do something that is wrong or different to any of the other pilots, in summary: "Treat me like a fool and I'll try not to let you down". [2]*
>
> *A senior trainer flying with a new F/O set the tone: 'As we haven't flown together before let us set the scene. I am a great believer that we enjoy each other's company and the flight - and of course we will also try do things properly. So if at any stage you aren't sure of what I'm doing, if I'm not doing it properly or you have a suggestion - please say. And I will do the same - does that make sense?' [1]*

A fundamental tenet of teamwork is ‘shared goals’. When team members perceive and desire a shared goal, they are more cohesive and supportive. Fortunately, at a macro level this is a given for a flight crew. However it is still up to the captain to create the sense of shared goals. This can happen early on, for instance by taking opportunities to stress joint tasks and even simply by using the first person plural for shared tasks and goals (“we will / let’s do this and that first”). Asking, or showing acceptance of another crew-members’ opinion is another way of hinting at joint goals. Most good captains do these things quite naturally.

There may be large differences in age and experience between crew-members. Younger, less experienced pilots can be reluctant to challenge or query a captain's actions. Similarly, there may be reluctance on the part of the cabin-crew to 'bother' the flight-crew with concerns. It is important to ensure that communication between team members is encouraged from the outset, even if that information turns out to be non-relevant or not important, or a challenge by a co-pilot proves the captain to be correct. Team members should not be afraid or embarrassed to speak up. Such behaviour should be part of role modelling: showing that the role of a good cabin crew member or first officer includes sharing concerns or information. If it is perceived as part of the professional role, then it will happen with less effort for most first officers. However, captains should still be aware of the vulnerability of some first officers to compliance or obedience.

Compliance (and even obedience) is probably a useful trait for groups in most situations. If a captain were questioned about every command then the crew would become dysfunctional. However, in critical or unusual situations where team members could feel uncomfortable with what is being done or requested, it is sensible to consider the influence of obedience and compliance. Captains should be conscious that a co-pilot acting on a command is not necessarily agreeing with that command, even when they act without question. In the same way, a co-pilot who does not question a course of action is not necessarily agreeing with that course of action. The following anecdote shows that even when specifically instructed, some first officers still find it difficult to speak up in the face of an unsafe situation.

> *My co-pilot had been with the company for about a year; we had flown together before and always got on well. As we planned our approach I made an error of perception and briefed that it would be my landing. The landing direction for an offshore approach is determined by the wind direction, obstacles and orientation of the platform and it is common that only one pilot will be visual with the helideck during the final stages of the approach. Once on final approach my mistake was obvious, yet despite asking the co-pilot if they were happy with the approach on more than one occasion, they continued to reinforce my poor decision.*

It can be seen that leaders should avoid any natural temptation to take comfort from the fact that group members do not show concern or fail to speak up about a course of action that they are involved with. It is natural to infer tacit support or agreement from the actions or inactions of others, and many accidents have occurred where the leader later admitted feeling reassured because the follower appeared to be comfortable with the situation. Only later is it discovered that the follower was acting out of compliance or obedience. It may be said that professionals would not fall into these seemingly obvious traps nowadays, but cases similar to this happen many times a year, and such incidents only seem obvious when viewed in hindsight.

Group decision-making

The group-think phenomenon may at first appear less likely with only two crew members (although one must remember the contributions of cabin crew and outside teams). However sometimes pilots will sacrifice their point of view in order to maintain relationships, give a good impression, or avoid the possibility of being wrong. This will be more likely to occur when the authority gradient is very steep (for example in a training or checking situation or whenever the captain's opinion can affect the first officer's prospects or confidence). This is a further reason to establish a good working climate straight away, and for a captain to emphasise their acceptance to be challenged or advised.

However in many cases a captain may still have difficulty in deciding whether a first officer's opinion is independent, or just an agreement (particularly in the situations described). An effective technique in these circumstances is for the captain to avoid leading or suggestive questions and try open questions. For example:

Leading question: "He said 3,000ft didn't he?"

Suggestive question: "Did he say 3,000ft?"

Open question: "What height did he tell us to level off?"

This can be surprisingly difficult to do in the heat of the situation. Unfortunately, leading questions often come more naturally, and additionally can feel more polite and supportive. Open questions demand a little thought in order to suppress the piece of information that one is focussing on.

> *Conducting a final line check for a converting P2. After pushback our ACARS load sheet didn't come through. We have to enter the runway and vacate to free up the holding point, which included a difficult 120 degree turn at night at a notoriously difficult airfield. So by now (50 minutes after push) we've burned a lot of contingency fuel but still no final figures. At what point do I return to stand for more fuel? I establish my bottom line but how do I have my calculations confirmed by a P2 who is likely to agree that the earth was flat if I said so. So I needed open questions, no statements e.g. 'what do you reckon reserve fuel is? When airborne at what stage would you be happy dispensing with an alternate? What options do we have?'. The answers are good. I ask P2 to work out a fuel figure that he'd be comfortable departing with; "What figure have you decided upon? …Sounds good to me what have we got in tanks? ….Ok do you reckon we can go? …Yep I agree anything else we need to do? …Great let's tell him we're ready for departure.*

In some circumstances, acceptance of another's opinion may be easier than attempting to justify or argue one's own, or risk further upsetting the team dynamic. If the decision is a minor one, then a pilot may feel that the crew relationship is more important than the outcome and so openly agree with their colleague. In the same way, even where no decision has been discussed, it is common for pilots to keep doubts about a situation to themselves because the other pilot appears to be comfortable with proceedings. This is a

group think effect, and it is not unusual for both pilots to be unaware of the other's doubts. To voice doubt or concern (in or out of the decision making process) is to counter group-think.

> *As we taxied out, it was clear that the weather was very bad and might affect the take off or climb out. The airport was well known for challenging conditions. It became very quiet on the flight deck; perhaps we were both thinking the same thing. Aircraft from other companies ahead of us were taking off, and aircraft were queuing behind us; everything was normal: no one else seemed concerned. More silence in the flight deck. I heard myself say "I'm thinking that we should go back to the gate and wait this out". "Yes, I agree" exhaled the first officer instantly, clearly relieved. We called our intention on the radio and took the available taxiway turn off, as the airwaves suddenly came alive with the same request from every aircraft behind us! [4]*

The above anecdote shows that social influence effects (similar to group-think) were setting in on two levels; in the flight deck of the particular aircraft, and across the airport operation. This was causing crews to continue as normal despite their doubts, because no one else seemed to be of accord. The captain's comment on the radio is enough to break the effect. Clearly many aircraft crews were having the same concerns, but did not want to be the only crew to return, and were doubtful because all other aircraft crews seemed to be acting normally. As soon as this captain made the radio call, it demonstrated to all the other crews that someone else had the same concerns, which dispelled the doubt, and gave them more confidence in their own assessments. As more calls were made the group influence effect took hold in the opposite direction. Simply voicing a concern can sometimes tip the balance.

Commanders should be particularly aware of risky-shift. The maintenance of a positive (if shallow) gradient will help to tackle this because the captain should feel a responsibility for all critical decisions, and not allow a feeling of diffused responsibility to be of influence.

It should be stressed that commanders should not feel that due to an expected role (sometimes inappropriately reinforced by CRM), all decisions must include the whole crew. There will always be occasions when the captain uses their discretion, which might mean acting independently as the leader if the situation demands it.

Scenario from a simulator check debrief:

> *Examiner: Why didn't you consult the FO and share ideas before electing to immediately divert? We are meant to involve our colleague…*
>
> *Captain: I considered involving the FO, but I noticed that he was already struggling with the high workload and was starting to make mistakes with the FMS - and I decided not to further increase his workload or distract him, especially as we were down close to minimum fuel and there were other aircraft in front of us. In this case I thought through the landing distance, weather and engineering availability.. and the diversion choice was completely obvious… so I decided not to waste time and fuel on*

unnecessary discussion. I do remember checking with the FO that he was comfortable with the airfield I announced and he said that he was.

In group situations, where critical decisions and actions are involved, a helpful mantra to remember is: “It doesn't matter who's right, it matters what's right”.

Application to CRM - Effects of groups and teams

In the classroom

The influence of groups is a wide-ranging topic with a strong research history. Taught well, it should be fascinating for an audience. Some of the research experiments (such as Milgram and Zimbardo) are worth outlining if time allows. The key theoretical points to put across are the importance of roles and norms and the influence these have on behaviour. From a decision perspective, the dangers of risky shift and group-think can be emphasized using appropriate case studies. Awareness of the effects and the maintenance of a sensible cockpit gradient are important countermeasures.

The subject and application of roles can be reinforced and explored by finding out what expectations captains and first officers (or pilot handling and pilot monitoring) have of their own and each other’s roles. The trainer can ask the participants questions such as: “what is a captain ‘like’ / what should a captain be like? What is an FO ‘like’?” The answers can be compared between the two groups to see if differences exist. What the facilitator is looking for is the *stereotype*[1], because that will inform the group about the role models that influence behaviour. The facilitator can help to emphasise the effective aspects of the roles. Similar exercises can be done for any job role (e.g. cabin crew).

Classroom sessions about social influence can discuss what aspects of an aircraft operation might be vulnerable to such effects. Some examples are:

- Wanting to be accommodating to ATC
- Wanting to please of passengers
- Wanting to impress others (e.g. flying a friend or doing an airshow)
- Not wanting to hold others up (e.g. accepting an abbreviated circuit) or keeping up a higher speed than desired.
- Not questioning a situation because another pilot looks comfortable with it.

An ambitious and capable trainer can have a lot of fun teaching about group effects because the audience can be used to create these effects, in order that they see the issues for themselves. For example: splitting into groups of five and giving the groups a

[1] A stereotype is the ‘aggregated’ set of behaviours that a person would expect from a role. Stereotyping is natural and unavoidable, although more commonly it is colloquially aligned with undesirable and judgemental behaviour, and so the word ‘stereotype’ might be best avoided in a classroom situation.

challenge such as a tricky logic puzzle can bring out many effects including role taking and group decision-making. By debriefing the groups the trainer can show how an informal leader probably emerged (why was it that person?), how the group dealt with differences of opinion, whether anyone suppressed their doubts (group think) etc. The issues emerging should quickly be applied to a flight deck activity / example. This sort of exercise can be rewarding and useful, but if done badly is boring for the audience or could appear irrelevant to their work. A trainer should avoid this sort of exercise if not confident in their classroom management, knowledge of group effects, debriefing skills, or ability to apply emerging phenomenon to flight deck activities in real time. It is also important to note that such exercises can take a lot of time.

The classroom trainer can also explain when group-think is likely (high authority or checking environment) and ask for ways of countering it. They should facilitate discussion in which countermeasures emerge such as the use of open questions when needing a double check. Practice at turning statements or leading questions into open questions can be done in a classroom CRM environment.

In the simulator

Social effects are difficult to teach, assess or observe in a simulated environment because the environment is socially artificial, and therefore people may act quite differently when in a real situation. For example, in the simulator some pilots may be less likely to openly express doubts and concerns to the other in case these prove unnecessary and draw the attention of the trainer to the fact that they are unsure about some aspects of the situation. The trainer needs to be sympathetic to explanations given by crews during debriefs, and be sensitive to issues that might have been caused by the simulated environment rather than the task itself. On the other hand, the trainer can use knowledge of roles, norms and groupthink to help understand and explain some seemingly strange behaviour and performance that is not explained by technical phenomena.

SECTION A, PART 2, CHAPTER 14

Leadership

Knowledge

Attempts to understand effective leadership can be traced back as far as Plato, who endorsed the theory of ‘expert embodied authority’ that stated that the most effective leader will be the person with the greatest appropriate 'expert' knowledge. Modern leadership theories understand 'expert knowledge' as just one part of one factor (the leader) determining effective leadership. For example, it is clear that the best captains are not always the most experienced pilots, and vice-versa. Such variance in leader effectiveness points to factors other than expertise to explain good leadership. Researchers in the mid-twentieth century recognised that the 'social atmosphere' or 'social climate' of a group was more responsible for its overall effectiveness than the leader. Because of this, a big part of effective leadership is now understood to be about optimising that climate. In the 1950s Bales noted that leader interactions fell into two distinct strains; those oriented towards the completion of the task, and those oriented towards the maintenance of relationships (in this respect, the similarity to group decision-making and other social phenomena is clear).

The later part of the twentieth century saw more models of leadership emerge, such as situational trait approaches, where effective leadership was seen as a happy match of a leaders’ traits and the situation that the group was in. This predicted that where some people may be good leaders in some situations, they might be poor in others. More modern theories such as situational behavioural models describe effective leadership as being a combination of situational variables and leader behaviours (rather than simply leader traits).

Scientific research in leadership is usually of the observational and self-reporting nature (i.e. observing leader behaviours and comparing these to effectiveness and group satisfaction), or examining case studies.

The three classically researched styles of leadership are autocratic, democratic and laissez-faire. Pure autocratic leadership is where all leader interactions and behaviours are focused on productivity (effectiveness), and relationship factors such as social cohesion are effectively ignored. An autocratic leader is not necessarily one who interacts in a hostile or stern manner but this can sometimes be the characterisation of a purely task-orientated leader. Democratic leadership is characterised by inclusive leader behaviour where ‘followers’ are given overt responsibility and included in steering tasks such as strategic decision-making. Democratic leadership can be roughly characterised as a balance between task-oriented and relationship oriented leader behaviour. Laissez-faire leadership is where the leader allows the group members to do whatever they wish (the leader may set or explain the tasks, but then does not stipulate or manage group

behaviour). Although usually researched as distinct groups, these leadership styles are best thought of as a continuum.

Early studies by Lewin, Lippit and White found strong evidence that (in classroom situations) autocratic leadership was the most effective for simple productivity, followed by democratic leadership. Laissez-faire was very poor. Democratic leadership led to more group satisfaction and therefore a more sustainable climate. In the temporary absence of the leader, productivity suffered seriously in the autocratic climates but little in democratic climates.

In general, a balance of task-orientated behaviour and relationship maintenance predicts more effective leadership. An imbalance in either direction can be detrimental.

In informal groups (such as groups of friends or classmates) leadership emerges ‘naturally’, whereas in formal and professional situations leaders are appointed. Either way, a balanced and effective climate is easier for a leader to produce if a leader has implicit ‘authority’ within the group. The term ‘authority’ is used here in a colloquial sense, as a way of describing the combined facets of the leader that make the group members implicitly consider that leader as being above them in the social hierarchy. In this sense, leader authority is a property of the followers, not the leader themselves. An informal leader who emerges has the advantage of implicit authority almost by definition (that is the reason that they are the leader), whereas a formal leader must ‘create’ that perception of authority. The characteristics and behaviours that make informal leaders emerge would be helpful to formal leaders too.

In the case of captains, the formalised position within the organisation is an important signal of authority, reinforced by seating position, uniform, etc. These identifiers help to establish authority, but are not in themselves sufficient. Clearly, overall respect for the organisations’ command process will contribute to this. Beyond this, authority is helped by task factors (such as expertise, good track record, ability to achieve goals, etc.) and social factors (such as being liked, respected, attractive, feared, etc.).

Application of Knowledge – Leadership

Although most leadership research has been done observing large groups or management teams, general parallels can be cautiously transferred to multi-crew flight decks. Flight deck authority gradients align approximately with the continuum formed by the three classic types of leadership. An autocratic gradient is one where the captain makes most decisions without consulting or considering the first officer. The captain’s behaviours are probably task orientated, and may be lacking in social maintenance. A number of accidents have previously been partly attributed to autocratic flight deck gradients, the most notable being the KLM/Pan Am runway collision in Tenerife (1977). One of the early aims of CRM was to reduce authority gradients. The aim was to encourage first officers and other crew-members to speak up (be assertive), and to encourage captains to be more inclusive and exercise joint decision making where possible. In essence, CRM principles aimed to reduce the flight deck gradient to a democratic situation (often called a

synergistic gradient). However in some cases the gradient reduction went too far and produced a near laissez-faire climate, where task-orientated behaviours were not properly prioritised. Such gradients lead to off-task conversation and behaviour, even at critical times. Accidents such as Delta 1141 at Dallas Fort Worth in 1988 demonstrate the effects of laissez-faire cockpits. Sterile cockpit requirements were one way of countering these sorts of problems.

The desired situation is a gradient that recognises the captain's authority, but retains relationships and synergistic working. This requires a balance of task-orientated and relationship orientated behaviours, the amount of which depends on the crew-members and the situation. It is impossible to be specific or prescriptive about the ideal mix, or even the ideal behaviours. In some cases, task-orientated behaviours will coincidentally be good for relationship maintenance, particularly where there is a strongly shared goal. If the crew work well as a team to attain joint overall goals, there is an extremely positive effect on relationships. Maintaining relationships is more challenging when tasks are going wrong, or the goals are not being achieved. It is important to note that leaders cannot achieve an optimal working environment through use of relationship maintenance behaviours only; the usual result of such behaviour will be a laissez-faire climate, which in the long-term is unsatisfactory to everyone, as well as being unproductive. In other words, being friendly and trying to be liked is only effective (beyond the short-term) if accompanied by task-orientated leadership that achieves task goals. In the long-term, too much emphasis on relationship-orientated behaviour at the expense of task-oriented behaviour will usually lead to the opposite of what is intended, and the subordinates will feel negatively towards the leader regardless of their attempts to be liked.

Captains must therefore retain authority and executive control over the overall climate and strategy, and should be seen to be doing so. It is important to recognise that good CRM is not about establishing a flat or shallow cockpit gradient, nor a very steep one. It is not just about being nice or being liked. In an ideal situation, the captain should feel sufficiently empowered to determine critical decisions in the best interests of flight safety, not in the best interests of CRM or crew relationships. Most effective first officers prefer positive leadership.

> *The FO was flying into a demanding airfield with maximum gusty crosswinds and the aircraft was damaged after a heavy side load landing. Subsequently the Captain said that on approach he was thinking 'I wish I was doing this' and the FO was thinking 'I wish he was doing this' … but no one said anything.*

In the above anecdote, the captain has avoided taking what he felt to be the safest course of action, in order to maintain the first officer's contribution to the task. This may be an unintended consequence of CRM training, because the captain mistakenly felt either insufficiently empowered to take the task-related action he wanted to, or he felt that the first officer's entitlements were more important than the captain's task preference. It also demonstrates that effective leadership depends to a large extent on those being led (followers). Followers can dictate part of the situational component of effective leadership.

Acceptance of the captain's authority is an obvious requirement, helped by respect for the organisation and process by which the captain was appointed. But good 'followership' also involves assisting in the creation of the right social and task climate. This might involve reassuring the leader of their authority and support, as well as completing tasks as required and keeping the leader informed of the status of those tasks. It also requires followers to communicate doubts and concerns about their own abilities when appropriate so that the leader can cater for these (as in the above scenario).

Followership behaviour motivated by goals other than joint goals can be destructive. An example would be a first officer attempting to be seen in a better light than their captain during an observation. Good followership involves taking a supporting role that does not attempt to undermine the leader.

Finally, it is worth considering that good leadership skills can be helpful in single crew operations, and so should not necessarily be restricted to multi-crew CRM training. Single pilots often have to show leadership when dealing with people who make up the wider operation. Examples might be in dealing with ATC (e.g. having to refuse an ATC request), dealing with passenger behaviour, or demonstrating authority when protecting safety interests against commercial or social interests. A good example follows;

> *The commander was to conduct a single-pilot task to transport a newly married couple from their wedding reception to the local airport, where they were to board a flight to commence their honeymoon. The couple emerged from the reception followed by an entourage carrying many heavy bags and it was immediately obvious to the commander that if he agreed to carry all the baggage he would be overweight. Resolving the conflict with the groom and bride's father required assertiveness, tact and diplomacy, normally dismissed as irrelevant during single pilot CRM training.*

Application to CRM – Leadership

Effective leadership should be taught as part of CRM training and assessed as part of most non-technical skills assessments (it appears in most behavioural marker systems). It is therefore important that CRM trainers can describe and recognise the difference between good and bad leadership (and factor in the positive and negative effects of situations and followers into their assessment).

In the classroom

In a classroom, the ability to practice leadership skills can be limited. A practical method is for the trainer to try to paint a clear and complete picture of what good leadership looks like, in normal and non-normal situations. If done well, this can act as a role model for participants. For obvious reasons, accident narratives are not ideal for this. Positive examples are less easy to find; the United Airways A320 that landed on the Hudson River is an obvious one, as is the well-known Sioux City DC-10 accident. Others can be sought from within the company, and from other pilots. The CRM trainer could use the NOTECHs (or similar) framework to support the examples. Although some examples of poor

leadership may be worth discussing, in a classroom situation analysis of good leadership will be much more effective. The CRM trainer should also take the opportunity to extract points about good followership from each example discussed. This may be less obvious.

Simulator and Line

The simulator or line trainer attempting to observe leadership behaviour through marker systems is in good historical company. Much scientific research in the leadership field has been through the development and use of observational taxonomies (also called scales) to collect comparable data on leader behaviour. Taxonomies attempt to measure specific observable leader behaviours, or tag them as being good or bad. Overall, good leadership will usually align with good consequences, but it is important to note that good leadership behaviours will not always achieve effective ends due to situational and followership reasons that a captain could not have reasonably foreseen or changed. Hence care must be taken when judging someone's leadership ability on the consequences of a single session such as a piece of LOFT training. The trainer should try to distinguish between poor leadership behaviours given the situation, and satisfactory leadership that does not lead to effective consequences due to subsequent occurrences or situational factors. The best way to do this is to firstly consider whether leadership behaviours were appropriate regardless of the consequence, before considering whether those behaviours necessarily caused the consequence. Behavioural markers can help, because they encourage the trainer to look at the specific behaviours rather than inferring them from consequences or debriefings.

