CHAPTER 1
Rationale and overview

1.1 Introduction

The basis for this research project originated from Hunter and Burke (1995) who acknowledged the existence of different criteria, which are applied to the assessment of pilots in their career path from initial selection to airline command. The fact that the short and long-term criteria are necessarily different seems to have been accepted by the industry with very little attempt to more closely align their purpose. For example, in his review of the selection process at the airline of study, Stead (1991) used the ability to pass initial airline training programmes as the principal validation criterion for the selection process used at the airline of study. However, it appears that the subject selection process was validated without regard for the long-term criteria because pilots who were selected using this process have failed Captain training programmes at a rate which periodically approached 20%. Such a large wastage translates into an unacceptable cost (at both the human and fiscal levels) to a commercial organisation and underscores the importance of accurate and reliable selection.

With current selection processes only capable of accounting for half the variation in pilot performance (Hunter & Burke, 1995), research is required to more accurately
define pilot performance. This is particularly the case when it is considered that Hunter and Burke (1995) are referring to performance following induction, and not to long-term performance. Taxonomies of performance cited by Hunter and Burke (1995) and others (e.g., Burke, Bradshaw, & Hobson, 1994; Burke & Burnett, 1994; Ellis, 1991) have focussed on broad, all encompassing, generic aptitudes to which specific cognition or behaviours (action indicators) have not been ascribed. In the operational environment, however, it is the demonstration of behaviour (Helmreich, Wilhelm, Kello, Taggart, & Butler, 1991) that is used as the definitive expression of performance. Consequently, the goal of this research was to galvanise the numerous opinions on command readiness within a particular airline into a practical performance profile, which could be used on a day-to-day basis and be further developed into a selection tool.

1.2 Context

This research was conducted within the aviation domain. Broadly, the task under consideration was that of piloting jet passenger aircraft (which involves the coordination of multiple crewmembers to produce an effective team) in a dynamic environment. Specifically, the management of flight aspects of the piloting role were of particular interest. Within crews at the airline of study, a hierarchy of responsibility is generally nominated with the most responsible crewmember being the Captain. Organisational, regulatory and common law authority is vested in this position of Captain. Broadly, this authority stipulates that the Captain is responsible for the final disposition of any aircraft committed to his or her charge. This devolved power not only includes the aircraft itself but also includes the passengers and the crew. Within international law, an aircraft is considered to be sovereign soil of the country of registration. Accordingly, while in command, the Captain is vested with some common law powers, such as the power of arrest.

The airline within which the research was conducted is, on a global scale, a medium-sized airline with extensive domestic and international route structures. However, within its own theatre of operation, the Pacific Rim, it would be considered a major carrier. It has been operating for over 80 years, during which time it has experienced periods of both government and public ownership. Over that period, the airline had
periods of both government and public ownership. Over that period, the airline has maintained a high safety record and is currently one of the safest of the world’s airlines. That record is attributed by the organisation to the disciplined approach of the engineering and flight operations departments to the tasks of maintaining and operating the airline’s fleet (ATSB, 2001).

The airline’s fleet presently consists of four Boeing-type jets. The two four-engined types (B747-300 and B747-400) are used principally on international routes. One of the two-engined types, the B767, is engaged in both domestic and international operations, while the other two-engined type (B737) is operated mainly on domestic routes. The latter came to the organisation as a result of a merger with a domestic carrier some eight years ago. For approximately four of those eight years, each type was operated as an independent entity within flight operations, with managers of each type being responsible for all of the pilot training on that type. However, a desire to standardise operations across the types prompted a reversion to a fleet structure, which centralised the oversight of training and operations management.

The international route structure of the airline has been developed over approximately 70 years. The communications with, and general support for, crews operating on the remote parts of the network at the beginning of that period were minimal. When the Captain signed for an aircraft at the home-port, he or she became the principal decision maker with respect to that aircraft and all attendant organisational and operational matters. That situation has changed little. The Captain still retains operational control outside national airspace. However, while within national airspace, more operational input is provided by other organisational personnel. The latter arrangement is similar to the dispatcher system established under the Federal Aviation Administration (FAA) model, where the Captain and the nominated dispatcher share operational responsibility through a coordinated flight watch system (FAA, Federal Aviation Regulation 121.535, 2001).

The airline entered the jet age in the 1970s by acquiring the B707. Pilots with World War II experience were the main source of Captains for this type (Fysh, 1970). Foreseeing a shortage of nationals capable of commanding jets, the airline entered into a heavy international recruitment programme in the early 1960s. This was
followed by an ab initio (no previous flight time) cadet pilot training scheme in the period 1965 to 1973. The recruitment of pilots from the local military and from general aviation recommenced during this period. Apart from the B737 type, personnel from these four sources command the company’s aircraft today.

In the case of the B737 type, an industrial disputation in 1989 caused a ‘spill’ of all piloting positions within the then domestic airline that operated this type. Some previously employed pilots returned to work for that airline after the dispute. However, a large number of experienced pilots were recruited offshore to fill the positions left vacant by those pilots who elected not to return, or who were denied employment. Many of these offshore personnel currently command B737 type aircraft within the core airline. The airline of study also wholly owns several regional airlines, which are operated under separate Air Operator’s Certificates (AOC). Pilots within these companies do not have direct access to the core airline promotion opportunities. Furthermore, some regional and low-density short-range international routes are operated under contract by an independent organisation whose only direct links to the core airline are through marketing arrangements (including the use of the core airline livery).

1.3 Research stimulus

The stimulus for this research originated from the training of Captains for the core airline’s international-capable aircraft types, namely the B767, B747-300 and B747-400. The airline’s training programme for these personnel is, by benchmarked standards, very stringent (e.g., when compared to programmes originating from the North American Advanced Qualification Programme [FAA, 1991]). Very few assumptions are made by the organisation about the abilities to command (act as Captain), which may have been acquired while operating as a co-pilot. Under the contract of employment, command vacancies are awarded under a strict date of joining seniority system. These allocations can be modified in three ways. Firstly, First Officers can elect to postpone command training by not bidding for an advertised vacancy. Secondly, the airline and the pilots’ union can agree to a variation to the award in order to cater for short term commercial needs. Thirdly, an attempt may be made to gauge the prospects of success in command training for each pilot.
This is generally based on the existing performance data for each pilot, which was collected at each recurrent training visit (four annually) and the annual check of route flying competence.

The existing performance data are collected using a ‘phase of flight’ structure with the addition of an all-embracing dimension termed *management*. Typically, the phase of flight method of performance appraisal would require that take-off, climb, cruise, descent, approach, and landing be assessed independently. The management (of flight) dimension has evolved to include any identified area of performance that is not covered by manipulation or procedures. It seems that enhancing the understanding of the management of flight and, subsequently, the data collected under the management dimension would be of value since failures of command (Captain) training programmes were generally attributed to degraded performance in the *management* (of flight).

The review of the performance data concluded that pilots did not fail command (Captain) training because they could not fly the aircraft. Rather, it was the art of *flight oversight* that seemed to elude them. The human and fiscal implications of a failure rate of up to 20% have not been lost on the organisation. Several attempts have been made to address the problem. The attempts to address the problem of failure of command (Captain) training have not included a redefinition of performance in the management of flight arena. Consequently, that is the stimulus for the present research. So that a pilot’s performance can be better understood, this elusive management of flight dimension needs to be defined. Individual training needs can then be identified. If the gap between a First Officer’s performance and the desired performance for commencement of Captain training is too great, Captain training can be postponed. Personal and organisational effort can then be applied to specific areas of need. Further, selection tools can be revisited to ascertain whether the ability of these tools to select appropriate personnel can be enhanced by targeting areas defined by this exploration of performance in other than manipulative aspects of piloting aircraft.
1.4 Research goal

The series of studies for this research project was developed with the view to defining specific aspects of management of flight performance in airline Captains within the airline of study. The scope of performance was considered to extend beyond the accepted manipulative (commonly referred to as ‘stick and rudder’) skills to include cognition and behaviour as they might be perceived to be evidenced in managerial aspects of the task of successfully operating an aircraft between a city pair. This approach appeared justified since Captain candidates within the airline of study continue to fail command training because of a perceived lack of ability in these cognitive and behavioural (management of flight) dimensions. To this end, the research studies were serial and progressive and were terminated only when the originating goal had been satisfied to the extent that the development of a management of flight performance profile (which could be translated into a prototype psychometric tool) was accomplished.

1.5 Thesis overview

This thesis contains a review of the related literature. The literature reviewed in Chapter 2 relates to the various aspects of the piloting role such as decision making, expertise, and workload. Chapter 3 is more specific in that the literature reviewed deals with situational awareness, a popular contemporary variable in pilot non-technical performance. Chapter 3 concludes with a series of research questions, which resulted from the review of the literature. Chapter 4 outlines the methodology, which was employed to guide the research. This derived methodology ensured that the outcomes of each study defined the need and laid the foundations for the ensuing study. Studies 1 through 5 occupy Chapters 5 through 9 respectively. The discussion chapter (Chapter 10) explores the aim of the research, the methods used to achieve the aim of the research, the outcomes of each study, and examines the consistency of the outcomes of this series of studies with contemporary topics like self-regulation. Areas requiring further research are also explored in Chapter 10.
Although each study in this research is relatively self-contained in the way that each topic is addressed, the global goal of adding definition to the non-technical aspects of pilot performance (i.e., management of flight) within the airline of study shapes the research. So that an understanding of the contribution that each study makes to this guiding goal can be developed, a brief outline of each study follows.

1.6 Study 1

The initial study identified and organised the performance markers currently used within the airline of study by personnel responsible for Captain training and checking. It was proposed that if it was possible to identify the command readiness markers used within the airline of study, a practical framework could be devised to organise these markers and, thereby, facilitate their use by all personnel. The need to explore the possibility that the existing initial selection processes are not reliable as predictors of success at the Captain training level has been established from the existing literature (Stead, 1991).

This study refers to a preliminary review of Captain trainees which seems to indicate that existing batteries of psychology tests employed by the organisation do not necessarily predict long-term performance (i.e., at the Captain training level). That is, poor and good candidates for Captain training cannot be discriminated on any of the dimensions presently tested during selection. The consequences of this proposition for the industry worldwide cannot be ignored, since the types of tests examined here are typical of those used throughout the industry. The exception to this generality is the Defence Mechanism Test (DMT) in use by some civil operators and armed services within Scandinavia and Australasia. However, validations of DMT methodologies have been questioned by some researchers (e.g., Trudel & Okros, 1989).

The methodologies employed in this study included open coding to identify the separate markers in use to assess management of flight, frequency distribution to establish the most supported markers, and axial coding to facilitate the grouping of markers according to function.
The emphasis on the use of markers to describe management of flight was considered a possible dimension of comparison across the training system. Anecdotal feedback from Captain training candidates on the variability of assessment criteria used for the management of flight dimension supported this approach. To that end, the emphasis that policy makers and training managers place on the use of identified markers was compared to the emphasis on markers amongst training and checking Captains. In this regard, a more acceptable and transparent system of assessment could result from a reconciliation of the differences identified in this study.

A model of performance based on the markers used within the airline of study was developed and reviewed for acceptance and useability at varying levels. Subsequently, the usefulness of the taxonomy (which principally contained indicators associated with management of flight) to the organisation was found to be limited. Thus, the need to reconsider the management of flight performance criteria identified in Study 1 in order to develop a more successful and transparent approach to selection, training, and performance assessment was identified (see Table 1.1). In particular, the most highly supported of the management of flight performance criteria in Study 1 (situational awareness) seemed to be the most appropriate avenue for further research. This was the catalyst for Study 2.

1.7 Study 2

The second study set about the task of establishing an organisational understanding of SA because there are several interpretations of SA and its possible predictive capabilities reported in the literature. Accordingly, the cultural understanding of SA within the organisation could be quite different to other reported expressions of SA. For example, the mechanisms which support the development and maintenance of SA within the culture of an organisation could be more expansive than those generally ascribed to the topic in contemporary literature. Consequently, the general correspondence of the organisational model to reported models would be low.

The challenge for this study was to devise and implement a research process, which would represent most concepts of SA and enable feedback from a representative sample to establish an organisational understanding of SA. Focus groups were
facilitated to gather individual and group intelligence on the topic of SA understanding. With focus group member agreement, the convenor (researcher) analysed the results, identified themes, derived an expanded and composite organisational definition, and presented this output to a larger group of pilots for consideration (see Table 1.1).

The feedback on the organisational understanding of SA (which was derived from the focus group process) was then analysed to reflect the views of the participants with the view to establishing a link between this organisational understanding of SA and more expansive constructs of information processing. In essence, it was found that SA does not exist as a ‘stand alone’ construct, but is subsumed by, and integral to, one or more expansive constructs. For example, the findings suggested that pilot management of flight performance is dependent, in part, on metacognitive activities such as goal orientation, monitoring and self-efficacy.

1.8 Study 3

Because Studies 1 and 2 did not fully define the management of flight aspect of pilot performance, Study 3 was initiated. Study 3 considered the process whereby pilots develop, implement and track their mental model of the task at hand. Once this had been completed, it was possible to assess similarities between this process and higher level constructs of human performance. As a consequence, a further refinement of the definition of airline pilot management of flight performance resulted. The aim of this study was to identify the principal themes of activity that experienced Captains at the airline of study engage to manage the risks involved in flying a high capacity jet aircraft between city pairs.

A total of fifteen semi-structured interviews of experienced line (N=7) and check (N=8) Captains was included in this analysis. The scenario of a call out (limited notice of a flying duty) to operate an unfamiliar sector was set. The transcriptions and the notes of the interviews were then examined for recurring, common themes of activity. Personnel who agreed to participate in this process were appraised of the possible uses of the material.
The inductive analysis of the interview data rendered a sequential use of activity themes. Activity control mechanisms (e.g., the self-initiation of intervention) and the role of automaticity in the activity process (defined by the themes which were identified) were examined. To this end, interview records were examined for evidence of routine behaviours and the part that they play in the management of a flight, be it familiar or unfamiliar. The process (defined by the themes) used by the participants to control task execution was examined for the maturity (sophistication) of its self-initiating properties. The development of management expertise over time and experience from a laboured and unsophisticated approach to an automatic and comprehensive ability was explored.

From this theme identification process, it was considered possible to advance the construction of an instrument that defined management of flight in a way that facilitated the collection of more qualitative data (Study 4) (see Table 1.1). The next stage of research involved expanding each of the themes which were identified so that activities which supported each theme could be isolated.

1.9 Study 4

To facilitate the collection of feedback regarding the results of Study 3 from a larger sample of Captains, the recurring themes concerning management of flight were initially expanded into action statements. Once this had been completed, the action statements were incorporated into a questionnaire. This questionnaire was then administered to a group of experienced line Captains. The perceptions of these Captains were then analysed for consistency of support for the action statements contained within the questionnaire.

An inductive process was employed to compile an action statement list to more fully define management of flight using the themes identified in Study 3 as sub headings. A questionnaire was developed and was distributed to 317 line Captains. Respondents were asked to indicate their agreement regarding the inclusion of the presented action statements in a routine designed to aid novice airline pilots develop management of flight expertise. This format was developed to limit the effect of the automaticity which expert airline Captains appear to have developed. The reliability of these data
was tested using Cronbach’s alpha. Additional questions to gather information on the attitude of Captains to management of flight expertise demonstrated by First Officers were included in this questionnaire (see Table 1.1).

The results were analysed to determine the consistency of the attitudes of Captains to First Officers’ management of flight expertise. The identification of the factors which were perceived to underpin the ability of First Officers to manage flight without intervention was a goal of this analysis. The impact of age and aircraft type on management of flight requirements and skill was also assessed.

The ten most favoured action statements and the ten least favoured action statements regarding management of flight were examined to determine the extent to which their contribution to management of flight relied on self-initiated activities. Feedback on the embodying construct was also analysed. Based on the results of this study, which showed general support for action statements describing management of flight, it was possible to identify a profile of pilot management of flight performance within the airline of study which lent itself to the development of a prototype psychometric questionnaire thought to be capable of discriminating between experienced Captains and other pilots.

1.10 Study 5

Study 5 concerned the development and application of a prototype psychometric questionnaire so that the ability of the questionnaire to discriminate between experienced Captains and other pilots could be investigated. The action statements identified in Study 4 were then expanded into representative items that amplified aspects of management of flight performance (a total of 404 items being attributed to the 40 action statements). These items were identified from qualitative data collected in Studies 1, 2, and 4. They were assembled into a multiple-choice format of 100 questions which proposed various aspects of management of flight. Each question contained four choices. The choices were assembled with regard to the levels of agreement with the action statements identified in Study 5 (from which the individual items for each question were drawn). This tool was designed to establish the activities
considered most and least important to respondents when trying to optimise the management of flight outcomes in the role of Captain.

The questionnaire was administered to disparate groups of respondents. That is, after a pilot study to fine-tune the instrument, it was administered to 46 experienced Captains. This process identified the questions in which there was the greatest level of agreement demonstrated in the answers. These questions of high agreement were then administered to a group of pilots seeking employment with the airline of study and a group of students enrolled in aviation studies at a university. The levels of agreement of the responses from the experienced Captain group, the employment applicants, and the university students were then compared in order to assess the discriminatory ability of the questionnaire with respect to aspects of management of flight (see Table 1.1).
Table 1.1


<table>
<thead>
<tr>
<th>Studies</th>
<th>Aim</th>
<th>Research Questions</th>
<th>Method &amp; Treatment</th>
<th>Participants</th>
<th>Response rate</th>
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</table>
| Study 1   | Identify markers to assess the suitability for command | 1. Is SA used by practitioners as a performance marker? 2. Can the subjective markers of command readiness be organised into a model of management of flight? 3. Would a model of management of flight performance be useful to all check and training Captains and command trainees? | Questionnaire  
Open coding, axial coding, frequency distribution of questionnaire results  
Use of 5 point Likert agreement scale to test acceptability of derived model of command readiness | 165 experienced check and training Captains (training managers, senior training/check Captains, line training Captains) | >40%          |
| Study 2   | Establish an organisational understanding of SA    | 1. Is strategic SA principally metacognitive in nature? 2. Is tactical SA similar to problem solving? 3. Does good management of flight performance rely on the presence of strategic SA? | Focus groups  
Inductive analysis  
Questionnaire  
Frequency distribution of questionnaire data | 58 check and training Captains  
101 line pilots | 88%  
82%
### Table 1.1 (continued)

**An Investigation of Management of Flight Performance by Airline Captains: An Overview of the Research Undertaken**

<table>
<thead>
<tr>
<th>Studies</th>
<th>Aim</th>
<th>Research Questions</th>
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<th>Participants</th>
<th>Response rate</th>
</tr>
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<tbody>
<tr>
<td>Study 3</td>
<td>Identify process of mental model development and situation assessment/control</td>
<td>1. Do experienced Captains use an identifiable process to develop mental models of a proposed flight? 2. What processes are used to adjust these mental models to cope with a changing operational environment? 3. How do pilots learn from an aviation experience?</td>
<td>Unfamiliar scenario  Semi-structured interviews  Data decomposition &amp; categorisation  Thematic attribution of categorised data</td>
<td>8 experienced line Captains  8 experienced check Captains (1 interview terminated due to work commitments. 15 used for analysis)</td>
<td>100%</td>
</tr>
<tr>
<td>Study 4</td>
<td>Identify activities which develop management of flight competence and verify the organisation of these activities</td>
<td>1. What actions support competent management of flight performance? 2. Can knowledge of these actions stimulate the acquisition of command management of flight competence? 3. Are these management of flight concepts supported by the Captain cohort?</td>
<td>Distribution of discussion paper  Development and circulation of 99 personal activity statements  Focus group construction of action statement questionnaire  Questionnaire (seven point Likert scale)  Frequency analysis  Stepwise regression  Pairwise correlation  Reliability analysis</td>
<td>63 check and training Captains canvassed, 27 responded  23 SMEs canvassed, 18 responded  3 SMEs  317 line Captains (approximately 50% of cohort) presented with a questionnaire describing management of flight.  170 responses received and analysed.</td>
<td>43%  78%  53% (approx 26% of cohort)</td>
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Table 1.1 (continued)


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<tr>
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<tbody>
<tr>
<td>Study 5</td>
<td>Construct and trial a psychometric tool designed to identify respondent Captain management of flight priorities</td>
<td>1. Based on the completed research, is it possible to construct a psychometric tool that will elicit responses regarding management of flight? 2. If such a test is administered to experienced Captains, will any consistency of responses be evident? 3. If such a test is administered to applicants for piloting positions, will they exhibit the same consistency of responses as experienced Captains? 4. If such a test is administered to pilots employed by other airlines, will they exhibit the same consistency of responses as experienced Captains at the airline of study?</td>
<td>Retrieve activity items which support action statements from the completed research Construct an ipsative psychometric tool incorporating items Conduct pilot study of ipsative tool Administer instrument to a group of experienced Captains with the view to further refinement Administer refined instrument to a group of applicants for pilot positions Administer refined instrument to a group of students engaged in tertiary aviation related studies Compare agreement in responses of respondents</td>
<td>Focus group members 5 training pilots 60 line Captains approached - 46 responses received and analysed 64 applicants for pilot positions - 59 responses received and analysed 217 university students enrolled in aviation studies - 67 responses received and analysed</td>
<td>100% 77% 92%</td>
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CHAPTER 2

Review of the literature

Part 1 – Aspects of the pilot management of flight role:
Some influences and outcomes

2.1 Introduction

The role of the pilot in command as manager of the flight remains an ill-defined aspect of overall piloting performance. Management of flight should not be confused with Crew Resource Management (CRM) although the two may be inextricably linked. Before the management of flight role of the pilot can be researched, one must have an understanding of some of the issues which impact upon the execution of this aspect of the piloting role and, some of the possible outcomes associated with managing flights.

2.2 The task of pilot in command

According to Layton, Smith and McCoy (1994), feasible methods for automating reasoning about complex, uncertain events which pervade enroute flight planning and execution do not exist. The task must remain human-centered at least for the time being. Further, Smith and Hancock (1995a) contend that one of the real problems facing the Human Factors (HF) community in the current formulations of domain-
related theory and practice is "the failure to articulate the presence in the environment of normative specifications and criteria for the performance of the agent's task" (p.139). Therefore, this chapter will review the literature with reference to some of the non-technical aspects of the piloting role of an airline Captain. The aspects of the piloting role that will be examined are expertise, risk, cultural influences, workload, decision making, and error.

With respect to the task which faces agents such as pilots, the lack of articulation of normative specifications and performance criteria translates into a lack of understanding of the task at the semantic, cognitive and operational levels and a lack of operator goal definition. Understanding and goal definition inform operators about what they are trying to achieve. From the perspective of goals, Endsley (1995) suggests that they form the basis of most decision making in the dynamic environment. Therefore, the human must also understand the task demands to enable the process (Flach, 1995).

The level of understanding of the task demands or goals will be influential on the amount of 'self-monitoring' that an operator demonstrates (Kanfer, Ackerman, Murtha, Dugdale & Nelson, 1994). This metacognitive skill impacts upon demonstrated performance (Beaumont, 1998), since the operational representation, the mental model (Johnson-Laird, 1983), is updated by such mechanisms (which effectively track operator progress). The basic notion that practice affects performance (Speelman & Kirsner, 1997) can only be enabled by task understanding and goal definition since, at the early stages of practice, performance will rely on declarative (factual) knowledge. With practice, production rules to achieve the goals will develop from procedural knowledge (Gordon, 1991; Speelman & Kirsner, 1997).

Within the realm of goals, there are individual goals as well as task goals. Individual goals have been defined as performance and mastery goals (Archer, 1994). In the contextual setting of aviation, these goals have influenced outcomes and cannot be neglected in the debate. The personal performance or ego goal motivates a percentage of operators and has been addressed in various vocations by some authors (e.g., Ginnett, 1993; Sumwalt & Watson, 1995) in their investigation of Crew Resource Management (CRM). Accidents where this personal goal was found to be negatively
influential were reported by Sumwalt and Watson (1995). The desire for mastery, or understanding and competence goals, also motivate a percentage of operators. The relative weight given to these individualised goals will influence outcomes with a shift to the mastery goal being the most desirable (Archer, 1994). The inference is that without task goals and personal goals (i.e., knowledge and acceptance of that which is to be mastered) there is reduced direction or focus for the operator.

2.3 Expertise and the management of flight

As a result of his research, Federico (1995) contends that experts are very context-dependent and employ schema-driven reasoning to manage tasks. This proposal implies that the knowledge necessary to assess situations is contained within schemata. This notion aligns broadly with the instance theory proposed by Logan (1988; 1992) which indicates that automaticity is derived from a store of exemplars from which a match for the current situation is drawn. The findings of Glaser and Chi (1988) support this notion. To achieve expertise, other markers of expertise such as the quantity and organisation of knowledge, the quality of short and long-term memory and problem representation abilities must be present (Buer, 1993; Glaser & Chi, 1988).

Charness (1996) contends that experts solve problems by recognition rather than by search. Developing this argument one step further, Charness (1996) proposes that operators maintain awareness by recognising critical events in a data stream. Awareness would be lost if such events were missed or incorrectly interpreted. Shuell (1990) proposes a three stage learning framework for skill acquisition which begins with exposure to routines, processes and practices, and progresses through an experiential and feedback phase to automatic task performance and expertise.

The learning process towards expertise can be controlled by the individual. This control depends upon the ability to be reflective and translate experience into expertise (Ertmer & Newby, 1996). However, experience alone cannot guarantee the development of expertise (Buer, 1993). Expert (directed, and thereby, efficient) learners, according to Ertmer and Newby (1996), are aware of “when they should check for errors, why they fail to comprehend and how they need to redirect their
efforts" (p. 4). Further, the authors contend that these expert learners know what is important, as well as knowing how, when, where and why to apply knowledge. This ability results from reflection and subsequent knowledge acquisition of self, of the task and the strategies required to achieve the goal (Pintrich, 2000). These metacognitive processes would appear to be applicable in aviation.

The topic of expertise and its characteristics have been considered by authors in other fields such as marketing. For example, Spence and Brucks (1997) provide some qualifying findings hitherto unreported by aviation researchers. Their findings indicate that experts are superior in handling unstructured, but structurable problems. This superiority is achieved due to a consideration of a smaller number of more diagnostic cues having imposed a more meaningful structure to the problem. Most researchers agree that experts exhibit a large knowledge base. Ye (1991) confirms this view as well as proposing that human knowledge has three features.

According to Ye (1991), all knowledge has structure, content and control strategies which organise its storage and use. Ye and Salvendy (1994) suggest that there are some definable differences between experts and novices in these areas. Firstly, experts rely on fewer and larger chunks of knowledge than novices. Secondly, experts tend to fine-tune their initial rough chunking of knowledge more than novices. These findings bear on the quality of awareness development and maintenance (as might result from the perception and the comprehension of events), since situation assessment, the initial step in the process, is thought by some authors to rely heavily on existing and novel knowledge acquisition, integration and use (Kass, Herschler & Companion, 1991).

Not surprisingly, experts tend to spend more time defining the problem in contextual terms and less time on solutions (Federico, 1995). However, when they are faced with impending information overload, experts will employ heuristics (Spence & Brucks, 1997). Therefore, it appears that the expert is more likely to rely on pattern recognition and employ heuristics in problem solving. Expert pilots may exercise these techniques. Further, Gordon (1991) contends that "experts may rely heavily on nonverbalizable types of knowledge" (p. 115) such as the knowledge associated with the concept of risk within the work domain.
2.4 A concept of risk within the piloting work domain

The conceptualisation of any problem may exist at various levels of abstraction ranging from a blank outline through defined components to functional performance characteristics (Gott, Lajoie & Lesgold, 1991). This proposal of hierarchical abstraction regarding problem organisation aligns with the finding of Ye (1991) regarding the features of knowledge. Both the problem and the associated knowledge require structure, content and control mechanisms, all of which may impact upon the attentional demands of the operator.

For example, according to Newell and Simon (1972), unsolved problems (e.g., identified risks) occupy a level of cognitive space (i.e., attentional and processing resources). The more complex the problem, the more space that will be occupied by the problem. The concept of problems occupying cognitive space (Newell & Simon, 1972) has much in common with the concept of risk spaces as proposed by Smith and Hancock (1995b). The difference is that risk management is far more complex than a single problem (Jensen, 1995) and its management has been heavily proceduralised (in some environments) in order to enable operators to cope with this complexity. Hence, the focus on risk is obscured since many inherent risks may be managed by procedures.

Notwithstanding, there have been attempts to define the risks confronting aviators at the practical level in an attempt to increase the understanding of risk management. For example, the Delta Airlines’ automation policy (McKnight, 1992) requires that automation be used at the level most appropriate to enhance the priorities of safety, passenger comfort, public relations, schedule and economy. This policy was devised to give guidance to flight crews about their use of the automatic pilot and associated functions and recognised that the capability of the device had raced far ahead of the understanding of the relationship between automation and human performance (McKnight, 1992). Delta’s policy is consistent with Layton et al. (1994) who specify the consideration of trade-offs (risk management) among goals such as safety, cost and passenger comfort as the primary in-flight task of pilots. However, these
approaches do not restrict themselves to the purely operational arena and would also include corporate goals.

The Delta policy clearly states the priority which the airline has ascribed to the component parts of its product. It highlights the expectations that potential passengers have when they consider air travel. Further, this examination of the airline product defines the problem or risk spaces (generic areas of potential failure in the product delivery and not to be confused with cognitive space) which exist in aviation (Smith & Hancock, 1995b). Safety (the highest priority) is easily understood using this risk space concept. Further, the notion that failure boundaries exist or are established within a risk space (i.e., the point at which a failure will exact a penalty) is inherent within the concept of risk.

The elements of risk (risk spaces), as defined by the Delta policy, will not simultaneously occupy equal cognitive space, and nor will this space be constant in size. Depending upon the moment-by-moment needs of the operation, the relative size of the cognitive spaces occupied by each product component will vary. For example, it is conceivable that almost total cognitive allocation (i.e., all attentional and processing capacity) may be occupied by passenger comfort problems when required. This comes about because human information processing is poor at distributing attention to more than one topic simultaneously (Cowan, 1995).

All facets of aviation, from engineering through ramp services to air traffic control (ATC) to the operation of the aircraft and the delivery of the product to the customer, react to episodes within these risk spaces. These risk spaces can be defined as areas where there is an inherent risk of failure which will adversely impact upon the operation and, subsequently, on the viability of the organisation. The aviation operator is the executive manager of the organisation's risk in all of these areas (Jensen, 1995).

Therefore, the task of aviation operators at the operational level would appear to be to mediate in order to mitigate the inherent risks. This ability to mitigate risk will depend upon many facets of the operator's competence, such as the ability to direct behaviours to generate skilled performance. A mediation process is implied in the
perceptual cycle as proposed by Neisser (1976) and expanded by Adams, Tenny and Pew (1995). This proposition contends that individuals sample the stimulus environment and modify relevant schemata which, in turn, direct further perceptual exploration. The process is continuous and circular, and the exploration of the elements of risk involved contributes significantly to goal attainment.

In the present era of air travel, safety may well be assumed by customers and the priorities of passenger comfort and schedule will take precedence. When flying is considered safe, the only discernible differences between airlines relate to the service aspects and the price of the ticket. Notionally, safety is a universal value. However, its practice is not (Helmreich, & Wilhelm, 1997). The reality is that the point at which action will be taken (action thresholds) (Smith & Hancock, 1995b) to mitigate the risk of failure vary considerably from organisation to organisation and from operator to operator. Consequently, as a scenario matures, the intervention point for each individual will vary. This variation can be explained, in part, by differences in organisational safety culture (shared practices) (Hudson, 1997; Westrum, 1995) and national culture (shared values) (Merritt, 1997).

Therefore, aspects of acceptability of separation tolerances, aircraft serviceability, environmental conditions and fuel state will define some of the intervention points in the aviation risk spaces. Some of these intervention points are generated by commonly used aviation mediation instruments like checklists, Standard Operating Procedures (SOPs), regulations and attendant rules. Each of these types of mediation instrument has a lexical (literal), semantic (accepted understanding) and action (response) level (Degani & Wiener, 1990; Hutchins, 1995) which results in varying interpretation and application by operators. This variance directly influences risk management.

Some of the action thresholds (intervention points) cannot be generated by SOPs. It is the interaction of the operator with the total aviation environment (ecological interaction) and the resultant knowledge that defines the action thresholds and the intervention required at the time and place in question (Endsley, 1995). The mitigation of risk depends on meta-mediation; “that is, a mediating artefact that organises the use of some other mediating artefact” (Hutchins, 1995, p.297). This
process implies that the individual successfully interrogates the environment, recognises the need to act, formulates an action plan and implements this plan. The implication is that this will be done in accordance with a blend of existing national (shared values) and organisational (shared practices) cultures as defined by Uttal (1983) and cited by Maurino, Reason, Johnston and Lee (1995).

2.5 Cultural influences on the management of flight

In exploring safety culture, Merritt (1997) defines culture as “the values, beliefs, rituals, symbols and behaviours, which help define us as a group, especially in relation to other groups,” (p.81). Hofstede (1980) defines culture as “the collective programming of the mind which distinguishes the members of one group from another” (p. 21). It can be concluded that culture dictates the reaction to changing circumstances, the way in which information is processed and the expectations of others within the group. On the flight decks of the worlds' airliners, culture has a great impact on the outcome, particularly the outcome of problem solving exercises and conflict resolution.

A culture of safety will be quite difficult to establish where the prevailing national culture attributes little value to human life (Maurino, 1996). Therefore, it is necessary to contemplate the attitude to safety in a culture where religious beliefs dictate that life after death is guaranteed to be of more use and more enjoyable than earthbound existence or where death is preferred to survival and the attendant loss of face. For example, the report on a B747 accident at Seoul in 1989 records the decision of the pilot and co-pilot to burn to death rather than survive to testify at the inquiry (Phelan, 1994). Some cultures, for example, see it as prudent to attribute success to fate or luck (Anca & Sarmiento, 1997).

The work of Hofstede (1980; 1991) revealed, for the first time, the differences which appear to exist between cultures. The existence of large power distance and individualism/collectivism coefficients in certain cultures was established. In cultures where a large power distance exists, it would be difficult for a subordinate to assert an opinion against that of a superior. Further, individuals would generally find it difficult to act without a group consensus being reached beforehand in cultures where
collectivism is preferred to individualism. Hofstede's work has been followed with research into aircrew culture (Merritt, 1997), the findings of which indicate a strong correlation between national and industry culture. Where national culture is not conducive to the natural development of a safety culture, the process of safety culture development requires a progressive, deliberate and experiential approach as used in Crew Resource Management (CRM) training (Maurino, 1996). Merritt and Helmreich (1996) and Maurino (1994) contend that recasting CRM as 'error management' has the potential to foster the transition of organisational cultures into cultures of safety.

Within similar cultural groups and subgroups, there can be differing attitudes to all aspects of aircraft operation including safety. In a research project comparing modes of transport, Braithwaite (1996) determined that while the attitudes of British and Australian pilots towards safety in the air were similar, their attitudes to the inherent safety of road transport were markedly different. When in control of a motor vehicle, British pilots assessed the level of risk as being high while Australian pilots thought that the risk was low. According to road fatality statistics, the British pilots surveyed can be seen to have a more realistic attitude to risks associated with motor vehicle travel than do Australian pilots. While this finding seems to have little impact on their respective positions on air transport, it could indicate the level of development of their respective individual safety cultures, or the differing mechanisms which each group uses to achieve its culture of safety. It points to the existence of a cultural cognition (shared thinking) or a way of processing information which is unique to that group of operators (Hutchins, 1995). Kabbani (1995), Ooi (1991) and Radzi (1995) report on the complicating nature of multicultural flight crews (with reduced cultural cognition) in the establishment and maintenance of safe cockpit teamwork.