After reading this section, it is worth reading through the Leadership and Management section of the NOTECHS marker scheme (see Chapter 20). This can be used to refresh the trainer prior to a session whether classroom, simulator or line.

SECTION A, PART 2, CHAPTER 15

Communication (communication, language, sharing mental models, assertiveness and verbal intervention)

Knowledge

It is generally accepted that crews who communicate and exchange operational information more often have more evenly distributed workload and commit fewer errors during critical phases of flight (Foushee and Manos 1981, Kanki and Palmer 1993). More modern research supports the premise that effective and frequent operational communication is related to positive crew performance. However this does not necessarily mean there is a simple relationship between the quantity of communication and the performance of the crew. It is possible that good crews also happen to communicate a lot. Research shows that the most effective crews discuss problems in greater depth and use low workload periods to discuss options and plan ahead (Orasanu and Fisher 1992). The relationship between performance and communication is less clear in abnormal and emergency situations however (Harris 2011).

The quality and timing of communication is probably even more important than the frequency. Simply put, communication is the passing of a message (information) from one party (a sender) to another (a receiver). In reality however each communication is a fragile serial process. Communication can fail because the message is omitted, poorly constructed, not transmitted, blocked or lost, not received, or because it is misinterpreted by the receiving party. It can be seen that successful communication is sometimes taken for granted, because there are many weak links in the chain, any one of which can cause a failed communication.

It has been shown that humans naturally use several channels when communicating or receiving information. Talking (verbal communication) is supported by other cues such as intonation and body language, although the main content of a spoken message is usually communicated verbally. Supporting a verbal communication with other cues, such as visual cues, can help to get a message across.

Obviously, many verbal communications fail in transmission because they are masked by other sound or noise. A less obvious (but more common) failure is caused when the receiver does not properly perceive or process the information that was otherwise audible. If they are engaged in other thoughts or activities, they may hear the communication and even react to it, but without processing the content. It is therefore important that the sender makes the message clear and simple (to maximise the chance of it being processed) and also sends it at an appropriate moment (not when the other party is engaged in hard mental effort).

Complexity, unfamiliarity and length of single communications are also known to lead to communication failures. The number of pilot requests for repeated taxi instructions increase with more complex instructions, as do read-back errors, because lengthy communications can overburden the working memory (Morrow and Rodvold 1993; Morrow et al. 1993).

Language

Nowadays, pilots from many different nationalities are competent in English, which makes it possible to have many combinations of nationalities rostered together. However this can cause problems. For example communication between English-speaking flight crew and 'English as a Second language' (ESL) flight crew of flight safety related issues on the flight deck has been noted as a precursor to procedural deviation (Sevillian and Jarvis 2013).

There is a minimum level of English language proficiency that all pilots and air traffic controllers working in international civil aviation must achieve. Pilots and controllers who speak English as a second language are expected to be proficient in ICAO standard proficiency; however ICAO proficiency does not cover all possible situations in aviation. As such, it is likely that pilots and controllers will also use 'Plain Language', particularly in non-routine situations. Plain Language sounds very similar to the natural English language, with all its informality and colloquialisms that many people grow up speaking. The crucial difference is that, like ICAO phraseology, Plain Language is primarily concerned with the aviation workplace and maintaining safe operations.

It can be easy for primary English speakers to forget that English is not their colleague's first language, and so fall into the use of colloquialisms, slang phrases, poor pronunciation, accelerated speech, and non-standard operational phraseology. All these can cause serious problems in communication. Indeed, perhaps counter-intuitively, it has been shown that when communicating operational messages in English, two people of the same non-English speaking language background make fewer communication errors between them than is the case where one communicator is a primary English speaker (Tiewtrakul and Fletcher 2010). This may be explained by the familiarity of the sounds, intonations and accents in use. However it underlines the importance of primary English speakers articulating clearly and adhering to ICAO standard phraseology where possible. Pilots should understand that many people who have learned English as a second language will be primarily familiar with standard and correct use of grammar and phraseology. Primary English speakers may be unaware that they rarely speak in this way themselves. For example, many younger English speakers use phrases such as "she was like.." instead of "she said..", which may make little sense to a non-native speaker. In an aviation context for example, an air traffic controller instructing a pilot to 'keep your speed up' (meaning maintain speed) may not be aware that such a phrase may be interpreted as 'increase speed' to a non-native English speaker.

Application – Communication

It is important to limit the amount of information being communicated at any one time, and use familiar phraseology and sequencing where possible. Standard operational terms and phrases are essential, particularly when one or both crew-members do not speak English as a first language. Even intonation and punctuation can completely change the perception of a message, as the following anecdote makes clear;

> *The crew were running through a minor electrical malfunction in the simulator. The checklist line read, "Bat switch on Emergency Gangbar ..... Off". This was read aloud by the PM as "Bat switch on, Emergency Gangbar off". The PF paused for a moment and asked the PM if he was sure. The PM confirmed he was correct and read the checklist again, punctuating it as before. The PF then carried out the drill as it had been read and instantly induced a total electrical failure.*

Clarity of communication can be improved by methods such as standardising and restricting vocabulary, using short messages, and presenting several types of cues such as visual and auditory (Huey and Wickens 1993).

> *Many years ago I had a German Captain in the LHS and an English F/O in the RHS (in the sim). During an EFATO drill the F/O (PF) gave the command "SUSPEND ECAM" (should have been "STOP ECAM"). The Capt cocked his head to one side for a moment then gave a brief nod of his head (he had taken a moment to translate the unexpected word then understood!). This gave me an ideal opportunity to reinforce the use of exact terminology to minimise misunderstandings, especially with our diverse ethnic/linguistic backgrounds in the cockpit. [3]*

Clarity of communication can also be improved by maintaining a steady speech rate and not speaking faster in situations of high stress. Advice from Jensen and Biegelski (1989) still holds true today. They list the communication skills that can be improved by CRM training as:

- Enquiry (countering the reluctance to seek clarification in case it calls into question their ability or hearing).
- Advocacy (stating beliefs despite one's social or team role)
- Listening: Jensen and Biegelski emphasise that this is a skill that can be improved by practice and learning.
- Conflict resolution: (Two-way communication and the stating of opinions and beliefs often causes conflict due to disagreements).
- Critique: (feedback to improve future performance).
- Crew resource management communication skills

Sharing information and mental models

In multi-crew aircraft, sharing of information is vital, particularly for the effectiveness of the monitoring task. The same situation can look quite different to two people, depending upon their intentions and awareness of what the other knows. Monitoring pilots are handicapped if they do not have a full picture of what the flying pilot is intending to do. It is common for a monitoring pilot to become distracted by a specific issue simply because information has not been communicated by the flying pilot. Consider an example: The flying pilot (PF) suddenly changes the heading in order to abbreviate the arrival. The monitoring pilot (PM) now becomes concerned about the amount of energy they have, and wonders whether to suggest further speed reduction. Additionally the PF has made no mention of another aircraft ahead, which will now be much closer. The PM thinks that the other traffic is still sufficiently far ahead but has to decide whether to point this out as well (there is often the risk of a small social cost in all such communications). The whole situation distracts the PM from normal monitoring tasks for several minutes resulting in vulnerability. However it need not have done because the flying pilot had taken it all into account already; the plan being to lengthen the downwind leg later in order to give more time to assess the strong crosswind on the final approach. But because this intention was not communicated, the monitoring pilot was unnecessarily distracted in assessing the situation and trying to decide whether to and how to intervene.

An example of good and easy practice of sharing intentions would be as follows;

> *Captain: 'I'm going into 'Flight-Level Change' now and going below the profile - I think there is a good chance ATC will cut the corner on us' [1]*

A further unfortunate effect is that something that is seemingly large and obvious may not be communicated because there is a natural assumption that it must be known.

> *Taxying out of Miami, FO's first line sector, very slow and cautious. Eventually we got airborne. In cruise, I asked how he had found his first take off in B747-400. He replied, no problem although I found the taxying a bit difficult as I have never taxied an aircraft before. He had over 2000hours and I had just assumed he had that experience (he had previously flown for an airline whose aircraft have no steering on right seat). [7]*

This can also be true of highly critical information. Communicating one's awareness of critical safety elements is therefore important even if these seem obvious. In many accidents it is possible (although usually impossible to know, even from CVR data) that seemingly obvious preventative information was known to some crew members, but either not communicated, or poorly communicated. These issues were pivotal in the original formation of CRM training, after accidents such as the 1977 Tenerife disaster and the 1978 Portland DC-8 accident.

The sharing of communications and mental models can be expanded to the whole flight operation to include other local traffic and air traffic control.

While offshore and before embarking on their final sector, the crew obtained a weather update for their destination, Aberdeen. The update confirmed that the destination met the criteria for a coastal airfield which permitted them to operate the final sector under IFR without holding an alternate. They lifted from the offshore platform and had been in the cruise for approximately thirty minutes when ATC began to advise that conditions at the airfield were deteriorating rapidly in fog. With insufficient fuel to go anywhere else they monitored the condition closely. A number of aircraft across the North Sea were similarly affected by this un-forecast deterioration and everyone began to pass ATC their intentions and holding endurance. The information enhanced the controller's situation awareness which enabled him to prioritise and co-ordinate the recovery.

It is established good practice for pilots to share safety information such as local weather conditions, including turbulence and wind shear. While there is a balance to be struck between useful communications and clutter, pilots should always consider communicating information that could be important for wider safety, when they are confident that others would benefit from that information. Unfortunately social effects sometimes prevent pilots sharing important information openly due to doubts about the communication (will it just add to others' workload? Will it show ignorance on my part? Is it already known? Is this information really important in any case?). This problem can occur to all levels of pilots, but is very common for recreational pilots as the following anecdote from a glider pilot demonstrates;

I was circling, almost at cloud base about 1000ft above the ATZ [Air Traffic Zone] of a large GA airfield that also had a VOR beacon associated with it. I listened in on the airfield frequency but it was busy so I did not want to bother them and I was drifting fairly fast anyway. Suddenly a twin-prop aeroplane appeared from a cloud and flashed past me. I then heard the pilot communicating a general message to watch out for gliders in the overhead. After a long pause (probably while the controller looked out of the window) I heard the controller repeat this message and also advise an en-route aircraft. He then tried to call me ('the unknown glider') but I felt like a naughty schoolboy and kept quiet. I had put the nose down and was speeding away. Whereas technically I'd done nothing wrong, I knew that I ought to have made a call to let them know I was there. Now I always make that call around airfields or beacons.

Assertiveness and intervention

Assertiveness is usually associated with a communication from a subordinate to an authority (e.g. FO to captain) but in some situations, for example when the FO is pilot flying, the captain may have to intervene and this may also require assertion.

Although it is important to be assertive when an intervention is urgent or critical, assertive communication is not usually a first resort. This is because assertive communications can carry a risk of creating a difficult flight deck dynamic and adding to a problem. This is something that many pilots understand implicitly, but would prefer not to admit. Even when

done perfectly well with use of standard phraseology, a receiver of an assertion might see it as undermining their authority.

> *I had not enjoyed flying with this captain, and then during the arrival we levelled out, power went on, and it became clear that he had forgotten to close the speed brake. I waited, hoping that he would notice, but he didn't. I recalled the procedure, and called "speed brake up" in the most respectful and professional tone I could. Nothing. I repeated it. Nothing. Procedure at this point was to close it myself, so I reached across to do so. He slapped my hand away and admonished me, whilst closing it himself. Not a single word was said after that, other than standard calls. If we had had a go around or an emergency, the atmosphere would have been dangerous.*

Most interventions are not urgent. In most cases skilful and experienced pilots will draw others' attention to the critical issue or parameters in a way that specifically updates situational awareness without aggravating, shocking, or startling the other pilot, in order to help maintain the cockpit dynamic (obviously this may be inappropriate in very critical cases). Since the problem is often that one pilot has not noticed something, the specific need is to draw that pilot's attention to the critical parameter to update their situational awareness. If done early enough, such an intervention need not be assertive or challenging. It could take the form of a hint or question. Here are examples of both:

The aircraft was hot and high (had more energy than desirable): a stable approach is looking unlikely, and it may not make an ATC height restriction:

Hinting:

F/O: 'Looks like a bit of a tail wind'

Captain: 'Yes, let's use a bit of speed brake"

Questioning:

F/O 'Looks like we are getting high – what's the plan?'

Captain 'I'm going to take the gear early"

FO 'Thanks'

The questioning method communicates what the pilot is thinking (providing situational awareness) and encourages the other pilot to share his plan. This can have the effect of saving face for the receiver, who does not have to confront the possible discomfort of feeling 'caught-out'.

When an intervention is really urgent or critical, the communication or action is far more important than the manner in which it is communicated. In such cases the momentary cockpit dynamic should be more resilient in any case (because of the shared threat).

If an urgent verbal intervention is required, an assertive comment should be de-personal, specific, and may contain brief information to update the others' situational awareness. It will often contain an instruction or solution.

We're not within the ATC height restriction, we need speed brake immediately

Of course, it would be hoped that an earlier intervention would have prevented the necessity for such an intervention. It is role-dependent and a matter of organisational choice (through procedures) whether such a communication should be accompanied by action (e.g. the monitoring pilot raising the speed brake).

Occasionally, even with direct and assertive comment of this kind, the verbal intervention may fail. This can be for a number of reasons, but the most likely ones are that the other pilot's workload is high or situational awareness is poor, or a very poor crew relationship exists (for example where a captain has lost confidence in a first officer). These situations would be particularly difficult if the intervention was from the first officer to the captain. Some airlines have critical phrases (prefixes) to be used in such instances, such as "Captain you must listen…". These can be very effective, but is important that they are only used in exceptional situations. Most interventions can be dealt with in the ways discussed, without resorting to these phrases (which do risk disturbing or undermining the crew dynamic).

Assertiveness and intervention training should help ensure that people speak out in the appropriate way at the appropriate time. It is as important for participants of such training to recognise that most situations require low-level intervention (drawing attention to something) so that it can be resolved, and this can and should be done early. Leaving interventions late, risks a more difficult and potentially disruptive verbal intervention. A trainer can use illustrations of incidents and accidents where team communication or functioning has been poor (or particularly good) to help reinforce their training.

The assertiveness of first officers has almost certainly increased since the widespread use of CRM training. This is probably due to role modelling as much as training. The formal role of the first officer is now strongly perceived to include speaking-up and sharing opinions, whereas this was not the case prior to CRM. Although probably a good thing, there is a danger that some pilots equate FOs speaking up and sharing decisions, to a flatter cockpit gradient. The difference between these two things should be emphasized in CRM training. First officers can speak up and share opinions, contribute to joint decisions and be responsible for part-tasks, but the commander must accept and be accepted as the leader and the final arbiter.

It is also important to note that there are two sides to assertiveness and intervention (in the same way that communication requires a sender and a receiver). As well as encouraging crewmembers to speak up when appropriate, pilots (particularly captains) should understand that their behaviour when acting as the recipient of that assertion sends a strong message about the expected role (a good example is from the previous anecdote from an anonymous first officer). There have been many cases of inexperienced pilots

speaking up and being either admonished, ignored or patronised. These individuals are less likely to speak up in future. If the captain does not agree with the assertion, then he or she should still acknowledge it (if and where possible). In such a case it may be inappropriate for the recipient to consider the best response in terms of relationships and climate in the moment, but in later debriefing they could show some appreciation of the communication (even if just to show that they value the other pilot making a sensible input). Such behaviour, particularly from a respected captain, can be very valuable in giving tacit information to junior pilots about how to appropriately carry out their role, and will pay dividends in the future.

Application to CRM - Communication

CRM training can help to prevent or minimise communication errors by explaining common communication problems and reinforcing standard language to ensure the error-free transmission of a message and its correct interpretation.

Classroom

CRM sessions in the classroom can give an opportunity to facilitate communication (perhaps in pairs) in order to highlight common problems, as well as practice creating clear and precise messages. If two classroom participants have to communicate without looking at one another, or using any visual cues, this adds to the level of difficulty in the communication and demands careful thought in order to optimise the message. Some people may be surprised at how they naturally rely on visual signs and gestures to assist the clarity of their messages, and so practicing clear communication through purely verbal means can be useful. Adding workload to the receiver is another good way of showing the problems of communicating in the flight deck.

Verbal intervention: Giving out (or reading) short scenarios and asking participants to offer the best statements to make in those situations can be a useful way of getting participants to consider when intervention is required and what level of assertion is needed (and not needed). Participants can consider exactly what piece of information must be communicated, and how best to do it given the urgency or otherwise. An obvious scenario is the one previously given, whereby a captain is using a flight-level change descent but nevertheless the first officer realizes that they will not meet a height restriction (or that they have already broken it - which would be treated differently in terms of communication, as indicated).

Simulator

The above classroom training can be easily transferred into very short (five minute) simulated scenarios if time and resource allows (even using a low-fidelity or PC flight simulator). Classroom activities that generate scenarios where certain levels and types of communication are required can be tried in simulators. Taking the example discussed (where the rate of descent is insufficient to meet a restriction or allow a stable approach), this could easily be set up in a simulator with different levels of urgency. The first officer

would then have to communicate an assertive intervention to resolve the situation. Afterwards the captain and first officer would discuss their experience of the interaction, and it would be interesting for the FO to hear the captain's experience of receiving it. Clearly, being role-play, the social dynamics will not emerge realistically, but most pilots can get a feeling for how these could have played out in reality.

SECTION B, PART 1

Specific Context Guidance

In this Part

Chapter 16

Automation human factors

Chapter 17

Working with external teams

Chapter 18

Specific guidance for cabin crew

SECTION B, PART 1, CHAPTER 16

Automation human factors

Many individual and crew performance areas discussed in Section A are applicable to automation and are therefore not repeated in detail here (although some key ones are emphasised). This section outlines automation background and current issues useful for the CRM trainer in order to assist them in integrating human performance knowledge into the modern flight deck environment. It is assumed that the CRM trainer has some piloting knowledge.

The complexity of flight deck automation has increased dramatically ever since the first recorded use of an autopilot in 1914. Early autopilots simply attempted to hold aircraft attitude, and hence they removed a core part of the pilot's physical flying task in certain non-critical parts of the flight. Autopilots started out as simple control systems; the only option being whether to engage or disengage them. Although they were simple to use, pilots had to continually monitor the situation because as well as being unreliable, autopilots were not able to maintain aircraft performance (only attitude, and then only within certain limits).

In contrast, much contemporary concern relates to the complexity of modern automation. But general complexity evolved as a necessity, and is not easily reduced. Because the first autopilots could only hold attitude, pilots had to disengage them, make corrections, then re-engage them. Solutions led to the first layer of complexity: controls that could adjust performance without disengaging the autopilot. With such controls, rather than disengage the autopilot to adjust the heading (for example) a pilot could rotate a knob one way or the other to steer the aircraft whilst the autopilot was still performing the flying task. Although making things much easier for the pilot, this functionality increased complexity, and clearly a number of knobs would soon be needed for adjustment of the various parameters. This would have to be followed by some form of feedback to the pilot about these settings: autopilot control panels were inevitable.

The next step was an autopilot that could hold a parameter (such as height or heading) and after that an autopilot that could be commanded to fly such a parameter. Clearly such an autopilot would need the same ability to enable pilots to control the performance parameters without having to disengage the flying task. By the 1950s, autopilot control panels commonly allowed pilots to select headings, altitudes, and even speeds, whilst the autopilot remained in command. Although more complex, this clearly reduced the workload of the physical flying task, even in quite critical situations.

Most experienced pilots can easily see how this would lead to yet more complexity: because autopilot 'modes' would become essential. Autopilot modes are simply the different ways by which the autopilot can achieve its goal. For example, if a pilot commands an autopilot to fly the aircraft to a new altitude, the autopilot needs to know how

the pilot wants that task to de done (there are many ways to do such a task). Automation complexity was therefore a necessary by-product of autopilot capability and functionality, and therefore not something that can now be easily reduced. Autopilots are not designed with the aim of being complicated, but very high levels of functionality makes that inevitable, and until a way is found to maintain functionality while reducing complexity, the use of automation will necessarily remain a complex pilot task.

Selectable parameters and modes culminated in the mode control panel (MCP), or flight control unit (FCU). The next big step was the use of programmed modes (with the introduction of flight management computers). This meant that instead of continually selecting new autopilot settings to achieve a route, pilots could pre-program a route (or now commonly select a pre-programmed route) and the autopilot would change headings, altitudes and speeds as required to fly the route, as well as display this information to the pilot. When such modes are engaged, the flying task can be completely taken care of, as well as the navigation and performance, but it is up to the pilots to monitor the situation, and so the display and information output from the autopilot is crucial.

As well as becoming more capable and complicated, autopilots have become much more reliable. Whereas in the past, pilots limited their use of automation and monitored it carefully when in use, some modern evidence points to crews becoming reliant on automation due to its high levels of reliability and capability.

> *Dependence on automatics could lead to crews accepting what the aircraft was doing without proper monitoring. Crews of highly automated aircraft might lose their manual flying skills, and there is a risk of crews responding inappropriately to failures.*
>
> Wood (2004).