Before the establishment of a positive safety culture within an airline can be considered, a starting point must be agreed. This will entail the identification of the attitudes of the aircrew group (within the airline) to aspects of safety, which can be seen to underpin a good culture of safety. Several authors have approached the subject of safety culture. Phelan (1994) cites "culturally embedded attitudes which tend to promote vertical management rather than a consultative teamwork approach to problem solving as influential in the cultivation of safety" (p. 22). These culturally embedded attitudes may also influence the process of establishing a positive safety
culture. Further, an understanding of the use of the word ‘culture’ in this context needs to be established.

The influence of culture on safety goes far beyond rules, regulations and procedures. The way that these action mediators will be interpreted and put into practice is strongly influenced by the prevailing culture. Cultural cognition is a specific way of approaching a problem and of reaching a solution, and may be an integral part of an aviator’s work profile (Hutchins, 1995). The implementation of rules where safety culture is largely undeveloped, will be strongly pathological (Hudson, 1997; Westrum, 1995). In an organisation operating at the pathological level, the rules will be obeyed out of fear of being caught if they are not followed. Lexical (word) recognition is present, but little interpretation takes place. This attitude to safety will not sustain the operation when unusual or unique situations are encountered, since the operators are not really considering safety but rather, the personal consequence of failing to obey the rules, all rules (Westrum, 1995).

Cultures with high coefficients of uncertainty avoidance are likely to have difficulty operating at other than a purely rule-based dimension (Hofstede, 1991) as this cultural attribute dictates that life is governed by rules, be they religious, social or bureaucratic. Consequently, their natural inclination towards an enhanced culture of safety is low (Merritt, 1997). Organisations within such cultures are more likely to be operating at this rule based level since the employees will impose their cultural norms on workplace practices (Reason, 1997). This, in turn, places more onus on the captains who, because of their experience and intimate self-interest, are probably working towards the preservation of a more enlightened safety standard of which the rest of the organisation may not be aware (Eddy, Potter & Page, 1976; Nance, 1986). This raises the point that if a culture of safety is to be embedded, all parts of the organisation need to understand what is involved in order to avoid an atmosphere of mistrust and blame (Westrum, 1995).

The next level of safety culture, as defined by Westrum (1995) and Hudson (1996), is reached when the individuals begin to become conscious that they should worry about safety. The operators begin to develop an understanding of the rules. At this level of understanding, personnel will not be able to generate the pessimism (healthy
wariness) required for a good culture of safety because they believe inherently that
the established procedures and rules will sustain the operation (Reason, 1997). They
will blindly follow the rules because the rules must be right. Westrum (1995)
describes this phase of development as the ‘bureaucratic’ stage. Relying heavily on
rules and procedures also promotes a reactive, rather than a proactive approach to the
maintenance of safe flight (Hudson, 1997). By inference, this reactive approach has
been shown to increase the possibilities for error (National Transportation Safety
Board, 1994, p.55). In order to generate the safest possible outcome, Captains must
be proactive (forward thinking) in their approach to the task.

In an organisation where safety is reliant on a pathological cum bureaucratic
approach, one finds that knowledge of rules and regulations is power (Westrum,
1995). The people in power know all the rules. Invariably, they generate them. They
compose them, applying their own cultural bias. The organisation, therefore, becomes
a clone of the leaders (Eddy et al., 1976; Nance, 1986). The capacity to think
independently is severely restricted. The organisation reacts to accidents and
incidents by tightening the rules, further restricting the need to problem solve (e.g.,
FAA sterile cockpit legislation). Responsibility is inherent in the rules. As a result,
the human factor is built out and the boundaries of blame are built in (Westrum,
1995).

These are the organisations where the notion of ‘pilot error’ is still thought, if not
expressed, as a causal factor in most accidents and incidents (Beaty, 1995). The first
tentative steps to correct this approach to accident causation occurred in the early
1970s. Allnutt (1976) concluded that “mistakes are a normal feature of human
behaviour and that aviation is a human activity” (p.89). The human remains the
single biggest variable in the safety chain (Lewis, 1995; Reason, 1997). Twenty years
later, organisations are still wrestling with the concept of human error and the world
aviation industry has only just begun to develop formal approaches to error
identification and mitigation (e.g., Maintenance Error Decision Aid, MEDA; Safety
Courses for Airport Ramp Functions, SCARF). In the meantime, the rules have
multiplied and the adage “if the accident didn’t kill the pilot, the inquiry did”
(Allnutt, 1976, p.90) still rings true in many cases (Beaty, 1995, p.239). One can
conclude that the pathological cum bureaucratic approach to safety is alive and well,
particularly in less mature and ‘start up’ organisations that are still trying to come to grips with the requirements of the regulators and in which the ratio of experts to novices is low (Peel, 1997).

In an organisation where the safety culture is well developed, the role of the leader takes on the air of coworker rather than enforcer (Hudson, 1996). In these circumstances, there is no mistrust or lack of understanding between organisational groups. Every crewmember behaves in a way that facilitates safe operations. The product component hierarchy (e.g., safety before schedule) has been established and understood. This is a “learning organisation” (Hudson, 1997): an organisation where information is treated as a resource rather than power, and where responsibility is devolved and accountability is accepted. In such a generative atmosphere (Hudson, 1996; Westrum, 1995), management accepts that error will occur, but that it is generally not intentional. Here, it is the management of error, which is important. However, this is not a blame-free environment, but an environment where the last person to touch the aeroplane is not held accountable without inquiry (Reason, 1997).

Errors stimulate the investigation of the system which was supposed to support the individual (Reason, 1997). That is the ideal. The reality, in most cases, is somewhat removed from the ideal. In the free market-type economy, the demands of economic survival add unwanted pressure to the day-to-day operation of airlines. Academics must publish or perish, airlines must be punctual or perish. The need to meet this demand of airline customers has prompted manufacturers to develop extensive Minimum Equipment Lists (MELs). These engineering documents allow aircraft to be despatched with multiple equipment downgrades. Sometimes these are downgrades which the captain would rather not accept. At best, they require thorough study before departure and are often very complex by virtue of their ‘work around’ (additional procedures required to cover the deficiency) nature.

In such a situation, the Captain must put the operation ‘on hold’ while investigating the acceptability of what is proposed. In some cases, the operation should be halted in the interest of safety. This is a bitter economic and inconvenient pill for the organisation and the ill-informed customer. The airliner captain is the last defence in the safety chain and, regardless of the sophistication of the organisational safety
culture in place, aircraft commanders must possess and activate a personal generative culture of safety. The main contributors to this expertise are extensive knowledge (Glaser, 1985; Glaser & Chi 1988; cited by Federico, 1995), the use of prototypical operational models as comparators for the current situation (Endsley, 1995), and behaviours which welcome new ideas and treat failure as a learning experience (Westrum, 1995).

The consequences of not adopting such an approach to safety can be severe. The flight environment is a real-time environment (Voll & Beaumont, 1997). The fuel in the tanks at the commencement of the flight converts to a finite time of flight. All management of flight processes must be completed in something less than that time, depending on the fuel reserves decreed by legislation, and the practical application or the forecast weather conditions. Further, the flight is expected to reach its destination. This dynamic, multidimensional environment (Salas, Prince, Baker & Shrestha, 1995) also generates multiple variables, all of which can impact on a flight (Voll & Beaumont, 1997). Maintaining an awareness of these variables and their sources is a major challenge facing an airline Captain.

What may not be apparent to the Captain of a flight is the complexity and the implication of such variables on the day. When heuristics cannot be used, the captain must rely on a suitable algorithm to deal with the situation. At the same time, flexibility is a must, since yesterday’s answer may not be appropriate for today’s problem. Self-directed mediation skills and tools must be used to successfully intervene at this level. This approach to the culture of safety can be transposed to other areas of product delivery with the same intention, to mitigate against the risk of failure to deliver the product to the satisfaction of all interested parties.

2.6 Workload and management of flight

Risk management could be concluded to be the primary operator task for airline captains and, as such, constitutes the work which the operator does. Depending on the operational circumstances, the workload to which the operator is subject will vary. The exploration of workload has occupied researchers for many years with several resultant approaches (Endsley, 1993; Hart, Battiste & Lester, 1984; Taylor, 1989).
Amalberti and Deblon (1992) found that when not engaged in identifiable tasks, 90% of a pilot’s reasoning time was given over to anticipation. This forethought helps to protect the pilot from extreme surges in workload (Adams et al., 1995).

According to Hart (1987), workload has six dimensions, three of which are demands made of the operator (mental demand, physical demand and temporal demand) and three of which concern the interaction of the operator with the task environment (performance, effort and frustration). Earlier work by Reid, Shingledecker and Eggemeier (1981) explored the dimensions of time, effort and stress. Raby and Wickens (1994) have defined the operator workload hierarchy as: what must be done, what should be done and what could be done. This prioritisation cannot take place without an awareness of all the facets of the task which must be completed.

The aviation adage ‘aviate, navigate, communicate’ defines a method of contextual prioritization. The actions which this adage suggest are designed to circumvent the tendency of operators to treat all tasks as being equally important (Raby & Wickens, 1994). The need to prioritise work (i.e., control workload) has been investigated from both the operator overload (Hart, 1987; Härter, Neal, Halford & Härter, 1998) and underload or boredom perspectives (Braby, 1993; Endsley, 1993; Sawin & Scerbo, 1995). Some of the methodologies used by these researchers rely on quantitative analysis, some on qualitative and some on both. The common ground of the research on workload lies in the subjective (qualitative) aspects of these assessment techniques. Qualitative assessment of workload (e.g., self-reporting) will be influenced by the conceptual understanding of workload (or boredom), the operator’s propensity to become bored, and the interaction between these state (achieved) and trait (inherent) attributes (Sawin & Scerbo, 1995). That is, workload may well exist ‘in the eye of the beholder’ (i.e., the individual’s subjective assessment of their workload) rather than the actual (measured) distribution of personal resources (e.g., attention) across multiple tasks.

Another factor that seems to influence apparent workload originates from anticipation of possible task requirements. Raby and Wickens (1994) noted that better performing pilots performed their tasks earlier than poor performers. This finding reinforced earlier work by Orasanu (1990), who found that better performing crews investigated
the need for, and conducted contingency planning earlier, than poor performers. Further, the work by Laudeman and Palmer (1995) revealed that operators who delayed the initiation of critical tasks of high priority experienced the highest level of workload. Cockpit task management errors (i.e., errors in the initiation, monitoring, prioritisation and termination of tasks) were found to be contributory in 23% of accidents and 49% of incidents (Chou, Madhavan & Funk, 1996). Task shedding was also investigated by Raby and Wickens (1994) who found that as workload increased, operators concentrated on high priority tasks and shed low priority tasks. Coincidentally, poor performers were found to dwell too long on particular tasks further delaying the commencement of critical tasks, thus increasing their workload as the task completion deadline approached.

These findings address the overconfidence bias described by Raby and Wickens (1994) which is defined as an unreal performance expectation in operators as to their ability to perform tasks in an accurate and timely fashion. Whereas Raby and Wickens (1994) speak of what must be done, what should be done and what can be done, the reality of the aviation environment is that this action hierarchy seldom comes into play. Within the aviation context, the imperative remains 'what must be done'. The essential activities associated with management of a flight must be prioritised, often by forethought, and completed according to a suitable time budget (i.e., a timely manner) to avoid high levels of workload. Inherent in successful management of flight is sound decision making which, of itself, produces workload and therefore, warrants further discussion.

2.7 Decision making and management of flight

In complex, dynamic decision environments (i.e., cognitively busy), decision making requirements can act as distractors to the primary tasks of aviating (i.e., aircraft manipulation, navigation and communication with ATC) (Härtel & Härtel, 1997). This situation can be alleviated if anticipation is developed and is used as the starting point for decision making in abnormal and emergency situations, that is, cognitively busy situations (Orasanu, 1994). Further, Orasanu (1994) contends that the quality of the decision making will depend on the understanding of the problem. Well defined and clearly understood problems can be solved using first level skills such as
inferential rules and strategies (Schraw, Dunkle & Bendixen, 1995). However, the failure to adequately define the problem implies the inability to use higher level skills (e.g., syllogistic reasoning) and their attendant larger cognitive requirements. Therefore, structuring and understanding of the problem is the first step in situation assessment (Orasanu, 1994).

Orasanu (1994) maintains that operators must determine the amount of time available to cope with the problem and assess the level of risk associated with the problem. Cohen, Freeman and Thompson (1995) agree. However, operators do not normally focus on the process by which they attain a problem solution (Berardi-Coletta, Buyer, Dominowski & Rellinger, 1995). The exploration of cockpit communication by Orasanu (1994) defined a number of identifiable (but not conscious) processes which a crew utilised in trying to assess the likelihood of wind shear at destination. Comment about the weather led to an evaluation of the situation, the development of a contingency plan, continued monitoring of the weather and requests for information. In this scenario, the decision making was progressive and timely thereby avoiding high workload.

Critical features of a problem need to be attended, remembered and applied (Berardi-Coletta et al., 1995). Orasanu (1994) recommends similar processes for multi-crew environments through thorough scanning patterns, monitoring by the pilot-not-flying and the verbalisation of the condition status. The latter two can be seen as metacognitive processes which “seem to encourage a proactive, self-reliant discovery process that does not appear to be part of the average problem solver’s repertoire” (Berardi-Coletta et al., 1995, p. 222). In the practical sense, effective decision making among airline crew members can be seen to rely on a degree of anticipation. The operator’s ability to develop this anticipation through thorough information processing techniques has the potential to reduce workload and, subsequently, error.

2.8 An element of accident causation

In his review of intervention strategies for the management of human error, Wiener (1993) details several sources of information which would indicate that interventions to manage error are required in the aviation domain. Primary in Wiener's account as
sources of information detailing interventions to reduce error in aviation are records of accidents, incidents and violations. Reporting systems such as the National Aeronautics and Space Administration’s (NASA) Aviation Safety Reporting System (ASRS) are cited as source documents for such occurrences. Several authors have used the ASRS to conduct research to test the validity of their understanding of concepts such as Situation Awareness (SA) (Endsley & Jones, 1995; Freeman & Simmon, 1991; National Transportation Safety Board, 1994; Strauch, 1996; Sumwalt & Watson, 1995).

A variety of methods ranging from word searches to detailed analysis of the human factors aspects of the accident and incident reports were used to identify instances of SA errors. The number of reports analysed varied from a few (Strauch, 1996) to hundreds (Endsley & Jones, 1995; Freeman & Simmon, 1991; Sumwalt & Watson, 1995). Generally, there were lexical, but not semantic differences in the definitions used to identify SA. That is, an ability to forecast events using information gleaned from an understanding of the circumstances influencing the flight could be seen as a widely held semantic understanding. Using the criteria contained within this understanding of SA (i.e., information gathering, comprehension of information and forecasting of events), the authors listed above recorded the frequency of SA errors which were adjudged to be contributory in the reports that were reviewed.

Where large numbers of error-related reports were analysed, 30% (Endsley & Jones, 1995) to 65% (Freeman & Simmon, 1991) of these reports contained references to SA degradation. These statistics indicate a requirement for additional research into SA so that existing problems with the topic can be clarified and intervention strategies can be developed to reduce the incidence of SA breakdown.

The use of the term SA, or more precisely, lack of SA, to define elements of accident causation has become widespread. When handing down its findings regarding the 1995 crash of American Airlines Flight 965 near Cali in Colombia, the Colombian Aeronautica Civil concluded that the flight crew’s lack of SA regarding vertical navigation, proximity to terrain and the relative location of critical navigation aids was a major contributor to the accident (Flight Safety Foundation, 1998). Similarly,
Härtel, Smith and Prince (1991) found that inadequate SA was cited as the primary causal factor in 70% of military accidents which they reviewed.

More definitive research by Jones and Endsley (1996) refined the definition of SA error. Their findings indicate that a failure to monitor or observe data was evident in 35% of SA errors. When examined at the next level of reduction, task distraction and workload were found to be the most recurring cause. Significantly, however, SA failure also occurred in situations where workload was not an issue. As a result of their consideration of automation-induced error, Sarter and Woods (1995) hold that this situation can arise where gaps in the operational mental model (i.e., the expectation of events) exist. According to Sarter and Woods (1991), this state of affairs results from the shift in operator role from that of direct control (manual flight) to that of supervisory control (automatic flight).

2.9 Summary

From this review of the literature, it can be argued that the work of the airline Captain, to wit, proactive risk management (O’Hare, Wiggins, Williams, & Wong, 1998) will not be completed satisfactorily under conditions of varying workload without the intervention of an anticipation mechanism such as SA. Further, the operator’s task can be seen as prioritised, self-regulated mediation which contains the operation within the desired thresholds of each identified risk and manages the workload. Given the evidence, it is not unreasonable to theorise that the ability to deliver competent management of flight performance is reliant, to a large extent, on the development and maintenance of operator SA.

While the origins of SA are firmly rooted in the field of accident investigation (Charness, 1996), the attractiveness of the construct as a performance indicator has ensured its use at the subjective (qualitative) level (e.g., Helmreich et al., 1991). At the very least, interest in SA can be seen as a welcome shift away from the ‘knobs and dials’ of airline operations to focus on an integrated system of evaluating realism (Endsley, 1993). However, the lack of understanding of the underlying processes has reinforced the subjective nature of the current use of SA as a performance marker. SA
is seen by the aviation industry as a major variable in demonstrated performance and needs to be understood more fully if this reliance is to be justified.
CHAPTER 3

Review of the literature

Part 2 - A contemporary variable

3.1 Introduction

Having explored some of the influences and outcomes associated with pilot management of flight performance and, having discovered numerous references to a performance variable known as Situational Awareness (SA), the topic of SA should be investigated further. The references to SA that were discovered in the initial review of the literature were concerned principally with accident and incident causation. These references did not attempt to fully describe the phenomenon of SA and its relationship to demonstrated performance by pilots.

This chapter will establish a contemporary understanding of this construct by examining those aspects of human performance that are thought to contribute to SA
development and maintenance. This review of the literature pertaining to SA comprises the following segments:

- An examination of the literature pertaining to the conceptualisation of SA;
- A brief review of ways that researchers have tried to assess SA;
- The introduction of a composite postulate of SA;
- A review of literature pertaining to aspects of this composite postulate (e.g., knowledge acquisition, attention, & memory);
- An examination of the concepts of novel information detection and metacognition;
- An exploration of the contribution that tactics and strategies make to outcomes;
- The introduction of the notion that self-regulation contributes to SA performance;
- The development of a framework for considering SA research findings;
- The tactical and strategic foci of existing postulates of SA;
- The contribution of mental modelling to SA development and maintenance; and
- The research questions which follow from the review of the literature.

3.2 The nature of SA

Endsley and Bolstad (1994) researched individual differences in SA in an attempt to establish discriminators between individual levels of performance. Military pilots (whose mission goals, duration and operating speeds are vastly different to those of civilian pilots) were used in limited numbers. According to Endsley and Bolstad (1994), spatial and perceptual skills were found to be very important for SA, while attention sharing and pattern matching were less influential. There was no evidence of a relationship between memory or analytic skills and SA (Endsley & Bolstad, 1994). However, Taylor and Selcon (1993) report a different outcome using a different methodology.

Taylor and Selcon (1993) claim that the subjective approach (Situational Awareness Rating Technique [SART]) which they adopted is a reliable measure of SA. SART
elicit subjective ratings for aircrew constructs of attentional demand, attentional supply, and understanding. With regard to SA, Taylor and Selcon (1993) note that “the lack of an integrated theory limits the inferences that can be drawn about underlying cognitive processes” (p. 5). However, Taylor and Selcon (1993) stipulate that a good definition of SA should take account of situational, attentional and cognitive factors. Accordingly, in reporting their results of further research, Taylor, Selcon and Swinden (1994) contend that measuring SA can be achieved by sourcing knowledge of important relationships and knowledge of the status of variables in the situation.

Although concerned mainly with team SA (as developed and shared by a group), Prince, Salas, Bowers and Jentsch (1996) approach the importance of common mental models as the foundation for good SA. It is assumed that each team member must have a highly developed mental model of the situation, and that mental model must be similar to that held by other team members in order to achieve maximum team effectiveness. Other researchers (e.g., Endsley, 1995) have also drawn attention to the importance of mental modelling in the formulation and maintenance of SA. For example, Taylor (1996) acknowledges the existence of mental models, but is not explicitly in support of such models. Nevertheless, Taylor (1996) does explore the function of memory with a view to equating awareness with the level of activity required to recall events from the memory. He also proposes that ‘forgetting’ or having forgotten information signifies a state in which there is a lack of awareness. Rabbitt and Maylor (1991) also refer to forgetting in their investigation of human performance.

SA is viewed, by some authors (e.g., Endsley, 1995; Regal, Rogers Boucek, 1988), as a derivative of information processing and, therefore, may embody a number of dimensions. Rabbitt and Maylor (1991) have proposed a construct of neural networking (interrelationships and associations within memory) which contains at least four hypothesised dimensions that discriminate information processing performance. The first, processing rate, has been explored in the past (Fitts & Switzer, 1962 cited by Lachlan, Lachlan & Butterfield, 1979) as has the second nominated discriminator, learning rate (Mannes & Kintsch, 1987). According to Rabbitt and Maylor (1991), the third dimension, the range and precision of input categorisation,
has also been shown to vary directly with the level of random noise (of which workload may be an example). System forgetting rate is nominated as the fourth discriminator of information processing. The first two of the discriminators are time-dependent to some extent (Rabbitt and Maylor, 1991). The debate which Rabbitt and Maylor (1991) join addresses the existence of numerous performance parameters, rather than a single master discriminator of information processing. This view supports the investigation of the other discriminating dimensions of information processing.

In relation to information processing, Klein (1996) contends that SA may well be an element of expertise. This focus can be classified into four aspects that are presumed to influence SA. These include an expectation of the next event, the selection of the most relevant cues, plausible goal identification, and the recognition of a typical course of action. These four aspects facilitate the translation of SA into decisions and actions. While it is difficult to establish the content of a person’s SA (Klein, 1996), questions about the future of test-related events can discriminate between expert and novice performance (Durso, Truitt, Hackworth, Crutchfield, Nikolic, Moertl, Ohrt & Manning, 1996). This view supports the dimensions raised by Klein (1996) which would entail some level of questioning about the future state of events. However, Durso et al. (1996) warn that in the world of chess, experts and novices are more similar in mastery performance than ranking would suggest (i.e., the mastery hierarchy of chess players is not easily defined based on their demonstrated grasp of future events).

Meister (1996) advances the proposition that complexity and the relative dynamic of the situation will, in the first instance, control the scope of the mental model that is developed. In the second instance, it will place time constraints on reactions. Therefore, if the measurement of SA is to be attempted, the methodology should encompass the complexity and dynamism of a task. Meister (1996) suggests that researching extreme, rather than normal situations, is of benefit and will render more opportunities to indicate how SA relates to other behavioural elements.

Tenney, Adams, Pew, Huggins and Rogers (1992) contend that the key elements of SA are the understanding of events and the anticipation of the consequences of taking
or not taking particular actions. According to Tenney et al. (1992), these elements will demand both an explicit and implicit focus on the part of the individual. Explicit focus involves attending to one goal at a time utilising working memory, while implicit focus involves concentrating on the overall representation of the situation. Further, Tenney et al. (1992) propose several strategies which facilitate multi-tasking, which they indicate is also an important aspect of SA performance. These strategies include: hearing the important information; chunking information; optimising attention to gauges; limiting attention to the necessary minimum; shedding, delaying and pre-loading; heuristics; and the use of non-competing resources (e.g., spatial and qualitative). However, there are other potential indicators of SA (such as aspects of memory) that require a great deal of additional research to determine their relevance.

Significant findings of SA research in the fighter aircraft environment deal with experience and aptitude (Waag & Houck, 1994). Waag and Houck (1994) found some level of association between previous experience and SA, but no significant correlation between aptitude and the ability to develop and maintain SA. The current qualification held by participants was also found to be influential in the level of SA exhibited by more highly qualified pilots demonstrating a higher level of SA. In this study, the more highly qualified pilots were, generally, also the most experienced. However, some instances were recorded where relatively less qualified and less experienced pilots received SA ratings that were more characteristic of their more experienced and qualified cohorts. This suggests that SA abilities may not be totally dependent on experience.

Sarter and Woods (1995) hold that it is futile to try to determine the most important contents of SA due to the absolute role of context which instantaneously changes the circumstances which contribute to the development of SA. However, it is not unreasonable to attempt to examine outcomes and determine the cognitive processes which might have contributed to these outcomes (Adams et al., 1995). Further, Adams et al. (1995) contend that while beliefs (expectations) might limit scrutiny, by definition, prior knowledge is most influential in the state of SA which is achieved. When reviewing the work of Freeman and Simmon (1990), Adams et al. (1995) observe that the failure to acquire information and the failure to interpret information contribute significantly to low levels of SA. Similarly, more recent accidents (e.g.,
Los Angeles tower controller forgot that a commuter aircraft was holding on the runway and cleared a jet to land on the same runway) indicate that forgetfulness plays a major role in the breakdown of SA (Adams et al., 1995).

Orasanu (1995) suggests that SA is the starting point for decision making, particularly in abnormal and emergency situations. If this is the case, an appropriate decision will be indicative of high levels of SA. According to Orasanu (1995), the observation of an outcome is held to be more representative of SA than the presence or absence of behaviour. This view is supported by Prince and Stout (1995) who hold that an individual’s performance in task components (e.g., manipulation) is likely to suffer when SA is low or lost. Liu’s (1996) finding that “increases in scanning demand tend to produce greater performance decrements and workload increments in concurrent spatial than in verbal tasks” (p. 396) indicates that, in the piloting context, where SA is low or lost, the increase in scanning which the SA deficit demands may impact adversely on performance of other task components (such as flight path control).

The effect of changes in task demand has also drawn comment from other authors. Selcon, Taylor and Koritsas (1991) contend that changes in task demand and difficulty are factors that influence both workload and SA. Consequently, it can be hypothesised that a dynamic scenario, in which the workload is increasing, would place increasing demands on the cognitive processes and the mechanisms which maintain levels of SA necessary to manage the unfolding situation. In this context, workload is considered to result from the prioritisation of time-dependent planning and forecasting activities which are required to meet current and future task demands (Raby & Wickens, 1994).

The hypothesis espoused by Selcon et al. (1991) holds with the view of Endsley (1993) that the need to maintain SA generates workload. This workload results not only from the proposed processes such as perception, comprehension and projection (Endsley, 1988), but also from the need to check ‘goodness of fit’ for data being processed with an existing schema (Noble, 1989). Noble (1989) maintains that “when the fit between the situation-specific data structure and the observed situation is good enough, this data structure can be used to interpret the situation” (p. 475). The views
of these authors suggest that SA is dependent on cognitive processing and the existence of situation-specific schemata.

3.3 Experimental design possibilities

A consideration of the views and findings expressed by authors such as Endsley (1993), Noble (1989), Orasanu (1995), and Prince and Stout (1995) leads to the conclusion that SA remains difficult to measure as an isolated construct. However, there could be aspects of SA development and maintenance (such as ease of recall and forgetfulness) which may be capable of discriminating between states of unawareness and awareness. In the design of research to explore a question which seeks to address this possibility, an unfamiliar situation, which does not allow the use of existing data structures to test the goodness of fit of the present situation (Noble, 1989) could possibly be used to remove any advantage that previous experience may provide.

Taylor et al. (1994) indicate that acquiring knowledge of important relationships and the status of variables within the air traffic control environment will give an indication of the level of SA. Gawron (1999 & 2000) agrees with this approach to the assessment of SA. Further, the data collection vehicle should be a task that embodies a typical level of complexity (Meister, 1996) that is consistent with the operational environment. This contextualisation of the study will ensure that outcomes are more easily observable and will, thereby, render the identification of processes and outcomes more likely (Adams et al., 1995). Appropriate questions about the future state of the system will also facilitate the detection of any differences between expert and novice performance (Durso et al., 1996; Klein, 1996).

Acquiring knowledge of the relationships and variables in a situation potentially addresses an aspect of awareness raised by Taylor (1996), who contends that the level of cognitive activity required to recall information is indicative of the level of SA achieved. Taylor (1996) suggests that the level of forgotten facts is commensurate with a lower level of SA. As mentioned previously, in their discussion on neural networks, Rabbitt and Maylor (1991) list “forgetting rate” as the fourth of four proposed discriminating dimensions of human information processing performance. This aspect of human performance is also explored by Adams et al. (1995) who
indicate that forgetfulness contributes significantly to the accidents and incidents so far attributed to breakdowns in SA.

Taylor (1996) suggests that the forgetfulness aspect of human performance influences mental modelling (development of event expectation) ability. Therefore, it might be hypothesised that remembering, rather than forgetting, could define the operating mental model and, thereby, directly influence the level of SA. However, the technique of shedding, that occurs during multi-tasking (Tenney et al., 1992), could confuse attempts to establish the role of forgetfulness in SA maintenance. If overloaded, shedding might be employed by experts to discard irrelevant information and, thereby, maximise the available information processing capacity at all times. Therefore, an experimental design would be required that identifies 'need to know'-type information to be certain that participants at all levels of expertise could be expected to retain the information.

Tenney et al. (1992) propose that the key elements of SA are the understanding of events and the anticipation of the consequences of taking or not taking action. This is consistent with proposals regarding projection as a component of SA and, subsequently, as a discriminator in the measurement of SA (Endsley, 1988). When considered in the practical sense, this proposed aspect of SA should manifest itself in the quality of the decisions which need to be made (Orasanu, 1995). Further, Klein (1996) maintains that questions about the future state of the system can discriminate between expert and novice performance.

This thesis pursues the perceptions of management of flight expertise by Captains at the airline of study. The relationship between current piloting qualification and SA performance has been reported by Waag and Houck (1994). The findings of Waag and Houck (1994) that more highly qualified and experienced pilots demonstrated higher SA, is of significance. It raises questions about whether the ability to gain a qualification was dependent on an innate SA ability and experience, or whether, once qualified, experience at the higher level of qualification rendered an improvement in SA skills. Within the aviation domain, this issue requires clarification.
By considering Liu's (1996) finding relating to the effect of increased scanning demand on workload in spatial tasks, together with the view of Selcon et al. (1991) that changes in task demand are factors in both workload and SA, a basis for considering the issue of increasing task demands on SA is established. An increased scanning demand could be introduced to test the effect of increasing workload on SA development and maintenance. This would require an inspection of several aspects of the relationships and the quality of the outcomes in the dimensions of SA and scanning effectiveness/accuracy.

3.4 A composite postulate of SA

The investigation into approaches to SA carried out by Dominguez (1994) produced a distillation of all of the perceptions of the subject which existed at the time. As an initial step in the exploration of the processes which can be seen to underpin SA, the consideration of a generic definition is of value. Dominguez (1994) contends that SA is the “continuous extraction of environmental information, integration of this information with previous knowledge to form a coherent mental picture, and the use of that picture in directing further perception and anticipating future events” (p. 11). Accordingly, an operator who conforms to this postulate would:

- process continuously,
- actively interrogate,
- recall existing knowledge,
- integrate novel information,
- update mental representations/models,
- generate expectations, and
- direct attentional resources.

This postulate supports the notion that the generation of expectation is the major desired outcome of SA development as proposed by Endsley and Smith (1996) who note that “avoiding the need to make on-the-spot decisions in stressful situations through anticipation and advanced response development can be seen as an effective strategy for coping with the demands of this environment” (p. 234). This statement
implies that, in order to successfully manage a flight under all conditions of operational stress, some forecasting of events and planning of responses is required. These practices may be perceived as automaticity.

Automaticity may be a variable in performance, as it relates to the maintenance of SA. The concept of automaticity has been explored by many authors. Cohen (1996) and Cowan (1995), for example, both propose that automatic processes require small amounts of attentional resources and effort, at the same time allowing attention demanding activities to be completed without interference. The contention that these automatic processes are generally well practiced is supported in the existing literature on expertise (Charness, 1991). While this is not disputed, there are other aspects of expertise (Glaser & Chi, 1988) which indicate that focused and structured knowledge retention, together with superior short and long term memory, will facilitate the exhibition of this type of expertise. Therefore, the role of knowledge in the maintenance of SA should be reviewed.

3.5 Knowledge

Hutchins (1995) discusses the requirement for the operator to be ‘a part of’ rather than ‘apart from’ the environment. This notion suggests that it is the operators who must bring the situation (physical) and awareness (cognitive) together (Flach, 1996). The development of SA requires information processing that is inextricably linked to the environment. For example, Hutchins (1995) maintains that the approach to SA developed by the indigenous navigators of Micronesia is totally ecological in the sense that these operators are as much a part of the environment as any of the cues which they use to develop and maintain SA (Hutchins, 1995).

It is contended here that the application of technology is not at a stage where aviation operators can adopt other than an ecological approach to SA. Only a small part of the total knowledge base required to successfully operate in the aviation environment is presented on cockpit displays. Aviation is still a three dimensional pursuit, subject to the vagaries of the environment and all who use or abuse it. A breakdown in SA will occur if operators lose sight of this reality. The initial focus for pilots concerns the interrogation of the environment for clues (knowledge) about the current situation. In
searching the environment for knowledge, operators must ensure that they do not falsely hear and see only data which they are expecting. This is referred to as confirmation (expectation) bias (Wason, 1960). This process of confirmation bias could exclude vital information (this can’t be happening to me!) and if unchecked, could seriously impede the ability of the operator to modify any original expectation to accommodate the latest information. Operators may be able to mitigate this effect by maintaining a critical and an open-minded approach to all that is occurring in the environment (Beaumont, 1997b; 1998; Flach, 1996).

The initial knowledge acquisition about a task and the structuring of that knowledge requires exploration so that the contribution of this important step in the development of SA can be understood. Consider a task which is unfamiliar. The first step is to organise the data collection pertaining to the task. The use of techniques such as structural alignment (Markman & Gentner, 1993) may be employed. Using this technique, an examination of the relationships between data, their attributes and the structure of the system in which they exist would be carried out. This technique lends itself well to the phase of flight (progressive, from the beginning to the end of a flight) task analysis (activity definition) used by many operators to establish performance indicators. The phase of flight establishes a structure which ensures the ‘one-to-one-mapping’ of data which a structural alignment technique requires. Such a structure (phase of flight) also provides a natural framework for operators to begin the process of data acquisition.

Framework approaches to the processing of required data are akin to chunking (storage of related pieces of information in larger units) which enables better use of the limited information processing capacity of individuals (Keinan, Friedland & Arad, 1991). When coupled with the process of information integration, the mediating process of information restructuring was shown by Keinan et al. (1991) to relieve cognitive stress (demand). In fact, higher cognitive stress resulted in the effective use of these techniques, leading to the finding that cognitive stress is not necessarily deleterious to cognitive functioning and that the use of techniques such as chunking and integration become automatic over time. Keinan et al. (1991) concur with the proposition that stress does occupy part of a person’s information processing capacity (i.e., in addition to existing problem or risk perceptions).
Gordon (1991) proposes an explanation of the process of skill acquisition which closely aligns with the views of Shuell (1990) regarding the existence of a multi-stage process (memorizing facts, establishing relationships between retained facts, and developing automatic performance) of task mastery. Gordon (1991) is, however, more explicit in her description of the process in that she proposes an initial cognitive stage which is typified by a laborious accumulation of declarative knowledge. This concept of knowledge acquisition also features in the ACT* theory of skill development proposed by Anderson (1983). Anderson derived this theory from the work of Fitts and Posner (1967) and proposed that skill development comprises an interpretative stage, a knowledge compilation stage and a tuning phase.

With respect to the compilation stage, pilots may use a template which outlines the task (e.g., the phases of flight) (Noble, 1993) to compile the necessary knowledge. At this knowledge compilation stage of skill development, decision making and problem solving would be slow and tedious. However, in the tuning phase, the repeated use of declarative knowledge results in domain-specific procedures. Gordon (1991) refers to this stage as the associative stage. Acquired knowledge may then exist as a schema which will mediate the understanding of the situation (Noble, 1989). Finally, these domain-specific procedures become 'second nature' in the autonomous stage.

The importance of this model of skill acquisition is highlighted by Gordon (1991) who says that “people becoming competent in a given domain move away from the use of symbolic or declarative knowledge and toward a reliance on perceptual, nonverbalizable procedural knowledge” (p. 101). Clearly, this stand has implications when trying to identify a process or construct which may be in general use within a contextual setting (airline operations) of a domain (aviation).

The current context within a work domain is a vital consideration when considering the data available (Markman & Gentner, 1993). In this sense, context would control the importance and emphasis which any piece of information assumes for the operation. For example, a weather report indicating conditions which would not allow a landing at the desired destination assumes a different contextual importance whether it is received ten minutes or ten hours before the estimated arrival time. The structural
alignment (assembling data with regard to the data attributes, data relationships, and the structure of the system within which the data exists) approach to data acquisition is supported by research in the field of chess expertise which revealed that experts appear to use a template of the board to recall set moves and develop their mental representation for the ensuing game (Gobet & Simon, 1996).

The notion that a template may be used has an analogy in theories of visual-spatial attention. The hypothesis of uncertainty reduction proposes that cued attention reduces errors and improves performance (Hillyard, Luck, Mouloua & Hawkins, 1996). The principle of a template serving the same purpose as cued attention in the cognitive sense is attractive, since the template fields provide the cues which focus the initial knowledge acquisition for the operator. It may well be that aviators use a template-type approach when preparing for a sector which they have not flown before. This generic template would define the structure, relationships and attributes which are held to organise data within working memory and requires further investigation.

In dynamic environments such as aviation, all the fields of the template cannot be addressed prior to the task execution. What can be proposed is that such a template, completed or not, identifies facets of the task which must receive attention to complete the operator’s knowledge acquisition. Schraw and Dennison (1994) propose that operator knowledge acquisition during the performance of a task is completed by employing metacognitive processes as the task proceeds. These reflective (self-checking) processes help identify the missing information and activate searches of the environmental stimuli for the missing knowledge (Hong, 1995). When considering the integration of missing, novel, updated or conflicting data, the ability of the operator to control attention is paramount.

3.6 Attention

Dominguez’s model (1994) suggests an in-built ‘attention for information’ controller as part of information processing. With the assistance of self-checking techniques, a highly developed template will focus the attention of the operator before and during the task. Monitoring (comparing reality to an expectation) also plays an important role
in the direction of attention in aviation-related tasks. For example, Jones and Endsley (1996) cite the failure to monitor or observe data as a contributory factor in 35% of incidents where SA errors were present. The level at which monitoring contributes to task performance goes well beyond the traditional meaning. Nelson and Narens (1994) contend that monitoring is the link between the cognitive (mental) model of the task and reality. Monitoring is not limited to data acquisition, but extends to meet the need to refresh the mental representation of the task (mental model) which is presumed to control task execution (National Advisory Mental Health Council, 1996; Wilson & Rutherford, 1989).

As an extension of attention, monitoring can best be described as structured, habituated attending. While Cowan (1995) notes that some unchanged stimuli will be processed voluntarily, without conscious attention or interpretation, he also proposes the case for the habituated advancement of unchanging stimuli (i.e., monitoring of unchanging stimuli). Further, Cowan (1995) contends that attention will be oriented by the novelty and the significance of the stimuli. However, the operator has to capture the stimuli before orientation can occur using these criteria. This is where automation in aviation has generated its own problems for the operator. The current state of reliability and the consistency of automation can lead to poor monitoring and complacency (Singh, Molloy & Parasuraman, 1993).

When reporting on their research, Hillyard et al. (1996) also emphasise the potential role of attention in the development and maintenance of SA. Attention-directing pre-
cues (such as a template or matrix) are presumed to “allow additional perceptual
processing resources to be allocated to the cued location” (Hillyard et al., 1996, p. 734). This finding has definable benefits in the initial data acquisition stage of learning about a task (Gordon, 1991; Shuell, 1990) or developing SA (Dominguez, 1994). Keele (1973) proposed that information which is retrieved from memory by perceptual cues does not require attention. Similar findings have been reported by Kim and Cave (1995) in their exploration of visual-spatial attention. Handy, Kingstone and Mangun (1996) found that perceptual factors influence the distribution of attention in that decreased target salience will concentrate attention on the expected location of the target.
Further, Liu (1996) contends that concurrent spatial tasks produce greater performance decrements through increased scanning demands. If the likely target location can be identified, attentional resources are concentrated in that area. Normal monitoring (scanning or sequential and short periods of attending to different information sources) gives way to focused attending. For example, sometimes air traffic control (ATC) enable this technique by giving bearing and range information about proximate aircraft. The proposal is that this reduction in uncertainty about where to look for data will have a beneficial impact upon resource allocation during the development and maintenance of SA (Hillyard et al., 1996).

When reporting that every increase in scanning demand produced a significant increase in response time, Liu (1996) comments on the theoretical models of serial (sequential, undivided attention) and parallel (divided attention, alternating) processing. This finding regarding scanning demand lends weight to the single channel information processing theory. On the other hand, the differential effects of scanning uncertainty during concurrent spatial and verbal tasks supported both the parallel processing theories of divided attention and the serial processing theories of selective attention (Liu, 1996). Such findings have relevant consequences in the design of cockpit displays which are promoted as assisting the development and maintenance of SA. In particular, the mix of visual and verbal information presentation is of significant interest. Designers of windshear alerting systems and TCAS have endeavoured to overcome some of the limitations of human information processing by providing both visual and verbal cues when these critical situations requiring windshear recovery and traffic avoidance are encountered.

The management of attentional demand appears to be accomplished in many ways. For example, Amalberti and Deblon (1992) propose that in-flight decision making becomes focused on collecting information to confirm that an already developed internal picture is accurate. In their opinion, experts use superior meta-knowledge to facilitate and optimize planning activities to only consider the ‘more likely’ eventualities. This process ensures a high level of in-flight workload management (Endsley & Smith, 1996). This approach to workload management was found, in part, to be the result of increasing the size of chunks (a chunk being a number of associated pieces) of information, rather than increasing the number of chunks in working
memory (Endsley & Smith, 1996). Logan (1992) would claim that the experts in these situations also had a large number of exemplars (stored in long term memory) to access in order not to have to consider alternatives during decision making. The important role of pattern recognition in the development of expertise is reported by the Basic Behavioural Science Task Force of the National Advisory Mental Health Council (1996). Additionally, Endsley and Smith (1996) note that the better performers in decision making did not verbalise alternatives.

Boronat and Logan (1997) found that during automatization (the development of automaticity), attention operates at both encoding and retrieval modes. That is, attention not only limits what will enter memory but controls what can be retrieved from memory by acting as the retrieval cue which draws associations from memory. Whether during encoding, retrieval or monitoring, attentional demands represent a major component of workload (Schuck, 1996; Wickens, 1994). For pilots, attention is demanded by visual, auditory, cognitive and psychomotor aspects of the task (Schuck, 1996). It might be proposed that any strategy which can reduce airborne attentional demands will effectively reduce workload.

On the basis of the evidence available, the development and maintenance of SA appears to be largely dependent on three mechanisms of knowledge acquisition: A mature task template, periodic self-checking and continuous, effective monitoring. Monitoring by an operator in aviation should cover not only data from aircraft instruments, but also the template fields (e.g., airport weather reports, other traffic, etc.), especially where missing, updated or conflicting data could be expected to impact upon the operation. Novel data may present at any time and, therefore, could be more difficult to recognise and process than expected data. Missing, updated and conflicting data could be relatively easy for the operator to detect because the operator could be responding to cognitive cueing through the use of a template and self-checking.

At the perceptual level, locations within the stimulus environment with features related to the identified target field (i.e., the missing, updated or conflicting data) will attract attention (Kim & Cave, 1995). Boronat and Logan (1997) found that attention cues access associations in memory (i.e., the task template and knowledge contained
Meaningful monitoring of template fields will not only detect environmental data, but will also cue what is already known about these fields and facilitate a comparative process thereby prompting decisions to take action as required.

3.7 Memory

Dominguez (1994) proposed that SA development and maintenance seems to require the integration of new information with memorised information. To facilitate this process of integration, data perceived in the operating environment must first be stored. This is assumed in most models of information processing (e.g., Cowan, 1995). The constructs of SA, as proposed by Endsley (1988) and Kass, Herschler and Companion (1991), claim their validity, in part, because of explicit data integration with existing stored data (i.e., new information is combined with memorised information). Prior knowledge has been discussed as an indicator of expertise, and priming structures to facilitate acquisition of information have been proposed (Baddeley, 1992). Indeed, these priming structures are the nub of one approach to SA (Regal, Rogers & Boucek, 1988). Further, the perceptual cycle proposed by Neisser (1976) could not function without efficient data retention. Indeed, the lack of data retention (forgetting) has been cited by Adams et al. (1995) as instrumental in accident causation. Further, Adams et al. (1995) recognise that “the memory demands of managing complex, multitask situations can be substantial” (p. 91).

The debate seems not to be about whether memory is required. Rather, it is the memory form and function which attracts most attention (Nyberg, 1994). Johnson (1992) discusses memory content and memory context and the supportive importance of each to the other. In trying to define ‘function’ in this context, several terms have evolved. Long-term, working, episodic and semantic are classifications of memory which it would be useful to explore when considering SA, since each may have a specific contribution to make. With regard to SA, the memory of data and events is only useful if the recollection can be accomplished at a later time (Adams et al., 1995). Further, such recollection of the information is only useful if there is a functional (relevance) filter applied to the recollection. Johnson (1992) talks of the use of agendas to filter the recall of information while Adams et al. (1995) speak of
focus (i.e., explicit focus versus implicit focus) to define the type of data being sought from the memory.

The fact that aviation operators would be required to commit data and events to memory to enable SA gives credence to the thoughts on semantic and episodic memory (Baddeley, 1992; Nyberg, 1994). The two-factor model of memory proposed by Tulving (1972) concerns contextual and factual aspects of memory. However, Nyberg (1994) contends that retrieval strategies may explain the apparent difference between semantic and episodic memory and are deserving of further research. In their review of memory, Nyberg and Tulving (1997) expanded long-term memory categorisation beyond episodic and semantic to include perceptual representation and procedural memory. While Shanks (1997) would argue that the evidence for such a differentiation is weak, in their rejoinder, Nyberg and Tulving (1997) were able to cite substantial research to support their view. Accordingly, their views on perceptual representation and procedural memory should be considered.

If, as claimed, there is a predictive facet to SA (Endsley, 1988), then as Baddeley (1992) contends, there must be an interface between memory and cognition. One of the roles of this interface would be to facilitate reflection (which binds content and context according to Johnson, 1992) on the past with the view to producing mental models that are useful for predicting the future and which will control future action. Within the aviation context, reflection appears to control the transformation of experience into expertise (Ertmer & Newby, 1996). According to Baddeley (1992), this is the function of working memory. Further, Baddeley (1992) would argue that working memory is not a unitary system but rather, a tripartite system which consists of a central executive that controls separately stored verbal and visual information.

Johnson (1992) expands on the forms that this information may take in memory. According to Johnson (1992), memory traces can exist as networks, episodes, cases, production rules, propositions, schemata and mental models. These notions share some similarity with the ‘tree theory’ put forward by Norman (1969) wherein memory traces were thought to be supported by association or branches. The ‘tree theory’ of memory can be seen as very influential on the development of mind mapping
techniques (Buzan & Buzan, 1993). All of these aspects of memory may contribute to the development and maintenance of SA as proposed by Dominguez (1994).

3.8 Detecting novel information

The detection and the integration of novel information is an important consideration in Dominguez’s (1994) model of SA. In this case, there is no existing information. Authors have argued for and against a phenomenon known as ‘novel popout’. Johnson and Schwarting (1996) describe this phenomenon as “the possible attention-capturing power of unexpected or novel singletons in otherwise expected or familiar fields” (p. 208). This concept generally holds with conventional theories on selective attention (which includes monitoring) in that attention is thought to be captured automatically by particular items (Cowan, 1995).

Although unable to disprove the existence of novel popout as a phenomenon, Christie and Klein (1996) argue strongly that the automatic capture of attention may not be stimulated by the novelty of information or events. However, Adams et al. (1995) hold the view that “able flight management depends on the crew’s ability to determine the relevance, urgency and procedural and goal related implications of each alerting signal or event” (p. 97). That is, operators within the aviation environment have to be able to distinguish between what is known and what is new.

According to Tulving and Kroll (1995), this ability will determine the necessity for encoding (storage) in long term memory. Further, they contend that the novelty assessment system probably does not influence attention or working memory processing of the environment. However, if the composite approach to SA is valid, operators must have a mechanism for the determination of novelty (Dominguez 1994).

With respect to SA, what has been proposed so far is that operators begin with a template and ascribe information to template fields. Where the informational needs of the particular field cannot be met, the data would be classified as missing, that is, known field, unknown data. Information from the environment is processed by the operator who scans as many of the template fields as possible for related information.
The ability to scan the template fields is controlled in the same way as attention is controlled, that is, by perceptual demands (Handy et al., 1996).

A mature template defines the salience of the data that is required and the less salient the information, the greater the search load (scanning) becomes, since a matching template field may not exist (Handy et al., 1996). However, each template field would have to be reviewed to determine the efficacy of this approach. The information would only be classified as novel when no match was found (Tulving & Kroll, 1995), that is, unknown field, known data. In this respect, novelty can be thought of as the reverse side of the missing data coin. Because this novel information lacks classification, further processing must be carried out by the operator.

Once novel information has been detected in the environmental data stream, the operator who is consciously maintaining SA will want to determine the possible effect of this hitherto unknown information on the operation which is being directed (Jensen, 1995). Having already noted the information (which was gleaned from an environmental episode) and being unable to obtain a template field match, the interested operator will try to gather more information (Orasanu, 1993). This step begins a process to determine the relevance of the information and which is controlled by the period of time perceived to be available.

The outcome of this process of relevance assessment will determine the type of influence that the novel information is perceived to have on the operation. This will range from no influence through immediate short term influence to extended long term influence. For example, Tenney et al. (1992) contend that part of a pilot’s job during the approach phase is to “ignore radio traffic to other aircraft except where it contains warnings of nearby hazards” (p. 5). In order to discount information about other traffic, the pilot would have to conduct a potential impact assessment of the transmissions since, on a global scale, this information is very seldom supplied by ATC.

While not addressing the issues of timing, Endsley (1995) does detail the need for developing tactics (short term management techniques) and strategies (relatively long term management techniques) as part of SA. When tactics and strategies are placed on
a time-line with the initial perception of the episode and the follow-up inquiry, a potential operational impact hierarchy can be proposed: episode, inquiry, tactic, strategy (Beaumont, 1998). Where there is a need to consciously pursue the resolution of an event, each stage in this process would require a decision to be made before proceeding to the next stage. Such a process relies on the ability to detect novel information in the first place. The template proposition of knowledge retention will enable this detection process if the inbound data stream is attended to and examined for template ‘field fit’.

This is where the process of SA development and maintenance takes on a circular characteristic rather like Neisser’s (1976) perceptual cycle model (direction of perception, sampling of the environment, semantic and episodic retention, and continuing direction of perception). Good SA moderates workload which enables analysis of data and template comparison which maintains good SA. This is, the process of SA allowing situation assessment (analysis) which results in SA. This concept of situation assessment coincides with the views of Adams et al. (1995). The processes beget the state and the state is all that can be observed in the work place. However, the likelihood of process detection will be enhanced by employing verbal protocols.

3.9 Metacognition

The amount of data on the template of the expert operator is most likely a result of operator experience (Orasanu, 1993) but can be controlled by techniques such as mind mapping (logical association) (Buzan & Buzan, 1993) and chunking (Kienan et al., 1991) where extracted information is assembled using relevance principles (structural alignment) and perceptual and cognitive similarity respectively. In the latter, the guiding template can be distilled by the operator from a prototypical operational model (mental model) (Amalberti & Deblon, 1992; Endsley, 1995) and committed to memory, rather than developed by ‘osmosis’ from experiences. Intervention at the meta-level (where mental models and representations are considered to reside) will also assist in this process (Nelson & Narens, 1994). In fact, the overall role of metacognition (knowledge of and regulation of one’s thinking) needs to be addressed in order to arrive at a full understanding of SA.
Dominguez (1994) details a self-directive component to SA. According to Dominguez (1994), this dimension requires the operator to consciously control the cognitive processes involved in the further perception and anticipation of future events. Nelson and Narens (1994), in their investigation of metacognition, describe the influence of the meta-level (where representations and models reside in memory) on the object level (reality) as control. The object level, in turn, shapes the meta-level model through processes such as monitoring and the active interrogation of the environments. (The term 'monitoring' is also used by other authors such as Schraw, Dunkle, Bendixen and Roedel [1995] when referring to the idea of evaluating one's own performance).

Robertson and Endsley (1994) contend that metacognitive skills are vital to superior SA. However, according to Jans and Leclercq (1997), the optimum level of metacognitive activity varies from domain to domain indicating that proficient metacognitive performance in general life may not translate into proficient metacognitive activity in aviation. In order to better understand these proposals, metacognition and metacognitive skills require some definition.

Pintrich, Wolters and Baxter (1997) have decomposed metacognition into three related areas. However, Brown (1987) contends that metacognition has only two related areas, namely the knowledge of cognition and the regulation of cognition. According to Pintrich et al. (1997), the first area of metacognition is knowledge of cognition itself which is usually confined to knowledge of person, tasks and strategy variables and their interactions. The next area involves metacognitive judgements and monitoring wherein the operator would, having taken steps to fully understand the situation, assess the knowledge requirements against memory and rectify any shortfall before progressing to the judgement phase. The final area includes self-regulation activities such as planning, strategy selection and use, and resource allocation (Pintrich et al., 1997). Borkowski (1996) supports the extension of a definition of metacognition to cover attributional facets such as motivation and effort.

Schraw (1994) indicates that there are identifiable learning performance differences which result from differences in metacognitive knowledge in the educational domain.
While not guaranteed, in most cases, high monitoring ability and self-awareness of this monitoring ability translates into superior performance (Schraw, 1994). Importantly, Schraw and Dennison (1994) propose that metacognition is separable from measures of aptitude and domain knowledge and cannot be predicted on this basis. Further, according to Schraw and Dennison (1994), metacognitive performance appears not to be related to aptitude and domain knowledge, but may play a significant part in the performance of complex tasks.

In their research into control monitoring skills (evaluation of one’s own performance), Schraw, Dunkle, Bendixen and Roedel (1995) found that general cognitive skills, which transcend domain-specific boundaries exist, and serve an important metacognitive role. Further, general monitoring skills are significant contributors in this respect. This research confirms the findings of Glaser and Chi (1988) regarding the existence of general monitoring skills. Within the context of problem solving, Ericsson and Smith (1991) contend that with extended practice the development of automaticity does reduce the conscious content of executive control (action) and monitoring disappears. Etelapelto (1992) holds the opposite view that expertise is, in part, characterised by self-awareness and monitoring of strategies. This view was supported by further research by Etelapelto (1993) who indicates that experts were aware of the strategies they used. This evidence reinforces the concept that experts generally have a more adequate awareness of their cognitive processes than do novices. How this awareness of cognitive processes might influence the success of problem solving is of interest.

In commenting on the work of Metcalfe (1986a), Weisberg (1992) proposed that further research in the area of problem solving would be of benefit. In addition to the dimension of the number of steps taken to solve problems, the metacognitive processes enabling the ability to predict success and the ability to report progress also attracted Weisberg’s attention. However, Metcalfe’s (1986a; 1986b) view that some problem solving uses insight and operates without the conscious recall of information from memory contrasts with these suggestions that aspects of problem solving are conscious processes. Given the evidence available, these two views may not be mutually exclusive, since researchers continue to propose constructs of SA which seem to rely on metacognitive skills (Smith & Hancock, 1995a) while others propose
processes of problem solving which are seemingly devoid of metacognitive skills (Klein, 1993).

In the case of SA, the position might well be that both types of processes are in use. Federico (1997) has started to address this issue with work on metacognitive models of situation assessment. His finding that "participants' implicit belief in, automatic adherence to, and unconscious use of schema-driven decision-making processes are directly reflected in their performance of experimental tasks necessitating situation assessment" (p. 156) (i.e., tacit knowledge) begins to explain the coexistence of the two views. His further conclusion that this statement is only true "if the abstract cognitive components of these higher-order cognitions are directly relevant to the execution of the concrete experimental tasks" (p. 157) completes the argument. The implication is that metacognitive skills will not be used when the higher-order (abstract) thinking which takes place in the schema is not directly relevant to the task.

Roberts and Erdos (1993) contend that metacognition is closely related to consciousness (state of awareness, intentionality). This proposal highlights the study of the cognitive architecture required to successfully monitor one's own thinking through consciousness. In his attempt to explain consciousness, Dennett (1991) arrives at a point which proposes that consciousness facilitates a form of cognitive parallel processing. This view is supported by Baddeley (1992) who proposes that conscious awareness provides a convenient way of representing simultaneously diverse streams of information about a common object. Because of the suggested link between consciousness and metacognition (Roberts and Erdos, 1993), it may be proposed that metacognitive strategies enable apparent parallel cognitive processing.

3.10 Tactics and Strategies

Roberts and Erdos (1993) suggest a similar approach to apparent parallel cognitive processing in that they believe that metacognitive processes are only brought into play as a result of an impasse which requires the selection of a new strategy. In other words, where automaticity fails, the use of conscious processing and strategies will be necessary to advance the cognition at hand. Strategies are considered to be explicit, articulate plans about 'when to do what' to manage predominately intellectual
activities in a better fashion (Perkins, Simmons & Tishman, 1990). Further, strategies are composed of less influential, sequential components called tactics (Winne, 1996).

According to Winne (1996), tactics can best be described as condition-action rules, while strategies are a number of condition-action rules which contribute to an encompassing decision making process or action plan revision. The verbalisation of strategies was found to be a predictor of success in the use of strategies by Huet and Marine (1996). The choice of strategy in decision making was also investigated by Todd and Benbasat (1994) who found that for strategies that require the same effort, the one which will produce the most accurate result will be selected. Conversely, their work indicated that where equal accuracy is guaranteed, the strategy expected to require least effort will be chosen. Todd and Benbasat (1994) conclude that while the required effort may not be the only criteria for strategy selection, it is certainly an important factor.

Perkins et al. (1990) contend that some strategies are more domain-specific than others. Indeed, they nominate several cognitive strategies to enhance learning which include reduction of workload on working memory through extended memory and physical representation, time sharing between cognitive and metacognitive activities, self-monitoring, and awareness of metacognition itself. The practical view of Adams et al. (1995) is that the development of SA helps protect the pilot from extreme surges in workload. This view proposes that SA is a cognitive strategy along the lines of those proposed by Perkins et al. (1990) in that SA is seen by Adams et al. (1995) to control workload. Finally, Adams et al. (1995) nominate several strategies which can be used in aviation namely: shedding, delaying and preplanning of tasks; using automatic parallel processing instead of serial strategies; the use of non competing resources in task execution; minimising perceptual dwell (attention) times by extracting only required information from the data stream; treating simultaneous events as conjoint rather than independent; and chunking of inbound information.

3.11 Self-regulation

Roberts and Erdos (1993) propose that cognitive strategies are not necessarily learned from previous experience and can be the result of reasoning. Previously, Perkins et al.
(1990) contended that context controls the method of learning strategic knowledge. That is, where there is no change of context, stimuli have the capacity to trigger similarity. Further, where there is a requirement to decontextualise principles, conditions required to effect the transfer need to be domain-independent to deliver higher-order strategies. In this environment, strategic rules can be derived through a five step analytic scheme: construct domain-specific scenarios, devise a strategic rule for each scenario, derive higher-order rules which reflect parallels among these rules, determine how lower-order rules can be subsumed by the higher-order rules, and test the new higher order rules within the domain (Perkins et al., 1990).

The similarity between the concepts contained within the broader subject of metacognition and the essence of SA development and maintenance cannot be overlooked. SA is proposed as a self-regulated cognitive function. Zimmerman (1995) postulates that it is one thing to possess metacognitive knowledge and skills but another altogether to self-regulate their use in the face of fatigue, competing attractions or stressors. This line of research has been pursued by researchers working in other fields such as education. For example, Hong (1995) developed a relationship between self-regulation, metacognition and awareness amongst students. Gott, Lajoie and Lesgold (1991) also detailed a relationship between self-regulation and metacognition. Beaumont (1998) has proposed that self-regulatory competence may be the essential difference between good and bad performers at the airline command level. This proposal is based on evidence from interviews of good performers who indicated that they employ a construct of self-regulation to control management of flight performance.

Hong (1995) contends that stronger 'trait' self-regulation delivers stronger 'state' self-regulation since this proposal indicates that selecting pilots with innate self-regulatory skills will lead to better vocational self-regulatory performance. The implication for aircrew selection processes is deserving of further development. However, before that process can begin, an understanding of what might be involved in a construct of self-regulation needs to be reached. To begin, one needs to consider every experiential aviation setting as a learning situation. By doing so, an exploration of how the operator controls his or her learning and the scenario simultaneously can be conducted along the lines of proposed self-regulation theory. Since research to date has centred
on the educational domain, the proposal would be that scenario control and learning processes are analogous.

As a starting point, Schunk (1995) suggests that goal setting and self-evaluation of personal capabilities are powerful enhancers of self-regulation (higher order strategy facilitating task completion) and self-efficacy (judgement of competence to perform the task). Hong (1995) verified a construct of self-regulation which depended on an element of self-checking for its viability. Goal setting models have also been proposed by Boekaerts (1996) and Winne (1995) which contain mastery and well-being components. The role of affect in self-regulation should also be considered (Zimmerman, 1995). Winne (1995), while recognising that further research needs to be conducted, proposes that self-regulation is dependent, to a large degree, on the scope of declarative knowledge and that it becomes highly automated and therefore unconscious. That is, self-regulation relies heavily on a critical mass of factual knowledge.

Boekaerts (1996) details several personal attributes which have been associated with high self-regulation. These are self-efficacy, the willingness to practice, commitment, time management, metacognitive awareness and the use of efficient strategies. On the other hand, poor self-regulation is characterised by impulsiveness, low goals, low self-efficacy, low control and avoidance behaviours (Borkowski & Thorp, 1994). Nordstrom (1996) holds that “when people monitor (visualize or mentally review) their action, they are engaging in self-regulation” (p. 713). Nordstrom (1996) also comments on the part that motivation plays in the corrective thinking abilities (detecting the need to adjust thinking) of perceivers during periods when there are demands on cognitive resources.

The presence and use of these features of self-regulatory behaviour are encompassed by the work of Boekaerts (1996) who promotes three skills which encapsulate the requirements for self-regulation. Firstly, one must be able to form a clear mental representation of the (learning) goal and to redefine it when necessary. Secondly, one must be able to devise a plan of action (model the required actions) and extend or redefine it as required and, thirdly, one must be able to monitor one’s behaviour, to detect mismatches and to assess progress towards the (learning) goal. These skills are
consistent with Zimmerman’s (1995) view that self-regulation is “a complex interactive process involving not only metacognitive components but also motivational and behavioural components” (p.220).

While many authors have hypothesised about the nature of self-regulation, the findings of Hong (1995) appear significant in their definition. Accordingly, a summary of these findings is appropriate. Firstly, the respective structures of state and trait self-regulation are very similar. That is, achieved self-regulatory abilities mimic innate self-regulatory abilities. Secondly, self-regulation yielded components of metacognition and effort. Metacognition subsequently yielded components of awareness, cognitive strategy (thought out set of activities; e.g., a rehearsal routine), planning and self-checking. Consequently, it may be proposed that self-regulation is an integral part of SA or more likely, that SA is an integral part of self-regulation. Either way, the analogies are strong and self-regulation appeals as a construct capable of enabling the control (management) of dynamic real-time environments at the individual and team levels.

3.12 Team SA

Flight management in airline environments usually involves a team, rather than one operator. That is, performance depends upon the coordinated activities of a team of individuals (Salas, Prince, Baker & Shrestha, 1995). Accordingly, it is appropriate that team SA be visited as a concept as well as specific constructs of individual SA are explored. One aspect of team performance centers around the metacognitive strategies shared by team members (Härtel & Härtel, 1997). These strategies encompass the anticipation (forethought) of the required actions, the use of similar reasoning processes and a contextualised and harmonious sense of timing. Robertson and Endsley (1994) suggest that mechanisms of attention, working memory capacity, long term memory store, mental models and goal setting are involved at both the individual and team levels.

The extension of this review to the team environment is justified, since team SA will depend on the SA which individual members possess to support their roles responsibilities (Endsley, 1993). This stand implies that team members must have a
common mental model of the situation to have good team SA. Such a state of affairs can only be achieved through effective communication between team members. Prince and Stout (1995) support this assumption regarding communication in their research on team SA.

The concept of common or shared mental models was also explored by Cannon-Bowers, Salas and Converse (1993) and has continued to muster support (Prince & Stout, 1995). Cannon-Bowers et al. (1993) and Prince and Stout (1995) concluded that it is really the quality of the communication and the subsequent quality of the shared mental model which determines the nature of team SA. However, a breakdown of team SA may be attributed to any or all of Morgan, Glickman, Woodward, Blaiwes and Salas’ (1986) teamwork behavioural dimensions namely, cooperation, the giving and receiving of criticism, team spirit and morale, adaptability, and coordination as well as communication.

More recently, these teamwork behavioural dimensions have been expanded to more specifically qualify the processes involved. For example, the Line/Line Operational Simulation (the Line/LOS; LLC) checklist designed by Helmreich et al., 1991) amplifies, in a useable fashion, the observable behaviours associated with team performance. This checklist focuses on communication with dimensions of inquiry, assertion and briefing being of particular interest. Other dimensions include planning, preparation, self-critique and group climate. Within each dimension, amplifying behaviours further define the team processes. The conclusion that team SA is a combination of individual SA and team processes can be drawn from this discussion (Salas et al., 1995).

3.13 Understanding postulates of SA

It has been proposed that research and development in the SA domain is in danger of assuming a circular life of its own by ignoring the underlying principles which enable the process (Flach, 1995). Therefore, it is necessary to identify and consider the factors which underpin the different approaches to the definition of SA. An examination of the many definitions of SA reveals that each was formulated within a specific context by researchers with identifiable research agendas (e.g., Adams et al.,
1995; Endsley, 1988; Sarter & Woods, 1991). These factors appear to have influenced both the definition and the scope of the mechanisms involved in SA development and maintenance.

Research context

The primary step in understanding the context within which operators must develop and maintain SA is to clearly understand the operators' task. The role of the fighter pilot in aerial combat (Endsley & Smith, 1996) is quite different to that which the same pilot assumes in mission navigation (Amalberti & Deblon, 1992). The SA emphasis and the means of developing it are identifiably different since the goals of the missions are dissimilar. Similarly, both of these expressions of SA can be seen to be different to the SA required by scheduled regular public transport pilots (Tenney et al., 1992), since the acceptable risks and desired outcomes are identifiably different. Therefore, it is not difficult to imagine that researchers working with one such group will develop a different response to that proposed by a colleague working with another group in terms of the elements that comprise SA. This argument runs along the similar lines to the cultural argument which has influenced the development of CRM training for different cultural settings (Merritt, 1997).

Researcher background

There is also an emergent pattern to the definitions of SA which runs parallel to the focus and level of academic qualification of the researcher. The practitioner will tend to explain what it is that she/he does in easily understood, practical terms so that other practitioners can understand and implement the procedures which have been found to work in the field (Jensen, 1995). On the other hand, an academic using theory (Charness, 1996) would be expected to analyse the topic in quite different terms to an equally qualified academic working within an applied environment (Endsley, 1988). Each would contend that they were in search of the 'truth'. Further, the scope of the processes and the knowledge involved vary considerably. Endsley (1995) approaches the topic by excluding all but the dynamic environment, whereas Jensen (1995) notes that thorough flight planning (a pre flight static function often completed without real time pressure) is also essential to the development of SA.
Research processes

Understanding how the operators develop and maintain SA is fundamental to any attempt to improve skill levels in the area through selection and training. Operators may be defined by cultural similarity (Merritt, 1997), outcome requirements (Tenney et al., 1992) or role classification (Beaumont, 1997a). To this end, grounded techniques, such as the cognitive task analysis (which considers higher level strategy usage as well as the knowledge and the skills required) (Seamster, Redding & Kaempf, 1997), direct experimental techniques using probes (Endsley, 1988), and subjective measures such as SART (using self-assessment, peer ratings, and instructor ratings) (Taylor & Selcon, 1993), are all capable of contributing to an understanding of SA.

Using such techniques, it is possible that differing definitions of SA could be determined for the various operators. While parts of all such processes may be transportable across group boundaries, the cognitive mechanisms involved must be critically examined for contextual fit. The key to effective SA training and measurement hinges on being able to accurately identify what the concept means to the client group. With this in mind, the foci of existing approaches to SA can be examined.

3.14 Foci of existing postulates of SA

When evaluating the various definitions of SA, the criteria should include practical application, since it is the utility of the construct to industry which will ultimately determine its acceptance. To date, SA, when defined as the perception of, the comprehension of, and the projection of, environmental elements (Endsley, 1988), has been widely identified as a causal component of accidents and incidents (e.g., Endsley & Jones, 1995; Sumwalt & Watson, 1995). While the need for training is acknowledged (Gaba, Howard & Small, 1995), training methodologies have not yet been agreed upon and implemented across the aviation industry. This is partly because there is no agreement regarding a unified approach to teaching SA. The operational context has been shown to be influential in this regard (Sarter & Woods,
1991). Therefore, this review will restrict itself to the airline sector of the aviation industry.

When the literature concerning SA is examined, one of the recurring themes is the concept of the 'big picture'. Some authors (e.g., Endsley, 1995; Gaba et al., 1995) also allude to the existence of an overview as a recurrent aspect to SA. The overview component of SA would, of necessity, be goal-driven. Safe flight is a goal and one of a number of previously discussed elements of risk of concern to airline pilots. Endsley (1995) states that “the safe operation of the aircraft in a manner consistent with the pilot’s goals is highly dependent on a current assessment of the changing situation” (p. 33). The strategic outcomes are dependent on tactical considerations, the former being goal-driven and the latter data-driven.

This difference between goal focus and data focus has been identified as a difference between experts and novices in that the novice will tend to be data focused (bottom-up) to the detriment of goal or context focus (top-down) (Federico, 1995). This approach is analogous to the novice being more tactically than strategically focused. The expert, on the other hand, probably achieves a balance by acting tactically where necessary to execute a strategy. Using the criterion of focus (tactical or strategic), the various definitions of SA could be categorised as strategic or tactical by intent. For example, Endsley’s (1988) view that SA is “the perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future” (p. 97) can be seen to be more tactical by intent than strategic. The explicit temporal and spatial limitations placed on the consideration of elements point in this direction as does her previously expressed view that goal achievement is dependent on the current assessment of the changing situation.

Smith and Hancock’s (1995a) version that SA is “adaptive, externally directed consciousness” (p. 138) represents a strategic approach to the same problem since, as Smith and Hancock (1995a) point out, adaptation and external direction imply that behaviour must be goal-oriented. When reviewing the position of Sarter and Woods (1991) using the same criterion of focus (tactical or strategic), their interpretation of SA is both strategic and tactical. They contend that SA is “the accessibility of a
comprehensive and coherent situation representation which is continuously being updated in accordance with the results of recurrent situation assessments” (p. 52). These differences highlight the inability of researchers to agree on a common definition of SA.

The differences between researchers may also be a reality in that given the contributions of context, and researcher experience and focus, the perceived utility of the construct may have dictated the result. In any event, the possibility of SA existing at two levels deserves further exploration. Certainly, most of the quantitative research which has been conducted thus far in simulated environments has a military (fighter aircraft) bias (Endsley & Smith, 1996; Waag & Bell, 1994). By definition, most military aircraft are tactically employed. Hence, one can conclude that unless these experiments were full mission simulations akin to Line Oriented Flight Training (LOFT), they would have collected data on confined situations (tactical SA). Some qualitative studies have revealed more about strategic SA. In particular, the work of Amalberti and Deblon (1992) added significantly to the debate by examining the total habitual envelope of their participants, thus including strategic as well as tactical considerations.