For a discussion of monitoring around automation, refer to Chapter 4, section A (vigilance and monitoring).

Reduced manual handling skills

A lack of practice of any skill has the potential to erode that skill and there is much anecdotal evidence to suggest that because some pilots rarely practice the physical flying task, their ability to handle the aircraft when needed is degraded. Some commenters suggest that this is a particular problem in younger generations of pilots, who have a smaller overall pool of manual flying experience to fall back on.

The CAA's 'Significant Seven' Safety Plan (CAA 2011) identified 'loss of control' as a high-risk area requiring attention. Most problems around 'loss of control' are said to stem from the modern reliance upon automation. 'Loss of control' encompasses the initial problem leading to the control loss (for example incomplete monitoring or inaccurate manual flying) and then the inability to recover from any subsequent aircraft upset (usually put down to either an inability of the pilot to recognise/understand the unusual attitude, or incorrect manual handling of the aircraft while in the unusual attitude).

Some commentators have claimed that the reduction in the number of ex-military pilots on commercial flight decks has contributed to a growing problem whereby fewer pilots have experience of dealing with aircraft upsets. Most military pilots have a great deal of aerobatic and unusual attitude flying experience, having received extensive training. Modern civilian pilots do not require a background in aerobatic flying, and there are numerous commercial pilots who have rarely encountered unusual attitudes in any aircraft.

Upset training (such as jet upset modules in type rating training) is partly limited by the inability of industry standard simulators ('6 degrees-of-freedom' simulators) to recreate realistic motion sensations. Such simulators cannot reproduce sustained acceleration forces or unusual sensations associated with jet upsets. Centrifuge simulators (with g-pointing capability) can provide quite realistic sensations for jet upset training but are in very limited use, mainly due to expense and infrastructure requirements. Similarly few airline pilots are given remedial upset recovery training in aerobatic aircraft or modified commercial aircraft. Such training might be beneficial to safety, but there is a lack of valid research and the area is debated. It is possible that large amounts of training and equipment would be required to make a very minor difference, given the number of occasions that such events occur and the amount of training each pilot would need in order to be able to learn and retain the skills required to make a critical difference in all such situations. Some argue that greater benefit can be derived from putting resources into 'upset avoidance' training (including training in better monitoring of automation). Such training however is less well developed than aircraft upset training, and has even less supporting evidence. At the time of writing much work is ongoing.

In terms of flying-skill degradation, there is debate around whether manual handling (physical flying) should be practiced more in order to maintain pilot skills. Many commentators have suggested that pilots should practice more manual flying in low-criticality phases of line duties. Although it is possible that such a practice might help maintain skills, there is no evidence that it would prevent more accidents or incidents than it would cause. Additionally there is no evidence that practicing compensatory tracking tasks in low workload flight phases helps to retain pilot skills. Even if it did, it is questionable whether it would improve pilots' abilities to cope with critical manual flight tasks including jet upsets, or improve monitoring performance in automated flight.

Unfortunately, the scientific research on the loss of manual flying skills is limited and somewhat inconclusive. Researchers have attempted to answer some of these questions by asking pilot opinions and experiences, and then analysing the narratives with various techniques. This can help to gain an overall perception or attitude of the pilot community, but can never answer questions about effects of automation, no matter how many people are asked, nor how impressive the analysis technique applied. There are many reasons why pilots have certain opinions, but more importantly human beings are notoriously inaccurate when discussing issues around complex skills and processes that they use every day, because they operate at a level of non-declarable knowledge. In future, the key to advancing the scientific knowledge around automation usage is likely to be in careful observation, experimentation and analysis of objective data.

Up to the time of writing, even where objective methods have been applied the main issues are still unclear. This is partly due to the huge complexities around the problem, and partly because of the difficulty of measuring and even defining 'manual flying skills'. Scientists have often used the discrete task of ILS-tracking in an attempt to measure manual handling accuracy, because the distance from the centre of the localiser and glideslope to the aircraft position can be easily measured throughout the approach. However flying an ILS is a very specific compensatory tracking task, and it is arguable whether this is really representative of a pilot's general manual handling capability: i.e. there is no evidence to show that accuracy in ILS tracking is representative of a pilot's manual flying ability in general. The statistical treatment is also problematic; for example a brief cross-track error of 100 metres just one mile from touchdown would disproportionately load the statistic compared to 100 metres of error at six miles from touchdown. For reasons such as these, conclusions are usually framed by numerous limitations. The critical parameter of airspeed lends itself better to statistical treatment. Ebbatson et al (2010) were able to provide evidence that pilots who are more current in manually flown approaches fly more accurately in terms of approach airspeed (using licensed crews in a Boeing 737 full category simulator, flying an ILS approach on one engine). There are very few other valid studies of this kind but there are as yet no studies that provide evidence supporting the opposite hypothesis (retention of manual flying skills). Along with anecdotal evidence, this does hint at the possibility that manual handling skills are lost through underuse. However the CRM trainer should be careful not to state this as indisputable fact.

In summary, although it seems likely that manual flying skills degrade to some extent due to lack of practice, this remains hypothetical. It is also not possible to know to what extent this occurs, whether it presents a significant risk, or how it can be safely addressed. Valid methods of researching the area must be developed so that further research can answer these questions.

Use of automation

Whereas pilots of early aircraft had a simple choice to have the autopilot on or off, modern commercial pilots have many automation permutations available. One extreme end of that continuum of permutations would be manual flight (no flight director, no auto-thrust, no enhanced map display), and the other end would be autopilot in command with FMC modes engaged (auto-pilot, flight director, auto-thrust, LNAV/VNAV). In between lie numerous possible combinations. Deciding what mode combinations to use at any time can itself generate workload, and setting those mode combinations up can produce yet more workload. Once in place with autopilot in command, remembering exactly what each mode means, and how the aircraft should be performing under them can be a further challenge for pilots. However unless a pilot is able to do this then the monitoring task will be partially flawed at best.

As well as the use of different modes, there are questions around when the automation must be used, which pilot should manipulate it, and when.

For all these reasons, different manufactures (and companies) stipulate automation policies and philosophies (usually type specific), which guide pilots in the use of the automation and sometimes stipulate what should and should not be done. For example some companies do not allow use of manual thrust at all on certain aircraft, whereas others allow manual thrust to be used but only with the autopilot disengaged. Policies also give guidance on pilots' roles, such as when the flying-pilot can make their own selections on the mode control panel.

In practice, pilots will also develop their own favourite ways of doing things within the framework of an automation policy. Hence, whereas there may be hundreds of different ways to use automation in theory, pilots usually select from a limited number of ways in reality.

Certain combinations of autopilot and mode usage can be considered similar enough to reclassify into a few 'levels' of automation, rather than lots of combinations of modes. When researching literature on this topic, it is important to recognise that the concept of 'automation levels' is understood very differently by academics than it is by operators/pilots, and this can cause confusion for either party. The common ground is that automation levels are seen as points on a 'continuum' that starts at the lowest level (usually manual tasks) and ends with complete automation of all tasks. For scientists and academics, the amount of augmentation, support and execution provided by the system (to the human) is what elevates each level. This leads to various ideas as to how many automation levels there are, but most academics propose the number to be between seven and ten. However in the flight deck, such classifications are not meaningful to pilots, so automation levels are considered as the main general configurations of the automation as used in practice. In both the scientific description and the practical usage, there are many different opinions and theories about how many automation levels exist and what they are. There is no right and wrong answer to this.

For pilots there are three major levels of automation: manual flight (i.e. no automation), use of tactical automation (e.g. MCP/FCU usage) and use of strategic automation (e.g. FMC modes). This is the easiest and most useful way for pilots to consider the levels. Some pilots would add the use of flight directors as another level (i.e. separate to manual-flying using 'raw data') and others would include combinations around the use of auto-thrust. Hence pilots usually consider there to be between three and six automation levels in practical use on commercial flight decks.

The use of these levels will depend on the type of operation but in almost all modern commercial flight operations there are only two short inflight phases that regularly involve use the lowest automation level (manual flight – with or without the flight director). These are take off/initial climb and final approach/landing (non-autoland). There will also be some non-normal situations that may require it such as go-arounds (in some older types) and autopilot failure. However some pilots like to manually fly some phases such as the entire climb or approach, where this is allowed by the airline's automation policy /philosophy.

Compared to manual flying, operating with the autopilot in command at a tactical level (use of MCP/FCU) has a lower immediate workload for the flying pilot. It may also lower the workload of the monitoring pilot since they may have felt the need to monitor more closely with the autopilot disengaged. Compared to use of the tactical automation, operating with the programmed FMC modes engaged is usually lower workload for both pilots because the route is then automated as well.

However, it was pointed out by Bainbridge (1983) that automation has acted to lower pilots' workload for flight phases in which it was already low, and increase workload for phases in which it was already high. This was termed 'the irony of automation'. For example, it is said that the workload in the cruise phase has been lowered beyond what it was previously, whereas automation caused the workload in the arrival phase to be even higher than it was before. Although often pointed to as if global and indisputable truth, it is really a debatable point. Most crews wait until their aircraft is in a high level of automation to engage in planning tasks and other non-flying tasks such as eating or making non-essential PAs to passengers. Equally, preparing for descent (which may begin at the top of climb in a short haul operation) is usually done with automation at a high level. Large parts of the cruise may be low workload for some operations such as long haul, but in very short haul operations (and towards the end of long haul flights) the cruise can become extremely busy and the automation relieves crew workload so that they can concentrate on planning and preparation tasks. Crucially however, at least one member of the flight crew should be keeping a close eye on what is happening during this time (e.g. flight path and airspeed monitoring). Hence the cruise is not necessarily a low workload phase. It is true that arrival and approach phases can become very busy, and in some situations the use of automation can add to the burden; particularly if any reprogramming of the FMC is needed. However it is usually debatable whether the root-cause of such a problem was the automation itself or the crew management of the resources available (and specifically the use of automation). For example a decision to reprogram the automation without a change of plan to allow the time to do so is arguably an issue of workload management. The management of automation is a modern crew skill which, done badly, can make the automation appear as more of a hindrance than a help.

On most flight decks, there is also a question about how the automation usage is managed by a two-person crew. If only one pilot has good awareness of what the automation has been programmed to do, then the other is severely handicapped in their ability to monitor and support. When pilots make changes or errors that the other is unaware of, then the automation will not perform as they anticipate and the resulting confusion can be draining, distracting and even dangerous. The complexity of automation means that it is not always obvious what has happened and the commonly quoted phrase "what's it doing now?" exemplifies the problem. Hence it is very important that programming of the automation and any on going changes are clearly communicated and understood by both pilots and that communication around the automation is standardised. It is usually appropriate that a pilot includes the automation mode when informing an intention, for example: "I'm going to descend to 5000ft in flight level change". This might be followed by an FMA (flight mode

annunciator) call-out such as “Arm, MCP SPD” if the company have such procedures in place on that fleet.

Some airlines have also attempted to use FMA callouts to support shared engagement and awareness, by stipulating that both pilots share the process (for example the pilot-flying (PF) makes the mode change, the pilot monitoring (PM) calls the active mode and the PF then calls any armed modes). While some problems can be solved by use of such practices, other problems can emerge in the long term (such as the PF not monitoring the active mode changes). It is always best to make such changes carefully and monitor the results. There is no undisputed best practice around such call outs.

Whether or not FMAs are called out, the monitoring of FMAs is essential. Only by knowing the modes that the automation is in can a pilot accurately interpret the situation displayed on the instruments. It follows that pilots must have good knowledge of what the FMAs mean. Unfortunately this is not always the case. Issues around FMA awareness (mode awareness) are particularly important in critical automation phases such as RNAV and RNP operations, where the automation mode is critical to maintaining a safe flight path.

Although these are technical issues, there is nothing wrong with the CRM trainer emphasizing the issues around automation generally and mode understanding and awareness in particular. Additionally, there are human performance issues that impact upon mode awareness: As well as factors such as vigilance decrement, fatigue, startle and stress, simple high workload caused by a distracting task or conversation can lead pilots to drop the monitoring of automation from their scan with potential consequences. All these sorts of issues can be usefully discussed in CRM classrooms.

Challenges for the future

There are many future (and current) challenges in terms of how pilots use and share automation as new technology appears on flight decks.

New interfaces such as ‘electronic flight bags’ (EFBs) and graphical user interfaces are becoming more common, as are devices such as iPads. One obvious CRM issue with some fixed EFBs as opposed to iPads is their placement (often facing outwards) meaning that in briefings (e.g. pre-take off or pre-descent) it is more difficult for pilots to incorporate them in discussion. Whereas previously pilots would have pointed at a diagram or plan, this has become difficult. Another challenge with all electronic devices is the quick retrieval of information that may be hidden under several electronic pages.

Head up displays (HUDS) are another challenge, and despite having been used for decades, they have only recently started to become common on civil flight decks. The use of this technology is usually not as obvious as it appears, and again has CRM implications; one cannot physically point out part a display to another pilot for instance. There are also numerous issues around human performance, particularly attentional issues due to the collimation of the HUD display. But fundamentally there is a question of whether, with the autopilot engaged, automation awareness is improved or degraded through the use of a

HUD, and so questions remain over how automation policies/philosophies should best incorporate Head-Up-Displays.

Many other challenges exist, including linkage between aircraft and air traffic. The CRM practitioner is encouraged to explore further resources around future issues (see the section below) in order to generate useful and interesting discussion with trainees.

Automation Resources on the Web (current as of 2014)

The reader can find a great deal of excellent information about automation on the Internet. Manufacturers' websites (e.g. Boeing and Airbus) contain useful information about the manufacturers' automation policies and recommended practices. Authorities such as the FAA and EASA also provide a lot of useful resources. Here are some examples of useful pages to visit (the links are correct at the time of publication):

- Automated Cockpit Guidelines – http://www.skybrary.aero/index.php/Automated_Cockpit_Guidelines_(OGHFA_BN)
- FAA Automation Report 2013 – http://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afs/afs400/parc/parc_reco/media/2013/130908_PARC_FltDAWG_Final_Report_Recommendations.pdf
- Airbus Flight Operations Briefing Notes – http://www.airbus.com/fileadmin/media_gallery/files/safety_library_items/AirbusSafetyLib_-FLT_OPS_SOP_SEQ02.pdf
- Automation in GA – http://www.faa.gov/regulations_policies/handbooks_manuals/aviation/risk_management_handbook/media/rmh_ch07.pdf

SECTION B, PART 1, CHAPTER 17

Working with external teams

CRM training for pilots and cabin crew is now well established and quite mature (although scope for improvement still exists – poor flight operations CRM features as a significant causal factor in CAA analysis of high risk events). There are however, many thousands of people working to support aircraft operations for which CRM training is either poor or non-existent. This chapter aims to assist CRM facilitators to understand the world of CRM beyond the aircraft door and some of the cultures and perspectives that exist.

When CRM trained personnel (e.g. flight crew, cabin crew) interact with personnel who have not been exposed to CRM training, there is specific potential for misunderstandings. For example, pilots may expect others to speak up if they perceive an issue, but this should not be assumed, particularly where others have not been exposed to CRM ideas and therefore may not share the same expectations of their roles. Different attitudes exist towards issues such as reporting and safety culture and so some groups may be generally less inclined to report incidents or to draw attention to problems where they perceive potentially negative consequences for doing so. Different teams may have very different interests to be served, and this can lead to problems where the interests of one party (e.g. ground handlers) come into conflict with the interests of another group, such as cabin crew or flight crew.

Hence, just knowing the extent of exposure to CRM, safety culture or TEM training that another group has had can be useful when working with other personnel. This chapter attempts to outline the situation at the time of writing.

A CRM instructor tasked with providing a joint training package for flight crew and ground staff should be able to use this chapter as a starting point for writing a course that will be well received by both parties. This chapter briefly assesses the level of CRM training that various parties receive, and looks at some issues that can emerge between flying and non-flying personnel.

Research

In preparing to write this chapter, a very broad field of opinion was sought, ranging from airline CEOs to ground handlers, in order to gain an understanding of what would or would not be practical or achievable as a means of introducing CRM training on such a broad scale.

It quickly became apparent that there is a vast range of understanding and knowledge as to what constitutes HF/CRM training and whether it is of benefit to a particular organisation or not. At most levels cost was a major concern; senior managers and CEOs understood the value of conducting this training but were keen to keep control of both the product and the cost.

The majority of airlines today make extensive use of contractors. Such contracts are hard to win and keenly priced, meaning that there is no room for extra training without incurring some cost. Every company who responded indicated that they would not conduct additional training unless the regulator or the customers mandated it. These responses are understandable but nevertheless run contrary to the recently published CAA HF strategy.

> *Vision – HF understanding is visibly demonstrated through appropriate attitudes and behaviours which result in a reduction of human error in the system*
>
> UK CAA 2014 - A Strategy for Human Factors in Civil Aviation

If progress is to be made in continuing to develop and progress the CAA HF strategy the message must be that CRM (in whatever context dependent forms; TRM, RRM, etc.) should be established and that in future any ground service contracts issued should stipulate elements of HF/CRM training at appropriate levels.

> *Our aim is to see everyone within aviation receive appropriate HF training according to their role*
>
> UK CAA 2014 - A Strategy for Human Factors in Civil Aviation

Air Traffic Control

Although the National Air Traffic Service (NATS) is the leading ATC provider in the UK at the time of writing, there are many others providing local control at many UK regional airports. Providers tend to have different views on HF training, but in the main the concept of CRM and human factors has transferred across to Air Traffic Control.

Many air traffic organisations around the world have tried some form of course or training provision that brings together pilots and air traffic controllers (NATS and Airways New Zealand are two examples). There is anecdotal evidence that pilots and air traffic controllers find these courses useful and feedback from candidates is generally good. One current limitation is that most such courses rely on joint issues ‘emerging’ in the sessions. Although this can be very effective, it means there is a great deal of variability between candidate experiences. Hence, one issue that remains to be addressed is a thorough analysis of specific joint task (pilot and controller) components requiring knowledge sharing, in order to systematically facilitate the most beneficial content. Other useful practices have been familiarisation flying for air traffic controllers and pilot visits to air traffic centres. There is general agreement that bringing together pilots and air traffic controllers to learn about each other’s work is beneficial.

Turnaround Co-ordinators (TCO) and Dispatchers

At the time of writing there is no mandated HF training for TCOs and dispatchers. Some airlines recruit their own staff, whereas others use contractors or 3rd party companies. Some airlines provide new hire and recurrent training for all TCOs. The airport services training team invariably runs these sessions. There are currently no recognised HF training

standards for the trainers and although they are often highly experienced and excellent in their roles they sometimes lack in depth HF knowledge. If the company has a human factors department (or specialists) then it might be possible to establishing a closer relationship with the TCO trainers, providing training support where required. Other initiatives include inviting TCO trainers on pilot initial or recurrent CRM training. While this doesn't expose all TCOs to a joint training session, it can build bridges and generate a positive response on the line. On the other hand, consideration should always be given to the effect this might have on the quality of pilot CRM sessions (i.e. if the session material needs to be changed, or certain topics are not followed through in the same depth as they would otherwise be).

The problem is more difficult with contractors, where the perennial problem of time and money emerges. Some proactive operators adopt a co-operative relationship between contractor and customer and as one senior manager said,

> *We are trying to move away from the unequal relationship between purchaser and service provider to a more collaborative relationship.*

Problems experienced by most operators revolve around a clash of cultures and poor communications skills. Generally this is manifested by poor relations between pilots and dispatchers, which impacts upon efficiency and in some instances safety.

For a local CRM instructor tasked with trying to ease these situations there is no simple solution. The problem is often a lack of communications between the two organisations or reluctance to change. Frequently there is a conflict of interest between aircrew and dispatchers. The crew's motivation is to make an on time departure while ensuring they don't take any unnecessary problems into the air with them. The dispatcher is performance driven and can sometimes fail to appreciate the flight crew issues. For example, while they might return to their office grumbling about the crew being picky about the pre-departure routine, the same crew may have to spend many hours dealing with the fallout from a poor decision.

In some cases, airline senior management could help this by encouraging the contractor's senior management to engage with HF training. This opening would allow the CRM instructor to invite these individuals to join in with company CRM where appropriate.

Friction can occur on the line between the company and contractor managers, resulting in pressure being applied to the TCOs to adopt an inflexible or even confrontational attitude. Comments like "I don't care what they say, this is the way we do it and that's it" were mentioned by TCOs when they tried to discuss operational differences with their managers. This attitude can then colour the relationship between pilots and TCOs that can lead to friction and compromise good CRM.

A typical scenario to illustrate this possible breakdown of trust is delay codes. TCOs are responsible for getting flights away on time and On Time Performance (OTP) is a major performance indicator. One airline CRM instructor reported that TCOs adopted a habit of putting any minor delays down to the crew arriving late at the aircraft or at "commander's

request". Pilots, while keen to make OTP, are usually far keener on making sure everything is in order before they depart. Over time pilots became aware of the TCOs tactics and naturally this caused friction. This resulted in a case where one captain refused to depart until a TCO manager came to the aircraft to confirm that the delay was not coded as late crew arrival at aircraft. This crew was probably not in the best frame of mind as they taxied from the gate. This situation could not be allowed to continue so the HF department arranged for a TCO to deliver a short briefing and discussion during recurrent pilot CRM training. This small intervention reduced friction and appeared to improve OTP.