According to Amalberti and Deblon (1992), experts exhibited superior metaknowledge (tacit) for optimising planning (devising the most suitable course of action) so that only likely eventualities were considered. This meant that during flight, the experts were confirming their existing mental picture of the situation by collecting data. This finding corresponds with Endsley (1995) who suggested that the current situation is matched with prototypical situations or pictures stored in long term memory. Similarly, Kaempf, Wolf and Miller (1993) report that 83% of tactical commanders’ pattern matched to situation prototypes as their decision strategy. The conceptualisation of situation prototypes broadens the debate significantly in that, the role of a predetermined script in the development and maintenance of SA is now being considered. The ways in which these prototypes might be developed needs to be reviewed.
3.15 Mental Models

The work of Johnson-Laird (1983) begins to explain how these situation prototypes might be developed. These prototypes probably exist as mental models (Endsley, 1993). These mental models can result from the parsing of language and the application of syllogistic reasoning to inbound data (Johnson-Laird, 1983). For example, syllogistic reasoning would be employed when aircraft A and B are on converging airways at the same altitude without sufficient longitudinal separation. Syllogistic reasoning would dictate that one aircraft will have to climb or descend, or, both may have to adjust speed to achieve the required separation. The results would then be stored in long term memory for retrieval at a later date. Similarly, experiences result in traces being laid down in long term memory. All of these memories probably exist as schemata (Johnson-Laird, 1983) and can be activated by scripts which sequence their use (Endsley, 1995).

According to Endsley (1995), mental models are described as complex schemata. Wilson and Rutherford (1989) reviewed the literature concerning mental models and devised a composite definition which proposes that “a mental model is a representation formed by a user of a system and/or task, based on previous experience as well as current observation, which provides most (if not all) of their subsequent system understanding and consequently dictates the level of task performance” (p. 619).

Using this definition, the prototypical models referred to by Amalberti and Deblon (1992) might be classified as mental models. The process which experts seem to use involves the construction of a prototypical model pre-flight which resides in memory as schemata or cases, directs attention to critical cues, and acts as the comparator for recurring situation models (Endsley, 1995). These authors (Amalberti & Deblon, 1992; Endsley, 1995) contend that some aspects of SA are addressed pre-flight to form a strategic goal-driven model. Thereafter, as data and episodes are perceived, situation assessments are made. These assessments are used in a tactical sense to confirm or alter the previously modelled representations of the flight (Amalberti & Deblon, 1992). In contrast, some authors contend that SA is not the model but rather, the mechanism by which the model is formed (Smith & Hancock, 1995a). While other
authors agree that SA is a process (Adams et al., 1995; Endsley, 1995), a state of SA is also hypothesised (Endsley, 1995; Sarter & Woods, 1991).

3.16 Resulting research questions

The review of the literature has revealed much about aspects of pilot performance which relates to SA. In particular, SA (as a construct) contains elements requiring further research to explore links to management of flight performance. Using the postulates, research and rationale provided, the following research questions are detailed to explore the management of flight performance profile of an identified group of airline pilots in general and the Captains within this airline in particular. Specifically,

1. Within the chosen contextual setting, what are the subjective markers used by practitioners to assess command readiness? (Study 1)
2. Can the subjective markers of command readiness be organised into a model of management of flight performance? (Study 1)
3. Would a model of management of flight performance be useful to all check and training Captains and command trainees? (Study 1)
4. Is strategic SA principally metacognitive in nature? (Study 2)
5. Is tactical SA more strongly related to problem solving and problem solving algorithms than strategic SA? (Study 2)
6. Does good management of flight performance rely on the presence of strategic SA? (Study 2)
7. Do experienced Captains use an identifiable process to develop mental models of a proposed flight? (Study 3)
8. What processes do experienced Captains use to adjust these mental models to cope with a changing operational environment? (Study 3)
9. How do pilots learn from an aviation experience? (Study 3)
10. What activities support competent management of flight performance by airline Captains? (Study 4)
11. Is there a perception amongst Subject Matter Experts that the knowledge of activities which support competent management of flight performance by airline Captains stimulates the acquisition of command competence? (Study 4)
12. Are these concepts of management of flight competence supported at large by the Captain cohort? (Study 4)

13. Is it possible to construct a vocationally oriented psychometric instrument using the completed research? (Study 5)

14. If such an instrument is administered to experienced Captains, will their responses exhibit any consistency? (Study 5)

15. Will pilots who are not in an airline exhibit the same consistency in their responses as Captains in the airline of study? (Study 5)

16. Will pilots of other airlines exhibit the same consistency in their responses as the Captains in the airline of study? (Study 5)
CHAPTER 4
Methodology and research design

4.1 Introduction

Since the aviation industry is highly sensitive to litigation and pilots tend to be highly scrutinised, research in the field of aviation has to be as unobtrusive as possible. This design constraint should, therefore, strongly influence the methodological basis of the research project. The operational norms of the system, organisation and individual, will also influence the final form of the research method. In particular, a level of conformity to operational norms is necessary since without this conformity, teamwork and self-efficacy would be eroded. Therefore, the development of a research methodology that is compatible with pilots and their operating environment is highly desirable. This chapter will examine historical and environmental aspects of aviation in order to define a suitable methodology and research design.

To that end, the application of a singular methodology should probably be avoided (Punch, 1994). Rather, flexible methodologies should be employed which will meet the needs of the research without offending the research environment. The argument to determine the most suitable methodology can be commenced from an atheoretical perspective knowing that in the final analysis, the nature of the politics of the situation will shape the research design and that ethics will shape the process (Punch, 1994). Further, Janesick (1994) contends that there is no such thing as value free or bias free research, since context, meaning, purpose, generalisability and the acceptance of data sources will all influence the research outcomes.
Guba and Lincoln (1994) hold that whilst ever theory and facts are interdependent, facts will not necessarily facilitate the development of singular theory, since values and facts are also interdependent. Findings are more likely created by the interaction of the researcher and the phenomenon, rather than discovered through objective processes (Guba & Lincoln, 1994). To begin the exploration of appropriate methodologies, the quality assurance mechanisms within the aviation industry can be investigated, since the industry is highly dependent on these mechanisms.

4.2 Challenging tradition

On March 10th, 1989, a Fokker F28-1000 operated by Air Ontario crashed on takeoff from Dryden in the province of Ontario, Canada. The initial analysis of the accident indicated that the pilot had tried to takeoff with ice on the wings (Moshansky, 1992). The lack of lift-enhancing devices on the leading edge of the wing of the F28 and the narrow performance envelope of this wing on takeoff meant that the smallest of disruptions to the airflow over the wing in this critical phase of flight rendered the airfoil incapable of generating the lift necessary to become airborne (Job, 1998a). The scientific approach to the investigation amounted to an “analysis of causal relationships between variables” (Denzin & Lincoln, 1994, p. 4). In other words, a deductive analysis was conducted which detailed what happened with the implication that pilot error had, once again, cost lives. This conclusion was taken on board by the press and some in the industry.

The immediate result was the circulation of advisory information to the industry in general and to F28 crews in particular. F28 operations proceeded without incident for the following two northern hemisphere winters. Concurrently, Justice Moshansky was investigating the Dryden accident at the behest of the Canadian Government. His Commission of Inquiry handed down its report in 1992 (Moshansky, 1992). In addition to the initial findings regarding scientific causation, this report identified crew, organisational and systemic contributory causes associated with the accident. A full understanding of why the accident happened had been achieved.
The Moshansky report focused squarely on the processes and the events immediately before the accident. The investigation leading to this report certainly employed both quantitative and qualitative processes to arrive at the reported findings (Moshansky, 1992). That this Commission of Inquiry identified causation through both deductive and inductive analysis was something of a breakthrough in accident investigation. This model of investigation which examines systemically latent conditions (dormant products of managerial, organisational and regulatory decisions) and active failures (these operational failures were traditionally the only failures that were addressed) is now widely used throughout the industry (Reason, 1997). This means that pre-conditions and precipitating actions are examined jointly to determine their relative causal contributions. However, the process of accident and incident investigation still invariably starts with a quantitative assessment of causation. The aviation industry uses scientific data to establish the initial position or fix usually because this quantitative data is readily available first from the CVR and the ‘black box’. The extent of the qualitative investigation which will be needed is then assessed.

4.3 Entrenched values

The lessons available from the Dryden accident were not absorbed by the industry in time to prevent a second accident of a similar nature on March 22nd, 1992 at New York’s John Fitzgerald Kennedy International Airport (Job, 1998b). This accident investigation, together with the evidence of the Moshansky (1992) report, galvanised the regulators and manufacturers into action (one accident can be written off as pilot error, two or more indicate frail practices). The regulations were amended to generate procedures and practices which would improve human intervention at critical points in icing conditions.

This result further reinforced the view that the aviation industry at large more readily assimilates quantitative data that dictate a change of limitations or procedures than qualitative data relating to human performance which require extensive training programmes to alter behaviour. Practices such as those employed in navigation, possibly contribute to this attitude. The accuracy of navigation is dependent upon a known starting point and quality fixing practices (position determination) along the flight path. An analogy exists in that when dead reckoning (soft data in that the estimated or last known wind is applied to aircraft heading)
has to be used to calculate a position because of the lack of a quality fix (hard data), the confidence with which navigational decisions would be taken decreases.

Quality fixing can be described in many ways. The advent of the Global Positioning System (GPS) has rendered the availability of very high quality fixing, at least as accurate as low level visual fixing (short range perception of position). However, this system is not always available. A quality fix in radio navigation can be derived from two position lines. The intersection of these two lines describes the position of the craft with a high degree of probability. Celestial navigation practices prescribe three position lines as desirable so that a triangle of probable position (a ‘cocked hat’) results. The closer that this triangle is to equilateral and the shorter the sides, the more reliable the fix becomes.

From this discussion, it seems clear that the aviation community would be more responsive to scientific data of a quantitative nature than it would be to qualitative data and that multiple examples are generally necessary to prove a point. In keeping with the environment of research, ‘softer’ data would carry more weight if a quality initial position could be derived through deductive analysis rather than induction or inference. Further, if the results from several lines of research can be shown to support the new position, then this new position will be more easily accepted by the population at large (Janesick, 1994). This would be particularly the case where the outcomes result from the application of gathered data to the established initial position. These environmental philosophies have been used as one of the catalysts for the methodological approach used for this research project.

4.4 Emerging Values

The accident at Dryden (Moshansky, 1992) has been used widely in the teaching of a relatively new and powerful facet of aviation curricula worldwide. Crew resource management (CRM) has been developed as a subject area to develop human intervention strategies capable of intervening before accidents and incidents occur. Lauber (1993) describes CRM as the effective use of all available resources to enhance the safety and effectiveness of flight. These concepts are now the rule, rather than the exception in aircrew curricula.
Increasingly, safety systems around the world have an expectation that aircrew will employ CRM strategies in the execution of their daily tasks. Conversely, aircrew expect organisations to use all of the available resources to advance the cause of safety with efficiency. A proposed research programme would fall short in the eyes of aviation research participants if all of the available research tools were not applied to the question by the researcher. In the light of CRM philosophies, it may be argued that research results will only be taken seriously if the researcher has endeavoured to tap into most resources by many means.

4.5 Quality assurance

The aviation industry generally is turning away from tradition in another sense which can positively influence the operating environment. The responsibility for quality will gradually pass from the regulator to the operator. The hands-on interventionist model used by regulators to date will be transformed into an internalised self-correcting process of Quality Assurance (QA) (New Zealand Civil Aviation Authority, 1996; Standards Australia, 1994). When properly implemented, this QA process should identify, document and correct latent conditions and active failures before they adversely influence product delivery. Underpinning the QA process will be a policy which will stipulate the philosophies and the desired outcomes.

The guidelines for such a policy will outline how the policy will meet the requirements of the rules and regulations, while maintaining relevance to the organisational goals. A clear statement on how customer expectations and needs are met will be integral to the guidelines. Preventative and corrective action procedures will also be prescribed. The core process will be subjected to regular review. These reviews will be planned, formally documented, inclusive and recorded (Hoyle, 1998). Specialist input will be incorporated in the review process.

QA programmes require that quality indicators be established to guide production and product delivery. Coupled with a comprehensive record system and tight document control, these quality indicators enable a gap analysis to be carried out at each review stage. The gap analysis identifies any deficiencies in the production cycle. The gap analysis will provide the feedback to the production system, thereby, enabling corrective and preventative measures to
be taken to assure quality. Therefore, a research process which can be seen to duplicate this QA process will be seen to conform generally to the new direction of the aviation industry.

4.6 Establishing scope

The research being undertaken is needs-based. Long term piloting criteria (which are concerned with management of flight) need to be identified and used to develop training programmes and selection tools. The final goal of such research would be, at the very least, to raise awareness in the area of study. More likely however, the implementation of some change process would also be desirable. The manner in which this change process was instigated would determine its success and, subsequently, determine the success of the overall research process. The aviation industry and, in particular, the airline sector, has developed a needs-based process to the initiation of change which has become acceptable to operators throughout the industry. The ability of a research methodology and subsequent research design to mimic that established process by establishing a need for the research and its possible outcomes, would likely enhance the prospects of success. This approach stems from the view that the research process belongs to the participants of the research and not the researcher.

Miles and Huberman (1984) point out that “no amount of evidence can prove me right and no amount of evidence can prove me wrong” (p. 242). This stand supports the notion that research is not capable of providing the researcher with irrefutable proof of personal hypotheses. Further, many qualitative researchers seem unable to resist the temptation to move beyond reporting ‘what is’ and regularly pronounce ‘what ought to be’ (Wolcott, 1990). Such an approach by a researcher will meet stiff resistance within the aviation community since outcomes in the aviation environment can be seen to be totally dependent on the gap between what actually happens and what ought to happen. The Dryden accident (Moshansky, 1992) is typical of the existence of such a gap. While some understanding of the research environment has been reached, the scope of the research base must also be established.

In addressing the scope of the research, the nature of Situational Awareness (SA) is of importance. As was seen in Chapter 3, approaches taken by some authors depict SA as both process and state (Endsley, 1995). If this is the case, then an exploration of the topic should
be possible using both quantitative and qualitative methodologies. Denzin and Lincoln (1994) contend that qualitative research focuses on processes and meanings, while quantitative research focuses on the measurement and analysis of causal relationships between variables. Therefore, a mixed-method approach would seem to be most appropriate.

4.7 Methodological suitability

The difficulties in operationalising the concepts of pilot performance such as SA have been highlighted by several authors (Bryman, 1989; Charmess, 1996). According to Bryman (1989), the process of operationalisation involves the translation of concepts into measures and variables. Such a process would need to be completed if quantitative research methodologies were to be useful, since it is the relationships between variables that interest the quantitative researcher (Denzin & Lincoln, 1994). This methodology removes interpretation from the result analysis, basically ignores context, and places little emphasis on processual aspects of the research topic (Bryman, 1989). Such a methodology would not involve observation, interviewing and documentary analysis, since these techniques are central to qualitative research (Punch, 1994) and applied quantitative research (Wiggins & Stevens, 1999).

Quantitative methodology accepts reality as singular and remote from the researcher (Creswell, 1994). As Creswell (1994) points out, the fact that substantial literature already exists on the subject (SA) and that this literature explores possible independent and dependent variables within the topic of itself facilitates quantitative research. The notion of using quantitative methodologies to establish a starting point becomes feasible.

While the nature of flight can be supported by pure science (Vinh, 1993), once the human is introduced into the loop, the nature of the operational equation changes significantly (Helmreich & Foushee, 1993). As detailed previously, the inability to meet the demands of command are seldom related to the inability to ‘fly the aircraft’. The measures and variables which define hand-flying tolerances for Captains are clearly stated, visible and easily applied. The assessment of the ‘management’ dimension during command training depends on some, if not all, of the qualitative techniques suggested by Punch (1994). A pilot study of command readiness conducted by Beaumont (1997a) has shown that the interpretation of management of flight is highly variable across the respondent group. While the notion of an initial,
quantitative fix was attractive and was pursued as far as is possible, the type of research methodologies which the topic demanded was largely qualitative.

4.8 Justification for qualitative research approach

An investigation of the management of flight aspects of airline Captain performance will encounter issues relating to the training curriculum which Captain trainees complete. Questions about curriculum are questions about quality, content and delivery. As Janesick (1994) points out, curriculum inquiry is most suited to a qualitative approach. Of the many aspects to curriculum research which Janesick (1994) raises, there are several which appear to have a place in the exploration of Captain training. Questions concerning the quality of the curricula employed, the interpretation of curricula components, the curricula in the life of the pilot (practical application), and the implicit theories of instructors about teaching and the curricula, will influence outcomes from Captain training programmes. While the proposed research is not concerned with training, defining the management of flight aspect of pilot performance will probably define aspects of a Captain training curriculum. Therefore, if at all possible, research which aims to define the management of flight aspects of pilot performance should be conducted using methods which will support the curriculum development for the training of new Captains.

Smith, Harre and Van Langenhove (1995) contend that psychological research should take place in the real world. This highly grounded research paradigm also highlights a concern for persons and individuals, rather than statistics and variables. If research is to be conducted on aspects of the Captain training curriculum, this research should be conducted in real world and involve the individuals who deliver and receive Captain training.

In the case of aviation, scientific data pertaining to the aircraft flight path and the inputs made by the pilots is available through Quick Access Recorders (QAR). However, the capabilities of these recorders limit their usefulness to that of parameter ‘watch dogs’. In other words, there is no focus on the personal aspects of language and discourse which are two further cornerstones in the research paradigm proposed by Smith et al. (1995). Quantitative research cannot generate the ethnography surrounding the research topic. What quantitative data collection can probably do is to support the case that qualitative research will be required to
advance the research. This is, in part, because of the difficulties in operationalising the concept under investigation and, in part, because the type of output possible from quantitative research will not fully address the nature of such a research question.

Bryman’s (1989) summary of the differences between qualitative and quantitative research methodologies proposes that pure quantitative research potentially pays little attention to context, allows little interpretation, lacks the ability to explore the processing aspects of the organisation, and demands that reality be expressed as facts. Qualitative research, on the other hand, is highly contextualised, emphasises the research process, is flexible, allows for data from various sources to be considered and has the ability to concentrate the research focus. Creswell (1994) views qualitative inquiry as the process of understanding a social or human interpretation of a problem, while the quantitative approach is presumed to restrict this methodology to the empirical testing of theory. The human topic of the research at hand (i.e., the definition of the management of flight concept) is highly contextualised and will require a vocational interpretation of the data. These features will require flexibility and that data from multiple sources to be considered.

4.9 Expanding on qualitative methodology

The question of researcher motivation should never be too far from consciousness when undertaking any research. In the case of needs-based research, the identified need will continue to drive the process. Even where there is a perceived need, only useful results will be adopted by the population of investigation, since the need may not have been established by contributions from the population at large (Guba & Lincoln, 1994). The views which are most likely to qualify in this regard will be those of an insider. Strauss and Corbin (1990) contend that qualitative methodologies are most useful in establishing these emic views and further, the validation of such views can be most elegantly achieved by grounding the qualitative methodologies.

According to Strauss and Corbin (1994), grounded methodology enables theory development as the research proceeds. The continuous interplay between data collection and data analysis (i.e., participants and the researcher) yields up the theory. Such a process is more suited to qualitative research, since most of the results are derived by means other than statistical
analysis (Strauss & Corbin, 1990). The inductive strategies used to analyse the data are the key to theory development (Charmaz, 1995). Induction implies that interpretations will be made. In such processes, it is essential that the participants be heard through the data (Strauss & Corbin, 1994). "Their concerns shape the direction and form of the research" (Charmaz, 1995, p. 30). In the process, road blocks to enlightenment such as bias, assumptions and rigid thinking patterns should be minimised so that the theory is a valid product of the data (Strauss & Corbin, 1990).

The test of grounded theory methodologies is inherent in the outcome (Strauss & Corbin, 1990). By examining the theoretical product, the processes used can be inferred. According to Strauss and Corbin (1990), if the research generates concepts which are systematically related to the extent that components are tightly linked, the methodology in use could be seen to approach a grounded technique. If, in the process, both the micro and macro conditions which affect the phenomenon have been studied, a further claim to a grounded approach can be made. Finally, if the findings are creative and identify and specify new directions for the area of study, then the process can usually claim full grounded status.

To ground theory, the researcher must be sensitised to recognise the issues and processes in the data (Charmaz, 1995). This can be achieved simply by questioning data for adverbial qualification (how, when, where and why?) (Strauss & Corbin, 1990) or by being conscious of one's background assumptions and interests (Charmaz, 1995). The balance between bias and sensitisation must, however, be maintained throughout. This can be achieved by maintaining a focus on the motivation for the research. It is impossible to ground theory development if the goal of the research is to support already developed hypotheses, since grounded theory is always traceable to the data which gave rise to it (Strauss & Corbin, 1994).

This fact that grounded theory is always traceable back to the data imposes limitations on the outcomes which can be derived from a grounded research process. The conditional matrix (limitations) proposed by Strauss and Corbin (1990) defines interactions which can be expected from the research. The choice of population description will impose transportability limitations on the developed theory. If a group within an organisation, within a community, and within a national culture is the subject of the research, then the ability to generalise the theory beyond the boundaries of the group is severely impaired. At best, the resultant theory
will be substantive, since the research context is both defined and contained. A formal theory could only be developed if the phenomenon was studied in several contexts. However, Strauss and Corbin (1994) note that most researchers are intent on the development of substantive theory in the first instance.

4.10 A useable research paradigm

Having discussed the benefits that qualitative methods can bring to this proposed research, some consideration of the paradigms which might guide the research is appropriate. Paradigms are generally applicable to both quantitative and qualitative methodologies (Guba & Lincoln, 1994). The preferred style of decision making for the pilot participants has been established as consensual (Qantas Flight Management Attitudes Questionnaire [FMAQ], 1995). This established belief about the preferred way to do business on the flight deck will also support a research paradigm which incorporates as much consensus as possible. Change within the organisation will have an increased probability of success where an outcome to this research can be finalised by a measure of consensus.

The role of consensus in this type of change would essentially be to add definition to already accepted but ill-defined concepts. Guba and Lincoln (1994) would classify the paradigm in use in such circumstances as constructivism (where the perceptual experience is viewed as an elaboration or ‘construction’ rather than a direct response to stimulation). Their interpretation of this paradigm allows for the research to be a flexible interaction between the investigator and the subject(s) of investigation. The theoretical outcome cannot help but be moulded by this situation since the researcher is both participant and facilitator while protecting the ethics of the investigation. While not an overly influential paradigm for research, the impact of constructivism on established methodologies can be explored to support the validity of the paradigm.

4.11 Classifying the proposed inquiry

The principles of ethnography (which involves cultural comparisons), with reference to this research project, should drive the process, since substantive theories are culturally-based. Ethnography also entails a reflective review of the process and researcher involvement
(Altheide & Johnson, 1994). Such a process would render "accounts of the interactions among context, researcher, methods, setting, and actors" (Altheide & Johnson, 1994, p. 489) and advance the understanding of the topic (which is the goal of an ethnographic approach). Ethnography facilitates an understanding at the individual level through the generation of a story-like representation (Altheide & Johnson, 1994). Wolcott (1994) describes the ethnographic process as learning by data collection, making sense of the data by analysis and checking the sense in a new light by interpretation. Such activity would generally conform to the hermeneutic (interpretative) methodology prescribed as present in the paradigm of constructivism (Guba & Lincoln, 1994). The paradigm of constructivism suggests that perceptual experiences are comprised of snippets of present and past data.

The application of a hermeneutic (interpretative) methodology would certainly employ inductive processes, since the interpretation is largely dependent on induction. According to Moustakis (1990), inductive analysis begins with immersion in the setting, proceeds through an insight incubation phase to a position of expanded awareness. Once this position is reached, a full description of the individual experiences and their synthesis into a meaningful and complete story can be undertaken. The analytic process so described lends itself well to the grounded theory methodology since the incubation and awareness phases imply sensitisation of the researcher to the issues contained within the data (Charmaz, 1995). The immersion of the researcher in the setting also facilitates the continuous interplay between the data collection and analysis which, according to Strauss and Corbin (1990), is fundamental to grounded theory.

However, this criterion of immersion can adversely affect the acceptability of the research outcomes since there are claims that ethnographic accounts which result from such close encounters are partisan and are limited by the contextual associations of the researcher (Altheide & Johnson, 1994). When research methods are challenged in this way, a validation argument must be mounted. While this could be a complex and detailed endeavour, according to Altheide and Johnson (1994), the argument can be bypassed if the criterion of usefulness is applied. This interpretation of validity sits well with the concept of needs-based research and given the discussion which has preceded this, an ethnographic account should be capable of qualifying as a valid result, if the usefulness of the research outcomes to the researched population can be identified unambiguously.
This validation will, in part, be drawn from the reflective account which has already been identified as an integral component of ethnography. This type of approach potentially overcomes some of the limitations which plague the application of research methodologies. Punch (1994) refers to distorting filters which reduce the authenticity of a method. By far the most prevalent filter is the singularity of perception and the resultant interpretation (researcher bias towards a preferred outcome). The process of continuous interaction between data collection and data analysis generates an effect similar to that achieved by multiple researchers. The latter is best achieved where there is acceptance of the researcher and the process is conducted in an open and accountable way so that there are fewer limitations on the scope of the researcher’s operation. Punch (1994) also warns of the use of restrictive research models which may be incapable of establishing the realities of the research environment. As Charmaz (1995) points out, this is less likely to happen where the advancement of the research is driven by the data, rather than preconceived concepts and hypotheses.

4.12 Accessing the data

Research participants generally know more than they are prepared to tell the researcher (Altheide & Johnson, 1994). The argument can be extended to suggest that researchers may not be skillful enough to elicit all the topical knowledge which the research participants possess. The degree to which this can be achieved will also depend on the type of research methodology which is used. Clearly, in the context of an ethnographic approach, quantitative methodologies will impose severe limitations on the depth and breadth of knowledge elicited. Alternatively, the goal of qualitative data collection and reporting is to allow “the informants to speak for themselves” (Strauss & Corbin, 1990, p. 21). When data is analysed, be it quantitative or qualitative, researchers seldom avoid some measure of interpretation. This act, according to Fielding and Fielding (1986), ensures that all research has a qualitative component.

The focus of research should be to extract all of the relevant data from the research participants. This approach will facilitate a superior ethnographic result since all facets of the participants’ interaction with the contextual environment will be probed. The mix of methodological philosophies by which this can be best achieved has to be decided.
Traditionally, the aviation community has responded best to scientific data. Only where the scientific approach is shown as inadequate are other methods of investigation embraced. Further, traditional practice would favour the initialisation of research from a known position or reliable fix. Thereafter, some degree of dead reckoning or ‘less reliable’ data can be introduced without degrading confidence in the established position.

This summary suggests that an acceptable way to proceed would be to initially establish the need to investigate the subject area. Having validated the need, leaning towards quantitative methodologies in the first experimental design would be acceptable since this methodology would provide the initial fix. If this methodology produces a need for further research, a shift to qualitative methodologies would be tolerated, provided that the investigation was grounded to the extent that research participants could identify their input to the final product. It would be essential to establish the goal of the research as the production of useful outcomes or tools to meet a need, and not simply the testing of theories or hypotheses.

A research method which extends grounded theory into another dimension has been proposed by Heron (1996). This co-operative research method allows more input to the final form of the research model from the research participants. According to Denzin & Lincoln (1994), quantitative research tends to exclude participants from the process development while qualitative research tends to focus on the research subjects and their contextual setting. However, co-operative research encourages the inclusion of the research subjects in the development of the research process (Heron, 1996). The participants actually participate. This principle sits well with the participative concepts of CRM (Lauber, 1993). Aviation research participants will feel included and the best possible outcome should result if a degree of participation is achieved.

If research is to elicit all that the participants might know about a topic, perceived ‘truth’ might be seen as the goal. “Truth is a local consensus about the most sophisticated construction around and is relative to a given group of people at a given time and place” (Heron, 1996, p. 10). In this sense, truth may well result from the research. Heron’s (1996) concept of truth underpins co-operative theory (contextualised consensus) and contains several facets which would be highly acceptable to the target aviation community. The population, temporal and situational facets define the context, and consensus defines the
methodology. An attempt to include the research population in decision making about the research would be of value. However, the nature and extent of this inclusive process would need to be integral, rather than superficial. A continuous review of proposed interpretations of processed data by participants would contribute significantly to the quality and usefulness of the end product by facilitating a continuing consensus.

The final blend of methodologies should facilitate access to the tacit knowledge which the research participants possess (Altheide & Johnson, 1994). This, largely unconscious knowledge store, is the nub of the inquiry into the performance and perceptions of experts who have automated their processing and actions to the extent that they are no longer fully aware of what it is that they do or how they do it (Chi, Glaser, & Farr, 1988). The proposals of Strauss and Corbin (1990) that the researcher must be sensitised to the research topic and that established biases, assumptions and thinking patterns should be abandoned during data analysis are vitally important to the quality of the end result. If such an approach cannot be faithfully adopted, the probability of establishing a nexus between what participants know and do and how they know to do the things they do will be low (Altheide & Johnson, 1994).

Wolcott (1994) points out, that nothing is known with certainty in social science and that there are as many versions as there are viewers. Therefore, the onus remains with the researcher to maximise certainty and to attempt to highlight similarities between versions of research output through good research methodologies and practices. These goals can be addressed through triangulation (Janesick, 1994). Not only should there be triangulation of methodology, but also an attempt to triangulate data sources, theory and investigators. Janesick (1994) goes on to suggest that interdisciplinary triangulation (the use of several types of methods or data) is also of value in order to enhance an understanding of the lived experience, rather than focusing on the aggregation of the research population into sets of numbers.

Triangulation enhances the basic research model of description, analysis and interpretation offered by Wolcott (1994) and provides more opportunities to uncover systematic relationships in the data (Wolcott, 1994). "The essence of triangulation rationale is the fallibility of any single measure as a representation of social phenomena and psychological constructs" (Fielding & Fielding, 1986, p. 29). The practical aviation environment and the
aviation research environment demand that a level of triangulation be achieved to establish confidence in the starting point and in the research results.

4.13 A research model

Within the subject airline, issues concerning management of flight are topical, foreshadow a greater problem, and certainly require the development and formulation of a proposal related to the topic (Stake, 1994). In order to facilitate the development of a proposal regarding management of flight, the research model (see Figure 4.1) needed to be flexible enough to accommodate the characteristics and strategies which were typical of the methodology being employed (i.e., a mixed-method).

![Model of overall research process](image)

Figure 4.1 - Model of overall research process

The research process represented by Figure 4.1 allowed decisions regarding the research process to be made before, during and at the completion of the various phases of the present research (Janesick, 1994). The focus and intent of this research project targeted the
establishment of a progressive, contextual consensus amongst participants. To accomplish this, the research model (see Figure 4.1) had to be capable of reducing the data to manageable representations. The latter process defines qualitative methodology (Janesick, 1994) and is achieved in the research model by multiple data collections and analyses.

Altheide and Johnson (1994) contend that such a methodological model must accommodate experimental design, outline a research schedule and stipulate temporal and spatial boundaries. Their view extends the final form of the research model to include the personal 'in-house' knowledge of the researcher which is accommodated through the inductive analysis process. The design goals of such a model would be to locate key phrases in the data collected from participants, interpret these phrases, check participants’ interpretations of these phrases, inspect these interpretations, and then offer a tentative definition (Janesick, 1994). Only at this point could any validation be attempted. These design features (Janesick, 1994) are incorporated in the research model that was developed (see Figure 4.1).

The components of the model which aimed to meet all the criteria discussed (see Figure 4.1) consisted of data collection followed by deductive or inductive analysis of the data. Having arrived at this point, reflectivity followed and the prospects of producing a representation were explored. A review of any representation was then sought from participants. This review stimulated more data collection, starting the process again. Only when the participant review process indicated that a contextual interpretation of the performance criteria pertaining to the management of flight by Captains in the airline of study had been achieved was verification considered.
CHAPTER 5

Study 1: Command readiness assessment

5.1 Introduction

The General Accounting Office (GAO) of the United States (US) cites the selection of pilots as the principal weapon to be used in the battle to reduce the accident rate within airline operations (Learmonth, 1997). Within the context of this statement, the implication could be drawn that selection into an airline should almost certainly guarantee promotion to Captain. Within US airlines, the scrutiny of command readiness appears to be cursory compared to the airline of study, with very few pilots refused a Captain training programme and with very few failures recorded. This represents a strict application of the established seniority system (longest serving pilot gets first choice), the speed/weight formula of pay determination (pilots get paid more for flying heavier/faster aircraft) and the basing/domicile system (pilots quite often delay bidding for command to satisfy personal preference to be domiciled in a particular city). Alternatively, an airline can take the view that selection does not guarantee promotion to command, and suffer the economic penalty of wasted training dollars. Both positions are unacceptable. A brief exploration of the problem is warranted.

With respect to the aviation domain, Hunter and Burke (1995) contend that an effective selection process should begin with a job analysis. This analysis results in a job description and a specification of the type of person who would be most suited to that job. The job analysis can be multifaceted and could consist of critical incident analysis (factual descriptions of specific instances of both satisfactory and unsatisfactory job behaviour),
interrogation of existing performance reports, the construction of a repertory grid (SME rating of job elements along dichotomous dimensions) and/or the use of a work profiling system. The resulting taxonomy of aptitudes then guides the construction of the selection procedure (Saville & Holdsworth, 1996).

Further, where used, test batteries do not vary significantly from organisation to organisation (Damos, 1995). As described by Stead (1995), the selection process at the airline of study contains a battery of five ability tests covering verbal concepts, diagrammatic reasoning, verbal critical reasoning, numerical critical reasoning and a numerical series. Furthermore, a two-part personality questionnaire covering maturity, reaction to pressure/stress, adaptability/flexibility, task orientation, crew orientation, decision making and command/leadership potential is administered to applicants for pilot positions (Saville & Holdsworth proprietary tests). The administrators of such a battery of tests see it as useful in the predictive sense. Additionally, the airline of study does administer a manipulative skills test, a simulated heavy jet exercise and two face-to-face interviews as part of its selection process.

As a precursor to this research project, a review of the results for 38 Captain trainees had been carried out. This group consisted of 20 good performers and 18 trainees who were considered by the training department with the airline of study not to have performed well. All had recently undertaken the Captain training programme for their assigned aircraft type. They also had completed the battery of tests described above, had been interviewed and completed a simulated flight assessment within the past 12 years. This review of Captain trainees was completed to examine whether there were any differences between poor performers and good performers in traditional measures of aptitude (the interview and simulated flight results were not considered). The results of this comparison are noted in Appendix A. While this summary of findings relates to extremes, an examination of individual cases revealed no concentration of strengths or weaknesses for any single case. Within the context of a single airline, no factor could be isolated to convincingly identify potential success or failure in Captain training programmes.

Outcomes within the aviation domain are usually performance-oriented (Helmreich & Foushee, 1993). Therefore, all selection test batteries should have the ability to assess the
potential to perform in all aspects of the job. The comparison of good Captain trainee performers and poor Captain trainee performers outlined in Appendix A was completed using results from selection tests typical of those in use throughout the industry. Given the continuing failure rate of Captain upgrade training (up to 20%), the dimensions which these test assess are not indicative of the likelihood of good long-term performance within the airline of study. The quality of the Captain upgrade training programmes could also contribute to the variable success rate. Consequently, there is a need to consider the underlying psychological processes to develop a more successful approach to selection and training. Within the airline industry, the ultimate performance test is that of Captain upgrade. Consequently, it would be appropriate to try to define the performance required of a candidate to be successful in such a training programme.

5.2 Component 1 – The identification of command readiness markers

5.2.1 Aim

The purpose of first component of this initial study was to identify (at the subjective level) the markers which experienced check and training Captains at the airline of study consider necessary to command a civilian jet transport in the global theatre of operation and to organise these markers into a model of management of flight performance.

5.2.2 Participants

The 69 personnel who took part in this research were all training personnel within a large Pacific Rim carrier. This population comprises three classes of personnel: Training Managers (who are also active trainers and checkers); Senior Training/Checking Captains (simulator and aircraft qualified training and checking personnel); and Line Training Captains (aircraft trainers and checkers) (see Table 5.1). The experience levels in the training role ranged from 6 months to 25 years and personnel were endorsed variously on B747-400, B747-300, B767, B737 and A300 type aircraft. Many of the participants had held training appointments on several of these types, although none was multi-endorsed at the time of sampling.
Table 5.1

Percent Response to Command Attributes Questionnaire

<table>
<thead>
<tr>
<th></th>
<th>Distributed</th>
<th>Returned</th>
<th>% of Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training Managers</td>
<td>29</td>
<td>11</td>
<td>38</td>
</tr>
<tr>
<td>Senior Training Cpts</td>
<td>62</td>
<td>24</td>
<td>39</td>
</tr>
<tr>
<td>Line Training Cpts</td>
<td>74</td>
<td>34</td>
<td>46</td>
</tr>
<tr>
<td>TOTALS</td>
<td>165</td>
<td>69</td>
<td>41</td>
</tr>
</tbody>
</table>

5.2.3 Procedure

A questionnaire was distributed to the training Captains through the internal mail system. The questionnaire contained two open-ended questions as listed in Table 5.2. The only qualifying instruction asked respondents to refrain from the use of generic terms such as ‘management’ and ‘leadership’, so that more precise areas of performance focus could be identified. The questionnaires were returned via the internal mailing system.

Table 5.2

Questionnaire Distributed to Training Captains

Please supply answers to the following questions:

1. When assessing a candidate’s suitability for command, what skills/attributes/practices are you looking for? Please affix numbers to each response to denote its priority. Explicit answers would be appreciated. For example, management is a multifaceted topic and should be broken down into areas of importance to you.

2. What additional skills/attributes/practices do you find in high standard candidates as opposed to average candidates?

5.2.4 Results

Since the research project prescribed several studies, the response rate (41%) for this study was considered sufficient to proceed to the next step. It was expected that the overall research
would generate a participation rate which would exceed 50%. The distribution of responses is listed in Table 5.1.

Open coding techniques (responses are classified according to their thematic similarity) (Strauss & Corbin, 1990) were then used to process the responses. Where the responses did not contain clearly stated key-words or phrases, each statement was analysed for concept, intent, limitation and individuality.

Table 5.3

Responses Coded as Representative of a Tactical Approach to Situational Awareness

- The highest level of situational awareness that allows him/her to respond to checklist items the first time
- Situational awareness
- Good awareness
- Awareness at all times of 3 dimensional position, rapidly assess variation from the desired and return to normal when possible
- Able to formulate an accurate mental model and maintain awareness
- Where the aircraft is in space, what operational problems are developing with weather, traffic, ATC etc and what’s happening with and within the aircraft
- Situation/time awareness
- Established cues and aide-memoirs to maintain awareness of the situation
- Practical thinking rather than verbatim application of the procedures eg slowing down to turbulence penetration speed on descent before reaching the turbulence when it is known to exist
- Good candidates maintain awareness, manage and get their crew to do the work
- The ability to look and plan ahead in their operation and not get caught out and have to use lots of speed brake, flaps and control inputs to achieve desired flight path
- Situational awareness of what is happening outside the cockpit with respect to other traffic, clouds etc
- Think ahead of the aircraft in different situations and places
- Awareness of the position and state of the aircraft, what’s going on around it and what still needs to be done
- Awareness of what is going on around them
- Using foresight under difficult conditions to manage the situation
- He or she will possess/project a high standard of situational awareness
- Ability to anticipate problems
- The ability to think of and manage the entire aircraft, not just the flight deck when confronted with a problem

Note: This theme of tactical SA was represented in 64 responses.
Forty-eight (48) unique markers (i.e., a dimension upon which a training Captain may assess a Captain trainee) were identified by grouping responses using these criteria and determining the pervasive theme. An example of the responses which were considered to represent a tactical approach (indicative of short term considerations) to situational awareness is given in Table 5.3. Examples of responses which were more indicative of a more global (strategic) approach to SA are detailed in Table 5.4. These responses were coded as representing maintenance of an operational overview.

Table 5.4
Responses Coded as Representative of Overview Maintenance (Strategic SA)

- An overall awareness
- Enroute weather gathering – diversion decision made early, not at minima on glide slope
- A broad awareness of operational situation, factors affecting same and downline results
- Ability to expect the unexpected
- Keeping the goals of the flight in focus
- Being able to “see the woods and the trees”
- An appreciation of the big picture
- Ability to see the big picture
- Doesn’t lose sight of the “forest for the trees”
- Candidate looks beyond current situation
- Hones in on important overall issues
- Meets operational and commercial goals
- Understands the overall operation
- Does not get caught up in detail and miss the big picture
- Maintains awareness of the whole aircraft and all requirements
- Good overview cognisance
- Keeps the big picture in perspective
- Maintains up to date overview
- Keeps overview balanced with normal and non-normal operations
- Total appreciation of all aspects of the operation
- Forms and executes optimum strategies for the sector

Note: This theme of overview maintenance was represented in 53 responses.

The maximum and minimum numbers of markers identified by respondents are listed in Table 5.5.
Table 5.5
Numbers of Unique Markers Identified by Each Sub-Group

<table>
<thead>
<tr>
<th>Participants</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training Managers</td>
<td>11</td>
<td>6</td>
<td>13</td>
<td>9.091</td>
<td>2.625</td>
</tr>
<tr>
<td>Senior Training Cpts</td>
<td>24</td>
<td>3</td>
<td>20</td>
<td>11.043</td>
<td>4.005</td>
</tr>
<tr>
<td>Line Training Cpts</td>
<td>34</td>
<td>6</td>
<td>23</td>
<td>11.455</td>
<td>3.709</td>
</tr>
<tr>
<td>Whole Group</td>
<td>69</td>
<td>3</td>
<td>23</td>
<td>10.925</td>
<td>3.71</td>
</tr>
</tbody>
</table>

The complete listing of the 48 identified markers for command follows in Table 5.6.

Table 5.6
Composite List of Markers Used to Assess Command Readiness (no assumed order)

- commonsense
- approachable
- command presence
- independent
- delegation
- aviation experience
- not over confident
- SOP adherence
- other CRM skills
- self motivation
- manipulative skills
- shows initiative
- assertive
- flexibility
- coaches others
- commitment
- logical
- communication skills
- accepts responsibility
- motivates others
- high self standard
- technical knowledge
- preparation
- recovery ability
- demands crew perform
- career self development
- situational awareness
- decisive
- overview maintenance
- sense of humour
- exhibits safety culture
- other e.g., maturity
- handles pressure
- professionalism
- self confidence
- ability to prioritise
- receptiveness
- analytical skills
- systematic
- upward assessment
- supports crew
- demands ongoing development
- thinks before acting
- worse case scenario planning
- consistency
- translates theory into practice
- participatory management style
- visualisation
The most frequently used performance markers were then identified. The limit of ten was struck, since this approximated the average number of markers identified across the whole group (see Table 5.7).

Table 5.7
The Ten Most Frequently Used Markers

<table>
<thead>
<tr>
<th>Marker</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>manipulative skills</td>
<td>67</td>
</tr>
<tr>
<td>situational awareness</td>
<td>64</td>
</tr>
<tr>
<td>communication skills</td>
<td>63</td>
</tr>
<tr>
<td>technical knowledge</td>
<td>60</td>
</tr>
<tr>
<td>supports crew</td>
<td>58</td>
</tr>
<tr>
<td>ability to prioritise</td>
<td>57</td>
</tr>
<tr>
<td>preparation</td>
<td>56</td>
</tr>
<tr>
<td>command presence</td>
<td>54</td>
</tr>
<tr>
<td>overview maintenance</td>
<td>53</td>
</tr>
<tr>
<td>self-confidence</td>
<td>50</td>
</tr>
</tbody>
</table>

Total number of responses = 69

The most frequently used markers in rank order by the respondent group are listed in Table 5.8. On the basis of this distribution, it was apparent that with the training managers included, there was less similarity between the three groups on the basis of their preferred makers of command readiness. However, there was considerable similarity between the Senior Training Captains and the Line Training Captains on the basis of the markers they most frequently used to assess command readiness. The policy makers and final arbiters in command assessment, the training managers, exhibited a different emphasis in their assessment of trainee Captains when compared to the personnel who were doing the bulk of the training and checking. For example, neither situational awareness nor overview maintenance appeared in the 10 markers most frequently used by training managers. This fact, together with the general
variance in the type and number of markers used by individual Captains, may explain some of the variance reported by trainees in the required standard for command.

Table 5.8
Markers Used by Respondent Groups

<table>
<thead>
<tr>
<th>Training Managers</th>
<th>Senior Training/Check Capts</th>
<th>Line Training Captains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manipulative skills</td>
<td>Manipulative skills</td>
<td>Manipulative skills</td>
</tr>
<tr>
<td>Command presence</td>
<td>Situational awareness</td>
<td>Situational awareness</td>
</tr>
<tr>
<td>Communication skills</td>
<td>Communication skills</td>
<td>Supports crew</td>
</tr>
<tr>
<td>Preparation</td>
<td>Career self-development</td>
<td>Technical knowledge</td>
</tr>
<tr>
<td>Self-confidence</td>
<td>Other CRM skills</td>
<td>Overview maintenance</td>
</tr>
<tr>
<td>Delegation</td>
<td>Ability to prioritise</td>
<td>Communication skills</td>
</tr>
<tr>
<td>Career self-development</td>
<td>Receptiveness</td>
<td>Ability to prioritise</td>
</tr>
<tr>
<td>SOP adherence</td>
<td>Overview maintenance</td>
<td>Preparation</td>
</tr>
<tr>
<td>Commonsense</td>
<td>Preparation</td>
<td>High self-standard</td>
</tr>
<tr>
<td>Technical knowledge</td>
<td>Technical knowledge</td>
<td>Command presence</td>
</tr>
</tbody>
</table>

5.2.5 Data Manipulation

The markers reported in the responses (see Table 5.6) were subsequently grouped into manageable chunks using axial coding techniques (Strauss & Corbin, 1990). Axial coding involves the reconstruction of data in novel ways so that it can be examined using different criteria. This technique flows naturally from the open coding (breaking down, examining, comparing and categorising) which yielded the markers. The criteria which guided this reconstruction were gleaned from CRM marker sheets (e.g., Line/LOS checklist, Helmreich et al., 1991) and from the analysis of behavioural markers conducted by Flin and Martin (1998). These documents represented a widely used tool (the Line/LOS checklist) and a recent analysis (Flin & Martin, 1998).
<table>
<thead>
<tr>
<th>Focus</th>
<th>Processes/Attitudes</th>
<th>Indicators</th>
<th>Probable Applications</th>
</tr>
</thead>
</table>
| Building Mental Models | 1. Exhibits safety culture  
Gaining experience  
Preparing  
Systematic  
Prioritising  
Analysing  
WCS planning  
Visualising  
Maintaining SA  
Maintaining overview | 2. Practical plan execution  
Consistency  
Manipulative skills  
SOP adherence  
Technical knowledge | Normal Operations |
|                  | 4. Self-motivation  
Self-development  
Commitment  
Initiative  
Independence  
Thinks before acting  
Sense of humour  
Commonsense | 5. High self-standards  
Self-confidence  
Seeks ongoing development  
Logical  
Command presence  
Demands crew perform | Adverse Operations |
|                  | 7. Receptiveness  
Participatory management  
Assertiveness  
Other CRM skills (e.g., conflict resolution) | 3. Handles pressure  
Accepts responsibility  
Decisive  
Professional | |
|                  | 8. Approachable  
Coaching  
Supports crew  
Communication skills  
Motivates others  
Upward assessment  
Delegation | 6. Not over confident  
Ability to recover  
Flexibility | Coping with Poor Performance |

The review by Flin and Martin (1998) revealed a categorisation of markers and the areas of the operation which they supported. Broadly, markers focus on cognitive (e.g., decision making & workload management) and social (e.g., teamwork, communication, & leadership)
aspects of performance (Flin & Martin, 1998). The cognitive aspects of performance identified by Flin and Martin (1998) rely, in part, on mental modelling abilities (Serfaty, MacMillan, Entin & Entin, 1997) while the social aspects are associated with one’s persona and the level of interaction between crewmembers (Hackman, 1993). Using these underlying influences, the markers identified in this study were then distributed on the basis of three areas of operator focus: building mental models, establishing persona, and generating interaction. Within each area of focus, the markers were distributed according to whether they could be categorised as a process or attitude and an indicator or behaviour associated with a process or attitude. The distribution of markers in this way is consistent with the allocation of elements of CRM categories accomplished by Flin and Martin (1998).

The results of this process are summarised in Table 5.9. The grouped markers in Table 5.9 (groups 1 through 8) were then assessed for the frequency of use by the three different respondent groups (see Table 5.10). This provided an indication of the principal areas of focus amongst the three groups in their assessment of command readiness. This analysis produced more consistent similarities between the three groups than did the consideration of the individual markers. Marker groups 1, 2, 4, and 8, as notated in Table 5.9, were shown to be the main areas of focus for the three Captain groups when considering the suitability of Captain trainees to be granted command.

Table 5.10
Ranked Preference for Grouped Markers by Training Captain Groups

<table>
<thead>
<tr>
<th>Training Managers</th>
<th>Senior Training Captains</th>
<th>Line Training Captains</th>
<th>Whole Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>4</td>
<td>8</td>
</tr>
</tbody>
</table>
5.2.6 Discussion

The large number of markers identified in this first part of Study 1 (research question 1) may be indicative of the complex nature of the task of defining management of flight performance. Further, organising this large number of markers resulted in a complex multi-dimensional model (research question 2). Because of the complex nature of the model of performance which resulted from this initial part of Study 1, the usefulness and usability of Table 5.9 needs to be investigated (research question 3).

5.3 Component 2 – An investigation of the multi-dimensional model of performance

5.3.1 Aim

The aim of this component of Study 1 was to assess the perceived usefulness and usability of the markers identified and organised in component 1 of this study to the training Captains (both senior training Captains and line training Captains) and the Captain trainees in the airline of study.

5.3.2 Participants

A questionnaire was distributed to the same group of training personnel who were asked to respond in Component 1 of this study (see Appendix B). A response rate of 45% (N = 74) was achieved (see Table 5.11).

Table 5.11
Response to Questionnaire on Multi Dimensional Model of Command Readiness Markers

<table>
<thead>
<tr>
<th>Personnel</th>
<th>Distributed</th>
<th>Returned</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training Managers</td>
<td>29</td>
<td>10</td>
<td>33%</td>
</tr>
<tr>
<td>Senior Training Capts</td>
<td>62</td>
<td>31</td>
<td>50%</td>
</tr>
<tr>
<td>Line Training Capts</td>
<td>74</td>
<td>33</td>
<td>45%</td>
</tr>
<tr>
<td>TOTALS</td>
<td>165</td>
<td>74</td>
<td>45%</td>
</tr>
</tbody>
</table>
5.3.3 Procedure

A further questionnaire (see Appendix B) was developed to seek the feedback on Table 5.9 with respect to its construction and utility since no previous comment had been sought from the respondent group regarding how identified markers should be processed. Responses to ten targeted questions were sought, with responses being recorded on a five point Likert scale (strongly disagree, slightly disagree, neutral, slightly agree, strongly agree) (see Appendix B). The purpose of each question was as follows:

Q1: Respondents were asked to consider all markers proposed by themselves and their colleagues and comment on their perceived useability as markers for command readiness within the airline of study.

Q2: The construction concepts underpinning Table 5.9 were reviewed by respondents and their application in identifying command readiness was then assessed.

Q3: The practical appropriateness (were any of the markers out of place) of the grouping of markers was assessed.

Q4: Comment was solicited on the extent to which Table 5.9 would assist training and checking of Captain trainees.

Q5: Feedback was sought on the suitability of terminology appearing in Table 5.9.

Q6: Respondents' perceptions of the quality of training they had already received in aspects of Table 5.9 were requested.

Q7: Respondents were asked whether they would use Table 5.9 as a training tool if supporting material was provided.

Q8: The ability of Table 5.9 to define common expectations for trainers and trainees was canvassed.

Q9: This question sought a response concerning the perceived ability of the information in Table 5.9 to assist training and checking Captains in the determining areas of good performance and areas requiring remediation amongst trainees.

Q10: Training Captains were asked to assess whether they thought that trainees could use this type of table as a study/mental preparation guide.
The results from this questionnaire were both anonymous and confidential. The results analysed by attributing values to the responses where 'strongly disagree' attracted a numerical value of 1 and 'strongly agree' attracted a value of 5.

5.3.4 Results

The mean responses are reported in Table 5.12.

Table 5.12
Means of Responses to Questionnaire Investigating Table 5.9

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean</th>
<th>Std Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: All identified markers are usable in defining the role of Captain.</td>
<td>4.71</td>
<td>.62</td>
</tr>
<tr>
<td>2: The underlying concepts of Table 5.9 are appropriate.</td>
<td>4.29</td>
<td>1.05</td>
</tr>
<tr>
<td>3: The groupings in Table 5.9 are practical.</td>
<td>4.15</td>
<td>1.13</td>
</tr>
<tr>
<td>4: The definition which Table 5.9 (or similar) offers will assist in the training and checking of Captains.</td>
<td>4.22</td>
<td>1.03</td>
</tr>
<tr>
<td>5: Terminology used in Table 5.9 is clear and explanatory.</td>
<td>3.83</td>
<td>1.22</td>
</tr>
<tr>
<td>6: Adequate training is given to Trainers and Trainees in all facets of Table 5.9.</td>
<td>2.15</td>
<td>1.13</td>
</tr>
<tr>
<td>7: Given supporting documentation, I would use Table 5.9 (or similar) in my training and checking duties.</td>
<td>4.17</td>
<td>.92</td>
</tr>
<tr>
<td>8: Table 5.9 (or similar) has the potential to match the expectations of the trainees with those of the system.</td>
<td>4.00</td>
<td>1.07</td>
</tr>
<tr>
<td>9: Table 5.9 (or similar) will make it easier to identify areas of strength and weakness in trainees.</td>
<td>4.20</td>
<td>.98</td>
</tr>
<tr>
<td>10: Trainees could use Table 5.9 as a self-preparation tool.</td>
<td>4.10</td>
<td>.97</td>
</tr>
</tbody>
</table>

These results were consistent in most of the areas canvassed. A notable exception was Q6 for which there was little agreement with the statement. Most respondents indicated that they had not received adequate training in some of the dimensions of Table 5.9. However, an
examination of the qualitative data which participants appended voluntarily to their responses seemed to indicate that agreement was not as universal as the quantitative analysis revealed. In an attempt to investigate the reasons for this apparent discrepancy, separate analyses of the responses from the two groups of personnel who offered qualitative comment, the Senior Training Captains (STC) and the Line Training Captains (LTC), was then conducted.

The analysis of data from the STC group and the LTC group revealed a stronger acceptance and understanding of Table 5.9 and its concepts amongst Senior Training Captains than amongst Line Training Captains (see Table 5.13 for mean scores). Variables which may have impacted upon the results include experience in command (Senior Training Captains = 13.32 years average and Line Training Captains = 10.67 years average) and the level of trainer training received by the two groups (Senior Training Captains = 2 months and Line Training Captains = 2 weeks). This different level of training may have produced a different level of understanding of the requirements for command readiness between Captains in the two groups. Of the 74 respondents to this component of Study 1, the responses of sixty-four Captains (31 Senior Training Captains and 33 Line Training Captains) were considered for these analyses (see Table 5.11).

The results listed in Table 5.13 were obtained from an unpaired t-test analysis, with adjustment for inequality of variance where necessary (Q4 & Q7). The variance for Q4 (p=0.002) and Q7 (p=0.025) were significantly different from each other. In both cases, Line Training Captain responses were more variable than the Senior Training Captain responses. Furthermore, the means for Q4, Q7, Q8, Q9 and Q10 for Line Training Captains were significantly lower than the responses for the same questions by Senior Training Captains. As a result, it was decided that further research was required to define pilot management of flight performance in a way that is more practical and useable to all training Captains when conducting Captain training and checking.

While not all respondents offered qualitative comment when completing the questionnaire in Appendix B, all of the qualitative comments from the responses are included in Appendix C. The general thrust of these comments indicated that refinement and simplification of Table 5.9 was required before being offered for practical use (see Appendix C). These comments can also be seen to support the need to develop a definition of command performance.
<table>
<thead>
<tr>
<th>Question</th>
<th>Mean (STC) N=31</th>
<th>Mean (LTC) N=33</th>
<th>Sig (equal variance)</th>
<th>Sig (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1: All identified markers are usable in defining the role of Captain.</td>
<td>4.74</td>
<td>4.65</td>
<td>.242</td>
<td>.634</td>
</tr>
<tr>
<td>Q2: The underlying concepts of Table 5.9 are appropriate.</td>
<td>4.48</td>
<td>4.00</td>
<td>.722</td>
<td>.138</td>
</tr>
<tr>
<td>Q3: The groupings in Table 5.9 are practical.</td>
<td>4.39</td>
<td>3.75</td>
<td>.275</td>
<td>.068</td>
</tr>
<tr>
<td>Q4: The definition which Table 5.9 (or similar) offers will assist in the training and checking of Captains.</td>
<td>4.65</td>
<td>3.70</td>
<td>.002</td>
<td>.004**</td>
</tr>
<tr>
<td>Q5: Terminology used in Table 5.9 is clear and explanatory.</td>
<td>4.09</td>
<td>3.40</td>
<td>.204</td>
<td>.067</td>
</tr>
<tr>
<td>Q6: Adequate training is given to Trainers and Trainees in all facets of Table 5.9.</td>
<td>2.04</td>
<td>2.25</td>
<td>.906</td>
<td>.547</td>
</tr>
<tr>
<td>Q7: Given supporting documentation, I would use Table 5.9 (or similar) in my training and checking duties.</td>
<td>4.61</td>
<td>3.70</td>
<td>.025</td>
<td>.001**</td>
</tr>
<tr>
<td>Q8: Table 5.9 (or similar) has the potential to match the expectations of the trainees with those of the system.</td>
<td>4.35</td>
<td>3.55</td>
<td>.122</td>
<td>.012*</td>
</tr>
<tr>
<td>Q9: Table 5.9 (or similar) will make it easier to identify areas of strength and weakness in trainees.</td>
<td>4.57</td>
<td>3.80</td>
<td>.132</td>
<td>.008**</td>
</tr>
<tr>
<td>Q10: Trainees could use Table 5.9 as a self-preparation tool.</td>
<td>4.39</td>
<td>3.80</td>
<td>.253</td>
<td>.026*</td>
</tr>
</tbody>
</table>

Note: * = significant at .05 and ** = significant at .01
5.3.5 Discussion

As indicated by the preliminary analysis of the group of Captain trainees in the airline of study, the selection instruments used in the airline of study may be incapable of reliably predicting management of flight performance potential at the command level. Further, as indicated by the present research, there appears to be some variation in the use of command readiness markers by training and checking Captains in the training and checking of Captain trainees (research question 1).

On the basis of the data and perceptions recorded during this study, the incorporation of the command readiness markers into a management of flight performance model was justified (research question 2). However, the list of markers that was derived (see Table 5.9) was perceived by many respondents to be impractical and therefore not as useful as might be desired (research question 3). Therefore, in order to understand why some candidates fail Captain training, the problem area of management of flight performance needs to be further pursued. Once the management of flight dimension of pilot performance has been defined, training and selection methods can be improved.

5.3.6 Conclusions

In order to determine the future direction of the present research, significant features of the present study need to be identified. Specifically, when deprived of generic terminology such as ‘management’, training Captains identified markers such as ‘situational awareness’ as being meaningful in their assessment of trainees’ suitability for command, to perform as a Captain and to manage the operation of an airliner in all conceivable circumstances. Further, SA appears to be required at two levels, the tactical short-term level and the overview or strategic level. This is evidenced by the thematic identification of two separate markers that define the topic: situational awareness and overview maintenance. Both types of markers appeared in the ten most frequently used marker list among Senior Training Captains and Line Training Captains (see Table 5.8). Good performance with reference to command readiness would appear to require the presence of both forms of SA in the view of both of these Captain groups. SA, as a significant marker of command readiness within the airline of study, should be investigated further.
CHAPTER 6

Study 2: Establishing an organisational understanding of SA

6.1 Introduction

The feedback on the proposals which resulted from Study 1, which identified SA as a regularly used marker of command readiness (see Table 5.9), suggested that the establishment of an organisational understanding of SA was a logical next step. If this could be accomplished, a comparison with existing theoretical constructs of SA could be conducted. This comparison could identify any differences, enhancements or idiosyncrasies which set the target organisation apart from research and understanding of the subject at a broader level. As a result of the first study, SA was now the topic of discussion amongst a wider audience within the target airline, since it was identified as second only to manipulative skills in its importance as an indicator of command readiness. The feedback from check and training Captains in Study 1 confirmed a perception of SA as an ingredient in the development of mental models for use in practical plan execution in both normal and adverse circumstances.

6.2 Rationale

As indicated in Chapter 5, the modelling output from Study 1 was devised with the view towards directing further research in the process of defining pilot management
of flight performance. Of necessity, part of this process involved the development of an understanding of SA from an organisational perspective. Although broad agreement with established constructs could be expected within the organisation, the definition of the components of these constructs had not been defined at the organisational level. The opportunity to do this was incorporated in the focus groups which had been convened to finalise feedback on Study 1.

6.3 Component 1 – To identify the components of an organisational understanding of SA

6.3.1 Aim

The aim of Component 1 was to develop the organisational understanding of SA so that this understanding could be considered and compared in Component 2.

6.3.2 Participants

Six focus groups of 7 to 12 training captains had already been planned in order to present the findings of Study 1 to participants and acquire additional data about that study (see Torn & McNichol [1998] regarding focus group composition). This sample was representative since participants were attendees at regular programmed meetings of training personnel which were selected at random for incorporation in the focus group programme. The purpose of these same focus groups was extended to address the first two steps in Heron’s (1996) co-operative cycle, namely, consultation with, and the integration of, the participants into the research decision making process. Once the data regarding the model generated in Study 1 had been distributed, a reflective process (with SA as the focus) was instigated. At this stage, there was no discussion between participants. Rather, participants were asked to consider why SA was deemed so important by the respondents in Study 1.

6.3.3 Procedure

Since these focus groups had already been planned, a degree of action research (research as an equal participant) was considered viable. This prospect retained a high
degree of correspondence with the research model proposed in Chapter 4 since inductive analysis and interpretation would result from these focus groups. Further, the concept of co-operative inquiry, as proposed by Heron (1996), provides a useful basis upon which to determine how to involve participants in the decision-making process as well as the data acquisition process for the subsequent research. Heron (1996) proposed four repetitive stages in his construct of co-operative research. Broadly, these stages are described as presentational, propositional, practical and experiential. The cycle is continued until well founded, highly grounded outcomes allow a strong claim to knowledge of the research topic.

A focus group format was considered suitable for the initial research in this study. This format provided the highest degree of correspondence with the proposed research model in that data collection, inductive analysis, and some interpretation were facilitated. Researchers who have used this methodology report on its ability to successfully source group phenomenology (Sim, 1998) and ethnography (Reed & Payton, 1997). However, the ability to interpret focus group data accurately is dependent on a prior, broad ethnographic understanding of the domain, since the focus group will only attend to a narrow band-width ethnography (Reed & Payton, 1997). The data need to be interpreted in the context of the organisational culture and procedures, rather than restricted to the topic of focus group activity.

Therefore, the interpretation of the data was, for the most part, inductive and facilitated the development of a useable questionnaire to elicit comment from a wider group (Kingry, Tiedje & Friedman [1990] cited by Torn & McNichol [1998] regarding the use of focus group output). The quality of the data dictates the final usefulness in this regard. As Sim (1998) points out, the thoroughness of data collection and the skill of the moderator are paramount. This contention implies that the precise thoughts of the group member ought to be recorded and that the moderator ensures that the nature and range of participant views are represented in the data. However, this process limits the generalisations which can be drawn from focus group data (Sim, 1998). Therefore, the most appropriate role of focus groups in research is that of the initialisation of the research process, rather than becoming instrumental in defining the final format of the research. This is an approach that conforms to the first
stage of Heron’s (1996) co-operative research cycle in that the contextual depth of the research question can be assessed.

Since these focus groups consisted of training Captains who had been offered participation in Study 1, the criticism regarding the non-representative nature of output which the focus group process has attracted in market research (Reed & Payton, 1997) was negated. Such criticism also results from the lack of evidence of the homogenous nature of the group in relation to the needs of the research (Torn & McNichol, 1998) as well as the definitive emphasis placed on the data (Reed & Payton, 1997). The homogenous nature of the focus groups (check and training Captains) and the directed nature of the deliberations by the focus groups (SA) further minimised traditional criticism of focus group functioning.

Notwithstanding, if focus groups can source data from a representative sample, and the data can be recorded faithfully, this research format can deliver in several ways. For example, focus groups can lay claim to a high level of face validity, since the thinking and feelings of participants can be sourced which, with ethnographically-based inductive interpretation, can render an in-depth understanding of the topic (Torn & McNichol, 1998). These views influenced the way that the focus group format was used in this study.

Initially, individuals within the groups were asked to write down what they thought that SA was, and how it could be developed and maintained in order to avoid problems associated with ‘group think’ (Minichiello, Aroni, Timewell & Alexander, 1995). Groupthink is the process whereby the group consensus is adversely influenced or biased by a flawed process or argument (Janis, 1972). Once this initial task had been completed, the topic was opened for group discussion. A well documented concept of SA, which included perception, comprehension and projection (Endsley, 1988) was presented briefly for consideration by individuals. During this expansive discussion, participants’ keywords, phrases and suggested themes were recorded. These were recorded on a white board so that the whole group could consider the issues from a broader perspective. This information was later transcribed from the white board by the researcher.
At the conclusion of this phase, group members were asked to summarise the aspects of SA in terms of their uniformity/variation, scope and complexity so that their conclusions could ultimately be considered along side the conclusions from the other focus groups. The results from each group were recorded for future reference. The groups were then asked to decide what should be done with the information tabled during this exploration of SA. The researcher was charged with pursuing the topic by summarising the output from the focus groups and presenting the result to a wider group of participants.

6.3.4 Results and discussion

Without exception, the groups agreed that SA, as interpreted by pilots in the carrier of study, was far more complex and far-reaching than the construct proposed by Endsley (1988). While acknowledging this, the groups also agreed that the variations in the interpretation by group members were also considerable. With one exception, this state of affairs led the groups to suggest a course of action to try to resolve the questions which the focus group process had raised. The exception, a group of 7, requested that their written ideas on SA be returned to them and that they not be included in any further exploration of the topic. No explanation was offered. The sensitive nature or the research environment and the research model in use dictated that the wishes of the participants be respected without question.

Broadly, the course of action adopted by the remaining five groups directed the convenor to analyse the written responses and records from the focus groups, develop a reasonable concept from this analysis, and present the findings to a larger group of pilots for comment and refinement. The participants in these five groups agreed that this process would be completed without further recourse to the contributing groups.

Open coding, which required responses to be decomposed into component parts, was initiated in order to identify the themes within the data. Four recurring themes were identified as a result of this coding. These themes were: the acquisition of knowledge; the retention of that knowledge; analysis of that knowledge; and the application of the outcome to the situation. Having identified the underlying themes, the individual actions, behaviours and states contained within the responses of the participants could
be attached to the identified themes using activity association. The exception to this general rule was the theme of retention. Within the focus groups, memory and techniques for memorising were explored to expand upon the expressed methods of the retention of knowledge contained within the responses of the participants. In particular, participants were asked to describe how they retained knowledge in order to aid SA.

The actions, behaviours and achieved states attached to the theme of acquisition were characterised by the terms: perceive, question, listen, share, vigilance, recency, overall experience, sensitive, systematic, continuous, disciplined, delegate, empathetic, and open-minded (see Table 6.1).

Table 6.1

_**Summary of the Recurring Themes and Attributed Actions, Behaviours and States Derived from the Output from the Focus Groups**_

<table>
<thead>
<tr>
<th>Acquisition</th>
<th>Retention</th>
<th>Analysis</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>perceive</td>
<td>memorise</td>
<td>deduce</td>
<td>predict</td>
</tr>
<tr>
<td>question</td>
<td>concrete</td>
<td>categorise</td>
<td>overview</td>
</tr>
<tr>
<td>listen</td>
<td>associations</td>
<td>assess</td>
<td>control</td>
</tr>
<tr>
<td>share</td>
<td>prioritised list</td>
<td>sift</td>
<td>appropriateness</td>
</tr>
<tr>
<td>vigilance</td>
<td>imagery</td>
<td>prioritise</td>
<td>timing</td>
</tr>
<tr>
<td>recency</td>
<td>mental models</td>
<td>compare</td>
<td>safety</td>
</tr>
<tr>
<td>overall experience</td>
<td>vocalisation</td>
<td>potential</td>
<td>optimise</td>
</tr>
<tr>
<td>sensitive</td>
<td>repetition</td>
<td>influences</td>
<td>reassess</td>
</tr>
<tr>
<td>systematic</td>
<td>mnemonics</td>
<td>mental models</td>
<td>remodel</td>
</tr>
<tr>
<td>continuous</td>
<td>chunking</td>
<td>pattern matching</td>
<td>review goals</td>
</tr>
<tr>
<td>disciplined</td>
<td>rote learning</td>
<td>understand</td>
<td>efficiency</td>
</tr>
<tr>
<td>delegate</td>
<td>structured plan</td>
<td>implications</td>
<td>worse case</td>
</tr>
<tr>
<td>empathetic</td>
<td></td>
<td>validity</td>
<td>beyond obvious</td>
</tr>
<tr>
<td>open-minded</td>
<td>resolve ambiguity</td>
<td>present &amp; future</td>
<td>non-normal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>revise plan</td>
</tr>
</tbody>
</table>
Following the review of the individual responses and the group discussion on memory, the following actions, behaviours and achieved states were ascribed to the recurring theme of retention: memorise, concrete (diagrams), associations (speed/thrust), prioritised list (most important first), use of imagery (sharp images of instrumentation), use of mental models (representations of objects and their properties), vocalisation (say to yourself), repetition, mnemonics, grouping into manageable chunks, rote learning, and structured plan (left to right or beginning to end) (see Table 6.1).

The analysis of information, as a recurring theme, encompasses the following actions, behaviours and achieved states: deduce, categorise, assess, sift, prioritise, actual compared to required, potential, internal and external influences, mental models, compare with previous experience, understand, consider implications, cross-check validity, and resolve ambiguity. On the basis of the outcomes of the focus groups, the application of knowledge included actions, behaviours and achieved states such as: predict, overview, control, appropriateness, timely, safety, optimise, reassess, remodel, review goals, efficiency, worse case scenario, beyond obvious, present and future, normal and non normal, and revise plan (see Table 6.1).

6.3.5 Conclusions

On the basis of this analysis of the thoughts and perceptions of a group of 51 experienced airline training Captains who comprised the focus groups, it is clear that, to them, SA is not a simple proposition. It is possible that their composite perception of SA is indicative of a controlling mechanism for safe and efficient flight in that it provides for the frequent revision of plans. The intent of many of the markers (other than SA) identified in Study 1 as useful in determining command readiness (see Table 5.9) is incorporated in the composite comprehension of SA which resulted from processing the focus group output. Using data from the current study, SA within the organisation could be said to be the core dynamic information management skill required by pilots and which extends far beyond the constructs reported in the literature thus far. If a larger group of pilots agree with this perspective, then the focus
of research to define pilot management of flight performance will need to be expanded beyond SA. Therefore, a second part to this study was initiated.