This is not to attribute blame to any parties. Very often (for example) TCOs are left with the feeling that captains give little or no thought to seeing the operation from the TCO point of view. TCOs also commented on poor communications skills by captains leading to unnecessary conflict.

Below are some cases to demonstrate the issues.

Case 1

A captain was on the flight deck with his feet up during a turnaround when the TCO asked for the load sheet the captain firmly said that he was the commander of the aircraft and it was up to him when the aircraft was ready to push back, so he refused to handover the signed load sheet until he was ready.

Case 2

The dispatcher approached flight deck for the signed load sheet at ETD -7. The captain was clearly on a personal call. The engineer was also waiting to sign off the tech log. The dispatcher gently tapped the captain on shoulder and asked if he would mind signing the tech log. The captain was very apologetic and ended his phone call. The dispatcher advised LCMs were complete and first officer confirmed they had the final load sheet and it was ok to close up. The captain confirmed he was happy to do so. The dispatcher was in the process of closing doors when captain arrived at the door and (according to the dispatcher) shouted at the dispatcher for being rude and told him he'd been flying since before the dispatcher had been born.

CRM instructors should consider the best ways to spend some time with these team members to help improve communications and break down barriers. Options include CRM instructors shadowing TCOs on shifts and CRM instructors providing informal sessions in contractor crew rooms.

Customer Service Agents (CSA)

CSAs deal with passengers and try to ensure that their experience is a good one. Most CSAs have been exposed to little or no CRM training. Many companies use contractors, so the problems explained in the previous section (TCOs) apply here, but it is still worth examining how the specific motivations of CSAs might conflict with that of the crew.

The principle measurement of efficiency for most gate staff is on time departures, therefore the motivation of the CSA is to get the passengers on and the doors shut. Knowledge of what happens beyond the gate is very limited and there is some anecdotal suggestion that an understanding of the crew perspective is not always encouraged. In discussions, many gate staff expressed desire to know more about what happens once the passengers are on-board. They were keen to understand how they fitted into the 'overall picture'. Below are some examples of the issues that can occur between crew and CSAs.

Case 1

This example happened to a long haul carrier operating from India to UK with UK and Indian crew. During boarding a very old frail Indian lady was brought to the aircraft door by the CSA. She spoke no English. The crewmember taking boarding cards at the door felt that this lady looked ill so she called the crew supervisor. When the supervisor arrived she spoke to passenger with the help of the CSA who interpreted. The supervisor spent some time questioning the frail passenger to determine if she was happy to fly. Throughout this exchange the CSA sought to re-assure the supervisor that the lady was fit to fly and that she was telling him she was able to look after herself. There was another Indian crewmember close by who spoke Punjabi. She started to listen to the conversation and quickly realised that the CSA was not accurately interpreting. She challenged him on this, at which point he admitted that he was trying to get the crew to take her because he did not want the hassle of off loading her and the penalty of a late departure.

Case 2

This example happened on a UK charter operator, operating into Florida. The boarding door crewmember became concerned about the behaviour of a male passenger queuing to board the aircraft because he appeared drunk and aggressive. She called the Cabin Supervisor who agreed with her assessment and asked the passenger not to board the aircraft, but to wait. At this point the passenger became aggressive and abusive. The supervisor called the gate and asked the gate staff to assist but was told that they had already assessed the passenger and were happy for him to fly. The supervisor told them she was not happy but the CSA supervisor said it was their policy that if they assessed a passenger was fit then they were fit. At this point the captain was called. He too assessed the passenger as being very intoxicated and not fit to fly. By now the passenger was becoming very aggressive and so the police were called. The passengers seated by the door witnessed the crew receive a sustained attack of foul-mouthed abuse before the passenger was eventually removed by the police. He was taken back to the gate area where he broke loose and ran amuck destroying some airport property. The airport SWAT team eventually subdued the passenger. The flight left on time. During the subsequent follow up, discussion between the airline and the handling agent revealed a lack of mutual understanding around decision-making and communications. The handling agent appeared uncompromising: if they assessed a passenger as being fit to fly, then they were fit to fly.

Both these examples demonstrate a clash of culture and a possible failure of CSA management to recognise some important HF principles.

1. *Culture:* Understand your own culture and that of the crew and think about how they might interact
2. *Teamwork and leadership:* It is a team effort to get an aircraft away safely and on time.
3. *Communication:* Swift effective communication between crew and CSA would have solved these problems almost immediately.

Airport Operations Staff

During the research that preceded the writing of this chapter, it was clear that the majority of airport operators and airport operations managers were familiar with human factors and keen to pursue HF training for their staff, though most seemed unsure how best to achieve this. The Airport Operators Association were open and helpful in compiling information about HF training for their staff.

Some airports are already conducting some HF training. This training would not necessarily be recognised as being a traditional model, but seeks to address some key areas of HF training, as follows:

1. Teamwork and leadership
2. Interpersonal skills
3. Dealing with conflict
4. Managing change
5. Reporting and SMS

Most discussion with airport managers centred on ramp operations staff. Many appeared to have an excellent understanding of ramp practice and safety around aircraft, but a limited understanding of the pilot perspective. They appeared to have a strong knowledge of the technical side of the operation but a limited knowledge of non-technical issues. Further discussions revealed that in many cases staff had a low level of understanding of the SMS and in most cases did not view HF practices as being related to their role. Below is an example:

> *One small regional airport reported that there was frequently a problem with chocks being left on the ramp area presenting a safety hazard. When staff were challenged about this during a discussion on company culture and safety culture, a number of them said that it was common practice to observe someone walk past the offending chocks into the terminal and telephone the fire department to tell them that chocks needed to be removed. This story was not an isolated occurrence. Others reported*

the same attitude towards foreign objects (FOD), i.e. that an individual would walk past the item and ask someone else to pick it up because it wasn't their job.

Ramp reporting culture is very varied, but some organisations are making good progress with introducing SMS and just cultures, whereas others are not. The Ground Occurrence Reports (GOR) system is not as mature as the ASR or MOR system and the majority of reports contain little information beyond a short factual account of the occurrence. A CRM instructor tasked with preparing a joint HF session should approach his or her local airport operations team and ask for some anecdotal information about recent occurrences. He or she should have no difficulty using this information to facilitate a useful and lively session with both pilots and operations staff, which can form the foundation of a good HF learning session.

When questioned, most managers appeared keen to use the skills of the CRM instructor. Hence an approach from the local CRM instructor to the airport manager might initiate HF training for airport operations staff.

Line Engineering

Human-factors training for engineers is mature across the industry. Engineering HF tends to concentrate on error detection and is technically orientated. That said, most line engineers appear to have a good understanding of how human factors affect them in their everyday work. Where they have less understanding is with regard to what the pilot is thinking. The reverse is also true; pilots currently appear to have a poor understanding of the engineer's perspective.

An approach was made to the Engineering Human Factors group of the Royal Aeronautical Society for their views on the relationship between pilots and engineers. Most members felt that in most organisations there is little contact between the two groups and that most interaction relates more to efficiency than safety. This is supported by a number of studies. It is likely that pilot/engineer interaction will continue to reduce as new aircraft are produced that have been designed from the outset to require less engineering input on turn round.

While perhaps desirable, joint training between pilots and engineers is unlikely to occur on a widespread basis. Opportunity for interaction during recurrent training could be beneficial, but getting the two teams together is very difficult if the same company does not employ both. During recurrent training guest speakers from the other group could give short presentations to promote understanding and gain a better perspective of the other's problems and challenges.

Cargo and Ground Handlers

Cargo and ground handlers have the least opportunity or requirement for interaction with pilots and crew. Informal discussion with members of the GHOST group revealed that there is some way to go before "just safety culture" is fully implemented and understood by both management and ground handlers. Some research from the Netherlands has

suggested that management have more belief in the justness of the current culture than do operational staff (Balk and Bossenbroek, 2010). Operational staff appear to believe that a primary management objective to be to find and punish those responsible for negative outcomes (i.e. they perceive a blame culture). In short the management feel they are running a just culture, the workers do not.

In summary

Pilots and cabin crew rely on the contributions of many other parties in order to achieve their operational goals. Some of those external groups will share similar cultures and values with the aircrew due to being immersed in the aviation culture (e.g. air traffic controllers) but some may have little exposure to this (e.g. ground handlers and loaders). Furthermore, it appears that the latter are the least likely to have undergone any form of CRM training. In addition, all groups will have different motivations and ways of working. Therefore there is potential for misunderstanding or misalignment of desires or requirements, and these can have safety implications. The possible sharing of CRM ideas and extension of CRM training to external groups could have benefits, if for no other reason than beginning to align culture and attitudes.

SECTION B, PART 1, CHAPTER 18

Specific guidance for cabin crew CRM trainers

This section aims to assist CRM facilitators involved in the training of cabin crew. It is to be used in conjunction with the other chapters of this document.

Any CRM instructor from a cabin crew background must have a sound knowledge of Human Performance and Limitations, which can be enhanced during a CRMI TTT course. However the motivation for learning and reading around this large but fascinating topic lies with the trainer themselves. If new cabin crew are to embrace and use 'good CRM', they need to recognise how CRM affects the way they operate both as an individual and team member.

Trainers involved in integrating procedural training with non-technical skills (CRM) should ensure that the procedural (SOP) content of the training session does not undermine or devalue how trainees' CRM skills need to be applied. The instructor therefore needs to have a clear CRM focus (e.g. decision-making, situation awareness, communication) together with specific objectives that they wish to highlight during the training session. These need to be integrated fully within the technical knowledge and skills.

Cabin Crew CRM Training (General)

Cabin Crew members are an essential part of the aircraft team. It is a demanding role, often with pressure to meet required service and sales targets, and assist with on time performance.

Communication and teamwork are two elements that require emphasis in cabin crew CRM training. Open and effective communicate is important both within the cabin team and with the flight deck crew. The Chain of Command and Authority of the Commander is clear and must be respected, and similarly within the cabin crew team the senior cabin crew member (SCCM) must be deferred to as the person with overall cabin responsibility.

Some pilots refer to cabin crew as their eyes and ears. Flight crew rely on cabin crew to effectively manage and communicate all cabin and passenger management issues. The flight crew require accurate and clear information which will allow them to make decisions about the next steps they should take. This is often in very stressful situations and in such a confined space and in flight this can often feel exaggerated. Hence communication skills are very important.

Examples of where cabin crew communication could have positively influenced accident events are Flight BD92, Kegworth in January 1989, Flight 1363, Dryden Ontario in March 1989, and Flight 797 in Cincinnati in June 1983. An example of where cabin crew actions did assist the flight crew is Flight 232, Sioux City in July 1989.

Many cabin crew working in the industry nowadays will probably have little or no knowledge or recollection of an accident or serious incident. Effective CRM training should incorporate scenarios and discussions focused around everyday operations as well as abnormal and emergency situations. The training should give cabin crew some key strategies and behaviours to manage different situations. Examples could be dealing with disruptive passengers or hand baggage issues. CRM should offer tools and techniques to help resolve and manage problems rather than focusing only on SOP responses. SOPs may be insufficient in themselves in terms of equipping cabin crew to deal with live situations. CRM gives the arena to practice important people management skills that complement SOPs.

Classroom training is the only opportunity to experience a simulated situation, be able to consider solutions and practice CRM techniques and skills. The learning often takes place in the debrief because the exercise should allow cabin crew to make errors and learn from them within a non-threatening environment. This requires good facilitation skills from the cabin crew instructor (see Chapter 21; 'Facilitation skills for CRM trainers').

The use of a behavioural marker systems is not mandatory for cabin crew, but their utilisation during a debrief may assist the cabin crew when learning specific behaviours and strategies to manage different situations (see Chapter 20; 'Behavioural Markers Schemes')

Introductory Cabin Crew CRM Training

General Human Factors, including human performance and limitations (HPL), should be taught during introductory courses. This is a broad topic with many theories, models and literature available in the public domain to help support training. Caution should be exercised when sourcing information from the Internet, and instructors should ensure that all information to be used is validated.

Cabin crew on an introductory course will not normally have any flying experience to draw upon during training. Trainers should encourage delegates to consider their study and/or work experience to date and to use this as a vehicle for meeting the objectives. Everyone will have examples of a good or bad day at work, and such anecdotes can be used to identify helpful or unhelpful behaviours and techniques for dealing with various situations and contexts. The trainer should link exercises into the aviation context and the error chain. Cabin crew should understand that errors are unintentional, because this is the basis of further CRM training.

Introductory CRM training considers the individual performance rather than the crew performance (see Section A, part A1), and an awareness of the limitations of the working memory is an important objective to cover (see Chapters 1 and 6).

Operator's CRM Training

This is a good opportunity for cabin crew who are new to an operator to learn about the culture and values of their new company – 'it's the way we do things around here' that they

need to learn about. Operator's CRM is about how the individual will work within the team environment, therefore building on the learning from the introductory course.

When developing training programmes, consideration should be given to the type of organisation (e.g. long haul, short haul or both, corporate, single cabin crew operation) and areas of operation. The experience level of the cabin crew within the company may also be considered as a key point to include in the programme.

Safety culture, risk management and crew-members' role in the area of reporting systems all come into effective training for the Operator. Using the risk assessment matrix from the Operators SMS system is an effective way to introduce and expand upon the Operator as the 'umbrella' with the cabin crew as a vital part within the organisation. Risk management behaviours and strategies can be introduced.

The use of de-identified company incidents is invaluable; a good example can be just as powerful as a poor example. Cabin crew should be made aware of trends (such as passenger behaviour on various routes) and the trainer should facilitate ways to deal with these sorts of specific challenges.

The trainer should bring in the concept of a 'Just Culture' as this part of this training.

At the end of an Operators CRM training course, cabin crew should be clear about their role as a team member on the aircraft and have a full knowledge of how their new company works. They should feel motivated and empowered to be a valuable resource within the organisation.

Operator Aircraft Type Conversion CRM Training

The aim of this training is to clearly define the human factor issues related to the particular aircraft type. Areas to address may include:

- All systems with particular emphasis on communication and areas that may be unfamiliar or different from previous experience and therefore result in rule based error.
- Number of cabin crew operating on the specific a/c type and how this may affect teamwork
- Configuration of passenger cabins, even location of flight decks on larger aircraft that may adversely affect effective crew co-ordination unless crew awareness is raised.
- Crew complement and operating with heavy crew on ultra long haul flights.
- Cabin crew responsible for more than one exit (particularly on a wide-bodied aircraft)
- Unfamiliar systems

- Possible challenges on corporate jets and smaller aircraft where cabin crew are operating as a single crew-member

Although cabin crew will have received the technical information on the above, there may be specific human factor issues that should be included in the CRM training, for example whether there is anything that could lead to error that they may otherwise be unaware of.

Recurrent CRM Training

Many Operators carry out joint flight crew and cabin crew CRM training. This can be very effective and has been shown to improve flight deck and cabin crew understanding of one another's roles and enhance communication during line operations. However, the tasks and roles of flight crew and cabin crew are very different and therefore over recent years there has been a move towards part-joint training and part-separate training. Some of the modular requirements differ: for example flight crew must include a module on Automation during recurrent training and cabin crew must cover the passenger and medical factors.

Recurrent training is perhaps the only opportunity in the year to develop cabin crew non-technical skills. The trainer should avoid simply repeating the initial course with a few adjustments. There should be a training-needs-analysis of the organisation with relation to incidents that occurred during the past year and these should form the basis of the training resources for modular sessions and exercises. The opportunity to share and learn from others is the main aim of recurrent training. Experienced crew-members should leave the training feeling motivated to continue or improve their use of non-technical skills and behaviours in line operations.

Effective recurrent training material should be more carefully researched than other CRM training course material. If there is little material 'in-house' available, then using examples from other operators can be valuable.

The de-identified results of an operator's behavioural marker system must be included in flight crew CRM training. If an operator used such a system for cabin crew (as previously mentioned) then this would give a valid picture from which to highlight and develop areas of strength and weakness for cabin crew.

Senior cabin crew member (SCCM) CRM Training

Section A, Part A2, Chapter 14 (Leadership) should be referred to, along with the following text, adapted from Airbus Flight Operations Briefing Notes (Effective Briefings for Cabin Operations).

The SCCM has an important role on the aircraft as a leader and a role model. They are the vital communication link between the cabin crew and flight crew, the cabin crew and the passengers, and the cabin crew team themselves.

Effective CRM can be helped or hindered as soon as a crew reports for duty. The atmosphere for the flight, including respect, trust, motivation and good communication is in the hands of the SCCM.

The SCCM is responsible for all cabin crewmembers and managing the overall workload by delegating tasks. As the team leader they have the ability to influence the behaviour of others and the ability to motivate the team to achieve their goals.

SCCMs should be encouraged to use their CRM knowledge, skills and attitude to enhance effective teamwork and co-operation. Using 'real life 'examples and scenarios during classroom training will support the behaviours and principles that the session is trying to address. Trainers should ask delegates to share their good and bad experiences when working with SCCMs during their time as main cabin crew. Example questions would be:

- What do they hope their leadership style will be once promoted?
- How can the SCCM support the flight crew during stressful situations?
- How can the SCCM liaise effectively with the flight crew when there are problematic passenger issues?

Operators should ensure that SCCMs receive appropriate training and have necessary skills, including leadership, decision-making and effective teamwork.

Corporate Aviation including Inflight-Service-Personnel (ISP) V Cabin Crew

Many corporate operators now train non-required cabin crew (under 19 seats) as full cabin crew and this is encouraged as best practice. Training needs to focus as above for single cabin crew operations.

Confusion and misunderstandings have been known to occur where the operator employs the services of inflight service personnel (ISPs) rather than fully trained cabin crew-members. Operators must ensure the flight-crews are fully aware that an ISP may not take any safety responsibility.

SECTION B, PART 2

CRM assessment and behavioural markers

In this Part:

Chapter 19

CRM assessment

Chapter 20

Behavioural marker schemes

SECTION B, PART 2, CHAPTER 19

CRM assessments

For many years there has been an expectation on the pilot Instructor community to fulfil a multifaceted role when giving adequate instruction to trainees, be they at the beginning of their aviation career or at the latter stages. Therefore in terms of operational flight safety, instructors hold one of the most influential positions in the industry. Evidence from accidents and reported incidents shows that human factors continues to be a central issue, being causal and contributory to most accidents and incidents. The instructor has the opportunity to reduce accident and incident numbers caused by human factors, if trained in the use of the appropriate tools. The regulation is clear on the expectation and abilities required of the instructor, but it offers little in the way of guidance. The purpose of this chapter is to clarify the regulatory expectation placed upon the instructor and assist in developing human factor competencies associated with this demanding role.

Requirements

There are primarily three areas within the requirements that affect the instructor from a human factors perspective. These are found within the following (and will be expanded here):

1. FCL.920 Instructor competencies and assessment
2. AMC1 FCL.920 Instructor competencies and assessment
3. AMC1 ORO.FC.115&215 (h) Assessment of CRM Skills

1. FCL.920 Instructor competencies and assessment

This requirement states that all instructors shall be trained to achieve the following competences:

- Prepare resources
- Create a climate conducive to learning
- Present knowledge
- Integrate Threat and Error Management (TEM) and crew resource management
- Manage time to achieve training objectives
- Facilitate learning
- Assess trainee performance
- Monitor and review progress

- Evaluate training sessions
- Report outcome

It can be seen that the majority of skills and competencies required of an instructor, over and above the knowledge and skills in operating the type/class held on the professional license, are human factor based.

2. AMC1 FCL.920 Instructor competencies and assessment

This requirement states that training should be both theoretical and practical. Practical elements should include the development of specific instructor skills, particularly in the areas of teaching and assessing threat and error management and CRM. It is clear that the instructor must be able to identify threat and error management (TEM) and CRM issues while training and/or observing crews.

3. AMC1 ORO.FC.115&215 (h) Assessment of CRM Skills

This requirement states that NOTECHS (non-technical skills evaluation) or other acceptable methods of assessment should be used. The selection criteria and training requirements of the assessors and their relevant qualifications, knowledge and skills should be established. The operator's stated 'behavioural marker system' must be used by the Instructor to assist in both assessing and training the candidate in acceptable dealing strategies. This is not only pertinent to an operator; the instructor is required to assist any candidate regardless of the role undertaken (operating on commercial air transport or not).

The role of the instructor is to develop the crew in their ability to both fly and operate the aircraft safely by developing knowledge, skills and abilities required. From a human factors perspective the crew will need instruction in developing dealing strategies for threats and errors during both normal operations and emergency handling. The instructor will therefore need to gather intelligence from a non-technical perspective during the total exposure time to the candidates. This would include, but is not limited to, briefing the operation and the debriefing.

As is always the case, the instructor will need to take adequate notes covering technical issues and more importantly any non-technical issues observed. It needs to be emphasised that both positive and negative issues should be recorded.

Crew/Pilot Responsibility (Threats and Errors)

Crews should conduct TEM assessment at appropriate times during the operation, and the instructor must have the ability to identify whether the crew conducted any such assessment. The most obvious time for the instructor to gather this information would be during a briefing. For example by considering what is specifically briefed (MSA, taxi route, weather) and looking for discussions on stress, workload and time management.

Flight crews must, as part of the normal discharge of their operational duties, employ countermeasures to keep threats, errors and undesired aircraft states from reducing

margins of safety in flight operations. Examples of countermeasures would include checklists, briefings, call-outs and SOPs, as well as personal strategies and tactics. The trainer must observe whether the crew dedicates significant amounts of time and attention to the application of countermeasures to ensure margins of safety during flight operations are maintained.