6.4 Component 2 – To assemble the identified components associated with SA within the organisation and to offer them for consideration by a larger group of participants

6.4.1 Aim

The aim of Component 2 of Study 2 was to assemble the recurring themes, the attributed actions, behaviours and states associated with SA within the organisation in a practical fashion, and offer the assembled components of SA (in the form of a questionnaire) for consideration by a larger group of participants.

6.4.2 Participants

In all, 101 participants (47 Captains, 31 First Officers & 23 Second Officers) completed the questionnaire on organisational SA as part of Component 2 of Study 2.

6.4.3 Procedure

If comment was to be sought concerning the recurring themes of SA listed in Table 6.1, and their attendant actions, processes and achieved states, a comprehensible summary of the data from the first component of the current study had to be produced. The development of a definition was seen as a practical solution to the problem of combining the intent of the identified actions, processes and achieved states. The recurring themes of acquisition, retention, analysis and application of knowledge would have to be included in a digestible fashion.

The following organisational definition of SA was derived from the themes: *Within the context of airline operations, flight crew can develop and maintain Situational Awareness by the continuous acquisition, retention, analysis and application of knowledge of events, conditions, data and variables.* This concept of SA presents a more global information processing/management model compared to existing
examples from the literature (e.g., Endsley, 1988). Nevertheless, this definition represents the focus group participants' perceptions of the topic and, together with the attendant actions, behaviours and achieved states, a questionnaire was presented to a larger group of pilots to determine the accuracy of the perceptions (see Appendix D).

There were two parts to the organisational SA questionnaire (see Appendix D), the first of which was designed to seek responses concerning participants' expressed agreement with the definition (yes/no). In the second part, participants were then asked to express disagreement with any of the incorporated actions, behaviours or states by striking them out as appropriate. The questionnaire was presented after the a recurrent training simulator session.

6.4.4 Results

As far as the proposed organisational definition is concerned, all but one respondent agreed with the concept expressed by the definition. The one dissenting opinion offered qualitative comment which expressed concern about trying to ‘reinvent the wheel’ when there was ample expertise on the topic available from outside the organisation. For the remainder, no qualitative comment was offered specifically in support of the definition in isolation.

Turning to the component parts of the definition and attributed actions, behaviours and achieved states, a frequency count of the rejected items contained within the questionnaire was initiated to define the level of agreement or disagreement with aspects of SA, as defined by the composite model. The proportion of agreement within the sample for the acquisition components of the composite model of SA is outlined in Table 6.2.
Table 6.2

Proportion of Agreement within the Sample for the Acquisition Components of the Composite Model of SA

<table>
<thead>
<tr>
<th>Proportion</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 90%</td>
<td>perceive, question, listen, vigilance, overall experience, systematic, continuous, disciplined, open-minded;</td>
</tr>
<tr>
<td>80%-90%</td>
<td>share, recency;</td>
</tr>
<tr>
<td>70%-80%</td>
<td>sensitive;</td>
</tr>
<tr>
<td>60%-70%</td>
<td>delegate, empathetic.</td>
</tr>
</tbody>
</table>

Table 6.3 records the proportion of agreement within the sample for the retention of knowledge components of the composite model of SA.

Table 6.3

Proportion of Agreement within the Sample for the Retention Components of the Composite Model of SA

<table>
<thead>
<tr>
<th>Proportion</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 90%</td>
<td>memorise, associations, prioritised list, vocalisation, repetition, grouping into manageable chunks, structured plan;</td>
</tr>
<tr>
<td>80%-90%</td>
<td>concrete diagrams, imagery, mental models, mnemonics;</td>
</tr>
<tr>
<td>70%-80%</td>
<td>rote learning.</td>
</tr>
</tbody>
</table>

The proportion of agreement with techniques used by the group and which could reasonably be associated with knowledge analysis is recorded in Table 6.4.
Table 6.4
Proportion of Agreement within the Sample for the Analysis Components of the Composite Model of SA

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 90%</td>
<td>deduce, categorise, assess, sift, prioritise, mental models, compare with previous experience, understand, consider implications, cross-check, resolve ambiguity;</td>
</tr>
<tr>
<td>80%-90%</td>
<td>potential, internal and external influences;</td>
</tr>
<tr>
<td>70%-80%</td>
<td>actual versus required.</td>
</tr>
</tbody>
</table>

Table 6.5 records the proportion of agreement with components of the composite model of SA that address knowledge application.

Table 6.5
Proportion of Agreement within the Sample for the Knowledge Application Components of the Composite Model of SA

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 90%</td>
<td>predict, overview, control, appropriate, timely, safety, optimise, reassess, efficiency, worse case scenarios, present and future, normal and non normal, revise plan;</td>
</tr>
<tr>
<td>80%-90%</td>
<td>review goals, beyond obvious;</td>
</tr>
<tr>
<td>70%-80%</td>
<td>remodel.</td>
</tr>
</tbody>
</table>

There was qualitative criticism of the terminologies listed for consideration in the knowledge analysis section. For example, ‘potential’, drew unfavourable comment from 5 respondents. Mental modelling attracted a higher agreement rating for use as a technique for analysis than it did as a technique for retention.
6.4.5 Discussion

Respondents were asked to ‘strike-out’ items of disagreement and leave in those items which could be used for the purpose of knowledge acquisition, retention, analysis and application. This may have led to expressions of personal choice, rather than conceptual usefulness. That is, individuals may cultivate and hone a personal skill set which serves them well in their efforts to develop and maintain SA. These results, therefore, probably reflect the perceptions of the most frequently used techniques, rather than passing comment on the useability of techniques.

With respect to research question 5 (Is tactical SA more strongly related to problem solving and problem solving algorithms than strategic SA?), respondents seem to support a more expansive concept of SA than those which explore tactical SA in the present literature. When comparing these perceptions with the definitions offered by others, in particular Endsley (1988) and Dominiguez (1994), this study has revealed (as identifiably different) the markers perceived to be in use by this cultural group to develop and maintain SA. The discussion of these results will follow two distinct lines to expand on the issues that were identified. Firstly, mechanisms which support situation assessment (the initial step in the development of SA) will be discussed. Secondly, the general fit of the approach that was derived to other concepts of SA will be explored.

Some researchers see knowledge as a very powerful contributor to situation assessment (e.g., Federico, 1995; Gawron, 1999). How that knowledge is amassed, retained, processed and used seems to be different according to the various approaches to defining SA. Endsley (1988) proposes that the perception and the comprehension of information are influential in developing an understanding of the situation which can then be projected into the future. Sarter and Woods (1991) expand this concept to include comprehensive situation representation and a continuous updating of those representations as important to situation assessment. Dominiguez (1994) suggests that these mental representations are continuously formed and are
used to direct further perception as well as operating as the principal tool for anticipation.

The perceived organisational (cultural) approach to SA derived during the present study conforms to the reported aspects of SA which concern the mental representation of the situation, and the subsequent use of the situation representation in maintaining SA. A continuous, cyclical process of SA development was suggested by the participants in this study. No disagreement with this proposal was recorded. Many amplifiers to the notion of perception were examined, including aspects of affect such as empathy, sensitivity, open-mindedness and discipline. None was rejected by more than 40% of the sample. While stress has been regarded as influential upon the achieved states of SA by previous authors (Endsley, 1995; Orasanu, 1997), the role of aspects of affect such as empathy and sensitivity has not been well documented. Further, the notion of previously established patterns, schemata and scripts (Endsley, 1995; Federico, 1995) as contributory to knowledge acquisition was also confirmed by the acceptance by participants of ‘overall experience’ and ‘recency’ as valid concepts.

This review of perceptions of SA within a single organisation also addressed the practical aspects of knowledge retention, rather than discussing memory as a multi-dimensional operator attribute as discussed in the existing literature (Cowan, 1995). From the focus group discussions, it appears that the participants were not really aware of memory functioning. Consequently, targeted questions were introduced to expand on the notions of memory when they were raised (e.g., What techniques do you use to assist/expand your ability to remember?). Rather, what was perceived to be important was how best to harness memory to support the process of SA development and maintenance since the natural discussion focused more on analysis and application than on retention.

Broadly, the items considered in this phase of the study support notions of priming structures (recall activated by related topics) (Baddeley, 1992), structural alignment (which defines similarity) (Markman & Gentner, 1993) and templates (organised memory fields) (Gobet & Simon, 1996) through the use of structured plans and prioritised lists to retain knowledge. The disciplined and systematic acquisition of
knowledge suggests the influence of agendas (foci) (Johnson, 1992) on SA development within this organisation.

Episodic memory (Baddeley, 1992; Nyberg, 1994) is suggested as a function facilitating the acquisition of experience (and tacit knowledge) and the use of recent experience in the development and maintenance of SA. The use of representations (Nyberg & Tulving, 1997) and mental models (Johnson-Laird, 1983; Johnson, 1992) were included by most respondents as functional in knowledge retention. Chunking (Keinan et al., 1991) was also used in the retention of knowledge by the participants. These mechanisms might be viewed as memory harnessing (storage), rather than memory activation (recall).

The results pertaining to the terms that reflect knowledge retention to the participants indicate that, within this cultural setting, most of the terms offered are perceived to have relevance. Rote learning was least favoured of the retention mechanisms. The outcome of this examination of knowledge retention indicates that a variety of memory mechanisms are perceived to be used. While this study did not establish whether each mechanism is used, it may well be that some mechanisms assume dominance at various times in the process of SA development and maintenance.

When considering the terms associated with the analysis phase of SA development, respondents at this carrier were more homogeneous in their agreement compared to that recorded when considering the acquisition and retention phases. The processes, achieved states and actions which were offered, defined this step with far more breadth than the comprehension stage proposed by Endsley (1988) or indeed the concept of integration offered by Dominguez (1994). The facets being considered here broached not only comprehension (understanding), but also the metacognitive processes (self-generated monitoring activities) identified by the participants as a necessary part of the process (categorise, prioritise, consider implications, actual state versus required state, consider potential, and assess) (see Table 6.4).

Over 80% of respondents considered both internal (e.g., tacit knowledge, cultural norms, etc.) and external (e.g., flight scheduling constraints) influences as contributory to the analysis component of SA development. Error management was
agreed as integral to this *analysis* phase of SA development through cross-checking and the resolution of ambiguity. Aspects of Naturalistic Decision Making (NDM) were considered (compare with previous experience) and also thought by respondents to be a valid part of this *analysis* phase. The perceived usefulness of mental models to facilitate this analytical step was also confirmed.

Regarding research question 4 (Is strategic SA principally metacognitive in nature?) and research question 6 (Does good management of flight performance rely on the presence of strategic SA?), respondent perceptions concerning *analysis* as part of the development of SA within this carrier expanded the debate considerably. The focus of this organisational approach began to change from strictly tactical, as Endsley (1988) would suggest, to a more strategic approach. This view is derived from the tendency amongst respondents in this organisation to see the maintenance of an overall or overview perspective (goal focused and strategic) as an important outcome of the process of SA development. The link between the object level and the meta-level of the concept of metacognition according to Nelson and Narens (1994) was clearly established as essential to the process, through the general agreement on the inclusion of reflective processes (review, reassess, revise and remodel). The usefulness of previous experience in the development of SA was also highlighted and is consistent with the views of Zsambok (1997) and Klein (1997) as expressed in their explorations of NDM. The usefulness of previous experience in the development of SA would rely, to an extent, on the existence of mental models (Johnson-Laird, 1983; Johnson, 1992) or prototypical models (Amalberti & Deblon, 1992; Endsley, 1995) which exist in long term memory and which were considered by respondents in their responses to this segment.

From the standpoint of this composite exploration of underlying processes of SA development, aspects of metacognitive ability support the process in both the pure sense (link object and meta levels through monitoring) and the applied sense by suggesting that the development of SA is a highly self-driven process (Robertson & Endsley, 1994). Without conscious and focused processing, which can only be instigated by the operator/s (i.e., self-regulated), SA development would lack direction and completeness. This awareness of strategies is considered by some authors (e.g., Etelapelto, 1993) to be an attribute of experts. Further, the control of
one's processing by oneself is related to the concept of self-regulation (Boekaerts, 1996; Hong, 1995).

The results from this study which pertained to the *application* of processed knowledge were consistent with the outcomes of the review of the *analysis* phase of SA development. The simple contention of a final projection (expectation) phase (e.g., Endsley, 1988) was abandoned in favour of a much more expansive approach to the role of SA development during this *application* phase. For example, elements of prediction (forecasting) exist in the view of these respondents. Reflective processes were also accepted by respondents as influential in this *application* phase of SA development. While it could be argued that reflective processes contribute more to the maintenance of SA, rather than the initial development of SA, the part that goal review and revision of the prototypical plan (i.e., elements of self-regulation) play in the development of SA is significant (Amalberti & Deblon, 1992; Endsley, 1995). This metacognitive dimension of SA development and maintenance has not been as clearly defined in previous research.

Goal orientation was further reflected in several other components of SA development and maintenance (including the terms optimise, appropriateness, overview, efficiency, timing, present and future, safety, and worse case scenario). This goal orientation, coupled with elements of self-efficacy through reflection, supports the perception that self-regulation may be a contributory element in strategic SA (Boekaerts, 1996; Hong, 1995; Schunk, 1995; Winne, 1995). Given the established alignment between the strategic focus of SA as proposed by Smith and Hancock (1995a) and Sarter and Woods (1991), and the perceived acceptability of the composite concept of SA under review in this study, support for a strategic approach to SA is strong. While most experimentation reported in the literature has focused on tactical (short-term response) SA development and maintenance, the perception of participants in this study is that strategic (longer-term goal driven) SA influences airline pilot management of flight performance.
6.5 Conclusions

Within the organisation from which the respondents were drawn, it appears that an acceptable construct of SA would comprise both tactical and strategic elements. The processes that are perceived to be involved in the development of SA are far more expansive than those that comprise a tactical approach (perception, comprehension, projection) to SA development and maintenance. The distinction between this tactical approach and the perceived strategic approach identified in this study is so broad that the construct which the strategic approach defines could be seen to be more closely related to concepts of self-regulation which have been proposed in other domains such as education in more recent years.

Concepts of self-regulation are highly dependent upon metacognition as their enabling facet (Boekaerts, 1996; Hong, 1995; Schunk, 1995; Winne, 1995). Therefore, SA, is considered by this respondent group to be more strategic than tactical in nature, and perceived to be highly reliant on metacognitive processes (research question 4: Is strategic SA principally metacognitive in nature?). Conversely, the tactical SA construct exhibits similarities to generic problem solving algorithms which comprise the gathering of information, the comprehension of this information through analysis or pattern matching and the application of a suitably derived or known alternative which may involve short term prediction of events (research question 5: Is tactical SA more strongly related to problem solving and problem solving algorithms than strategic SA?).

While a relationship between poor performance and degraded SA seems to have been established (Endsley & Jones, 1995; Freeman & Simmon, 1991), the association between good performance and good SA remains unsupported. In part, this could be explained by the proposition that SA is not an identifiably individual construct capable of empirical scrutiny. Rather, it may be that the concept of SA is integral to, and subsumed by, a more expansive construct such as self-regulation. The exploration of the composite organisational approach developed for this study would seem to support this notion.
It may well be that airline pilot management of flight performance is more dependent upon a broader, yet unidentified construct which incorporates the concepts supporting both tactical and strategic SA. While not asked directly, this group of participants seems to support, by default, the notion that strategic SA is integral to good pilot management of flight performance (research question 6: Does good management of flight performance rely on the presence of strategic SA?). The key components of the organisational construct of SA which seem to set it apart from proposed constructs of tactical SA, appear to be metacognitive in nature (e.g., compare with previous experience, reassess, review goals, revise plan, remodel, actual versus required) since these types of monitoring activities were perceived by the respondents to be integral to their concept of SA (see Tables 6.4 & 6.5).

In summary, the pilots who responded in this study appear to support the notion of that continuously comparing what is actually happening to what should be happening is essential to SA. Through this apparent agreement, they also seem to support the engagement of goal orientation and self-efficacy processes. These outcomes necessitate that an investigation beyond contemporary constructs of SA be undertaken. Such an investigation has the potential to establish a more robust construct of airline pilot management of flight performance.
CHAPTER 7

Study 3: Beyond situation awareness

7.1 Introduction

In sequence, the studies preceding Study 3 identified SA as a commonly used marker of command readiness within the airline of study (Study 1) and established an organisational understanding of SA (Study 2). In Study 2, the perception of SA within the airline of study was found to be more expansive than constructs of SA currently reported in the literature. Study 3 identified the common themes of activity which experienced line Captains engaged to complete an unfamiliar piloting task. Study 3 consisted of a number of semi-structured interviews which were then analysed to identify the common themes. These common themes were found to add definition to the concept of management of flight performance within the airline of study and approximate the construct of self-regulation.

7.2 Rationale

When researching the markers by which training Captains determine suitability for command in Study 1, it was apparent that while the list of identified markers was large (48), the ten markers that were perceived to be most frequently used by a large sample of training Captains (165) were reasonably consistent. The markers in ranked order were: manipulative skills, situation awareness (SA), team atmosphere, technical knowledge, overview maintenance,
communication skills, ability to prioritise, preparation, high self standard and command presence. This group of markers has some commonality with those used by Helmreich et al. (1991) to evaluate CRM performance through the Line Oriented Simulation (LOS) checklist (team management, crew communications, situational awareness, and decision making).

A comparison of the list compiled during Study 1 with the ranked lists of CRM elements produced by Flin and Martin (1998) (prioritisation, conflict resolution, communication, planning, briefing, inquiry, checklists used, self-critique, preparation, procedures, situation awareness, time management, decisiveness, decision making, workload distribution, decision communication, listening, cabin crew inclusion, and procedure orientation) reveals differences in the sophistication of markers. By comparing Flin and Martin’s list with the list compiled in Study 1, it appears that without specific education and training, aviators tend to use broader markers than those proposed by the CRM researchers associated with many airlines. However, both ranked lists lack application order. That is, regardless of the breadth of the marker list, there is little attempt to sequence the CRM behaviours in a recurring order which would mimic the way that pilots might exhibit the behaviours when completing a flying operation. Later versions of the Line/(LOS) checklist do attempt to add a temporal dimension through a consideration of behaviours by phases of flight (Helmreich et al., 1991).

The nature of the task of flying an aircraft between a departure point and a destination in a finite time requires that, in most instances, actions be executed in a prescribed order. Similarly, the accompanying cognitive processes will assume some order. Typically, instructional system design task analyses of the type conducted under Advanced Qualification Program (AQP) Advisory Circular (AC) 120-54 (FAA, 1991) are generally completed by phases of flight. This process of analysis tends to concentrate on the actions required to complete each phase of the flight, and not the underlying cognitive tasks. The resulting task list usually focuses on procedural and manipulative aspects of piloting. The Line/LOS Checklist does, however, propose that behaviours (and cognition) are repeated by phase of flight. By inference, the repetitive nature introduced through ‘phase of flight’ is perceived to add definition to CRM performance since observations of the same behaviour are elicited several times during a flight.
The aviation industry has reached the understanding that behaviours, as much as manipulative skills, are capable of defining pilot performance (Helmreich & Foushee, 1993). Therefore, the issue to be resolved centres on what types of cognition and attendant behaviours should be used for the purpose of evaluation. This question leads to the proposal that a form of Cognitive Task Analysis (CTA) should be used to resolve the matter. O’Hare, Wiggins, Williams and Wong (1998) cite one such method as an analysis of actual user activity in an already functioning system. The approach used by O’Hare et al. was successful in identifying the decision making methods used by operators in a time compressed, dynamic environment. In this respect, the approach of O’Hare et al. (1998) is coincident with that of Seamster, Redding and Kaempf (1997) who view CTA as a mechanism by which an understanding of the relationship between theory and practice can be developed.

The work of Seamster, Redding, Cannon, Ryder and Purcell (1993) concerning the CTA of air traffic controllers produced a detailed model of the task. Seamster et al. (1993) considered this model in parallel to the mental model that was required to support the task. Their finding that experts maintain a very organised and comprehensive cognitive view of the task supports the notion that experts develop and maintain an elaborate mental model of the task. Alternatively, O’Hare et al. (1998) concentrated on the Critical Decision Method (CDM) form of CTA. The CDM investigates the methods employed by contextual experts to make decisions in time critical situations. On the basis of their research, O’Hare et al. (1998) suggest that situation assessment is the critical component of decision making under pressure. Further, decision making in these circumstances is seen to define the nub of performance.

Endsley (1993) found that prototypes of situations are built and stored as mental models. Similarly, Johnson-Laird’s (1983) research revealed that the parsing of language and the application of syllogistic reasoning to inbound data can build such models. It was found that experience contributes to the long-term memory store. According to Johnson-Laird (1983), such memories probably exist as schemata or cases (exemplars) and can be activated by scripts which sequence their use (Endsley, 1995). Wilson and Rutherford (1989) hold the view that the accuracy of mental models dictate the level of task performance where cognitive strategies are required.
Amalberti and Deblon (1992) found that sound prototypical (mental) models were influential in generating accurate navigation by crewmembers. Endsley's (1995) research supports this finding that the process which experts seem to use involves the construction of a prototypical model pre-flight which resides in memory as schemata, directs attention to critical cues and acts as a comparator for recurring situation models. Further, situation assessment, one of the critical factors of the CDM form of CTA, can be seen to rely heavily on prototypical modelling (O'Hare et al., 1998).

While situation assessment refers to the mechanism by which SA is attained (Smith & Hancock, 1995a), the existence of SA, the state, cannot be ignored (Sarter & Woods, 1991). With respect to the navigators of military aircraft, evidence exists to suggest that a level of SA is established pre-flight, and that this strategic, goal-driven model is used in a tactical sense to process perceived data and episodes to assess situations and, thereafter, to confirm or alter the previously modelled representation of the flight (Amalberti & Deblon, 1992). According to Klein (1993), prototypical models may result from previous experience, as well as through deliberate knowledge acquisition and structuring.

Kaempf, Wolf, and Miller (1993) report that 83% of experienced tactical commanders matched patterns of actions to situation prototypes as the basis of their decision strategy. The proposed use of prototypical models is, of itself, a type of pattern matching strategy in which reality is compared to expectation. If a match occurs, no further consideration besides task execution needs to be made. Where a mismatch is detected, an inquiry is conducted to resolve the ambiguity and to produce a valid operating model (executive script).

The concept of continuous comparison of what is happening with what was expected to happen implies metacognitive activity since the meta-level representation and the object level are being compared (Nelson & Narens, 1994). Dominguez (1994) details a directive component to SA which can only be achieved by situation assessment, and which also implies metacognitive activity (i.e., SA is the “continuous extraction of environmental information, integration of this information with previous knowledge to form a coherent mental picture, and the use of that picture in directing further perception and anticipating future events” [p. 11]). Robertson and Endsley (1994) also contend that metacognitive skills are vital to superior SA. Further,
Pintrich, Wolters and Baxter (1997) propose that self-regulation activities, such as planning, strategy selection and use, and resource allocation, are as much a part of metacognition as are knowledge of cognition and metacognitive judgement and monitoring. These views imply that self-regulation and metacognition are key components of SA and overall pilot performance (i.e., management of flight).

SA development is further complicated by automaticity. If the view is taken that the ability to control dynamic, real-time scenarios can be learned, the task of identifying the supporting construct is simplified somewhat. This perspective is supported by the notion of phased learning (memorizing facts, establishing relationships between retained facts, and developing automatic performance) (Shuell, 1990), and the reduction of conscious content of executive control delivered by automaticity (Ericsson & Smith, 1991). However, where an impasse is detected by the executive control, metacognitive processes are activated to select a new strategy (Roberts & Erdos, 1993).

The views of Ericsson and Smith (1991), Roberts and Erdos (1993), and Shuell (1990) concerning the application of metacognitive interventions suggest that it is possible for operators in airline environments to begin with a relatively unsophisticated routine for flight management which will become automatic with practice. Provided that the originating routine contains the elements necessary to complete the task, the cumbersome and time consuming nature of this originating routine will be overcome by multiple exposure. Novices may be unaware of the operating interventions because of their low skill base, while experts may appear to be unaware of the interventions which they use because of the level of automaticity that has developed.

7.3 Aim

As previously mentioned, task performance in dynamic, real-time environments can be considered to rely, in part, on mental modelling (Wilson & Rutherford, 1989) and situation assessment (O’Hare et al. 1998). The cognition and behaviours which underpin these processes can be considered in order to try to define a construct of performance (in this case, management of flight performance). This would entail establishing the process by which pilots
build reliable mental models of the task and thereafter, assess situations. As a result, the aim of this study was to identify the process which experts use to develop mental models and, subsequently, to assess and control situations that occur during a flight (i.e., define the management of flight function).

7.4 Participants

There was a total of fifteen participants comprising seven line Captains and eight check or training Captains. semi-structured interviews were conducted. Given the finding from Study 1 that line Captains and training Captains probably have different views concerning operational and training matters, a representative sample was taken from these two groups. The average age was 50.7 years, with an average time in airline command of 6583 hours for both groups. Interviewees were approached on an availability and consent basis (a pseudo-random selection).

7.5 Procedure

A semi-structured interview technique was used for data acquisition, since a trial interview revealed that the fully recursive format (Minichiello, Aroni, Timewell & Alexander, 1995) was not suitable. In particular, the expectation that a conversational interview could consistently yield appropriate data was unrealistic. A flexible format was established, and interviewees were asked to set aside an hour to complete the interviews. A set of open questions was used to stimulate initial responses (see Appendix E). Other clarifying and expanding questions were generated throughout the interviews. While it was recognised that this interview format would greatly reduce the ability to compare results, this sacrifice was considered worthwhile in order to obtain a more detailed explanation of the informants’ perception of reality (Minichiello et al.). However, it should be noted that the real purpose of this series of interviews was not necessarily to gather comparable data, but to identify recurring themes in the responses.

There was no attempt to obtain quantitative data, since the interviews comprised 17 open and some random probing questions. These types of questions best suited the purpose, since the object of the exercise was to gather the thoughts, ideas and opinions of the interviewees and
not to seek comment on theoretical perspectives. Therefore, the interviews were task-oriented and were aimed at establishing how individuals completed tasks which they were set. The expectation was that the resultant data would be useful in formulating an instrument, which could be used to collect quantitative data.

The interviews were conducted in isolation at a venue of choice for the interviewee. This was usually a workplace site, although two interviews were conducted in the homes of the interviewees. Each interview was preceded by about five minutes of unrelated (personalised) conversation to establish a non-threatening environment. The format of the interview, the method of recording the interview, and the use to which the data would be put was explained to participants towards the end of this period. Interviewees were asked for their consent to the interviews being recorded. The records of interview comprised audiotapes and field notes. The audio records were transcribed into written format for analysis. One interview could not be completed because of a roster change, which necessitated that the interviewee report for duty earlier than was originally scheduled. This partly completed interview was not used in the subsequent analysis.

The respondents were asked to reply openly and fully to each question that was asked. At this stage, the topic had not been introduced. Once the interviewees indicated a readiness to begin, they were informed that their thoughts on flying a sector was the topic of discussion. At this point, interviewees usually asked some clarifying questions. Once these had been fielded, the sector for consideration was announced. Nominally, this was a flight from Bogota to Buenos Aires, unless it was established that the interviewee had previously operated extensively in the South American theatre. However, none of the interviewees had flown in South America before. An example of a transcript of an interview is given in Appendix F. This example reflects the type of questioning that was conducted. However, because of the chosen structure, there was variation in the sub-questions used (and recorded), although the intent was retained in order to cover the same areas. In some cases, information was offered, thereby negating the need to target that information by questioning.

It was considered vitally important for the data collection process to have each interviewee consider a city pair between which he or she had never previously operated. The purpose of
generating an unfamiliar operating environment was to try to reduce the automaticity that experience and familiarity brings (Ericsson & Smith, 1991). Preliminary conversations pointed to a highly automated and unconscious approach to flying familiar sectors, and this is consistent with evidence regarding automaticity. One of the characteristics associated with automaticised performance is that interviewees may find it difficult to identify and verbalise their thought processes in such circumstances (Minichiello et al., 1995).

The responses were further manipulated through the application of time pressure to the exercise to simulate the realities of flight. Each interviewee was told that he or she had been phoned at home with only about three hours to be on board a departing flight as a passenger to go to Bogota. Having announced the pre-conditions, interviewees invariably asked for a couple of minutes to consider the situation before the audio recording commenced. The opening question was standard to the extent that interviewees were asked to explain what they would do to successfully complete this flight in unfamiliar territory. Thereafter, however, it was primarily the response, which shaped the ensuing question within the context of the overall direction of the interview defined by the set of open questions (Appendix E). The aim was simply to progress the interview through the assigned flight (i.e., from the pre-departure time which was available, through positioning sectors to Bogota, the short lay-over in Bogota, the departure, cruise, approach and landing and to the terminal and beyond at the destination). Because the interviewee was relying on a hypothetical mental model of the operation, and was not actually living the scenario, focusing statements were used as precursors to some questions. Interviewees were advised that clarifying inquiry would be allowed throughout, since it was considered important to secure accurate perceptions and opinions on the topic areas being discussed.

The control of the interview was vested in the interviewees to the extent that they were briefed that they could call the interview off at any time and that the tape would be handed over to them to erase. Tapes were not transcribed for a period of at least one month in order to allow interviewees time to consider their position. No interview was terminated in this manner and no subsequent tape recall took place. Interviews were conducted over a four-month period as personnel became available. Interviewees were made aware, at the outset, that their responses would be used to develop further research within their organisation.
7.6 Results and discussion

In recording the data, each response was coded to enable generic identification. The codes that were used to identify each response were: LC1, LC2, etc for line Captains and TC1, TC2, etc for check or training Captains. This coding was expanded to include the years as a Captain, hours in command and age. For example, LC3/11/8000/51 was the third line Captain interviewed and had been a Captain for 11 years, had accrued 8000 hours in command and was 51 years of age at the time of interview. The quotes that follow have a five-segment identification code that designates Captain qualification (training or line), position in interview sequence, years as a Captain, command hours and age at time of interview. Once transcribed, the interview data was examined for recurring themes and processes. This examination approximated a combination of open coding (Strauss & Corbin, 1990) and analytic induction (Minichiello et al. 1995). This methodology relies heavily on the immersion of the researcher in the research environment and the sensitisation of the researcher to the research environment (Altheide & Johnson, 1994). Only through this continuous interaction can insight and expanded awareness be achieved. However, it should be noted that induction renders substantive output, which cannot be generalised beyond the boundaries of the research group.

The data was decomposed, examined, compared and categorised. The categorising process rendered the concepts which seemed to pertain to the management of flight function. Since the interviews had been conducted more or less in a phase of flight sequence, the grouping of the concepts which resulted, also took on a sequential, if not a chronological form. For example, the proposed scenario was not a regular event in the working lives of the interviewees. All respondents reported less than five such occurrences in airline careers averaging 30 years. Therefore, the recorded approaches could be considered as reasoned responses, rather than automatic reactions to familiar triggers.

The level of reasoning by the respondents in this situation could be seen to be closely associated with metacognitive activity in that interviewees were seen to consciously question themselves as to the course of action that should be adopted. For example, respondents reported that “You need to be looking ahead as far as you can” (TC5/13/9500/52) and “I
would ask myself what's different about this, how will I approach this operation?" (TC8/10/6000/49). These were typical of interviewees who began to prepare by establishing a personal starting point. All interviewees responded to the suggested scenario by indicating that they would initiate a process of information gathering. Interviewee LC1/1/2500/50 indicated that "The first thing that I would do is go downstairs to consult my world atlas." while interviewee TC1/11/9000/50 reported that "Once I had finished talking to crewing about the assignment, I would be straight on the blower to the route qualifications people to find out what information they could give me". Interviewees reported that this information gathering process was essential, since they had no prior knowledge of operating in the area. The importance of this part of the management of the flight is typified by comments like "Basically what I want to be able to do is to get into a position whereby I have a good amount of background knowledge" (LC5/9/6000/47) and "I have got to study the information that is available before I leave" (LC4/9/6500/46). Since time was short, the strategies used to complete this sub-task were innovative and resourceful. Other agents (e.g., pilots who have flown in the area) were involved with a few references to the internet. "I would call up other pilots who are familiar with area" (LC6/9/6200/49), "I would use my database as much as possible before I leave home" (LC7/10/6000/52), and "You can get a lot of information from CNN and the web in these situations. It doesn't take long" (TC7/12/8000/50) were examples of strategies used to obtain information.

The goal was to establish a data-rich template of the proposed operation that was subsequently manipulated to structure the acquired knowledge into a useable format. This self-generated tactic could have resulted from reaching an impasse in current knowledge and self-questioning of knowledge levels of the proposed route and was manifested in statements like "The first thing that I'm going to do is try to get as much information as I can from anyone who knows anything about it" (LC4/9/6500/46). Other statements like "On this sector everything is going to be a bit of a surprise and just the lack of familiarity would make me more cautious" (TC6/11/10000/49) and "I would keep analysing whether there is anything I have missed" (LC3/11/8000/51) also indicated a need to consciously initiate self-questioning. This self-questioning was evident from the initial notification through to flight completion for all participants.
Once decided, the procedure upon which each interviewee embarked was very clearly defined, identifiable, and consistent. There was very little hesitation in the initiation of the task actions, and the steps, which needed to be undertaken, flowed very freely, without extensive questioning by all participants. This suggests that, although the exact scenario was not experienced regularly, the processes used to cope with such a problem were seemingly well honed and in regular use, albeit possibly at a sub-conscious level in more familiar operating environments.

In all cases, a crew briefing followed the planning phase (e.g., "When I get to the airport, the first thing that I would want to do is meet the crew" [TC6/11/10000/49]). The crew briefing facilitated information sharing with the whole crew as soon as possible. This briefing opportunity was also used to source information that the rest of the crew might have about the operating environment. Understanding that "Often the CSM has more information than I do about passengers, catering, etc." (TC6/11/10000/49) and "It's quite amazing, some Second Officers have actually flown in these sorts of areas" (LC3/11/8000/51) were examples of the thinking which prompted respondents to ask other crewmembers what they knew about the proposed operation. Generally, this was the point at which strategies for coping with the operation began to become more decisive ("I'd sort out how we would handle the departure. Who would do what, etc." [LC6/10/9200/49]).

The sourcing of information and the use of information were evident throughout the pre-flight stage for all participants. The desire to establish firm expectations was paramount. "I want a level of preparedness. There are going to be surprises anyway, but I want to try to anticipate some of those surprises" (TC6/11/10000/49), and "I want to be able to think it through before I go so I can work out what to expect and what I don't know" (TC4/11/9000/51) are reported views concerning the establishment of expectations of the flight. Some level of contingency planning was reported at this stage with 'terrain' an oft-expressed major consideration (e.g., "On the way over I will be thinking about any special procedures that the mountains might require" [TC2/12/7000/52], "Before I leave, I would know where I can go and where I can't on the way" [LC6/10/9200/49]).
The implementation of the plan and the conduct of the actual flight were significant because of the realisation amongst participants that, in this circumstance, cognitive (processing) capacity would be at a premium because the unfamiliar operation would necessitate conscious implementation of the operating plan which had been devised. This aspect was approached through expressions of the preparation which would be attempted. “You have to be ahead of the aeroplane” (TC2/12/7000/52), “Little things build up, but you can eliminate this sort of stress by preparing well” (TC3/12/7000/51) and “Mentally rehearsing the sector tells me where I’ll be short of time so I adjust my plan” (TC1/11/9000/50) outline the types of strategies used to avoid mental overload. One interviewee remarked, “The thing that frees me up is preparation” (LC5/9/6000/47). Realising that, in the circumstances, self-preparation could not be as thorough as might be desirable, the focus on team participation was apparent. For example, the following quote: “Now tell me all the things that I have forgotten and which might come up. Have any of you been to this area before?” (LC4/9/6500/46) was representative of the techniques which these experienced Captains employed to ensure that enough cognitive capacity (thinking capability) was retained to cope with the moment by moment operation when it took place.