The crew would usually discuss the aircraft systems providing some threat countermeasures during the brief. The following would be examples of “hard” resources that flight crews employ as systemic-based countermeasures:

1. Airborne Collision Avoidance System (ACAS)
2. Ground Proximity Warning System (GPWS)
3. Standard operation procedures (SOPs)
4. Checklists
5. Briefings
6. Training

Other countermeasures are more directly related to the human contribution to safety. These are personal strategies and tactics, and individual and team countermeasures. These would typically include canvassed skills, knowledge and attitudes developed by human performance training, most notably by Crew Resource Management (CRM) training. The Instructor/examiner needs to ensure that the crew is trained in the development of their dealing strategies. There are basically three categories of individual and team countermeasures:

- Planning countermeasures: Essential for managing anticipated and unexpected threats
- Execution countermeasures: Essential for error detection and error response
- Review countermeasures: Essential for managing the changing conditions of a flight

Enhanced TEM is the product of the combined use of systemic-based individual and team countermeasures.

Instructors Responsibility (assessment or identification of threats and errors)

Under the requirements of Part FCL, the instructor is required to train both theoretical and practical elements of the operation, but must also be competent in the area of teaching and assessing TEM and CRM. As previously suggested, specific aircraft systems must be considered as threat countermeasures and should be briefed accordingly by the crew. As well as identifying these, instructors should attempt to pay attention to less technical (more

human factor orientated) aspects of the crew's execution of threat and error management. To help achieve this, during formal instructor training the trainee instructor must be introduced to the assessment and instruction of human performance and limitations, including the principles of threat and error management and appropriate countermeasures developed in CRM. It is important that an instructor is able to observe all pertinent threats during both the briefing/debriefing stages and during the activity. To achieve this, the instructor needs to formalise the process during the planning stage.

The Instructor should be able to observe and formulate an accurate opinion of the candidates in order to assist in assessing any pertinent threats. This can take the form of obvious traits, states, attitudes or dynamics between the crew-members. These sorts of issues can expose the operation to predictable hazards in the same way as technical issues, but can be more easily missed by instructors, especially when fully engrossed in other aspects of their role. The purpose of such considering at this stage is to prepare for potential eventualities during the training detail. Most instructors would do this as a matter of course but a more formal focused approach might be beneficial. To assist this process the following assessment system is offered:

An effective assessment system

Application of the principles of TEM and CRM principles to training:

1. Application and practical uses;
   The instructor will need to make an initial assessment during the first contact with the candidate under check. Whilst first impressions can be misleading if not considered in context (due to pressure of the check, nerves, etc) the opportunity to gather useful insight should not be ignored. The initial appraisal should never be used as a specific debrief point but will be of use when developing the overall picture.

2. Assessment methods;
   As with most TEM there are clues as to the potential hazards: the area the instructor needs to concentrate on initially is specifically associated with the candidate's demeanour. The instructor will need to determine whether there are any evident traits that could cause hazards.

3. Individual corrective actions;
   The intention of the assessment is to assist the instructor in offering guidance through facilitation to the candidate on potential hazards evident within the training experience. It would be valuable for the instructor to assist the candidate in developing strategies for dealing with similar circumstances in future.

4. Debriefing techniques.

If not dealt with in a considerate way, the subjective nature of this sort of assessment has the potential to devalue the experience. It is therefore essential that the debriefing be as facilitative as is possible.

Instructor instruction on strategy development to counter threats

The regulatory process associated with the training for professional licences mandates that all pilots receive training in human performance and limitations. This is contained within the regulation from FCL.120 LAPL to FCL.515 ATPL. It would be valuable for the instructor to review the requirements of HPL training for the professional licence holder. Having reviewed the subject matter the following items are pertinent to the instructional role:

The instructor needs to be able to:

- Summarise the current approach to human error in aviation and explain factors that influence human reliability.
- Explain the relationship between personal ‘mental models’ and the creation of cognitive illusions.
- Compare unintended and intended deviations from standards, leading to negative consequences.
- Train the candidate in developing strategies that can be used to reduce human error.
- Describe the major factors on which decision-making should be based during the course of a flight
- Explain how risk assessment, commitment, and pressure of time affect decision-making strategies. Risk assessment is the determination of quantitative or qualitative value of risk related to a concrete situation and a recognised threat (also called hazard).
- Describe the positive and negative influences exerted by other group members on an individual's decision-making process. Several factors influence decision-making. These factors, including past experience, cognitive biases, age and individual differences, influence what choices people make. Understanding the factors that influence the decision-making process is important to understanding what decisions are made.
- Justify the need for being aware of one's own performance before and during a flight and possible consequences of its result as part of a pilot's professionalism.
- Name the main steps towards regaining lost situation awareness.

- Compare the team coordination during the flight training phase and commercial flight operation.
- Describe the function of communication in a coordinated team.
- Distinguish between co-operation and co-action.
- Explain the term 'synergy'.
- Define the term 'cohesion'.
- Define the term 'groupthink'.
- Define the term ‘risky shift’.
- Explain how behaviour can be affected by the following factors:
  - Persuasion
  - Conformity
  - Compliance
  - Obedience
- Distinguish between status and role.
- Explain the terms ‘leadership’ and 'followership’.
- Describe the trans-cockpit authority gradient and its affiliated leadership styles.
- Illustrate different leadership styles and judge their influence on communication patterns and behaviour of crew-members.
- Name the most important attributes for a positive leadership style.
- Define and distinguish between personality, attitude, and behaviour.
- Summarise the influence of pilot relevant personality traits on pilots' performance in the cockpit environment.
- Explain the influences of different levels of motivation on performance in taking into consideration arousal and task difficulty.

Observation skills

In practice, crew observation has a formal assessment component and an informal component. The formal assessment component is the observation in line with behavioural markers and involves documenting the specific CRM behaviours that are noticed as part of the assessment. The informal component of observation is less obvious but arguably more important, and may or may not feed into behavioural markers. In practice this is simply the instructor’s observation, using his/her own experience of good practice and good CRM, to

spot any ongoing or developing safety related issues around the operation, and debrief accordingly. Some examples are offered below. Although all observational skills will improve with experience, it is nevertheless important to take all opportunities to practice and obtain feedback on one's observational performance. The instructor should regularly reflect on what the goals of crew observation are, and how they are to be achieved.

Observational examples

Example 1

During a routine observation it was apparent at the briefing stage that the crew may have issues. This was evident from the first officer being young, enthusiastic and assertive but the older commander being less enthusiastic and evidently less knowledgeable. Initial impressions suggested the possibility of potential conflict between this crew that may expose the operation to hazard. Although one should be careful not to look specifically for evidence to confirm early impressions (confirmation bias), such observations can be important to note (or remember) in case they prove founded later and can add value to the analysis of crew performance (i.e. providing root causes, learning points, and future strategies to be considered).

Subsequently during the session whilst the first officer was flying in the holding pattern with one engine inoperative (no auto-thrust) a conflict developed whereby the first officer disagreed with the commander regarding a QRH action. To resolve the conflict the first officer neglected his primary role of flying the aircraft and dedicated his time to checking and questioning the commander in his use of the QRH. With the lack of performance monitoring, the aircraft speed decayed to stick shaker minimums, the autopilot dropped out and the aircraft rolled over. At this point the TRE froze the simulator and curtailed this part of the check.

At the debrief stage the TRE did not make the association between the behaviour evident at the briefing stage and the eventual loss of control. Whilst the event was in no way predictable from the observed actions early in the detail, those observations were a clue to a potential hazard that needed to be monitored.

Example 2

Consider how the following set of circumstance would be viewed;

It was decided to reposition the aircraft in a downwind position where the crew were held stationary (using position freeze) whilst they conducted their preparation. Once the crew had completed all the preparation and briefings, the session was restarted for a real time 'one engine inoperative' ILS and go-around. Initially there was some confusion as to the correct configuration of the aircraft, as the TRE had selected some flap to align with the simulator reposition needs. The approach was flown successfully followed by the go-around. During the go-around the acceleration and flap retraction process was not completed in accordance with the company SOPs. The TRE assessed this as a failed item that would require retraining and retesting. The problem

arises in assessing root cause. During facilitative debriefing it appeared the crew may not have been as complicit as was previously concluded. During the reposition the crew were placed in a configuration that would indicate the approach phase had started and therefore a trigger for setting other than a default acceleration altitude was missed.

Example 3

The Captain was dealing with an engine failure utilising the company mnemonic to assist in the process. The progress of this strategy was interrupted by a simulated cabin crew request to clarify the violent vibration felt within the cabin. The captain immediately invited the cabin crew member into the flight deck and was prepared to give a brief covering the nature of the emergency, his intentions, and the time remaining before the landing and if there were to be any special instructions. Fortunately before being completely distracted by this interruption the captain was able to refocus on the engine failure and associated priorities. The remainder of the simulator detail was handled well by the crew with some commendable management. The CRM assessment covered all the company defined behavioural markers focusing on the successful outcome of the simulator check.

However it is worth considering whether the TRE could have offered the crew anything that could enhance their operation and develop their resilience to other evident threats. If not, then it could be that the debrief assisted the crew in confirming their actions for future similar events. It was very easy for the cabin crew member to interrupt the flow of the captain's thinking when the workload was not excessive. The TRE could have assisted the crew in identifying the very real effect of distractions and how subtly they could be introduced.

Non-technical skills (NOTECHS) assessment

The concepts of MCC and CRM as defined in Part-FCL and Part-ORO may appear at first glance to be somewhat different, however, closer comparison shows that they are in fact the same.

The CRM training and checking requirements in Part-ORO apply to both multi and single-pilot operators; the MCC requirements in Part-FCL emphasise the competencies required in the multi-crew environment.

Comparison demonstrates that in reality, Part-FCL and Part-ORO require exactly the same competencies to be trained and then tested.

MCC concept (Part FCL)	CRM concept (Part ORO)
'Multi-crew cooperation' (MCC) means the functioning of the flight crew as a team of co-operating members led by the pilot-in-command. The objectives of MCC training are to develop the	'Crew Resource Management (CRM) is the effective utilisation of all available resources (e.g. crewmembers, aeroplane systems, supporting facilities and persons) to achieve a safe and efficient

MCC concept (Part FCL)	CRM concept (Part ORO)
technical and non- technical components of the knowledge, skills and attitudes (competencies) required to operate a multi-crew aircraft.'	operation. The objective of CRM is to enhance the communication, human factors and management skills of the crewmembers concerned. The emphasis is placed on the non-technical aspects of the crew performance.'

From AMC FCL.735:

MCC competency requirements	MCC knowledge requirements
▪ Communication ▪ Leadership and teamwork ▪ Situation Awareness ▪ Workload Management ▪ Problem Solving and Decision Making ▪ Monitoring and Crosschecking ▪ Task Sharing ▪ Briefing ▪ Flight Management	▪ Human Factors ▪ Threat and Error Management ▪ Crew Resource Management ▪ Application of Threat and Error Management and CRM principles. ▪ SOPs ▪ Aircraft systems ▪ Undesired aircraft states ▪ PF and PNF roles ▪ Emergency and abnormal procedures

From AMC ORO.115, 215:

CRM competency requirements	CRM knowledge requirements
▪ Communication ▪ Application of Threat and Error Management and CRM principles. ▪ Threat and Error Management ▪ Leadership and teamwork ▪ Situation Awareness ▪ Workload Management	▪ Error detection, error prevention ▪ Application of Threat and Error Management and CRM principles. ▪ Information acquisition, processing and Situation Awareness ▪ SOPs ▪ Human Performance and Limitations

CRM competency requirements	CRM knowledge requirements
▪ Problem Solving and Decision Making ▪ Use of Automation ▪ Task Sharing ▪ Stress, Stress management	▪ Automation Philosophy ▪ SOPs ▪ Operator Safety Culture

The training and testing of non-technical skills is an integral part of initial licensing and the demonstration of continued proficiency under Part-FCL and Part-ORO. There are five events during which CRM/MCC competence is specifically assessed: the License Skill Test (LST); the License Proficiency Check (LPC); the Operator Proficiency Check (OPC); the Line Check, and for ATQP fleets, the Line Orientated Evaluation (LOE).

An individual should not normally fail a skill test or proficiency check for poor non-technical skills in isolation; the failure should normally be linked to a technical failure.

SECTION B, PART 2, CHAPTER 20

Behavioural marker systems

The technical outcomes of pilot actions have long been the basis for assessment. Maintaining and/or not exceeding important parameters such as airspeed and altitude became the norm early on, and are still used today along with many other indicators such as good navigation and the ability to consistently demonstrate certain manoeuvres such as take off and landing. Such measures are relatively objective, meaning that the opinion of the assessor should have only a small overall effect. However such indicators give little insight into the non-technical performance of the pilot or crew such as ability to communicate effectively, or manage workload. Although this was recognised many years ago, non-technical skills remained a small part of pilot assessment until relatively recently (under headings such as ‘airmanship’).

With the introduction and growth of CRM a method of CRM assessment was needed. The only realistic method available was the observation of crew behaviour, and this is still the case today. There are major problems with this method, mostly stemming from its subjective nature; for example it is not an inherently reliable system (one trainer may judge things very differently to another, or even themselves on a different day). In an attempt to resolve these issues, scientifically established methods of behavioural observation were adapted for use within aviation training and assessment.

A well-established scientific method for recording and analysing behaviour is the construction of lists (or taxonomies) of behaviours that the scientists expect to see (the items in the list can be called behavioural descriptors). The observer refers to the list while watching the activity (or a recording of it) and notes each of the behaviours as they notice them occurring. This process is usually repeated for samples of people. Reliability and consistency of the descriptors is usually scrutinised statistically (i.e. by use of inter-rater reliability tests) in an attempt to counter some of the subjective nature of the data collected.

Using scales of this sort, scientists can produce data about peoples’ behaviour, and this can be analysed alongside factors such as peoples’ performance.

The adjustment of this sort of methodology for assessing the behaviour of a flight deck crew during a single session is still debated, but is nevertheless firmly established in the form of behaviour marker systems. The general idea behind behavioural marker systems is to provide a set of descriptors that when identified by the instructor or trainer, indicate effective (and in some marker systems, ineffective) CRM behaviours. Hence, a key principle of the system is that trainers are able to recognise the behaviours consistently in the training environment. Many marker systems have been produced and a variety of consistency measures have been attempted in order to demonstrate their consistency.

The two most well known marker systems are the University of Texas (UT) system and the NOTECHS scheme, but it is important to stress that there are many behavioural marker systems in existence. The two schemes are shown here as examples only.

University of Texas (UT) Behaviour Marker System

The UT system is considered to be the first major behaviour marker scheme and was developed from research by Helmriech et al in the early days of CRM. It was subsequently used as the basis for many airlines' behaviour marker schemes (Flin and Martin 2001). The UT scheme splits CRM into 13 general elements, each one being accompanied by a number of exemplar behaviours used to assist the trainer / examiner to identify good CRM performance.

Importantly, in common with most subsequent behavioural marker systems, the UT system only provides positive markers. This has been questioned in terms of its validity for use as an assessment tool, and arguably led directly to the development of NOTECHS. The UT system is shown below (Table 2)

SOP briefing	The required briefing was interactive and operationally thorough	Concise, not rushed, and met SOP requirements. Bottom lines were established	P-D
Plans stated	Operational plans and decisions were communicated and acknowledged	Shared understanding about plans. "Everybody on the same page"	P-D
Workload assignments	Roles and responsibilities were defined for normal and non-normal situations	Workload assignments were communicated and acknowledged	P-D
Contingency management	Crew members developed effective strategies to manage threats to safety	Threats and consequences anticipated. Used all available resources to manage threats	P-D
Monitor/crosscheck	Crew members actively monitored and crosschecked systems and other crew members	Aircraft position, settings, and crew actions were verified	P-T-D
Workload management	Operational tasks prioritised and properly managed to handle primary flight duties	Avoided task fixation. Did not allow work overload	P-T-D
Vigilance	Crew members remained alert of the environment and position of the aircraft	Crew members maintained situational awareness	P-T-D
Automation management	Automation was properly managed to balance situational	Automation setup briefed to other members. Effective recovery	P-T-D

	and/or workload requirements	techniques from automation anomalies	
Evaluation of plans	Existing plans were reviewed and modified when necessary	Crew decisions and actions openly analysed to ensure existing plan was best	P-T
Inquiry	Crew members asked questions to investigate and/or clarify current plans of action	Not afraid to express a lack of knowledge. “Nothing taken for granted” attitude	P-T
Assertiveness	Crew members stated critical information and/ or solutions with appropriate persistence	Crew members spoke up without hesitation	P-T
Communication environment	Environment for open communication was established and maintained	Good cross talk – flow of information was fluid, clear, and direct	G
Leadership	Captain showed leadership and co- ordinated flight deck activities	In command, decisive, and encouraged crew participation	G
Key to Phase: P = Pre-departure/Taxi; T = Take-off/climb; D = Descent/Approach/Land; G = Global			

Table 2. University of Texas (UT) behavioural markers rating scale

1 = poor	2 = marginal	3 = good	4 = outstanding
Observed performance had safety implications	Observed performance was barely adequate	Observed performance was effective	Observed performance was truly noteworthy

Table 3. The rating scale for the UT marker system

The NOTECHS Behavioural Marker Scheme

Categories	Elements	Example Behaviours (positive)
Co-operation	Team building and maintaining	Establishes atmosphere for open communication and participation
	Considering others	Takes condition of other crew members into account
	Supporting others	Helps other crew members in demanding situations
	Conflict solving	Concentrates on what is right rather than who is right
Leadership and managerial skills	Use of authority and assertiveness	Takes initiative to ensure involvement and task completion
	Maintaining standards	Intervenes if task completion deviates from standards
	Planning and co-ordinating	Clearly states intentions and goals
	Workload management	Allocates enough time to complete tasks
Situation awareness	System awareness	Monitors and reports changes in system's states
	Environmental awareness	Collects information about the environment
	Anticipation	Identifies possible future problems
Decision making	Problem definition/diagnosis	Reviews causal factors with other crew members
	Option generations	States alternative courses of action. Asks other crew members for options
	Risk assessment/option choice	Considers and shares risks of alternative courses of action

Table 4. The NOTECHS Behavioural Markers

Very poor	Poor	Acceptable	Good	Very good
Observed behaviour directly endangers flight safety	Observed behaviour in other conditions could endanger flight safety	Observed behaviour does not endanger flight safety but needs improvement	Observed behaviour enhances flight safety	Observed behaviour optimally enhances flight safety and could serve as an example for other pilots

Table 5. NOTECHS grading guidance table

The NOTECHS system (Table 4, above) was developed to fulfil a need within the JAA (Joint Aviation Authorities) for a generic method of non-technical skills evaluation for use by their operators (Flin et al 2003). It is composed of four categories (Cooperation, Leadership and Managerial skills, Situational Awareness and Decision Making). Each is broken into a number of elements with exemplar behaviours. The primary difference between NOTECHS and most other behavioural marker systems is the inclusion of both positive and negative CRM behaviours.

For more in depth information about NOTECHS, refer to Klampfer et al (2001) or other documentation from the GIHRE (Group Interaction in High Risk Environments) project, or the JARTEL project.

PART B, PART 3

CRM effectiveness

In this Part

Chapter 21

Facilitation skills for CRM trainers

Chapter 22

Resources for improving CRM effectiveness, including:

Chapter 22a

Ten point checklist for assessing overall CRM effectiveness

Chapter 22b

Guide to assessing a CRM ground trainer

Chapter 22c

Short Guide to Performance Standards for CRM trainers

Chapter 22d

Informal checklist for CRM trainer competencies

Chapter 22e

Informal guide to twenty instructional traps and faults of CRM trainer

Chapter 22f

Trainer Competencies

Chapter 22g

Examiner Competencies – simulator

Chapter 22h

Report Writing and Handover guide

SECTION B, PART 3, CHAPTER 21

Facilitation skills

For any training to be effective, trainers must communicate information clearly. Additional to the effective transmission of information by the trainers, learners must engage with the content in order to properly understand and accept it. The latter is particularly important where attitudes towards CRM are concerned. Pilots' attitude towards CRM is an oft-debated issue and regularly researched. There were certainly some problems in the early days of CRM, when some pilots did not accept CRM ideas and there was even some open hostility. Although things have changed, the CRM trainer will still find a number of CRM sceptics in any session, and these critics usually have sound reasons for their attitudes.

It is sometimes said that style of delivery is more important than content of a training session. This mind-set can be damaging to CRM in general. Although style of delivery is important, aviation professionals are an intelligent audience; the trainer who puts presentation before content will be noticed, and will adversely affect attitudes to CRM. Unfortunately it is still common for a skilled facilitator to run a superbly enjoyable and seemingly thoughtful session after which participants fill in fine reviews, but from which they recall little of value the day after. Before concentrating too heavily on methods of delivery, the CRM trainer must get the content right.