This concern for cognitive capacity (to avoid overload) during the operation tended to lead to deliberate pace-setting strategies. References to these pace-setting strategies included: “Keeping the crew in their best roles, in other words, the F/O is the best person to give support” (TC6/11/10000/49), “If you want the crew to slow down, put your feet up and look relaxed. They’ll read that as a sign that the pressure is off” (TC8/10/6000/49) and “Tell the crew that we’ll only go when we’re ready” (TC1/11/9000/50). Time compression (not allowing extra time to complete normal activities) was avoided by strategies such as the loading of additional fuel and organising to be at the airport in Bogota earlier than normal (e.g., “Organise the crew, get to the briefing office or aircraft quite a bit earlier than normal” [LC4/9/6500/46], “We just have to take extra time and extra leeway in every area including fuel ordering to allow for things that normally pan out but on this sector they may not” [TC7/12/8000/50]).

The task demands were clearly prioritised with safety driving the proceedings (e.g., “You want as much information as you can possibly get on the upcoming operation so that you can do it
safely” [LC5/9/6000/47]) . The use of self-checking metacognitive mechanisms was evident at this stage. A comparison between actual and desired states (situation assessment) was reported as important to the satisfactory progress of the flight. Statements like “Keep analysing whether there is anything that you have missed. Check the weather, the fuel, and diversionary airports” (LC7/10/6000/52) were typical of the activities employed to satisfy the need for the actual state to equate to the desired state.

Maintaining a common crew mental model of proceedings was reported as a primary task by all participants (e.g., “Keeping all the crew in the loop in this strange environment is very important. More than ever, everybody must understand every new instruction from ATC” [TC7/12/8000/50]). All interviewees reported the review of in-flight contingency plans (e.g., “I would be very interested in updating weather on the way just in case they get it more wrong than normal and I have to go someplace else” [TC3/12/7000/51], and “The off-route terrain is just as important as the on-route terrain around these places because it is between you and some diversion airfield” [TC4/11/9000/51]). In most cases, an emphasis was placed on addressing this aspect pre-flight (e.g., “Not knowing the route will lead me to develop fallbacks that I don’t already know about, alternate routings, other airports, high ground, expected weather and the like will be considered before I start.” [LC7/10/6000/52]). In some cases, only in-flight consideration was deemed appropriate. One pre-flight approach included “looking for red flags, things like 20,000 foot high mountains or 4,000 foot high airfields” (LC1/1/2500/50).

Fuel jettison times and engine out procedures were also a part of this Captain’s pre-flight routine (i.e., “So, if an engine goes boom and there are multiple problems, I’ve already done my homework on fuel dump times, holding patterns and so forth” [LC1/1/2500/50]. A heightened suspicion of air traffic control instructions and other operators was evidenced by statements like “My two main concerns would be traffic and high ground” (TC6/11/10000/49) and “I would be thinking about air traffic control, their competence, other operators and separation” (LC2/10/5000/49). All of the interviewees employed a continuing process of questioning the status of the flight, the environment and other crew. Typical expressions of this activity included: “I’m always ticking things off in the back of my mind to make sure that there is nothing that I should have done but haven’t” (LC7/10/6000/52), and “If I was down on fuel,
I'd be checking the actual winds against the forecast after I'd done a drag and trim check." (LC6/10/9200/49). These activities were designed to reduce ambiguity and were reported as most important in these unfamiliar circumstances (e.g., "I am always looking for things that don't seem right. You need to put your finger on the reasons for mismatch and fix it quick." [TC1/11/9000/50].

Several interviewees inferred that consultative decision making would be useful throughout this type of flight. For example, "If there's a decision to be made, I'll be making the time to make sure that all the ideas from the crew are considered." (TC4/11/9000/51), and "Good F/Os are capable of saying NO to what you think is best, but you'll probably only hear them say NO if you include them in the decision to start with" (TC1/11/9000/50) demonstrate this preference. The realisation that the expertise for completing the flight successfully lay with the crew as a whole, rather than the Captain was significant. One Captain declared that he would GRADE (consultative decision making algorithm [see p. xvii]) the whole flight (i.e., I use the GRADE process. I GRADE the entire flight" [TC2/12/7000/52]). Another expressed the same sentiment by stating "I would prefer to have a crewmember to bounce things off" (LC3/11/8000/51). All interviewees expressed the opinion that they would find out what the other crewmembers could contribute to the operation, in most cases, at the first meeting (e.g., "I have to know what the other crew know about this operation as soon as possible because I know how much I don't know" [TC8/10/6000/49] and "As part of my standard teambuilding at first meeting, I ask where others have operated and what their experience levels are" [TC1/11/9000/50]).

The review of the flight and crew performance was reported by all participants as important in order to improve the standard of operational knowledge for this sector, both at the crew and organisational levels. Comments like "Pilots are their own worst critics. They're reviewing their performance all the time" (TC2/12/7000/52) and "I always talk to the crew after we actually shutdown and discuss anything we could learn. Something unexpected" (TC6/11/10000/49) support this notion. Personal performance was highlighted as a post-flight consideration with the goal being to improve performance in the future. Statements like "You look back on the sector honestly and work out how you could have made it better" (LC2/10/5000/49) (reflection-on-action) and "Assessing my own standard and how I think I am
going against what I want to do" (TC3/12/7000/51) (reflection-in-action) were representative of the type of comment which was indicative of this activity. Several respondents indicated that they would conduct a crew debriefing at a suitable venue during their stay in the destination city (e.g., "Sometimes I bring up the flight and what we could have done better over a beer after we sign off. It seems less threatening to some people." [TC7/12/8000/50]). These are activities typical of reflective practitioners (Henley, Turney & Schick, 2001; Schön, 1998; Zimmerman, 2000).

7.7 Conclusions

When recurring themes from the interviews were summarised, the resultant construct of management of flight was found to consist of processes aimed at:

- getting to work as self-prepared as possible;
- gathering all of the possible knowledge about the sector and structuring this knowledge;
- building strategies about how to conduct the flight;
- implementing plans and strategies;
- monitoring and adjusting flight progress; and
- assessing personal and crew performance.

These strategies support the notions of mental model development and adjustment raised by research question 7 (Do experienced Captains use an identifiable process to develop mental models of a proposed flight?), research question 8 (What processes do experienced Captains use to adjust these mental models to cope with a changing operational environment?) and research question 9 (How do pilots learn from an aviation experience?) in that they enable the development of mental models of the proposed flight, facilitate change as required by the operational environment, and foster learning from the experience through self-assessment (through critical reflective practices).

The participants who report using these strategies to complete their task also appear to use metacognitive activities such as reflection and self-assessment to control the whole process. Driving the operation towards the best possible conclusion is as much a part of the overall
effort as are the activities identified as part of the management of flight performance construct. The Captains who were interviewed suggested that they rely mainly on themselves to initiate this process. Other crewmembers would be asked to contribute, but because of different levels of experience, the Captain would be the main driving force behind the operation.

This type of self-direction through self-regulation was reported by expert aviators to be highly automated. The perception of the interviewees in this study is that the cognitive processes and actions which support their personalised construct of management of flight performance are largely conducted at the sub-conscious level. "I normally don't have to think about what I'm doing because I've done it many times before" (TC3/12/7000/51) and "Now that I think about it, I don't really think about it on a day-to-day basis except for this sort of exercise perhaps" (TC7/12/8000/49) represent the general thrust of comments on this aspect of task execution. An automated routine has evolved over thousands of hours and hundreds of sectors.

Regardless of the individual rate of assimilation of the specifics of this simulated operation, the process developed appears similar across the individuals who took part in the interviews. Whether consciously engaged or not, each of the interviewees expressed the existence of a personalised performance controlling model for management of flight with common components (as listed on page 137). Variation in this reported model was limited to timing and form rather than intent. For example, some used a written template of the required activities to guide task execution while others relied on a mental representation (e.g., "I will be preparing my little pieces of paper to cover each port before I leave on my next London trip" [LC1/1/2500/50] and "I run through each segment of the flight in my mind before I do it, the take-off as I approach the holding-point and so on" [TC4/11/9000/51]). This variation in strategy use was particularly so with regard to contingency planning (e.g., "I rely on my personal data base, my experience, for my contingency plans. I don't necessarily develop detailed contingency plans before each flight" [TC2/12/7000/52] as opposed to "So, if an engine goes boom and there are multiple problems, I've already done my homework on fuel dump times, holding patterns and so forth" [LC1/1/2500/50]. However, these successful airline Captains control and moderate their management of flight performance by initiating sequential and repeated behaviours, which are expressions of cognitive processes. Unlike Study 1 (where differences in focus with respect to command readiness markers were established between the
training Captain groups), as a result of the analyses of the interviews in the present research, no appreciable differences in strategies were detected between line Captains and training Captains in this study.
CHAPTER 8

Study 4: Establishing a construct for management of flight performance

8.1 Introduction

In Study 3, the recurring themes (that described the approach of experienced airline Captains to the task of managing a flight between city pairs where they had never operated) were reported. These themes (self-preparation, knowledge gathering, plan and strategy building, implementation of plans and strategies, monitoring progress and performance assessment) identify broad areas of focus for pilots trying to structure an approach to an unfamiliar task. However, the research has not so far detailed the perceived cognitive processes or actions which might be associated with each focus area. While some attempt has been made to identify individual behaviours which will enhance pilot performance in the past (Flin & Martin, 1998), the use of an umbrella construct has not been achieved to organise performance-enhancing activities, such as those provided by the themes identified in Study 4. Across the industry, phase of flight (take-off, climb, cruise, descent, approach and landing) is the only organising division of activity, which has been used.

The goal of Study 4 was to examine the types of activities that would define the management of flight aspects of pilot performance by expanding on the themes identified in Study 3. Further, the organisation of these activities using the recurring
themes identified in Study 3 was also proposed. To achieve these goals, there were several progressive components to Study 4. The components of this study will be treated as separate stages for the purpose of reporting. The components of this study were:

1. the inductive development of actions statements to define management of flight aspects of pilot performance;
2. the use of these action statements to develop a questionnaire; and
3. the distribution and collection of the questionnaire and the analysis of data obtained from the questionnaires that were returned.

This process of development and data collection was consistent with the research model which was established (see Figure 8.1) through an examination of the research environment and suitable research methodologies (see Chapter 4). The strength of this model hinged on the opportunity which it generated for the participants to influence the shape of the final outcome.

Figure 8.1 - Model of the overall research process
Consistent with the processes outlined in Figure 8.1, the initial task was to establish, through further data collection and inductive analysis, amplifiers for the recurring themes identified in Study 3. So far in this research project, several data collection procedures, analyses, interpretations, presentations and reviews by participants have been conducted. That process has rendered recurring themes of activity which warranted further investigation. These recurring themes were:

- getting to work as self-prepared as possible;
- gathering all possible knowledge about the sector and structuring this knowledge;
- building strategies about how to conduct the flight;
- implementing plans and strategies;
- monitoring and adjusting flight progress (an indication of reflection-in-action);
- and
- assessing personal and crew performance (and indication of reflection-on-action).

8.2 Component 1 - The development of the activity statements

8.2.1 Aim

The aim of this first component of Study 4 was to produce activity statements that expanded on the themes identified in Study 3.

8.2.2 Participants

Compared to previous studies, Study 4 involved a greater commitment of participant’s time. Consequently, the support of the airline’s management for the study was sought and, subsequently, obtained. Once this support had been obtained, a focus group was established which included a pilot union representative, and an organisational management representative, with the researcher as chairperson. Eleven training management captains, two pilot union representatives and fifty randomly selected training captains also participated by providing input to the development process.
8.2.3 Procedure

Initially (at the direction of the focus group), the principal researcher produced a discussion paper (see Appendix G). This discussion paper was derived from many sources. The previous studies (Studies 1, 2, & 3), literature on the topic (e.g., Westrum, 1995; McKnight, 1992) and training courses used by the airline of study (i.e., CRM awareness training) provided the information used to create this discussion paper. The discussion paper was vetted by the focus group members and circulated to all of the 63 participants. Since this discussion paper proposed an expanded view on the topic of management of flight, verbal feedback was solicited by focus group members from a sample of participants. Individual interviews were arranged to facilitate the feedback process. This feedback was sought in order to give an indication as to whether the development of a definition of management of flight had value and should proceed in the direction that the discussion paper proposed. The focus group members then considered the verbal feedback that had been received and to amplify the recurring themes from Study 3 into activity statements. The results of studies 1, 2, and 3 were also used as source material at the first and subsequent meetings of the focus group.

8.2.4 Results and Discussion

The discussion paper generated a great deal of interest in the topic of defining the management of flight aspects of pilot performance without focusing thinking along the lines of the recurring themes that were previously identified. This process provided the focus group with a wider view from which to start deliberations. A total of 27 verbal responses were recorded. Only 4 responses indicated any reservations about the value of proceeding with this development. The 23 positive responses included comments such as: "We need something more than we have now. Let's see where it leads." (TMC4); "I've never looked at management like this before. It makes sense." (TC39); "Having something like this will make it easier for me to teach management." (TC14); and "It would have to be more organised and easier to digest, but it's worth doing." (TC23). All of the four negative comments indicated doubt as to whether the complex topic of management of flight could be reduced to a standardised, yet simple form. In general, the comment "Trying to detail exactly how
we should manage could be very counter productive. We all do it a slightly different way, yet the job gets done." (TC24) summarises the negative sentiment.

The outcome of the first focus group meeting was a comprehensive list of 99 personal activity statements which were produced by inductive analysis (see Appendix H). This list was a distillation of 367 activities (subsequently referred to as items) that resulted from a brainstorming and a review of the data relating to each recurring theme. The records of interview of the 15 experienced captains from Study 4 provided most of the originating ideas for this list. The items were assembled under subheadings derived from the recurring themes (i.e., the notions of self-regulation identified in Study 3) that the group reviewed. The result was a representation of the management of flight aspects of pilot performance which might be seen to be both sequential and cyclical.

In the case of the least complicated and straight-forward flight imaginable, the pilot would not be required to adjust the original approach to the task. The process can be viewed as sequential. As indicated by participants in Study 3, when new, missing or updated information comes to hand, the process becomes cyclical, since the operator will be obliged to revisit some activities (e.g., clarifying information, changing tactics and revising strategies) numerous times to achieve the goal. The dynamic nature of the operating environment indicates that, in most circumstances, a cyclical approach to a task would need to be adopted. This cyclical approach was influential in the development of the action statement questionnaire.

8.3 Component 2 - Development of an action statement questionnaire describing the management of flight function

8.3.1 Aim

The aim of the second component of Study 4 was to develop a questionnaire from the activity statements identified in the first component of Study 4. The questionnaire format was considered by the focus group convened in the first component of Study 4 to be the most practical way of eliciting feedback on the action statements from a large sample of the Captain population at the airline of study.
8.3.2 Participants

Initially, a total of 18 subject matter experts (SMEs) participated in this second component of the Study 4. These participants were identified from performance records detailing their perceived expertise as training Captains. The focus group members from the first component of Study 4 also participated in a second phase of the second component of the study.

8.3.3 Procedure

The initial step in this component of Study 4 was to develop a purposive sampling with the view to clarifying the activity statements where required. Purposive sampling was chosen to ensure that meaningful feedback was received from a group of interested SMEs. In the first instance, 23 SMEs were asked to consider the underlying construct of management of flight (i.e., elements of self-regulation). That is, the SMEs were asked whether the themes of self-preparation, knowledge gathering, planning, strategy building, implementation of plans and strategies, checking flight progress and self-assessment appropriately defined the management of flight task (see Appendix H). Since only an indication of disagreement or agreement was sought from this purposive sampling, a four point Likert scale was used for them to indicate their view.

Respondents to this purposive sampling were also asked to indicate how the proposed activity statements, which expanded each theme, should be modified to better reflect the activities required for successful management of flight by Captains. This process called for the deletion and addition of activity statements where required. Respondents were also asked to identify the six most important activity statements in their finalised list (see Appendix H). The focus group members from the first component of Study 4 then reviewed the feedback from this process with the view to finalising the action statement questionnaire intended for wider distribution.
8.3.4 Results

Of the 18 participants who provided input on the action statement list, only 11 responded to the initial issue of construct applicability. Table 8.1 details the distribution of the responses. Even though the sample size was small, it appeared that there was more perceived agreement than there was disagreement with the proposed construct of management of flight within this group of respondents. The SMEs who did not respond to this question did not indicate any required changes to the underlying construct in their written amendments.

Table 8.1
SME Responses to the Appropriateness of the Proposed Management of Flight Construct

<table>
<thead>
<tr>
<th>Scale</th>
<th>Strongly disagree</th>
<th>Slightly disagree</th>
<th>Slightly Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Responses</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

With reference to the task of refining the activity statements, there were many rewording suggestions, but there were very few definite rejections of proposed activity statements. In all, only one statement was rejected by a majority of respondents ('I use a comprehensive matrix to develop my operating plan') (see Appendix H).

Some of the qualitative comment that were received from respondents included:

- "We probably need to do all of these things, but the number is overwhelming." (SME 11);
• “Is there any way of making sure that the important things get done first?” (SME 6);
• “I don’t understand what all of these statements mean. They need to be more practical!” (SME 14);
• “You seem to be saying the same thing many times.” (SME 5);
• “Some of these statements are so obvious that I question the need to state them at all.” (SME 17);
• “Why inflict this detail on everybody when only a few need this type of detailed training?” (SME 12); and
• “Some of these statements could be grouped under headings like leadership and communications.” (SME 9).

With the exception of the last comment (which was a sentiment expressed by only two respondents), these qualitative comments were taken into consideration by the focus group when developing the revised list of activity statements (see Appendix H). Further, a reduced list of 40 action statements was produced by the focus group (see Appendix I and Questions 15 through 54 of Appendix K) by examining the intent of the original 99 activities (from Component I of Study 4) using the criteria of similarity, association, purpose and perceived importance as solicited in the questionnaire instructions (i.e., number the six most important statements in each section). Since an important practical application of a more comprehensive definition of the management of flight aspects of pilot performance would focus on the training of potential Captains, the 40 action statements were presented as a routine for the development of management of flight skills by novice airline pilots. As previously established, this management of flight area of pilot performance generates most angst amongst trainee Captains because, until now, it has not been clearly defined.

In addition to the 40 action statements, the focus group produced a number of considerations regarding Captains’ attitudes to the way in which First Officers managed flights under supervision (see Questions 1 through 14 of Appendix K). The results of Study 1 indicated that the most supported markers of suitability for command (as perceived by training Captains) were manipulative skills, situational awareness, communication skills, technical knowledge, support of crew, ability to
prioritise, preparation, command presence, overview maintenance, and self-confidence (see Table 5.9).

The view of the focus group was that the perceptions of line Captains (who were the target population in the third component of Study 4) regarding aspects of some of the most supported non-technical markers from Study 1 (see Table 5.9) should be sought. The contention was that line Captain perceptions might provide an indication of the practices perceived to contribute most to competent management of flight by First Officers. The focus group members felt that if a few key indicators used by Captains to assess First Officer management of flight competence could be identified, a method of providing targeted feedback more quickly to First Officers might be possible.

8.3.5 Discussion

The second component of Study 4 produced a composite list of activity statements, which were associated with the recurring themes from Study 3. This information was initially presented for consideration by 23 SMEs (see Appendix H). The scope of the topic of flight management presented some difficulty for succinct, yet comprehensive presentation in the written form. This presented some difficulty in the reduction of the 99 activity statements (see Appendix H) into the 40 action statements (see Appendix I).

The 40 action statements (see Appendix I) were derived from a list of 99 activity statements (see Appendix H). The 99 activity statements were derived from 367 items (contained in Appendix L, and which resulted from a brainstorming of the activities associated with the themes identified in Study 3 plus the qualitative output of Studies 1 through 3). Therefore, it is not surprising that meeting the expressed need of the SMEs to produce a reduced number of action statements, while maintaining the intent of a much larger number of activity statements, was a difficult task. However, the focus group was satisfied that the intent and the form of the revised questionnaire were consistent with aim of the final part of Study 5.

With regard to Questions 1 through 14 (of Appendix K), this section of the questionnaire sought to establish the perceptions of Captains about aspects of
management of flight that are perceived to contribute to good performance by First Officers in flight management. In particular, perceptions about the contribution that the two facets of SA, tactical and the strategic, make to overall management of flight expertise in First Officers were canvassed. Further, the perception of respondents in Study 1 was that SA was the most useful non-technical marker in assessing command readiness. Consequently, the focus group decided to include a question regarding the levels of SA maintained by the crews of other carriers so that the perceptions of Captains at the airline of study about the SA demonstrated by the crews of other airlines could be gained (Q6: Do aircrew of other airlines exhibit a lack of localised SA often?). Anecdotally, pilots at the airline of study perceive that, generally, they demonstrate better SA than some crews in other carriers. This perception seems to be based upon episodes of some crews of other carriers requesting climbs or descents through levels occupied by other aircraft in close proximity, indicating an apparent lack of SA.

8.3.6 Conclusion

By seeking feedback from SMEs and by processing the feedback from these SMEs through a focus group, it was possible to construct a questionnaire on aspects of management of flight that was acceptable in both length and detail. Further, the focus group considered this revised questionnaire useable to fulfil the aim of the last component of Study 4 (i.e., the collection and analysis of data using the revised questionnaire).

8.4 Component 3 - Administration of the action statement questionnaire and analysis of the collected data

8.4.1 Aim

The development of the action statement questionnaire describing the management of flight function was completed using the experience, perceptions, and input of training Captains. Prior to this component of Study 4, the perceptions of line Captains regarding management of flight had not been canvassed. Therefore, the aim of this final part of Study 4 was to administer the action statement questionnaire describing
the management of flight function to a representative group of line Captains at the airline of study and to analyse the data to determine the levels of support by the Captain respondents for the proposals contained within the questionnaire.

8.4.2 Participants

The questionnaire describing the management of flight function of Captain performance was distributed to 317 randomly selected line Captains. The random selection of participants was achieved by applying an independently nominated factor of between 1 and 10 to advance progress down the alphabetical list of prospective respondents. The process was repeated until 317 (approximately 50% of the Captain cohort) current Captains on all types were identified. One hundred and seventy (170) responses were received. However, random selection did not guarantee a cross-section of experience or type. The characteristics of the sample of those Captains who responded are outlined in Table 8.2 and Table 8.3.

Table 8.2
Frequency of Captain Respondents by Command Experience (X 1000 hours)

<table>
<thead>
<tr>
<th>Command experience (X1000 hours)</th>
<th>Number of Captains</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1</td>
<td>7</td>
</tr>
<tr>
<td>1 – 2</td>
<td>18</td>
</tr>
<tr>
<td>2 – 3</td>
<td>16</td>
</tr>
<tr>
<td>3 – 4</td>
<td>9</td>
</tr>
<tr>
<td>4 – 5</td>
<td>18</td>
</tr>
<tr>
<td>5 – 6</td>
<td>22</td>
</tr>
<tr>
<td>6 – 7</td>
<td>25</td>
</tr>
<tr>
<td>7 – 8</td>
<td>16</td>
</tr>
<tr>
<td>8 – 9</td>
<td>7</td>
</tr>
<tr>
<td>9 – 10</td>
<td>10</td>
</tr>
<tr>
<td>&gt; 10</td>
<td>13</td>
</tr>
<tr>
<td>Experience not indicated</td>
<td>9</td>
</tr>
<tr>
<td>TOTAL</td>
<td>170</td>
</tr>
</tbody>
</table>
Table 8.3

Frequency of Captain Respondents by Operated Aircraft Type

<table>
<thead>
<tr>
<th>Aircraft type</th>
<th>Number of Captain respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>B767</td>
<td>51</td>
</tr>
<tr>
<td>B747-2/3</td>
<td>27</td>
</tr>
<tr>
<td>B737</td>
<td>33</td>
</tr>
<tr>
<td>B747-4</td>
<td>46</td>
</tr>
<tr>
<td>Type not indicated</td>
<td>13</td>
</tr>
<tr>
<td>TOTAL</td>
<td>170</td>
</tr>
</tbody>
</table>

8.4.3 Materials

Paper copies of the questionnaire were produced for distribution to potential respondents. The internal mail system at the airline of study was used to facilitate the distribution and collection of the questionnaires.

8.4.4 Procedure

A personalised letter, signed by both the chief pilot and the president of the pilot union, was sent with each questionnaire (see Appendix J). This letter demonstrated support from both the Flight Operations management personnel and the labour organisation representing the potential respondents. Once the responses had been received, the data were recorded on an SPSS database.

Relationships between Q14 (Can First Officers manage without intervention when they are pilot flying?) and Questions 3 (Does a flat cockpit gradient contribute significantly to safety?), 4 (Can poor SA cause poor management of flight?), 5 (Are there localised and overview aspects to SA?), 7 (Do First Officers generally have good localised SA?), 8 (Are First Officers prone to lose sight of the big picture?), 10 (Do younger pilots rely on technology for safety?), 11 (Do inexperienced pilots rely
on SOPs to manage?), 12 (Are First Officers generally organised and structured in their approach to sector flying?), and 13 (Do First Officers ask for critique on their management of flight performance?) (see Appendix K) were assessed using Spearman’s rank correlations (Steel & Torrie, 1960).

Questions 15 to 54 (of Appendix K) were dealt with in a different fashion. A reliability analysis was conducted using Cronbach’s alpha to assess consistency in the variation of responses over Q15 to Q54. The function was applied to each segment (i.e., preparation, planning, strategies, implementation, monitoring progress, and self-assessment) of Q15 to Q54 (see Table 8.5). Agreement with each action statement was then assessed to determine which action statements were perceived to contribute to the description of the management of flight function proposed by the questionnaire.

To achieve this agreement assessment, the retrieved scores were coded 1 through 7 in synchronisation with the contextual scoring block used by respondents (see Appendix K) (i.e., 1 = 1, 1+ = 2, 2 = 3, 2+ = 4, 3 = 5, 3+ = 6, 4 = 7). This scoring block is used in all assessment of technical aircrew within the airline of study. A score of 1 equates to poor performance and a score of 4 signifies a high standard of performance. The conversion of the scores was done to facilitate data processing since the plus and the minus signs used in the contextual scoring block presented processing problems.

A frequency count was then conducted in the first instance to determine the relative level of agreement for each question (ranking for any agreement is reported in Table 8.6). In this second instance, the responses were collapsed so that the questions were able to ranked by the number of Captains who recorded high agreement. The ranking by question number which resulted from this process is reported in Table 8.7. This ranking was designed to provide a more meaningful reflection of participant perceptions of the most frequently used activities.

8.4.4 Results

The relationships between questions 3 to 14 (Spearman’s rank correlation) are presented in Table 8.4. Q7 (r (167) = .35, p<0.001), Q8 (r (166) = -.35, p<0.001), Q12 (r (167) = .41, p<0.001) and Q13 (r (167) = .27, p<0.001) all have significant
associations with the response to question 14 (see Appendix K). The correlations between the response to questions 7, 12 and 13 and the response to question 14 are positive. That is, Captains who perceive that First Officers can manage without intervention when they are pilot flying (Q14) also perceive that First Officers have good localised SA (Q7), are generally organised and structured in their approach to sector flying (Q12), and ask for critique of their management of flight performance (Q13).

There is a significant positive relationship between Q7 and Q12 and Q13 (r (167) = .45, p<0.001 & r (167) = .20, p = 0.009 respectively) as might be expected from the established positive correlation between these questions and Q14. There is a significant (r (166) = -.21, p = 0.005) negative correlation between Q7 and Q8. Since Q8 was written in the negative, the ability to maintain localised SA and keep sight of the ‘big picture’ are positively related (see Appendix K). The negative correlation between the response to Q8 and the response to Q14 suggests that Captains who perceive that First Officers can manage without intervention when they are pilot flying (Q14) also perceive that First Officers are not prone to lose sight of the ‘big picture’ (Q8).

Table 8.4
Summary of Rank Correlation between Variable in Questions 3, 4, 5, 7, 8, 10, 11, 12, 13, and 14. (167≤N≤170 in all cases)

<table>
<thead>
<tr>
<th></th>
<th>Q3</th>
<th>Q4</th>
<th>Q5</th>
<th>Q6</th>
<th>Q7</th>
<th>Q8</th>
<th>Q9</th>
<th>Q10</th>
<th>Q11</th>
<th>Q12</th>
<th>Q13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q3</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q4</td>
<td>0.20*</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q5</td>
<td>0.18*</td>
<td>0.36**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q6</td>
<td>-0.01</td>
<td>0.15</td>
<td>0.19*</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q7</td>
<td>0.06</td>
<td>0.04</td>
<td>0.04</td>
<td>0.02</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q8</td>
<td>0.16*</td>
<td>0.12</td>
<td>0.19*</td>
<td>0.24*</td>
<td>-0.21*</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q9</td>
<td>0.25*</td>
<td>0.03</td>
<td>0.18*</td>
<td>-0.01</td>
<td>0.03</td>
<td>0.13</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q10</td>
<td>0.00</td>
<td>0.13</td>
<td>0.22*</td>
<td>0.08</td>
<td>-0.11</td>
<td>0.27**</td>
<td>0.07</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q11</td>
<td>0.07</td>
<td>0.04</td>
<td>0.07</td>
<td>0.08</td>
<td>0.09</td>
<td>0.13</td>
<td>0.01</td>
<td>0.24*</td>
<td>--</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q12</td>
<td>0.00</td>
<td>-0.05</td>
<td>0.02</td>
<td>-0.01</td>
<td>0.45**</td>
<td>-0.24*</td>
<td>-0.02</td>
<td>-0.09</td>
<td>0.07</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Q13</td>
<td>-0.02</td>
<td>-0.05</td>
<td>0.13</td>
<td>0.08</td>
<td>0.20*</td>
<td>-0.17*</td>
<td>-0.01</td>
<td>-0.13</td>
<td>-0.09</td>
<td>0.18*</td>
<td>--</td>
</tr>
<tr>
<td>Q14</td>
<td>0.03</td>
<td>-0.05</td>
<td>0.06</td>
<td>-0.13</td>
<td>0.35**</td>
<td>-0.35**</td>
<td>0.04</td>
<td>-0.07</td>
<td>0.03</td>
<td>0.41**</td>
<td>0.27**</td>
</tr>
</tbody>
</table>

* <.05; ** <.001
There is a significant \((r(167) = .36, p<0.001)\) positive relationship between Q4 (poor SA can cause poor management of flight) and Q5 (there are localised and overview aspects to SA). Captains who perceive that poor SA can cause poor management of flight also perceive that there are localised and overview aspects to SA. In addition, there is a significant positive relationship between Q8 (First Officers are prone to lose sight of the ‘big picture’) and Q5 (there are localised and overview aspects to SA) \((r(166) = .19, p = 0.014)\). Captains who perceive that First Officers are prone to lose sight of the big picture also perceive that there are localised and overview aspects to SA.

No relationship appears to exist between Q7 (First Officers generally have good localised SA) and Q5 (there are localised and overview aspects to SA) \((r(167) = .021, p = 0.789)\). Furthermore, there is no relationship evident between hours (experience) and endorsed type of aircraft and questions 14 (First Officers can manage without intervention when they are pilot flying), 7 (First Officers generally have good localised SA) or 8 (First Officers are prone to lose sight of the ‘big picture’). The variable ‘type’ has a significant correlation only with Q5 (there are localised and overview aspects to SA) and Q11 (inexperienced pilots rely on SOPs to manage) (see Appendix K), while there was no relationship between any of Q1 through Q14 and ‘hours’ (experience). The results of the Cronbach’s \(\alpha\) analysis of the questionnaire segments are reported in Table 8.5.

### Table 8.5

**Reliability Analysis of Responses to Questionnaire Sections using Cronbach’s \(\alpha\)**

<table>
<thead>
<tr>
<th>Questionnaire segment</th>
<th>Cronbach’s (\alpha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q15 – Q18 (preparation)</td>
<td>.7167</td>
</tr>
<tr>
<td>Q19 – Q24 (planning)</td>
<td>.8247</td>
</tr>
<tr>
<td>Q25 – Q30 (strategies)</td>
<td>.8547</td>
</tr>
<tr>
<td>Q31 – Q42 (implementation)</td>
<td>.8180</td>
</tr>
<tr>
<td>Q43 – Q50 (monitoring progress)</td>
<td>.8575</td>
</tr>
<tr>
<td>Q51 – Q54 (self-assessment)</td>
<td>.8085</td>
</tr>
</tbody>
</table>
The results of the frequency count of any agreement and higher agreement for questions 15 through 54 are reported in Table 8.6 and Table 8.7 respectively. The questions have been recorded in descending order of the number of respondents indicating agreement (Table 8.6) and higher agreement (Table 8.7).

Table 8.6

<table>
<thead>
<tr>
<th>Question</th>
<th>n in disagreement or neutral</th>
<th>n in agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q28 (managing workload for all crew by delegating, setting the right pace, resisting pressure)</td>
<td>0</td>
<td>169</td>
</tr>
<tr>
<td>Q45 (maintaining tactical situation awareness of other traffic, weather, air traffic workload etc)</td>
<td>0</td>
<td>169</td>
</tr>
<tr>
<td>Q18 (having the book knowledge required for command)</td>
<td>1</td>
<td>169</td>
</tr>
<tr>
<td>Q46 (maintaining a strategic overview to ensure flight goals are met)</td>
<td>1</td>
<td>167</td>
</tr>
<tr>
<td>Q27 (developing alternatives to cover things that may not go to plan [e.g., altitude blockages])</td>
<td>2</td>
<td>167</td>
</tr>
<tr>
<td>Q51 (regularly reviewing all aspects of their performance)</td>
<td>2</td>
<td>167</td>
</tr>
<tr>
<td>Q53 (acting on self-feedback to modify attitudes, processing and actions)</td>
<td>2</td>
<td>167</td>
</tr>
<tr>
<td>Q19 (gathering all possible knowledge &amp; intelligence about each sector)</td>
<td>3</td>
<td>167</td>
</tr>
<tr>
<td>Q37 (informing passengers in an open and honest way)</td>
<td>2</td>
<td>166</td>
</tr>
<tr>
<td>Q38 (maintaining an atmosphere of safety and security for all on board)</td>
<td>2</td>
<td>166</td>
</tr>
<tr>
<td>Q43 (frequently checking what is happening &amp; comparing that to what should be happening)</td>
<td>2</td>
<td>166</td>
</tr>
<tr>
<td>Q48 (reviewing contingency plans as they become operationally usable)</td>
<td>2</td>
<td>165</td>
</tr>
<tr>
<td>Q34 (recognising, harnessing &amp; praising superior knowledge &amp; expertise in other crewmembers)</td>
<td>3</td>
<td>165</td>
</tr>
<tr>
<td>Q47 (noting events, asking questions if uncertain, developing tactics &amp; changing strategies)</td>
<td>4</td>
<td>164</td>
</tr>
<tr>
<td>Q52 (generating accurate and honest feedback for themselves)</td>
<td>5</td>
<td>164</td>
</tr>
<tr>
<td>Q42 (accepting responsibility for driving the flight to the most successful conclusion possible)</td>
<td>4</td>
<td>163</td>
</tr>
<tr>
<td>Q23 (using safety, passenger comfort, schedule &amp; efficiency criteria to guide their planning)</td>
<td>5</td>
<td>163</td>
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</table>
Table 8.6
Questions 15-54 of Appendix K Ranked by Number in Any Agreement (cont’d.)