		Instructing	Facilitating
1	What do the words imply?	Telling, showing	Making easy, enabling
2	What is the aim?	Transfer knowledge/skills	Gain insight/self-analysis to enable an attitude change
3	Who knows the subject?	Instructor	Both
4	Who has the experience?	Instructor	Both
5	What is the relationship?	Top-down	Equal
6	Who sets the agenda?	Instructor	Both
7	Who talks the most?	Instructor	Student
8	What is the timescale?	Finite	Infinite
9	Where is the focus?	Instructor/task	Student/attitudes/behaviour
10	What is the workload?	Medium/high	Intense
11	What are the trainers' thoughts?	Judgemental	Non-judgemental
12	How is progress evaluated?	Test	Observation/self-assessment

Table 6. Differences between Instruction and Facilitation (Dismukes and Smith 2000)

Once the trainer has decided on effective content including achievable objectives, they should consider the most effective ways to deliver it. The method of delivery will depend upon what is being taught, and what the objectives are. In practice, there are two basic forms of delivery: instruction and facilitating. The differences between instruction and facilitation are outlined in Table 5.

Instruction can be described as being primarily a telling activity, where information is communicated to trainees through either direct communication or demonstration, with questioning primarily used to check understanding or reinforce key messages. Facilitation on the other hand, can be described as a technique that helps trainees to discover for themselves what is appropriate and effective, in the context of their own experience and circumstances.

Both techniques are useful and have their place. Instruction is the most efficient technique to employ for straightforward knowledge transfer; it would be laborious and unnecessary to teach a straightforward and precise subject such as an electrical system using facilitation. Instruction is quick and efficient, and can be used to train larger numbers of people. However trying to teach appropriate attitudes using instruction is difficult, particularly if the instructor does not have the authority or credibility required. One reason is that a person's behaviour is based on their own past experiences and values and therefore telling people

to behave differently carries the implication that their values are wrong. Facilitation allows for values and beliefs of trainees to be accounted for, and is therefore less likely to create internal conflict (CAA 2006).

To facilitate well, a trainer starts by deciding on objectives; what a successful session would achieve in terms of audience knowledge, understanding or attitude. They then decide what needs to be done in order for the participants to achieve these objectives by themselves. The audience can gain their own understanding by engaging in activities, such as answering well-framed questions or analysing data or case studies that the trainer has prepared. The skill of the trainer is to prepare and guide the session in a way that allows discovery of the desired points by audience members, but avoids generating a lot of off-task discussion (wasting time), unsolvable disagreements, or the audience reaching the opposite conclusions to those desired. These are all dangers of facilitation, and trainers must therefore plan and act carefully.

The following four facilitation skills should be practiced and used whenever possible:

1. Effective Questioning
2. Listening
3. Observation of behaviour
4. Role modelling

1. Effective Questioning

Asking the right questions at the right time is a fundamental skill of facilitation. Appropriate questioning techniques are:

Open Questions

Open questions are constructed in order to elicit objective answers that are not skewed by the questioner's agenda. The nature of open questioning lends itself to long and detailed explanations where these are required. The participants' response to an open question is not anticipated or implied by the questioner, and whereas post-question prompts can steer the answer to explore particular areas, they should not suggest or hint at what the questioner's expectations. Open questions often start with words such as 'what, when, why, where, who, how'.

Closed Questions

Closed questions are those where the possible answers are restricted or even implied. Multiple choice or dichotomous questions are closed, e.g. "Do you think this topic is useful?" (The equivalent open question would be "what do you think of this topic?"). Closed questions are used to check understanding or to invite short and controlled contributions. Closed questions often start with words / phrases such as 'do you, don't you, did it, was it'.

Probing and prompting

For many reasons, people sometimes answer questions without giving much information, and the facilitator wants more. Facilitators must be careful not to narrow the possible responses to an open question by following it up with a closed one; a skill of a facilitator is to obtain more information to the original question without changing it. Hence to develop an answer, facilitators should use open and objective phrases such as ‘tell me more about that’, or ‘what are the reasons behind that?’

The following types of questions are best avoided where possible:

- Leading questions ‘it was a classic case of human error wasn’t it?’
- Multiple answer questions ‘what was it? Human error, weather, technical failure?’
- Rhetorical ‘How can a crew be safe if they don’t communicate properly?’

2. Listening

It is frustrating for participants if a trainer appears unable to listen and engage with participants’ views. It has often been said that hearing is done with your ears whereas listening is done with your mind. In this respect the term active listening means that a person is concentrating carefully on what is being said, so that they can really understand the other person. The following mnemonic (LISTEN) could help trainers to appear more engaged:

- Look interested;
- Inquire with questions;
- Stay on target;
- Test understanding;
- Evaluate the message;
- Neutralise your thoughts, feelings and opinions.

CAA (2006)

3. Observation of behaviour

The ability to observe and discuss behaviour and attitudes as well as technical issues is a skill that trainers need to practice to become effective facilitators.

4. Role modelling

The importance of role-modelling was discussed in Chapter 13, and it applies to an instructor or trainer in the same way as others. Students should observe appropriate ways of acting and communicating and experience the positive effects on themselves. It is therefore important that the CRM trainer has good communication and ‘people’ skills such as showing the ability to take on board contrary opinions or accepting criticism.

Participant feedback in developing facilitation skills

To continuously improve one's facilitation skills, a trainer should regularly seek feedback from those being trained. If participants appear to be giving no criticism then the following possibilities should be considered:

- The trainer is doing a good job
- The trainer has a reputation of difficulty when dealing with criticism
- The trainer is not respected enough (feedback is considered 'not worth the effort')
- The trainees believe there is nothing to be gained from feeding back

Feedback that is collected in a simple way, straight after a session (often known as happy sheets) should be treated with caution because it often reflects emotionally affected responses that bias the reactions. People who enjoyed being in a session will tend to state that the session content was useful. Similarly trainees who dislike a trainer or got bored will tend to see less value in the content. Hence a trainer who adjusts their session content based on immediate or simple feedback risks making a mistake, as does the trainer who believes they are doing a good job because the feedback was excellent.

Although more difficult, collecting open feedback after a few days will be more useful. Participants will have had time to consider the content and will be less affected by their experience of the trainer or presentation. Collecting feedback by talking honestly to participants is usually more beneficial than feedback sheets, particularly when done out of the session context.

All trainers will receive criticism and must be prepared to view it objectively and not personally. Very few participants are interested in making comments as personal attacks on trainers, even if it looks that way. A trainer must be dispassionate, and it can therefore be helpful to ask a trusted other to give their impression of one's training feedback.

SECTION B, PART 3, CHAPTER 22

Resources for improving CRM effectiveness

This chapter is divided into eight parts:

a) Ten point checklist for assessing overall CRM effectiveness

b) Guide to assessing a CRM ground trainer

c) Short Guide to Performance Standards for CRM trainers

d) Informal checklist for CRM trainer competencies

e) Informal guide to twenty instructional traps and faults of CRM trainer

f) Trainer Competencies

g) Examiner Competencies – simulator

h) Report Writing and Handover guide

SECTION B, PART 3, CHAPTER 22A

Checklist of 10 practical indicators of effective CRM

Introduction

The purpose of this checklist is to offer an easy set of indicators of effective CRM throughout a company. It offers 10 items for the operator, the training pilots and the line pilots. Not all items are relevant to every operator, nor of course is the list exhaustive, but it can act as a starting point from which to determine the effectiveness of the CRM programme, and whether it is making a difference to line flight crew performance. The checklist is designed to promote understanding and identify strengths or gaps in overall CRM.

Operator

1. CRM is integrated into training programmes to align the SIM and Ground School
2. CRM has a scientifically robust basis in its design, as far as possible.
3. CRM targets or aims are set for training and SMS monitoring
4. Training data are used to assess and evaluate CRM skills. Skills are individually assessed (rather than a simple CRM pass/fail)
5. Feedback on FDM and/or ASR includes analysis of CRM issues
6. The safety management system recognises CRM issues
7. CRM articles or papers are distributed to the pilots (e.g. via safety magazines)
8. Instructors are suitably trained/checked in CRM and receive on-going development
9. In-depth CRM is understood beyond just teamwork/communication/joint training
10. There is a mix of joint and role-specific separate training

Training Pilots

1. CRM training has clear aims in terms of specific skills to develop
2. Routine and overt use of behavioural markers in briefing and debriefing
3. Trainers are able to identify CRM root causes of both effective and poor performance

4. Simulator lessons allow crews to practice time management skills that replicate the real world
5. Instructor is able to pass on practical CRM tips to enhance pilot performance
6. Instructors can use CRM models or illustrations to help pilot understanding
7. Instructors are able to facilitate reasonably well
8. Instructors limit the number of debrief items to maximise in-depth learning
9. Trainers are able to role model CRM skills
10. Training is practical, and integrates both technical and CRM aspects

Flight Crew

1. Pilots are familiar with the Behavioural Marker System
2. Pilots demonstrate CRM skills openly (such as avoiding rushing / sharing thinking)
3. Flight deck tone is relaxed and professional
4. Problems are anticipated
5. Contingency plans are included in briefings (such as diversion routes)
6. Formal briefings are updated when things change
7. Things are done in a timely way through the flight
8. Pilots routinely seek feedback from one another to maximise learning
9. Pilots are able to self-reflect on their performance to enhance self development
10. The flight deck gradient is appropriate to the situation

SECTION B, PART 3, CHAPTER 22B

Guide to assessing a CRM ground trainer

This section is modified from the examiner guidance that was used within the UK CRM accreditation scheme (for a CRMIE when examining a CRMI). The CRMIE is referred to as the assessor, and the CRM trainer as the candidate.

This brief is to assist in the assessment of a CRM (ground) trainer in the class environment. It includes an easy to use checklist in the form of effective CRM trainer knowledge, skills and attitudes so that assessors will know what to look for.

The checklist and form are practical tools that reflect the reference material in the short guide (Chapter 22, Part C). They are designed to help the assessor make and record an assessment of the candidate's suitability to train CRM on the ground. The form is also useful for the candidate to appreciate the requirements that are being observed and assessed. They are not mandatory and an assessor is free to use his or her own company paperwork.

In the early stages of CRM training the test should also include encouragement and development of CRM teaching and assessment skills. Assessors should also bear in mind that whilst some CRM ground-school training pilots may be experienced in their role, classroom facilitation skills may still be new to them.

Documents

In addition to any course material CRMI Examiners should also be familiar with the general content of the following documents:

- The short guide to performance standards of ground Instructors (Chapter 22, Part C)
- Standards Document 29 (available at www.caa.co.uk)
- NOTECHS or company CRM Standards

Preparation

The assessor will need to establish the type of course, review the syllabus/course material and establish the experience level and recency of the candidate and course trainees. Additionally a date/time should be agreed to allow for extra opportunity for briefing/debriefing of the candidate.

Briefing / Conducting the assessment

The assessor needs to brief the candidate in plenty of time before the course starts. This ensures there is time to:

- Set an open and professional tone
- Discuss the assessor's role (including seating position and involvement with the class)
- Discuss briefing the class about the assessor
- Establish what the training objectives are for the session
- Allow an opportunity for the CRM trainer (candidate) to ask questions
- Establish how many courses the candidate has run in the validity period
- The assessor should maintain an unobtrusive role during the training, leaving the CRM trainer responsible for course conduct and timing
- The assessor should bear in mind that the needs of the trainees

Debriefing/Report

- Assessors should adopt an appropriately relaxed but professional tone required for the debrief and deliver the test result at the outset
- The overall aim is to facilitate learning and for the assessor to role model an effective debriefing that ensures that the candidate makes the analysis of their own performance
- The debriefing should focus on the candidate's development and include an appropriate balance of positive and negative feedback.
- Any written report should reflect the debrief. In addition the assessor should bear in mind the following points:

Examining CRM trainer performance requires that an assessor displays the best examples of CRM skill in handling the CRM trainer candidate throughout the test, without losing any of the objectivity required to ensure a minimum standard.

Assessment Criteria

Full details of reference material for instructor competence are contained in "The Short Guide to Instructor Standards" (Chapter 22C). The candidate should explain the reasons for the training at the outset. The aim of the assessor's checklist (below) is to provide a summary of the key knowledge, skills, and attitudes as an aid to making an assessment of the candidate's competence. The assessor may find using this simple 8-point checklist of effective knowledge, skills and attitudes to be an easy way to analyse and assess the appropriate important performance elements.

Were the training objectives achieved, YES or NO?

In deciding, consider the following:

1. Did the candidate demonstrate the knowledge required for the role?
2. Did the candidate encourage trainees to participate, share their experience and self-analyse?
3. Did the candidate identify and respond to the trainees' needs relative to their expertise/experience?
4. Did the candidate incorporate NOTECHS or company CRM standards when appropriate?
5. Did the candidate integrate practical CRM within technical training and line operations?
6. Did the candidate identify CRM reasons for accidents / incidents?
7. Did the candidate regularly check for understanding and resolve ambiguity?
8. Did the candidate demonstrate effective instruction and facilitation skills?

If further assistance is required in addition to the above checklist, the examiner could ask him/herself whether the candidate:

- Overtly supports CRM principles in word & deed (actively role models good CRM).
- Works hard to establish a rapport with trainees.
- Is open and honest.
- Creates an atmosphere of trust and respect
- Preserves confidentiality.
- Shows themselves to be a good listener
- Uses a sense of humour.
- Is supportive of any fellow trainers.
- Is always patient, sensitive and respectful of others
- Seeks feedback and responds appropriately
- Openly strives to improve their own performance

SECTION B, PART 3, CHAPTER 22C

Short guide to performance standards for CRM trainers

The purpose of this Short Guide is to give guidance and information to operators, providers of CRM training and CRM trainers, on the necessary standards of competence.

This Short Guide details what CRM trainers need in order to be considered competent in each of three different contexts:

- Simulator & Base Training
- Line Training
- Ground School Training

Material in these three contexts is naturally similar, but is laid out separately to avoid the need to cross-refer between contexts. In each of the contexts there are four main Areas of Competence: -

a) Designs training

b) Delivers training

c) Assesses trainee progress

d) Continuously improves the effectiveness of the training

The Areas are subdivided into 12 Units of Competence, each of which contains a number of Performance Elements and Background Knowledge. Those elements marked in **bold** are essential and the rest are options. To meet the requirements, trainers must be able to demonstrate competence in all the essential elements plus five option elements.

Simulator and base training

Unit	Performance element	Knowledge
A1 – Designs CRM training sessions	**1. Identifies training requirements** 2. Selects CRM standards 3. Builds in methods of evaluating training effectiveness	▪ Understanding objectives ▪ Company and industry requirements ▪ Training techniques ▪ Relevant regulatory requirements ▪ CRM standards
A2 – Prepares resources	**1. Ensures activities are practical and realistic** 2. Ensures facilities meet requirements 3. Assists in the preparation of briefing materials	▪ Simulator procedures and resources ▪ Available equipment
B1 – Integrates CRM training	**1. Makes CRM links with technical training and Standard Operating Procedures (SOPs) where appropriate** 2. Makes links with flight safety, customer service, company policy	▪ Company technical and operational training procedures and requirements ▪ Human Factors
B2 – Creates a climate conducive to learning	**1. Establishes CRM credentials and rapport with trainees, and clarifies roles** **2. Clarifies training objectives and methods** **3. Ascertains and supports trainees' needs**	▪ Potential barriers to learning, including awareness of cross-cultural issues ▪ How to put trainees at ease
B3 – Presents knowledge	**1. Communicates clearly, accurately and adequately** 2. Creates and sustains realism in the detail	▪ Distinguish between process and content outcomes ▪ Ways to elicit participation ▪ Methods of giving information/adult learning styles
B4 – Facilitates learning and coaches individuals	**1. Encourages trainees to get involved** **2. Focus is on trainees not themselves** **3. Overtly supportive of CRM principles in word and deed (i.e. role-models good**	▪ Facilitation ▪ How to give constructive debriefing and feedback ▪ The difference between coaching and

Unit	Performance element	Knowledge
	CRM) **4. Motivating, patient, confident and assertive manner** 5. Conducts one-to-one coaching/debrief of crew members as appropriate 6. Encourages mutual support, teamwork and sharing of individual learning experiences	demonstration/instruction ▪ Group dynamics
C1 – Monitors and reviews progress	**1. Continuously monitors and responds flexibly to the training session** **2. Ensures objectives are achieved** 3. Reviews progress with trainees	▪ Methods of tracking performance in the simulator ▪ Methods of tracking performance ▪ Principles and purpose of reviews ▪ What constitutes valid and reliable information
C2 – Assesses trainees' performance	**1. Assists trainees to assess own individual and tram performance against CRM standards** 2. Sets new/additional learning objectives	▪ Uses of video playback and debriefing to facilitate learning
D1 – Evaluates CRM training sessions	**1. Elicits feedback from trainees** 2. Tracks training session processes against agreed criteria 3. Keeps appropriate records	▪ Methods of assessing and improving session effectiveness
D2 – Evaluates and develops own practice	**1. Regularly reviews own performance, strengths and development needs** **2. Collects feedback about performance from others** 3. Keeps abreast of developments from Regulator, trade press, etc. 4. Maintains a written development record against development potential	▪ Methods of assessing own performance ▪ Methods of improving own performance

Line training

Unit	Performance element	Knowledge
A1 – Designs CRM training sessions	**1. Identifies training requirements** 2. Selects CRM components of line check 3. Provides opportunities for demonstrating CRM competency.	▪ Company and industry requirements ▪ Training techniques ▪ Relevant regulatory requirements ▪ CRM standards
A2 – Prepares resources	Not applicable	Not applicable
B1 – Integrates CRM training	**1. Makes CRM links with technical training and Standard Operating Procedures (SOPs) where appropriate** 2. Makes links with flight safety, customer service, company policy	▪ Company technical and operational training procedures and requirements ▪ Human Factors
B2 – Creates a climate conducive to learning	**1. Establishes CRM credentials and rapport with trainees, and clarifies roles** **2. Clarifies training objectives and methods** **3. Ascertains and supports trainees' needs**	▪ Potential barriers to learning, including awareness of cross-cultural issues ▪ How to put trainees at ease ▪ Trainees' experience level and expectations ▪ Adult learning styles
B3 – Presents knowledge	**1. Communicates clearly, accurately and adequately** 2. Looks for training opportunities	▪ Ways to elicit participation ▪ Methods of giving information
B4 – Facilitates learning and coaches individuals	**1. Encourages trainees to get involved** **2. Focus is on trainees not themselves** **3. Overtly supportive of CRM principles in word and deed (i.e. role-models good CRM)** **4. Motivating, patient, confident and assertive manner** 5. Conducts one-to-one coaching/debrief of crew members as appropriate 6. Encourages mutual support, teamwork	▪ Facilitation ▪ How to give constructive debriefing and feedback ▪ The difference between coaching and demonstration/instruction ▪ How to encourage trainees to ask questions and seek advice

Unit	Performance element	Knowledge
	and sharing of individual learning experiences 7. Debriefs on practical application of CRM skills	
C1 – Monitors and reviews progress	**1. Continuously monitors and responds flexibly to the training session** **2. Ensures objectives are achieved** 3. Reviews progress with trainees	▪ Methods of tracking performance ▪ Principles and purpose of reviews ▪ What constitutes valid and reliable information
C2 – Assesses trainees' performance	**1. Assists trainees to assess own individual and tram performance against CRM standards** **2. Conducts formative assessments** **3. Makes assessment decision and provides clear feedback** 4. Sets new/additional learning objectives 5. Keeps appropriate records	▪ Observation techniques ▪ Methods of collecting evidence
D1 – Evaluates CRM training sessions	**1. Elicits feedback from trainees** 2. Tracks training session processes against agreed criteria 3. Keeps appropriate records	▪ Methods of assessing and improving session effectiveness
D2 – Evaluates and develops own practice	**1. Regularly reviews own performance, strengths and development needs** **2. Collects feedback about performance from others** 3. Keeps abreast of developments from Regulator, trade press, etc. 4. Maintains a written development record against development potential	▪ Methods of assessing own performance ▪ Methods of improving own performance

Ground school training

Unit	Performance element	Knowledge
A1 – Designs CRM training sessions	**1. Identifies training requirements and delivery resources** **2. Sets objectives** 3.Builds in methods of evaluating trainee effectiveness 4. Incorporates a variety of activities in design.	▪ Understanding objectives ▪ Company and industry requirements ▪ Training techniques ▪ Relevant regulatory requirements ▪ CRM standards
A2 – Prepares resources	**1. Ensures activities are practical and realistic** 2. Ensures facilities meet requirements 3. Assists in the preparation of briefing materials 4. Ensures materials are adequate and clear	▪ Existing materials ▪ Copyright and intellectual property ▪ Company training standards
B1 – Integrates CRM training	**1. Makes CRM links with technical training and Standard Operating Procedures (SOPs) where appropriate** 2. Makes links with flight safety, customer service, company policy	▪ Company technical and operational training procedures and requirements ▪ Human Factors
B2 – Creates a climate conducive to learning	**1. Establishes CRM credentials and rapport with trainees, and clarifies roles and confidentiality** **2. Clarifies training objectives and methods** **3. Ascertains and supports trainees' needs**	▪ Potential barriers to learning, including awareness of cross-cultural issues ▪ How to put trainees at ease
B3 – Presents knowledge	**1. Communicates clearly, accurately and adequately** 2. Creates and sustains realism in the detail 3. Maintains interest	▪ Distinguish between process and content outcomes ▪ Ways to elicit participation ▪ Methods of giving information/adult learning styles

Unit	Performance element	Knowledge
B4 – Facilitates learning and coaches individuals	**1. Encourages trainees to get involved** **2. Focus is on trainees not themselves** **3. Overtly supportive of CRM principles in word and deed (i.e. role-models good CRM)** **4. Motivating, patient, confident and assertive manner** 5. Uses exercises and activities to maximise learning 6. Recognises and responds to individuals' needs 7. Encourages mutual support, teamwork and sharing of individual learning experiences	▪ Facilitation ▪ How to give constructive debriefing and feedback ▪ The difference between coaching and demonstration/instruction ▪ Group dynamics ▪ Group facilitation techniques
C1 – Monitors and reviews progress	**1. Continuously monitors and responds flexibly to the training session** **2. Ensures objectives are achieved** 3. Reviews progress with trainees against formal benchmarks	▪ Methods of tracking performance
C2 – Assesses trainees' performance	**1. Assists trainees to assess own individual and tram performance against CRM standards** 2. Sets new/additional learning objectives	▪ Uses of video playback and debriefing to facilitate learning ▪ Methods of assessing knowledge and skills
D1 – Evaluates CRM training sessions	**1. Elicits feedback from trainees** 2. Tracks training session processes against agreed criteria 3. Elicits formal course evaluation from trainees 4. Keeps appropriate records	▪ Methods of assessing and improving session effectiveness ▪ Evaluation techniques
D2 – Evaluates and develops own practice	**1. Regularly reviews own performance, strengths and development needs** **2. Collects feedback about performance**	▪ Methods of assessing own performance ▪ Methods of improving own performance

Unit	Performance element	Knowledge
	from others 3. Keeps abreast of developments from Regulator, trade press, etc. 4. Maintains a written development record against development potential	

SECTION B, PART 3, CHAPTER 22D

Informal checklist for CRM trainer competencies

The following is an informal checklist for spotting competencies for CRM trainers (i.e. to answer the question: what does a good CRM trainer need?)

1. Classroom

a) The ability to interact with and manage a group (typically 6 to 8) in a classroom environment, by maintaining interest particularly using an essentially facilitative style, almost throughout.

b) The ability to pre-plan an objective and timely training session/module to incorporate (a).

c) To deliver (b) effectively by achieving the pre-planned objectives

d) To set an example to the trainees throughout

e) To be able to use delivery media effectively and flexibly (e.g. Presentation Software, whiteboard, blank charts, diagrams, film or DVD as appropriate.

f) Where training CRM tutors, to be able to demonstrate good versus poor facilitation as a particular skill (under facilitation, over facilitation and balanced facilitation).

g) To be able to assess the progress and needs of each trainee effectively and continually.

2. Simulator and aircraft - TRI/SFI (Training Session)/ line trainer

a) The ability to interact with tutorial group trainees appropriately

b) The ability to pre-plan (or adapt existing syllabus) to the needs of the trainees

c) To deliver ‘b’ in an effective manner to achieve a good blend of technical training objectives with CRM training objectives.

d) To deliver a good balance of “telling”, “selling” and “facilitating” as appropriate to the stage of training and the needs of the trainees.

e) To be able to connect realistically poor and sound CRM activity to the technical outcomes in the simulator and be able to explain them meaningfully

f) The ability to conduct assessment of performance of crew and individuals with regard to CRM/Team Skill progress.

g) The ability to conduct de-briefing sessions using a sensible balance of facilitation style with telling and selling so as to reinforce CRM/team leadership items as they connect with the technical aspects, and where appropriate deliver that assessment to the crew.

3. TRE/SFE/Line Examiner

a) To deliver a clear test verdict (“pass” or “not to standard required”) as an opening to the debriefing of the individual or the crew as appropriate.

b) In the case of a “fail”, be able to deliver “the main reasons why” in order of priority.

c) In all cases, after the “Verdict” and “Reasons”, be able to use the skills set out in “2a, d, f, g” and most importantly “2g”, to expand the test or examining session so as to achieve meaningful learning and, where appropriate, reinforcement.

SECTION B, PART 3, CHAPTER 22E

Informal guide to twenty instructional traps and faults of CRM trainers

The following is an informal guide to common problems seen when observing CRM trainers.

1. Not checking for understanding when giving participants tasks to complete.
2. When discussing 'core' CRM theory, not exploring participants' personal experiences or allow sharing of experiences to give validity to the subject.
3. Miss-management of case studies by not getting the participants to study fully any associated text in advance or during breaks. This can lead to rushed reading during the course immediately before the exercise starts, or participants being unable to gain the most from the discussion.
4. Not challenging participants to give more thought and examples to their comments.
5. Failure to resolve ambiguity when it appears.
6. A lack of planning for when two Instructors are working together, in terms of deciding how they will jointly run the course.
7. A tendency to instruct at times when facilitation would have been more effective and appropriate.
8. Tendency to verbalise personal experiences more than exploring the experiences of the group.
9. Avoiding or 'skimming-over' subject matter that they are uncomfortable with rather than working to become more knowledgeable, or using participants to support the topic.
10. Not addressing difficulties encountered when participants do not have English as their first language (or culture).
11. A lack of a clear understanding of the course aims and objectives (this is common when the course was not written by the Instructor).
12. Not having or communicating a clear strategy when working with a large group and/or multiple trainers.
13. Not using the room and space to the best advantage.

14. Not looking critically at course content to ensure it meets the participants' needs.

15. Ineffective strategy to ensure attention is maintained, particularly with large groups.

16. Ignoring those participants who are quiet, rather than trying to include them.

17. Not considering the content of computer-based presentation software to ensure it gives scope for comment.

18. Being driven by the limitations of presentational software packages.

19. A lack of NOTECH content or lack of alignment with the organisation's Safety Management System (SMS).

20. Coping strategies for participants are not agreed or are missing.

SECTION B, PART 3, CHAPTER 22F

Trainer competencies – simulator and aeroplane

Definition of grading

	Requiring improvement	Basic standard	Good	Very good
Competence	**1**	**2**	**3**	**4**
Preparation and pre-flight briefing	▪ Little or no reference to H&S ▪ Accepts inadequate facilities ▪ Lack of preparation/No proper Lesson Plan ▪ Poor time keeping ▪ Starts briefing without introduction ▪ Order of play not defined ▪ Little or no interaction with crew ▪ Little or no use of board or other visual medium ▪ Reference only to 'What' is to be accomplished with very little 'How' it is achieved, and no 'Why' ▪ Explanations verbose and/or muddled ▪ Briefing is detached	▪ Identifies basic H&S aspects at the outset ▪ Ensures facilities are suitable and functional ▪ Appropriate resources prepared in advance ▪ Has a prepared Lesson Plan with a Sequence; Teaching points; and the 'set-up' parameters listed for each exercise ▪ Introduces the training session correctly, and states the Aims ▪ Allows ample time for each element ▪ States who will do what and when ▪ Briefs from the classroom to the simulator or aircraft and back again	▪ As per 2 plus: ▪ Good introduction with clearly defined Aims and more specific Objectives ▪ Identifies the needs of the crew to create a climate conducive to learning ▪ Uses facilitation appropriately ▪ Clear structure and clarity for all visual aid work ▪ Includes CRM NOTECHS / MCC / TEM seamlessly into all areas ▪ Generates a relaxed atmosphere ▪ Good technical explanations ▪ Uses key words and concise phrases to convey meaning very effectively ▪ Immediately, able to give alternative	▪ As per 2 & 3 plus: ▪ Introduction immediately puts the crew at ease, and sets the professional tone of the session ▪ Moves effortlessly from instruction to facilitation and back to instruction as required ▪ Generates a very high level of engagement with crew, responds to their needs, and develops an empathy with them ▪ Has an in-depth knowledge of HF for the application of CRM / MCC / TEM principles ▪ Defines clearly what is expected of the crew, but

	Requiring improvement	Basic standard	Good	Very good
	from the practical exercise that will be flown in the simulator or aircraft ▪ No questioning at the end to check student knowledge ▪ No re-cap or summing up of the main points at the end ▪ Safety aspects of aeroplane training not mentioned ▪ Little or no time allowed for comfort break/thinking time between the briefing and flight	▪ Uses “You and I” in preference to “We” ▪ Briefs all items required ▪ Invites questions ▪ Provides all required documentation ▪ Introduces CRM NOTECHS ▪ Understands MCC concepts and TEM principles ▪ Uses some visual aids to support teaching points ▪ Explains ‘What’ is required, and ‘How’ to achieve it, and also ‘Why’ it is done that way ▪ Technically correct explanations, but may not yet be particularly concise in delivery ▪ Occasional use of key words and phrases ▪ Checks student knowledge at the end with a few questions ▪ Re-caps on the	explanations if something is not understood ▪ Has a highly attuned sense of airmanship	explains that the instructor is there to guide them throughout ▪ Has a comprehensive technical knowledge ▪ Very responsive to questions ▪ Visual aids support and enhance the briefing and teaching points ▪ Excellent ‘patter’ throughout

	Requiring improvement	Basic standard	Good	Very good
		main points ▪ Provides a 10 minute comfort break before going to simulator or aircraft ▪ Briefs safety aspects for aeroplane training		
Simulator operations	▪ Insufficient or no simulator safety brief ▪ Limited familiarity with IOS ▪ Irregular observation of crew ▪ Incorrect R/T ▪ Distracted by IOS at key observing moments ▪ Limited note taking ▪ Inappropriate use of freezes and repositions ▪ Poor radar vectoring ▪ Lax adherence to simulator times	▪ Checks simulator log and approvals ▪ Gives a simulator safety brief ▪ Efficient use of IOS ▪ Presents repositions to crew correctly ▪ Pre-warns the crew of failures to achieve best training value ▪ Effective note taking ▪ Provides a short break at half time	▪ As per 2 plus: ▪ Crew enters the simulator with the correct scene set ▪ Introduces failures appropriate to crew actions ▪ Adjusts 'running sequence' to optimise time management ▪ Identifies crew or individual fatigue	▪ As per 2 & 3 plus: ▪ Very realistic scenarios ▪ Role play of other agents responsive to crew's actions ▪ Comprehensive observation/notes ▪ High level of flexibility to the training plan
Aircraft operations	▪ Unstructured approach to Flight Planning ▪ Pays 'lip service' to Met / NOTAMs etc. ▪ Shortcuts checklist but has no approved	▪ Considers all aspects of the flight in context with the task in hand/background and experience level of the student ▪ Understands fully	▪ As per 2 plus: ▪ Conveys flight safety message to students by setting a good example	▪ As per 2 & 3 plus: ▪ Sets an impeccable example, and inspires students to do the same

	Requiring improvement	Basic standard	Good	Very good
	Training checklist as a substitute ▪ Training SOP's missing or inadequate ▪ Uses inadequate screening for simulated IMC (ineffective screening for student and/or poor lookout for instructor) ▪ Incorrect use of screens	the safety aspects involved in aircraft training ▪ Uses a Training Checklist ▪ Uses Training SOP's ▪ Specifies individual duties throughout – e.g. Lookout, R/T, and Navigation ▪ Safe use of well designed screens at appropriate times		

	Requiring improvement	Basic standard	Good	Very good
Competence	**1**	**2**	**3**	**4**
Instruction in the simulator or aircraft	▪ No pre-emptive briefs as reminders of what comes next ▪ Allows crew to proceed on a 'trial and error' basis (experiential learning) with little or no instructor input before each exercise commences...or ▪ Repeats large chunks of the pre-flight brief unnecessarily ▪ Emphasis on the	▪ Pre-briefs each part of the exercise ▪ Good bias towards 'How' to accomplish the desired outcome, not just 'What' is required ▪ Uses appropriate instructional technique – demonstration, follow through, observation, etc ▪ Supplies appropriate instructional input in	▪ As per 2 plus: ▪ Has a more incisive view of what the student needs depending on their experience / background – and is able to tailor the instruction accordingly ▪ Knows the common errors for each category of student ▪ Uses high quality 'patter' – repeats	▪ As per 2 & 3 plus: ▪ Increases the confidence and skills of the crew throughout the training event ▪ Entirely empathetic approach, tolerant of student mistakes ▪ Makes the learning experience thoroughly

	Requiring improvement	Basic standard	Good	Very good
	'What' rather than the 'How' ▪ Uses conversational delivery style lacking in key words or phrases – Talks too much....or ▪ No commentary at all ▪ Gives technically inaccurate or ambiguous commentary ▪ Instructs by 'examining' ▪ Overloading of failures, with no pre-warning ▪ In-disciplined handover of control ▪ Briefs and de-briefs whilst the student is flying ▪ Intervenes too early or too late ▪ Does not recognise when the training is becoming negative ▪ Does not provide any encouragement ▪ Gets angry or frustrated by the crew performance ▪ Sets a poor example to students	the form of patter, prompts and cues ▪ Intervenes when and where necessary ▪ Observes faults and provides adequate corrective guidance ▪ Uses mini debriefs to provide feedback when students have capacity to listen (i.e. not flying) ▪ Provides correct technical input ▪ Uses correct hand-over of control procedure (in both the sim and aircraft) ▪ Provides sufficient student practice to consolidate skills learned ▪ Teaches from the Known to the Unknown ▪ Delivers all the teaching points ▪ Has a disciplined approach to SOP's ▪ Provides encouragement by giving praise ▪ Teaches to	the same key words and phrases used in the briefing ▪ Interventions are timely to achieve the best training value ▪ Accurate observation and clear identification of root cause of any faults – and able to provide very good corrective remedies ▪ Facilitates error analysis ▪ Able to teach an evolution by using different explanations for different learner styles ▪ Has an empathetic approach to the students ▪ Uses time management in a flexible way to achieve the best training outcome	enjoyable

	Requiring improvement	**Basic standard**	**Good**	**Very good**
	▪ Gives vague targets ▪ Teaches the whole exercise as the finished article – no building blocks ▪ Does not consider crew experience / background – therefore does not establish what is known or unknown ▪ Presses on regardless of crew performance/ fatigue (to tick all the boxes) ▪ Works through the half time break ▪ Poor time management	proficiency ▪ Recognises student fatigue ▪ Utilises good time management		
Debriefs	▪ Chronological ▪ No prioritisation of faults ▪ Does not identify root causes ▪ Little opportunity for crew to review their own performance ▪ 'Nit-picking' ▪ Cursory review of the flight...or ▪ Debriefs for an excessively long time	▪ Prioritises areas for improvement ▪ Holds the agenda ▪ Some use of facilitation ▪ Encourages crew to provide their views ▪ Discusses CRM / MCC / TEM ▪ Supports company SOPs ▪ Limits debrief to 3 or 4 main points, plus 3 or 4 minor ones ▪ Debriefs good	▪ As per 2 plus: ▪ Starts with an introduction ▪ At ease with facilitation to move the debrief in the required direction ▪ Draws common faults together – perceptive to root causes ▪ Links CRM NOTECHS / MCC and TEM into the debrief ▪ Balances praise	▪ As per 2 & 3 plus: ▪ Allows the crew drive the agenda but with the instructor controlling it ▪ Achieves crew consensus ▪ Seamless integration of the CRM NOTECHS/ MCC and TEM into all aspects of the operation ▪ Crew leave with

	Requiring improvement	Basic standard	Good	Very good
		aspects as well as the faults ▪ Compares individual performance against the objectives ▪ Generates a brief summary ▪ Gives preparatory work for the next lesson ▪ Produces a written training report	and criticism ▪ Concise and informative report writing	clear and concise learning points
Regulations	▪ Insufficient knowledge of ATO syllabus ▪ Poor understanding of privileges held	▪ Adequate knowledge and application of ATO standards ▪ Understands privileges held ▪ Adequate knowledge of CAA documentation	▪ As per 2 plus: ▪ Thorough working knowledge of applicable regulations and relevant CAA Standards Documents ▪ Knows where the ATO sits in the regulatory framework	▪ As per 2 & 3 plus: ▪ Clear and detailed knowledge of all relevant EASA regulations and UK policy documents (e.g. Information Notices) ▪ Understands implicitly the ATO and Instructors' responsibility for delivery of training standards

SECTION B, PART 3, CHAPTER 22G

Examiner competencies – simulator

Note: The competencies in Column 3 are in addition to those in Column 2, whilst those in Column 4 are in addition to those in Columns 2 and 3.

	Requiring improvement	**Basic standard**	**Good**	**Very good**
Competence	**1**	**2**	**3**	**4**
Briefing	▪ Lack of preparation ▪ Starts briefing without introduction ▪ Lack of engagement with the crew ▪ Little or no interaction with crew ▪ Little or no use of board or other visual medium ▪ Little or no reference to H&S	▪ Invites questions ▪ Generates a relaxed atmosphere ▪ Briefs all items required by Doc 24 ▪ Provides all required documentation ▪ Introduces NOTECHS ▪ Use of visual aids to support teaching points ▪ Identifies H&S requirements	▪ As per 2 plus: ▪ Good introduction ▪ Identifies the needs of the crew ▪ Delivers the Doc 24(A) or Doc 24 (H) element without change of style ▪ Uses facilitation appropriately ▪ Clear structure and clarity for all visual aid work ▪ Includes NOTECHS seamlessly in all areas	▪ As per 2 and 3 plus: ▪ Generates a high level of engagement with crew ▪ Responds to the needs of the crew ▪ Defines clearly what is expected of the crew ▪ Very responsive to questions ▪ All visual aids support and enhance the briefing and teaching points
Simulator operations	▪ Limited familiarity with IOS ▪ Irregular observation of crew ▪ Incorrect R/T ▪ Distracted by IOS at	▪ Checks simulator log and approvals ▪ Efficient use of IOS ▪ Presents repositions to crew correctly	▪ Crew enters the simulator with the correct scene set ▪ Introduces failures appropriate to crew actions ▪ Adjusts ‘running	▪ Very realistic scenarios ▪ Role play of other agents responsive to crew’s actions ▪ Clarity of

	Requiring improvement	**Basic standard**	**Good**	**Very good**
	key observing moments ▪ Limited note taking ▪ Inappropriate use of freezes and repositions ▪ Overloading of failures ▪ Poor radar vectoring	▪ Correctly sequences failures ▪ Accurate observation of faults ▪ Effective note taking	sequence' to optimise time management ▪ Identifies crew or individual fatigue	examiner/instructor role ▪ Comprehensive observation / notes ▪ High level of flexibility to the training / checking plan

SECTION B, PART 3, CHAPTER 22H

Report writing and handover guide

Ensure that training reports are focused, effective and fully inform the trainee and the next trainer of progress, problems and pointers for development.

When writing a training report, satisfy the requirements of the next trainer, the trainee and the training manager.

The **Next Trainer** needs the report to:

- Be a legible, relevant, concise, factual and accurate record of what occurred
- Identify areas of weakness
- Record outstanding syllabus items
- Record training progress
- Suggest changes/improvements necessary (plus agreed timescales)

The **Trainee** needs the report to:

- Be clear, honest, accurate, factual and constructive
- Be a clear record of progress made against appropriate standard (course, company, CAA) and feedback given
- Include agreed changes/improvements (in terms of tasks/ timescale/content)

The **Training Manager** needs the report to be:

- A permanent record, particularly of progress made and deviations from the standard
- A record of completed exercises and outstanding items

In order to achieve the needs of all 3, we can use the following format:

- Commentary - agreed facts plus outstanding items
- Appraisal - progress
- Pointers - agreed changes

The trainer has a responsibility to write clear, balanced, legible, honest, relevant, succinct and accurate records. Moreover, the trainer must ensure that the intended message is the same as the perceived meaning when the report is read.

Unless this responsibility is taken seriously, reports may be incomplete, inaccurate, ineffective, contradictory or confusing.

The **Trainer** must:

- Be truthful, honest and accurate.
- Identify problem areas and agree corrective action/timeframe.
- Provide feedback and review trainee progress.
- Provide a permanent record of the training facts.
- Ensure the written report matches the verbal debrief.
- Meet company needs – especially when managing poor progress.
- Think – has my report addressed everyone's needs and will their perception match my intention?

Having written your training notes, re-read them. Are they clear, objective, concise and relevant? Many training reports tell more about the writer than they do about the trainee! The ability to write good training reports/handover notes is a skill that requires practice. But, of course, good handover notes are invaluable to effective training.

SECTION B, PART 4

CRM in safety management

In this part:

Chapter 23

CRM in safety management

Chapter 24

Use of taxonomies

SECTION B, PART 4, CHAPTER 23

CRM in safety management

Safety Management is mandated by EASA as an integrated part of an Operator's Management System.

One of the key elements of a Safety Management System is the identification of hazards and how those hazards are managed through effective risk mitigation. Poor CRM should be considered an aviation hazard whereas good CRM is an effective risk mitigation.

CRM related hazards can be identified through:

- Flight crew training and competency checks (line checks, OPCs, LPCs)
- During CRM training
- LOSA activities
- Event investigation
- Audits and surveys
- Mandatory and Voluntary reporting
- Flight Data Monitoring (FDM)

Where CRM is being used as a risk mitigation it is important that it is assessed to ensure that it is robust and effective through ongoing assessments such as LOSA and through CRM training that reflects the current operations and the safety issues being identified by the SMS.

It is important that there is management commitment at the highest level within the organisation to the SMS and that same management commitment should be there for effective CRM and the safety policy should reflect this.

The SMS requires the operator to monitor the organisation's safety performance. This should include a combination of audits, surveys and performance monitoring using safety performance indicators. To achieve this the organisation must utilise all available data to analyse the level of risk. Historically, organisations have never been particularly effective at either identifying or assessing human factor risks. This is mainly due to the potential subjective nature of identification. Whilst on first examination the process appears simple, the potential of pigeonhole assessment of human factors leading to incorrect action is common. Any work conducted in this area needs to be treated with care utilising personnel who have suitable training and credibility. It needs to be emphasised that the outcomes from any action must reduce the risks and this reduction should be identifiable.

Present regulation requires operators of aircraft over 27000kgs engaged in commercial air transport to have an FDM programme. The data captured should be utilised to enhance safety and identify any negative trends. The system must not to be used to trap crew with associated punitive action. The organisation has the ability to set parameters within the FDM programme for all phases of flight but it is important that the information collected is assessed correctly. To ensure that human performance related issues are identified it is imperative that the crew associated with the identified triggers is offered the opportunity to explain why actions were taken, or not taken, that led to the event.. For this to be effective there should be a just culture that should be defined within the organisation's safety policy with supporting processes on how it will be applied in practice.

The safety policy should actively encourage effective safety reporting and, by defining the line between acceptable performance (often unintended errors) and unacceptable performance (such as negligence, recklessness, violations or sabotage), provide fair protection to those reporting an occurrence or involved in safety investigations. A just culture may not however preclude the "criminalisation of error" which is legally, ethically and morally within the sovereign rights of any state, provided established international agreements are observed.

> *Regulation (EU) No 376/2014 on the reporting, analysis and follow-up of occurrences in civil aviation supports a proactive and evidence-based aviation safety management system in the European Union by requiring the reporting of occurrences. To assist in achieving this, national authorities are encouraged to develop occurrence analysis procedures.*

It is anticipated that each organisation established in a member state shall develop a process to analyse the details of occurrences collected in accordance with Articles 4 and 5 (Mandatory and Voluntary reporting) in order to identify the safety hazards associated with those occurrences and assess their risk. Based on this analysis it shall determine any appropriate corrective or preventive action required for the enhancement of safety.

Internal Occurrence Reporting Scheme - GM1 ORO.GEN.200(a)(3)

The overall purpose of this scheme is to encourage the reporting of safety-related information such as errors and near misses that might not be reported through mandatory reporting systems in order to improve the level of safety performance of the operator.

The scheme is an essential part of the overall monitoring function and is complementary to the normal day-to-day procedures and 'control' systems. It is not intended to duplicate or supersede these other systems. The scheme is a tool to identify those instances where routine procedures have failed.

The regulation does not directly reference human factor assessment. However a vast majority of reportable incidents will have human factor causes or contributors, so it is imperative that a considered HF review is conducted.

Occurrences to be reported are those where the safety of operation was or could have been endangered or resulted in an unsafe condition. If, in the view of the reporter, an incident did not endanger the safety of the operation but could do so in future (for instance if it was repeated in other common circumstances) then a report should be made. What is considered to be reportable on one class of product, part or appliance may not be so on another; the absence or presence of a single factor (human or technical) can transform an incident into an accident.

During the data collection process it would be valuable if the following personnel were suitably trained in investigating HF causes or influences associated with the reportable incident:

- Reporting party (Pilot, Cabin Crew, Maintenance Engineer, Dispatcher, etc)
- Assessor/analyst
- Safety Manager

It is only when appropriate assessment has been made regarding incidents that effective mitigation can be introduced. When a system fails a number of causes can usually be identified. In the past, contributory factors were sometimes overlooked due to assumptions that technical failures were causal. Similarly, deeper causal factors can be overlooked if blame is simply placed on the human (e.g. pilot error). As the human features somewhere in almost every incident, it would be wise to consider the organisational and environmental influences on human performance. To achieve this effectively all participants need to have the skills and knowledge to make valued judgments, be it when reporting, assessing or developing mitigation.

SECTION B, PART 4, CHAPTER 24

Use of taxonomies

One of the most difficult activities associated with occurrences is the categorisation or coding of contributions and causes, especially when considering human factors that are often involved. Researchers have attempted to develop ways of supporting such assessments; the most popular general process being the use of taxonomies. Taxonomies can be exhaustive lists of causal factor and descriptive categories, from which one or more categories can be assigned to an incident or accident. Taxonomies are a useful tool for analysing large amounts of data from a wide variety of operations. Their goal is to provide a broader picture of events and trends, which informs objectives and discussion. Bear in mind that the collection and classification of this data is only the starting point. In order for the data to provide meaningful outcomes it needs thorough analysis and structured discussion.

Taxonomies also have their limitations. A taxonomy that has generic and high level categories may be simpler to use but will not provide the level of detail required to produce meaningful analysis. A highly complex taxonomy will suffer from increasing levels of subjectivity when applying it, and may struggle to show meaningful trends. EASA has developed a taxonomy associated with ECCAIRS (European Co-Ordination Centre for Aviation Incident Reporting Systems). This taxonomy includes a number of human factor elements that try to strike a balance between the wide range of human factors events while providing a level of detail that allows for valuable insight. Other taxonomies exist, and operators are free to create their own. Such taxonomies can assist reporters, analysts and operators when analysing data in order to inform initial and recurrent training. Any developed system would need to feature within the safety manuals. Additionally, training would need to be provided for the use of such systems, particularly for those evaluating/assessing root causes.

SECTION B, PART 5

CRM regulation

In this Part:

Chapter 25
CRM regulation

SECTION B, PART 5, CHAPTER 25

CRM regulations

The History of Aviation Regulation

Subsequent to the end of hostilities during the Second World War and with the increased demand for Commercial Aviation across the World there was an identified need to ensure all operating standards for aircraft were maintained at an acceptable level. To facilitate this need the Chicago convention 1944 was established. This convention was effectively the birthplace of the International Civil Aviation Organisation (ICAO). To this day the regulatory framework remains linked to the recommendations made by this body.

ICAO was set up to offer a set of International standards. To achieve this, guidance documents in the form of Annexes were developed to offer Standards and Recommended Practices (SARPs). Annex 6 was produced for the Operation of Aircraft; International Commercial Air Transport were first adopted by the Council on 10 December 1948 pursuant to the provisions of Article 37 of the Convention on International Civil Aviation (Chicago, 1944) and designated as Annex 6 to the Convention. They became effective on 15 July 1949. The Standards and Recommended Practices were based on recommendations of the Operations Division at its first session in April 1946, which were further developed at the second session of the Division in February 1947.

Annex 6 – Operation of Aircraft

Part of the ICAO mandate was for research to be undertaken with the explicit directive of identifying the causes of all accidents. The research to be undertaken was to provide the aviation system with the tools to prevent recurrence. In the majority of accidents there was an identifiable human factor cause. Equipped with this knowledge ICAO recommended training in the principles associated with human performance. This training was to be introduced with the intention of influencing the following areas in Aircraft Operations

- Flight Crew
- Cabin Crew
- Maintenance personnel
- Flight dispatch
- Training
- Manual design
- Checklists
- Aeroplane instruments and equipment

ICAO Definitions

Human Factors principle

Principles which apply to aeronautical design, certification, training, operations and maintenance and which seek safe interface between the human and other system components by proper consideration to human performance.

Human performance

Human capabilities and limitations which have an impact on the safety and efficiency of aeronautical operations.

For clarity this document will only cover the regulation associated with Flight and Cabin Crew. Whilst there are clear indications that many other parties influence the Operation of Aircraft and could potentially affect safety, the regulation for these parties is either absent or substantially different from the regulation associated with Flight Crew.

EASA Part-FCL

As the Chicago Convention already provides for minimum standards to ensure the safety of civil aviation and environmental protection relating thereto, the European Community essential requirements and rules (Part FCL) adopted for their implementation have been developed to ensure that member states fulfil the obligations created by the Chicago Convention, including those vis-à-vis third countries.

Part FCL Subpart J and K (instructors and examiners)

The regulations associated with pilot instructors and examiners involved in the issuance of licences have been written to ensure these personnel have the capability to instruct and examine. As all examiners must also be instructors the competencies associated with the instructor read across both disciplines.

Part FCL states: all instructors amongst other things shall be trained to integrate threat and error management (TEM) and crew resource management, during any instruction. This training should be both theoretical and practical. Practical elements should include the development of specific instructor skills, particularly in the area of teaching and assessing threat and error management and CRM. The Instructor must also be competent in the assessment of trainee performance and observing of CRM behaviour.

The most challenging area for the instructor is to apply appropriate corrective action after assessing a candidate. This document offers information and guidance for the instructor and examiner qualified under Part FCL to achieve the best possible results from the assessment of crew. The ability to identify, facilitate, debrief and further train human factor issues is essential for the continued development of the professional pilot.

Through the process of attaining licence endorsements as either an instructor or examiner the competent authority is required to ensure standardisation of these competencies at both the initial endorsement stage and during the revalidation/renewal processes.

The competent authorities also have the responsibility of ensuring that inspectors are suitably qualified to make these assessments.

EU-OPS

Annex III to Regulation (EEC) No 3922/91 has been based on a set of harmonised rules adopted by the Joint Aviation Authorities (JAA) called Joint Aviation Requirements for Commercial Air Transport (Aeroplanes) (JAR-OPS 1).

Regulation (EEC) 8/2008 updated Annex III in order to reflect the amendments made to JAR-OPS since 1st January 2005 (Amendments 9 to 12) before the date on which that Annex became applicable (16 July 2008).

Principles established in ICAO SARPs were introduced into EU-OPS to include CRM training for Flight and Cabin Crew.

EU-OPS Subpart N and O

The regulation associated with these SARPs is expanded within EU-OPS (Subpart N and O). The regulation, through TGL 44, further clarified how this training was to be conducted including guidance as to syllabus content, training personnel requirements and regularity of training events.

CRM instructors in the context of EU-OPS include both ground and line training. For ground CRM Instruction the regulations cover Initial operator's crew resource management (CRM) training, conversion training and checking, recurrent training and checking, command training, and operators' conversion courses when changing operator.

Elements of crew resource management shall be integrated into the conversion course, and conducted by suitably qualified personnel.

Conversion training is to be conducted by suitably qualified personnel in accordance with a detailed course syllabus included in the operations manual. The operator shall ensure that the personnel integrating elements of CRM into conversion training are suitably qualified.

Recurrent training and checking for Pilots shall include Crew resource management training

Presently the regulatory requirements state elements of CRM shall be integrated into all appropriate phases of recurrent training; and a specific modular CRM training programs shall be established such that all major topics of CRM training are covered over a period not exceeding three years.

Operators are required to establish procedures to update their CRM recurrent training program. Revision of the Program shall be conducted over a period not exceeding three

years. The revision of the program shall take into account the de-identified results of the CRM assessments of crews, and information identified by the accident prevention and flight safety program.

The regulations state ‘all CRM training for Flight Crew shall be conducted by suitably qualified personnel’. The emphasis on the suitable qualification is to ensure the training conducted by these personnel is effective. These personnel must not only have the knowledge, skill and ability but also the credibility within the group to facilitate the learning experience. Operational experience in the field of commercial aviation is important. It is unlikely that a professional pilot would be offered best practice guidance on how to manage aeroplane operations by anyone other than a pilot of at least similar qualification. To this end the UK CAA introduced the CRMI accreditation system.

The UK CAA accreditation system is further clarified within Standards Document 29 V5. Doc 29 effectively clarifies who can achieve the role of Instructor and takes a pragmatic approach towards those personnel not qualified as recommended by offering a process for attaining the requisite credible experience.

As European aviation regulation is further developed and standardised, the process and responsibility to provide suitably qualified Instructors for CRM Training is likely to be devolved to industry and closely monitored by the relevant competent authority. Whilst this may be a future arrangement the present position for UK AOC holders is to adhere to the EU-OPS Regulation and follow the guidance within Standards Document 29. Any changes to the regulation, acceptable means of compliance or guidance material for CRM training will be reflected in an amended Standards Document 29 (this document will be renamed to coincide with such changes).

Maintenance of standards and checks of effectiveness

With the ever changing and increasing complexity of the aviation system the role of the pilot remains challenging. The evidence of human factor causes associated with accidents remains at such a level that continued education to assist the pilot in developing dealing strategies is essential.

The present position to ensure instructor standards in CRM training is clarified within Standards Document 29. The UK CAA accreditation system was designed to ensure that all instructors were to be current within the role and be able to demonstrate continued competence every 3 years.

In terms of what training is required and how this is developed (Risk based), EU-OPS Subpart P states what documentary guidance must be provided for all specified training. In terms of CRM training, the operator must provide a training syllabi and checking program:

- For flight crew - All relevant items prescribed in Subpart E and N
- For cabin crew - All relevant items prescribed in Subpart O

Regulatory expectation

Operators are tasked with the confirmation of standards and checking of effectiveness of their training personnel, specifically when considering CRM training, evaluation or assessment for the following disciplines:

- Instructors and examiners for licence issue, revalidation or renewal
- Instructors to offer ground CRM training
- Instructors for line training including checking and assessment

The ground training should cover subject matter contained within the CRM table (TGL 44). It is essential that operators review their specific CRM identified issues and tailor both the subject matter and training to reflect operator identified issues. To identify the issues the operator should review FDM results, training reports, SMS identified risks and any other oversight processes. Whilst the regulation indicates all subject matter should be trained following a modular process the operator needs to identify which specific areas would benefit from greater emphasis. The complete content package should be covered over a three-year period.

The process utilised when developing the ground training package should be annotated within the Training Manual indicating at what depth any subject is to be covered. TGL 44 indicates what subject matter needs to be covered during specific training experiences. The depth of training is further defined as follows:

Overview

Will normally be instructional in style. Such training should refresh knowledge gained in earlier training.

In Depth training

Will normally be interactive in style and should include (as appropriate) case studies, group discussions, role play and consolidation of knowledge and skills. Core elements should be tailored to the specific needs of the training phase being undertaken.

The following list indicates the subject matter covered within the CRM table:

- Human error and reliability, error chain, error prevention and detection.
- Company safety culture, SOPs, including organisational factors. CRM training should reflect the culture of the operator and be conducted by means of both classroom training and practical exercises including group discussions and accident and serious incident.
- Stress, stress management, fatigue & vigilance.

- Information acquisition and processing, situation awareness, and workload management. The training experience should cover examples of a lack of information or crew management.
- Decision making.
- Communication and coordination inside and outside the cockpit, Leadership and team behaviour, and synergy. The training should incorporate analysis of communication problems.
- Automation and the philosophy of the use of automation (if relevant to the type). The training should include the operations policy concerning the use of automation as stated in the Operations Manual; and System and human limitations associated with the use of automation. The training must also provide appropriate knowledge, skills and behavioural patterns for managing and operating automated systems. Special attention should be given to how automation increases the need for crews to have a common understanding of the way in which the system performs, and any features of automation that make this understanding difficult.
- Specific type-related differences.
- Case based studies.

Future regulation for Operations as mandated by EASA - Part ORO

The regulation within Part ORO reflects the regulation within EU-OPS with few differences. However the responsibility for the selection of personnel, maintenance of standards and selection of course material will be with the operator. The maintenance of these standards will be overseen by the competent authority.

The following table clarifies the two different regulatory approaches to CRM – Pilot Licencing and Air Operations.

Training for Licence issue		
Reference	**Part FCL and Part ORO**	**Why and when?**
	'Airmanship' means the consistent use of good judgement and well-developed knowledge, skills and attitudes to accomplish flight objectives	Definition
FCL.735.A	Multi-crew cooperation training course — aeroplanes (a) Knowledge of Human Factors, TEM	All pilot (PPL – ATPL) licence training

Training for Licence issue		
	and CRM; (b) Application of TEM and CRM principles to training.	
AMC1 FCL.925	**Additional requirements for instructors for the MPL** Development of specific instructor skills, particularly in the area of teaching and assessing threat and error management and CRM in the multi-crew environment.	All Instructors for any pilot licence
GM1 to Appendix 5	**Integrated MPL training course** Principles of Threat and Error Management	Clarification of the requirements
AMC1 FCL.920	**Instructor competencies and assessment** Integrate TEM or CRM makes TEM or CRM links with technical training. Observes CRM behaviour.	Any Instructor for licence issue
AMC1 FCL.930.TRI	**TRI — Training course** The course should place particular emphasis to the role of the individual in relation to the importance of human factors in the man-machine environment and the role of CRM.	Any Instructor for licence issue
Operating for an AOC holder		
ORO.FC.115	Crew resource management (CRM) training	Before operating, in the aircraft type or class training, recurrent training and during a command course.
ORO.FC.215	Initial operator's crew resource management (CRM) training	Before commencing unsupervised line flying.
ORO.FC.220	**Operator conversion training and checking** (a) CRM training shall be integrated into the operator conversion training course.	To be offered during conversion training

Training for Licence issue		
ORO.FC.230	**Recurrent training and checking** These checks may be conducted by suitably qualified commanders nominated by the operator, trained in CRM concepts and the assessment of CRM skills.	Specifically Line check or LPC/OPC (for ATQP includes LOE/Training)
ORO.FC.230	**Recurrent training and checking** (c) Line check Line checks may be conducted by a suitably qualified commander nominated by the operator, trained in CRM concepts and the assessment of CRM skills.	Annual line check every 12 months (ATQP fully compliant 24 months)
ORO.FC.230	**Recurrent training and checking** (e) CRM training (1) Elements of CRM shall be integrated into all appropriate phases of the recurrent training. (2) Each flight crew member shall undergo specific modular CRM training. All major topics of CRM training shall be covered by distributing modular training sessions as evenly as possible over each three year period.	All training but including ground recurrent training for an AOC holder

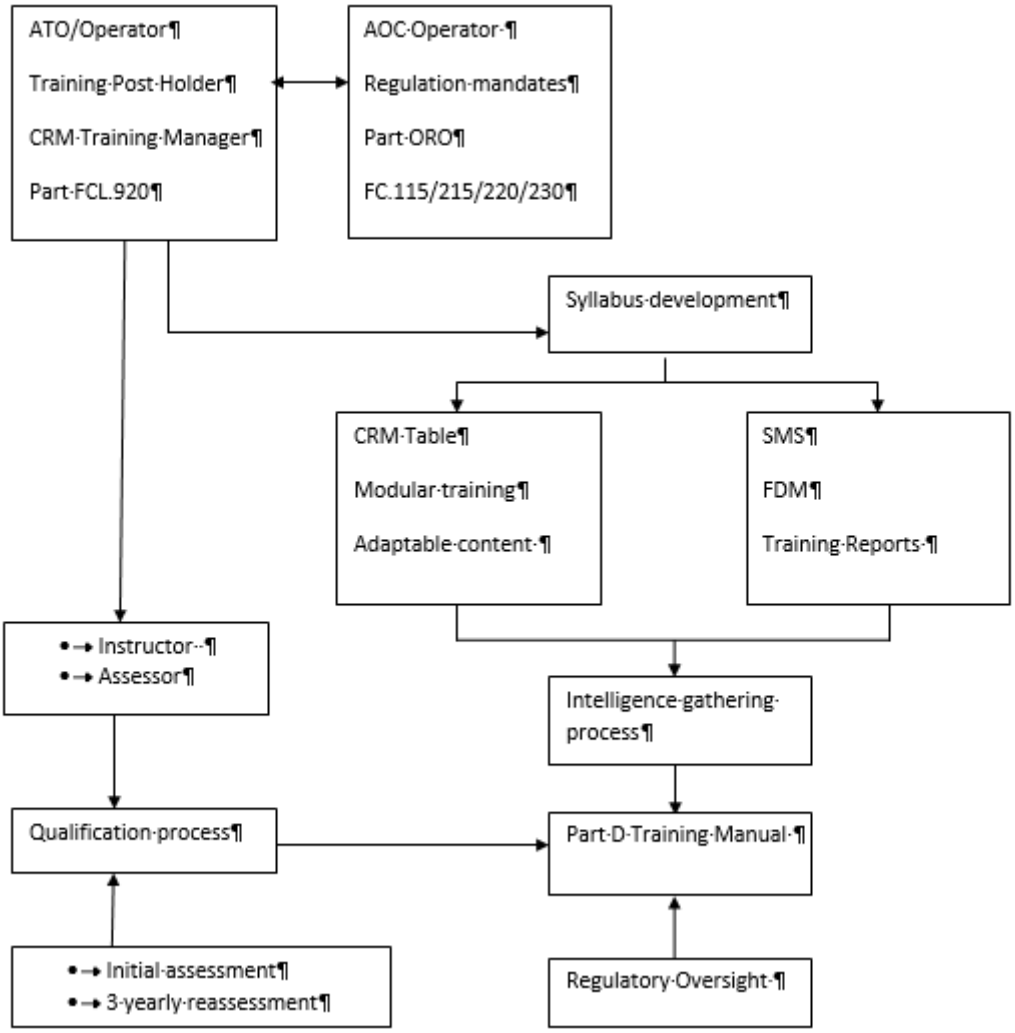
A checklist for Operators

- Syllabus - **AMC2 ORO.MLR.100 Operations manual**
  - Guidance to include at what stage CRM training is mandated (initial, recurrent, command etc).
  - Syllabus developed from the CRM table including operator defined requirements and confirmation that all subjects will be covered (3 year period).
  - Manual - Process to develop training material associated with identified hazards and associated risks, SMS, FDM data, feedback from all trainers.

- CAA acceptance - ORO.MLR.100 Operations manual.
    - NPA process.
- Instructors - ORO.AOC.135 Personnel requirements.
    - Clearly defined guidance for development of new instructors and a process for standardisation including
    - Ground
    - Line
    - Simulator
    - 3 year re-assessment process for both Ground and line Instructors/trainers.
    - Standardisation of both CRI/TRI and CRE/TRE (all licence associated instructors/examiners).

CRM Training Program

The flow diagram below shows the process that CRM training courses should follow.



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