<table>
<thead>
<tr>
<th>Question</th>
<th>n in disagreement or neutral</th>
<th>n in agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q29 (acknowledging their own strengths &amp; weaknesses &amp; using resources accordingly)</td>
<td>6</td>
<td>163</td>
</tr>
<tr>
<td>Q31 (modifying expectations as current information is acquired &amp; following revised plan)</td>
<td>6</td>
<td>163</td>
</tr>
<tr>
<td>Q15 (having their own life in order with stress levels low enough to maximise learning)</td>
<td>7</td>
<td>163</td>
</tr>
<tr>
<td>Q20 (structuring sector information in a useful way like phase of flight)</td>
<td>7</td>
<td>163</td>
</tr>
<tr>
<td>Q22 (develop useful “what if” scenarios for each sector)</td>
<td>6</td>
<td>163</td>
</tr>
<tr>
<td>Q17 (consciously developing a good understanding of the goals of airline command)</td>
<td>7</td>
<td>162</td>
</tr>
<tr>
<td>Q21 (establishing expectations of the flight to minimise surprises)</td>
<td>8</td>
<td>161</td>
</tr>
<tr>
<td>Q32 (inviting input from crew at first meeting and resolving to give input proper consideration)</td>
<td>8</td>
<td>161</td>
</tr>
<tr>
<td>Q33 (communicating detail to all crew to ensure that all crew have the same expectation)</td>
<td>8</td>
<td>161</td>
</tr>
<tr>
<td>Q36 (recognising &amp; managing conflict within the crew &amp; assertive behaviour by crew members)</td>
<td>7</td>
<td>160</td>
</tr>
<tr>
<td>Q25 (devising actions to manage finite resources like fuel, pre flight time, duty hours etc)</td>
<td>10</td>
<td>159</td>
</tr>
<tr>
<td>Q16 (checking motivational &amp; energy levels (in particular for commencing command training))</td>
<td>11</td>
<td>158</td>
</tr>
<tr>
<td>Q26 (having turbulence and delay management plans which optimise comfort &amp; safety)</td>
<td>13</td>
<td>156</td>
</tr>
<tr>
<td>Q54 (asking for feedback from others when self-assessment doesn’t provide the answers)</td>
<td>13</td>
<td>156</td>
</tr>
<tr>
<td>Q40 (seeking coaching where a need is perceived and timing permits)</td>
<td>14</td>
<td>153</td>
</tr>
<tr>
<td>Q30 (having an error recognition and management strategy)</td>
<td>16</td>
<td>152</td>
</tr>
<tr>
<td>Q44 (initially treating all perceived information as if it could have an impact on the flight)</td>
<td>17</td>
<td>151</td>
</tr>
<tr>
<td>Q41 (avoiding the use of information as power)</td>
<td>18</td>
<td>150</td>
</tr>
<tr>
<td>Q49 (trapping, owning and managing error)</td>
<td>16</td>
<td>149</td>
</tr>
<tr>
<td>Q39 (trying to recover failures in customer expectation delivery)</td>
<td>19</td>
<td>148</td>
</tr>
<tr>
<td>Q35 (using a thorough consultative decision making process)</td>
<td>19</td>
<td>147</td>
</tr>
<tr>
<td>Q24 (rehearsing the sector before going to work)</td>
<td>23</td>
<td>147</td>
</tr>
<tr>
<td>Q50 (continuously questioning self, the status of the flight &amp; others to uncover discrepancy)</td>
<td>24</td>
<td>144</td>
</tr>
</tbody>
</table>
Table 8.7

Questions 15 to 54 of Appendix K Ranked by Frequency of Higher Agreement

<table>
<thead>
<tr>
<th>Question</th>
<th>n in slight agreement, neutral or any disagreement</th>
<th>n in agreement and strong agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q45 (maintaining tactical situation awareness of other traffic, weather, air traffic workload etc)</td>
<td>6</td>
<td>163</td>
</tr>
<tr>
<td>Q19 (gathering all possible knowledge &amp; intelligence about each sector)</td>
<td>6</td>
<td>163</td>
</tr>
<tr>
<td>Q18 (having the book knowledge required for command)</td>
<td>7</td>
<td>162</td>
</tr>
<tr>
<td>Q38 (maintaining an atmosphere of safety and security for all on board)</td>
<td>7</td>
<td>161</td>
</tr>
<tr>
<td>Q43 (frequently checking what is happening &amp; comparing that to what should be happening)</td>
<td>9</td>
<td>159</td>
</tr>
<tr>
<td>Q42 (accepting responsibility for driving the flight to the most successful conclusion possible)</td>
<td>10</td>
<td>157</td>
</tr>
<tr>
<td>Q46 (maintaining a strategic overview to ensure flight goals are met)</td>
<td>13</td>
<td>155</td>
</tr>
<tr>
<td>Q29 (acknowledging their own strengths &amp; weaknesses &amp; using resources accordingly)</td>
<td>14</td>
<td>155</td>
</tr>
<tr>
<td>Q51 (regularly reviewing all aspects of their performance)</td>
<td>14</td>
<td>155</td>
</tr>
<tr>
<td>Q47 (noting events, asking questions if uncertain, developing tactics &amp; changing strategies)</td>
<td>14</td>
<td>154</td>
</tr>
<tr>
<td>Q28 (managing workload for all crew by delegating, setting the right pace, resisting pressure)</td>
<td>15</td>
<td>154</td>
</tr>
<tr>
<td>Q27 (developing alternatives to cover things that may not go to plan [e.g., altitude blockages])</td>
<td>22</td>
<td>147</td>
</tr>
<tr>
<td>Q15 (having their own life in order with stress levels low enough to maximise learning)</td>
<td>22</td>
<td>147</td>
</tr>
<tr>
<td>Q48 (reviewing contingency plans as they become operationally usable)</td>
<td>21</td>
<td>146</td>
</tr>
<tr>
<td>Q34 (recognising, harnessing &amp; praising superior knowledge &amp; expertise in other crewmembers)</td>
<td>22</td>
<td>146</td>
</tr>
<tr>
<td>Q52 (generating accurate and honest feedback for themselves)</td>
<td>25</td>
<td>144</td>
</tr>
<tr>
<td>Q53 (generating accurate and honest feedback for themselves)</td>
<td>25</td>
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</tr>
<tr>
<td>Q20 (structuring sector information in a useful way like phase of flight)</td>
<td>25</td>
<td>144</td>
</tr>
<tr>
<td>Question</td>
<td>n in slight agreement, neutral or any disagreement</td>
<td>n in agreement and strong agreement</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>----------------------------------------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>Q37 (informing passengers in an open and honest way)</td>
<td>25</td>
<td>143</td>
</tr>
<tr>
<td>Q31 (modifying expectations as current information is acquired &amp; following revised plan)</td>
<td>27</td>
<td>142</td>
</tr>
<tr>
<td>Q23 (using safety, passenger comfort, schedule &amp; efficiency criteria to guide their planning)</td>
<td>28</td>
<td>140</td>
</tr>
<tr>
<td>Q16 (checking motivational &amp; energy levels ([in particular for command training]))</td>
<td>29</td>
<td>140</td>
</tr>
<tr>
<td>Q17 (consciously developing a good understanding of the goals of airline command)</td>
<td>30</td>
<td>139</td>
</tr>
<tr>
<td>Q36 (recognising &amp; managing conflict within the crew &amp; assertive behaviour by crew members)</td>
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<td>137</td>
</tr>
<tr>
<td>Q30 (having an error recognition and management strategy)</td>
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<tr>
<td>Q32 (inviting input from crew at first meeting and resolving to give input proper consideration)</td>
<td>32</td>
<td>137</td>
</tr>
<tr>
<td>Q21 (establishing expectations of the flight to minimise surprises)</td>
<td>34</td>
<td>135</td>
</tr>
<tr>
<td>Q54 (asking for feedback from others when self-assessment doesn’t provide the answers)</td>
<td>35</td>
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<tr>
<td>Q22 (develop useful “what if” scenarios for each sector)</td>
<td>35</td>
<td>134</td>
</tr>
<tr>
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<td>37</td>
<td>132</td>
</tr>
<tr>
<td>Q49 (trapping, owning and managing error)</td>
<td>35</td>
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<td>Q25 (devising actions to manage finite resources like fuel, pre flight time, duty hours etc)</td>
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<td>130</td>
</tr>
<tr>
<td>Q41 (avoiding the use of information as power)</td>
<td>40</td>
<td>128</td>
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<tr>
<td>Q40 (seeking coaching where a need is perceived and timing permits)</td>
<td>44</td>
<td>123</td>
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<tr>
<td>Q44 (initially treating all perceived information as if it could have an impact on the flight)</td>
<td>50</td>
<td>118</td>
</tr>
<tr>
<td>Q26 (having turbulence and delay management plans which optimise safety and comfort)</td>
<td>51</td>
<td>118</td>
</tr>
<tr>
<td>Q35 (using a thorough consultative decision making process)</td>
<td>52</td>
<td>114</td>
</tr>
<tr>
<td>Q24 (rehearsing the sector before going to work)</td>
<td>57</td>
<td>112</td>
</tr>
<tr>
<td>Q50 (continuously questioning self, the status of the flight &amp; others to uncover discrepancy)</td>
<td>57</td>
<td>111</td>
</tr>
<tr>
<td>Q39 (trying to recover failures in customer expectation delivery)</td>
<td>65</td>
<td>102</td>
</tr>
</tbody>
</table>
8.4.6 Discussion

With regard to the results of inquiry about the ability of First Officers to manage without intervention, there are some indications of the perceived reasons for good performance. Participants who responded positively to the question pertaining to the First Officers’ ability to manage the flight without intervention also responded positively to the question about First Officers’ localised SA. These respondents also responded negatively to the question pertaining to the proneness of First Officers to lose sight of the ‘big picture’. This suggests that a relationship exists between perceptions of First Officers’ ability to manage the flight and perceptions of their localised SA and propensity to lose sight of the ‘big picture’.

The variable ‘type of aircraft’ was found to have a significant correlation only with Q5 (there are localised and overview aspects to SA) ($r (154) = .21, p = .01$) and Q11 ($r (154) = .16, p = .05$) (inexperienced pilots rely on SOPs to manage). In broad terms, at the time that the research was conducted, the ‘type of aircraft’ within this carrier defined operational boundaries, with the shorter range B737 generally being restricted to domestic routes while other types were operated on both domestic and long-range international routes. The correlation between ‘type of aircraft’ and Q5 and Q11 mentioned above would seem to indicate that further research is required to explore the possible associations between ‘type’ and the perceptions about the localised and overview aspects of SA combined with the way that younger pilots tend to use SOPs to manage flights.

With respect to perceptions about the levels of SA maintained by the crews of other carriers (Q6), there was very little outright disagreement ($n = 13$) and considerable higher level agreement with the statement (Agree: $n = 52$ & Strongly Agree: $n = 25$). This would seem to indicate that, of those participants who responded, most perceived that the statement was valid (i.e., lack of localised SA is often demonstrated by aircrew in other airlines). Qualitative comment supports the contention that awareness of proximate traffic demonstrated by other airlines’ crews is the main reason for this perception (e.g., “Airline X tried to get a clearance through our level with only one minute separation over Delhi” (LC87) and “You have to watch out for airline Y, they don’t listen out for other traffic” (LC139).
When the responses to Q15 to Q54 (Appendix K) were considered, there was a level of agreement by most respondents (i.e., responses of slightly agree, agree, and strongly agree) with all items proposed by the questionnaire (Table 8.6). While there was some variation in the level of agreement (responses 5 through 7), the number of responses indicating neutrality and disagreement (responses 1 through 4) were low (i.e., there was little disagreement) compared to those indicating some level of agreement. Most agreement was indicated for the questions which considered workload (Q28), and tactical SA (Q45). Least agreement was evident within the areas of continuous questioning of self, others and flight status (Q50), rehearsal (Q24) and the use of the organisational decision making process (Q35).

It is important to note that the rankings provided in Tables 8.6 and 8.7 are relative. That is, they describe relationships between the items within the item list. They are not definitive in the sense that pilots would do well to include all of the top ten in their routine and exclude the bottom ten from their routine. The lowest ranked item still attracted approximately 65% of respondents at the agree/strongly agree level with 88% of respondents indicating some form of agreement with this item. A reasoned case can, therefore, be put to propose that there is a perception that all the items are of use for the purpose of developing management of flight expertise. Some items do, however, warrant more attention than others.

8.4.7 Conclusions

From the agreement expressed by respondents, there is a perception that the activities described by the action statements outlined in the questionnaire depict competent management of flight performance by airline captains (research question 10: What activities support competent management of flight performance by airline Captains?). Further, there is a perception amongst a sample of experienced airline Captains at the airline of study that the knowledge of activities which describe competent management of flight performance by airline Captains could stimulate the acquisition of command competence (research question 11: Is there a perception amongst SMEs that the knowledge of activities which support competent management of flight performance by airline Captains stimulates the acquisition of command competence?). These perceptions are held by most of the Captains who responded to the
questionnaire (research question 12: Are these concepts of management of flight competence supported at large by the Captain cohort?).

It also appears that some of the action statements that describe management of flight are similar to many of the elements of self-regulation. For example, Boekaerts (1996) details goal directedness, a sense of self-efficacy, metacognitive awareness, and commitment to success as essential elements of self-regulation. Q46 (maintaining a strategic overview to ensure that flight goals are achieved) could be said to relate closely to ‘goal directedness’. Q51 (regularly reviewing all aspects of their performance) and Q29 (acknowledging their own strengths and weaknesses and using resources accordingly) are concerned with self-efficacy. Q43 (frequently checking what is happening and comparing that to what should be happening), Q38 (maintaining an atmosphere of safety and security), and Q45 (maintaining tactical situational awareness of other traffic, weather, air traffic workload etc.) depict metacognitive awareness. Q42 (accepting responsibility for driving the flight to the most successful conclusion possible) would be indicative of commitment to success.

In addition, the umbrella construct (self-preparation, planning, strategy building, implementation, progress monitoring and self-assessment) did not attract any adverse comment in this research. The questionnaire (see Appendix K) proposed this umbrella construct as a routine to develop management of flight expertise. Respondents perceived that the umbrella construct was a useful means of developing management of flight expertise. That is, the action statements which are included in the umbrella construct define the management of flight concept.

Hong (1995) holds that metacognition and effort contribute to the effectiveness of self-regulation. Hong (1995) further decomposes metacognition into elements of awareness, cognitive strategy (e.g., mental rehearsal), planning, self-checking, and effort Q45 (maintaining tactical situational awareness of other traffic, weather, air traffic workload), Q43 (frequently checking what is happening and comparing that to what should be happening), Q42 (accepting responsibility for driving the flight to the most successful conclusion possible), Q38 (maintaining an atmosphere of safety and security) and Q 46 (maintaining a strategic overview to ensure that flight goals are met) all represent aspect of awareness. Q47 (noting events, asking questions if
uncertain, developing tactics and changing strategies if required), and Q46 (maintaining a strategic overview to ensure that flight goals are met) outline cognitive strategies which might be employed to enhance self-regulation. It could be said that Q19 (gathering all possible knowledge and intelligence about each sector) describes an aspect of the planning phase of self-regulation. Q51 (regularly reviewing all aspects of their performance), and Q29 (acknowledging their own strengths and weaknesses and using resources accordingly) involve self-checking processes. Satisfying Q18 (having the book knowledge required for command) would require effort.

Winne (1996) explored the use of a response hierarchy to optimise tactic and strategy use. The elements listed in Q47 (noting events, asking questions if uncertain, developing tactics and changing strategies if required), and Q23 (using safety, passenger comfort, schedule and efficiency criteria to guide their planning) suggest a hierarchical approach to tactic and strategy development. The position established by Zimmermann (1995) after a review of the available literature supports the views of Hong and Winne concerning the elements of the construct of self-regulation. As seen above, the substance of some of the action statements identified in Study 5 appear to be consistent with the elements of self-regulation.

The results of Study 4 indicate that the action statements that evolved as a result of the present research project were supported by a sizeable sample of Captains in the airline of study (see Table 8.6 and Table 8.7) (research question 12). Further, Study 4 has revealed the possibility of a construct that is far more comprehensive than SA, and that appears to be considered useful by experienced Captains to describe management of flight expertise and could be used to train less experienced pilots at the airline of study. The proposed construct of self-regulation appears to subsume concepts like SA (Q45 & Q46) and decision making (Q35) since these aspects of management of flight appeared as action statements within the wider construct (preparation, planning, strategy building, implementation, progress monitoring and self-assessment).
Figure 8.2: Model of the elements self-regulation derived from Boekaerts (1996), Hong (1995), and Winne (1996)

Therefore, it appears that the notion of self-regulation proposes that airline pilot management of flight performance as a more inclusive construct than those previously proposed by authors who have researched separate aspects (e.g., SA and decision making) of management of flight performance (i.e., Endsley, 1988; Klein, 1996). Even though the research regarding self-regulation originates in the educational domain, the principal elements of management of flight performance in the aviation context are perceived by experienced Captains at the airline of study to be self-regulatory (and consequently metacognitive) in nature. Figure 8.2 illustrates a flexible
interaction between the components of management of flight since they are interrelated.

While Figure 8.2 seems to encompass some of the aspects of competent command management of flight within the airline of study, the purpose of this model may not be immediately apparent to the practitioner. Safety is the stated principal focus for all involved in aviation (Helmreich & Wilhelm, 1997; Layton et al., 1994; McKnight, 1992). Therefore, in the practical sense, the purpose of the process of self-regulation could be seen to be the detection of discrepancy, threat or error so that appropriate interventions can be initiated. The review of intervention strategies for the management of human error conducted by Weiner (1993) raised the detection function of the piloting (management of flight) role (see Chapter 2). In effect, the preparation, planning, and strategy building facets of the construct of self-regulation are said to require a level of forethought (anticipation) (Pintrich, 2000). Anticipating what could/should happen will result in the development of an expectation.

This expectation will translate into the executive script (knowledge of when what needs to be done by whom) and will be used until such times as the operator detects a need to change. The implementation of the expectation, which has been developed, requires the application of communication and team skills which were identified under Implementation in the questionnaire used in Study 4 (see Q31 to Q40 of Appendix K). For example, Q32 (which addresses the establishment of an open environment for communication wherein input is both valued and acknowledged) received a high degree of agreement.

Evaluation is also an integral part of the monitoring of progress. Here, the operator is comparing what is actually happening to what was expected to happen. This requires the adequate processing of all of the information entering the operating environment. This suggests that situation assessment is a continuing process. Such a process usually requires that the operators use effective clarification techniques. The high level of agreement for Q47 (noting events, asking questions if uncertain, developing tactics and changing strategies if required) showed that the respondents to the action statement questionnaire used in Study 4 support the notion of effective clarification being necessary.
Q47 also seems to support the importance of being fully appraised of the situation in order to recognise discrepancies, threats or errors (i.e., Q47: noting events, asking questions if uncertain, developing tactics and changing strategies if required). This ability is largely metacognitive in nature (Pintrich, 2000), since the operator is seen to intervene at the cognitive level by consciously or unconsciously questioning the status of the flight (Orasanu, 1993). Verbalising thinking could be indicative of this process (e.g., *What have we missed?*). An operator who is overtly encouraging all of the crew to search for mistakes or missed activities on a regular basis is probably likely to detect these shortcomings as they occur.

Once discrepancies, threats or errors have been detected, the activation of intervention processes is required. In the airline environment, these interventions will originate from two sources: the team leader or other team members. According to Orasanu (1993), if the team leader identifies the need for intervention, and time is not critical, she/he should initiate a form of decision making consultative even if the course of action seems clear to her/him. If subordinate team members identify the intervention needed, a process of graduated assertiveness should ensue (Helmreich et al, 1991).

These interventions are then applied to the expectation of events to produce a revised operating plan that, in turn, is implemented and evaluated. At the personal level, if discrepancies in performance are detected through self-assessment, the individual should undertake a process of intervention to upgrade the deficient skill. If this is not possible through personal efforts, coaching should be sought.

Figure 8.3 (following page) summarises this domain-oriented, functional approach to the management of flight. Figure 8.3, along with the action statements identified in Study 4, detail many of the components of good CRM (Helmreich et al., 1991). However, both the construct of self-regulation (which encompasses the action statements) and the domain-oriented functional model of management of flight (Figure 8.3) are more explicit in the definition of *why* and *how* CRM skills should be integrated to detect discrepancy, threat and error. The importance of metacognitive processes to the successful management of flight is also evident from the discussion of the concepts embodied in these two constructs (Figure 8.2 and Figure 8.3).
Airlines have been reasonably successful in hiring suitable personnel or, at least, have assumed that the selection process in use identifies the type of personnel that they need. Given the output from this study, test batteries could be examined to verify their ability to confirm the presence of metacognitive and self-regulatory skills. Training programmes could also be expanded to include strategies which promote metacognitive and self-regulatory skills. Finally, performance indicators could also be
devised to reflect individual understanding and use of the concepts outlined by this research.
CHAPTER 9

Study 5: Constructing an ipsative questionnaire based upon the perceptions of competent airline Captains concerning management of flight

9.1 Introduction

The purpose of Study 5 was to construct and apply a questionnaire. The construction of this questionnaire was accomplished using guidelines suggested for the construction of psychometric instruments. The development of the questionnaire was an iterative process and the final version was applied to different groups of pilots. The responses of these groups of pilots were compared for consistency.

9.2 Rationale

The behaviours and characteristic of Captains that were identified in Study 4 are of limited value unless there is some degree of predictive validation for the traits or skills associated with management of flight. Clearly, if validated, these behaviours could form the basis of subject area teaching material. However, Studies 1 through 4 have also resulted in a level of decomposition of the management of flight construct within the airline of study. Many of the generic and specific management of flight behaviours have been isolated (see Study 4). Therefore, according to Rasmussen (1986), the present research has rendered a form of job analysis that amplifies the management of flight
aspects of airline Captain performance. According to Gregory (1996), such a job analysis is a prerequisite for the construction of a questionnaire of a vocational nature. Hence, a further use of significance for the output of Studies 1 through 4 could be the development of a psychometric selection tool. This selection tool could be applied at both initial entry and pre-Captain training stages of a pilot’s career with the airline of study if the outcomes of this series of studies are established as valid.

While no such psychometric tool is currently employed within the airline of study, issues of affect appropriateness (emotional response) are compared through the Occupational Personality Questionnaire (OPQ) (Saville & Holdsworth, 1994). It should be noted however, that the OPQ does not address the Captain’s role specifically. Unlike this series of studies (where some degree of task decomposition has been achieved), no job analysis of the captain’s role was conducted as part of the process of development of the OPQ. Although the OPQ does cover several constructs related to the role of piloting (e.g., communication and decisiveness), it does not target behaviour associated with the management of flight construct. Data from Studies 3 and 4 suggest that self-regulation is perceived to be the process underpinning control (management) of the dynamic real-time aviation environment (flight) by captains at the airline of study. Further, since the ultimate goal would be the development of a selection tool, the construction of the present questionnaire was accomplished using guidelines proposed by researchers on the topic of psychological test construction.

The psychometric questionnaire was designed to study the consistency in the responses from experienced line Captains from the airline of study and other groups of pilots from backgrounds other than the airline of study. This examination of response consistency gave an indication of differences between the groups. Some differences were expected since, anecdotally, even when Captains from other airlines have been inducted into the airline of study as potential instant Captains (i.e., they did not have to start as co-pilots), their success rate in the Captain training programme has not been better than upgrade trainees from within the airline of study.
9.3 Considerations concerning the construction of a psychometric tool

Regardless of whether self-regulation is a state (learned) or trait (innate), there were many issues that had to be explored before a format for the proposed psychometric questionnaire could be determined. While many of these issues related to the construction of the items to be used in the questionnaire (Anastasi & Urbina, 1997; Gregory, 1996; Murphy & Davidshofer, 1994), issues that relate to the type of questionnaire to be employed, standardisation, reliability and validity also needed to be addressed. Gregory (1996) proposes a six-stage construction process that is designed to establish the validity of the final form of a psychometric tool and comprises:

- defining the purpose of the tool;
- selecting a scaling method;
- constructing the items;
- testing the items;
- revising the tool; and
- publishing the tool.

Gregory (1996) proposes that personality tests “measure the traits, qualities or behaviours that determine a person’s individuality” (p. 38). By deduction, questionnaires of the type being developed could potentially be adapted in the future to sample the traits, identified qualities and behaviours which define and are predictive of the capabilities required for competent airline Captain performance. Further, aspects of aptitude in the case of aircraft Captains rely on interpersonal, motivational and attitudinal characteristics of persons engaged in this vocation (see Study 4). In this respect, Anastasi and Urbina (1997) would classify a test which seeks to address such issues as a personality test.

The reliable forms of personality tests, checklists, inventories and projective techniques (Gregory, 1996) are available for consideration when deciding the form of the questionnaire being developed. The proposed questionnaire will involve keying (propose choices) established organisational behaviours (i.e., the action statements relating to the management of flight as established in Studies 3 and 4). These behaviours are presumed
to be symptomatic of management of flight by Captains at the airline of study (Anastasi & Urbina, 1997). Psychometric tests generally require participants to complete some form of mental task and record a response, self-report on issues of affect, or submit to observation within a contextual setting (Murphy & Davidshofer, 1994). All of these design criteria necessitate the careful construction of test items contained within a psychometric test to ensure reliability and validity.

The construction and assembly of the questionnaire items should dampen ceiling and floor effects (significant numbers of very high or very low scores) (Gregory, 1996). The psychometric shortcomings associated with matching questions (choices are not independent of one another) renders their use undesirable in the present design (Gregory, 1996). True/false questions may produce socially desirable responses (Gregory, 1996; Murphy & Davidshofer, 1994). According to Gregory (1996), forced choice formats exhibit good psychometric qualities and counter the problems associated with true/false questions. Further, using the forced choice format with an ipsative design (a reflection of self rather than a comparison of self against norms) mitigates the problems associated with cue development and distractor construction, since one cue can be used for the entire questionnaire and none of the items in each set of items (e.g., four) is unreasonable (Murphy & Davidshofer, 1994). Murphy and Davidshofer (1994) detail additional benefits of the multi-choice item response format, such as the ease and speed of scoring, reduction of guessing error, and the removal of examiner judgement from the scoring process. However, the ability of multi-choice questions to deliver these advantages relies heavily on the quality of the question construction.

Gregory (1996) suggests that the number of choices within each item will influence the difficulty of the item within a multiple-choice questionnaire. For example, an item containing four choices gives respondents a 25% probability of guessing the most desirable answer. In such a case, the difficulty index is calculated using the following formula: \((1.00 + .25) \div 2 = .63\), with the desirable range being .3 to .7. Further, Murphy and Davidshofer (1994) contend that feelings of coercion, perceptions of the social desirability of particular lines of response, an unwillingness to cooperate, random
responding and dissimulation (faking) will all influence the outcome. However, the issue of social desirability can be addressed through the use of choices that are approximately equal in desirability (Murphy & Davidshofer, 1994). By using items derived principally from Study 5 (where agreement by line Captains with all action statements was found), this aspect of questionnaire design was accommodated. Further, dissimulation will be harder to sustain when choices of similar social desirability are used (from Study 4).

Issues other than social desirability (e.g., guessing & dissimulation) which influence questionnaire development have more to do with the attitude of the respondents to the questionnaire, rather than questionnaire construction. Finally, the questionnaire format had to cater for the possibilities of acquiescence (consistently answering in the affirmative) and deviation (the tendency to give unusual or uncommon responses) (Anastasi & Urbina, 1997). Forced, multiple-choice type items which contain choices of similar socially desirability may partially address these issues, and these criteria were met by using items that were principally drawn from actions that were supported by the participants in Study 4.

Murphy and Davidshofer (1994) draw attention to several important issues surrounding the construction of psychometric test items (that can also be applied to questionnaire items) including the vocabulary used and the length of the items. Murphy and Davidshofer (1994) contend that ambiguity, the use of double negatives, sexist, racist and offensive language are to be avoided. A more subtle influence which Murphy and Davidshofer (1994) raise as potentially adverse is the belief system of the developer, in that the test (questionnaire) may not be valid. To overcome this bias, developers should ensure that the items directly reflect the theorised need (i.e., to detect differences between Captains at the airline of study and other pilots in the management of flight dimension), and not their own need.

Gregory (1996) summarises the guidelines for writing multiple-choice questions as:

- choose words that have precise meanings;
- avoid complex and awkward word arrangements;
include all information needed for response selection;
- put as much of the question as possible in the stem;
- do not take stems verbatim from textbooks;
- use options of equal length and parallel phrasing;
- use *none of the above* and *all of the above* rarely;
- minimise the use of negatives such as *not*;
- avoid the use of non functional words;
- avoid unessential specificity in the stem;
- avoid unnecessary clues to the correct response; and
- submit items to others for editorial scrutiny (p. 139).

In deciding the type of questionnaire best suited to the purpose of developing a prototypical psychometric questionnaire in the present study, the cultural nature of a proposed questionnaire could not be ignored. In particular, a highly contextual test cannot be avoided when research is limited to one airline. Therefore, in the current study, external (pertaining to other organisations) validity could not be assessed. The sample size is also an issue. Tabachnick and Fidell (1996) argue that, statistically, the maximum sample sizes from medium-sized organisations (less than 1000 participants) are too small to test the linear combinations of variables required to assume multivariate normality (where each variable and all linear combinations of the variables are normally distributed). On the other hand, an ipsative type of test requires no comparison to the norm, and is simply a reflected sampling (*of self by self*) which gives a comparison against preferred personal behaviours and attitudes (Reber, 1995).

The reliability of the questionnaire was a consideration, since the questionnaire in the present study was used to discriminate between groups of participants. The reliability of the questionnaire can be examined at two levels: internal and external. Externally, the most common models for testing reliability involve a test/retest format where the results from an initial application are compared to those of an application later in time (Anastasi & Urbina, 1997; Gregory, 1996; Murphy & Davidshofer, 1994). However, the internal reliability of an instrument can be tested in other ways.
One of the goals of this process of calculating internal reliability is to determine whether or not participants are responding to questionnaire items in a consistent manner. One method that achieves this involves dividing the questionnaire into halves and comparing the responses from the same group of participants to each half of the original instrument. This is referred to as the split-half technique (Anastasi & Urbina, 1997; Gregory, 1996; Murphy & Davidshofer, 1994). A more appropriate method of investigating internal reliability involves the calculation of a coefficient, which gives an indication of the consistency of responses across all of the questions. However, this calculation requires continuous data and this condition could not be satisfied by the ipsative format of the questionnaire used in the present study.

Of the techniques discussed to test either external or internal reliability, the alternate form and split-half formats can result in measurement error because different test items are used to measure the same construct (Gregory, 1996). On this basis, these techniques were rejected for this research. The test/retest technique was seen as a valid way of approaching external reliability. However, the research environment at the airline of study imposed some limitations on the application of this technique. The Captain cohort had recently been approached several times to participate in the present and other research initiatives, and retesting the population could not be negotiated. Only the responses from participants in the pilot study (n = 5) could be compared to the responses from the group of experienced line Captains (n = 46) to give any indication of reliability.

The issue of research saturation also prevented any assessment of validity of the questionnaire, since an assessment of validity (the questionnaire actually measures what it is purported to measure) in the present study could involve developing alternate forms of the questionnaire and applying these alternate forms to a group of participants. The consistency of the results from these alternate forms would be a measure of validity (Anastasi & Urbina, 1997; Gregory, 1996; Murphy & Davidshofer, 1994). However, as mentioned above, it was perceived that the Captain group had reached a point of research saturation.
9.4 Study Overview

Generally, the development of the present questionnaire (Study 6) followed the guidelines suggested by Gregory (1996) for the construction of tests (define the purpose of the test, select a scaling method, construct the items, test the items, revise the test, and publish the test) since they were seen as applicable to questionnaire construction as well. The purpose of Study 5 was to develop a questionnaire that samples perceptions of Captain's regarding management of flight actions at the airline of study. The actions (behaviours) considered in the questionnaire were concerned with the long-term criteria (i.e., criteria pertaining to success at Captain training [see Study 4], rather than short-term criteria which have been related to success at initial airline training [Stead, 1991]), the second area of consideration in selection according to Hunter and Burke (1994).

To promote user understanding and future development of the questionnaire, the types of tests already employed at the airline of study were influential in the decision process relating to choice of questionnaire format. Within the airline of study, tests that require participants to complete some form of mental task and record a response (reasoning tests), and submit to observation within a contextual setting (simulated flight), are used. Additionally, emotion is investigated through the Occupational Personality Questionnaire (OPQ) (Saville & Holdsworth, 1994).

Normative data are used to score verbal, numerical, spatial, mechanical and diagrammatic reasoning. Data collected from the OPQ are also compared to normative data which enables a standard tens scoring for individuals. This method of scoring divides the score scale into ten units. Each unit represents a one-half standard deviation band width except at the extremities, sten 1 and sten 10, which extend below and above 2 standard deviations from the mean. The ipsative format and the standard tens scoring would be an acceptable way to proceed for the proposed questionnaire, since this format and scoring are already in use, understood and accepted within the airline of study.
Therefore, Study 5 consisted of four sequential components with the following aims:

1. to construct the questionnaire with items from the data that have resulted from previous studies (in particular Studies 1, 3 and 4);
2. to conduct a pilot study with a small group of pilots to facilitate the revision of the questionnaire;
3. to administer the revised questionnaire to a larger group of experienced line Captains; and
4. to administer the questionnaire in its final form to other identifiable groups of pilots and compare the outcomes across the groups.

9.5 Component 1 - Constructing the items to be used in the questionnaire

9.5.1 Aim

The aim of this first component of Study 5 was to assemble the items (minimum of 400) from the qualitative data resulting from Studies 1, 3 and 4, attach these items to the 40 action statements that resulted from Study 4, and convert these items into 100 questions according to the levels of support which the action statements (to which they were attached) received in Study 4. Further, a core question was constructed to prompt two types of response (i.e., a most likely to perform and a least likely to perform response) relating to each of the 100 questions.

9.5.2 Participants

The focus group established for this component of Study 5 consisted of five SMEs. These personnel were all experienced training Captains (with an average of 8.4 years experience as a training Captain) with an expressed interest in training development.
9.5.3 Materials

The action statements and results from Study 4, together with the data from Studies 1 and 3 were used in developmental discussions of the psychometric questionnaire.

9.5.4 Procedure

The procedure followed for this component of Study 5 comprised the following steps:
1. revisiting the 40 actions statements from Study 4;
2. attributing the 367 items recorded by the focus group in Study 4 to the 40 action statements;
3. revisiting the data from Studies 1 and 3 to identify a further 37 items (all that were apparent) and attributing these to the 40 action statements;
4. ensuring that each action statement was supported by at least 10 items;
5. constructing a core question to elicit responses at two levels (most likely and least likely to perform) for each question; and
6. allocating items to questions in the psychometric tool using the hierarchy of higher support question grouping established in Study 4 so as to generate a representative sample of priority choices from distal, neighbouring or same group action statements (see Table 9.1).

A subjective ranking of the 40 action statements (see Q15 to 54 of Appendix K) had been solicited in Study 4 (see Table 8.7). This ranking was used by focus group members to decide the hierarchy of items to be presented in the questionnaire. The items in each question were selected from four groups of questions from the subjective ranking of the 40 action statements in Study 4 (see Table 9.1).
Table 9.1

Questions from Study 4 Ranked and Grouped by the Level of Higher Agreement by Respondents (see Table 8.7)

<table>
<thead>
<tr>
<th>Most support (N = 163 to 154 in higher agreement)</th>
<th>Upper mid-support (N = 147 to 142 in higher agreement)</th>
<th>Lower mid-support (N = 140 to 130 in higher agreement)</th>
<th>Least support (N = 128 to 102 in higher agreement)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 45</td>
<td>Question 27</td>
<td>Question 23</td>
<td>Question 41</td>
</tr>
<tr>
<td>Question 19</td>
<td>Question 15</td>
<td>Question 16</td>
<td>Question 40</td>
</tr>
<tr>
<td>Question 18</td>
<td>Question 48</td>
<td>Question 17</td>
<td>Question 44</td>
</tr>
<tr>
<td>Question 38</td>
<td>Question 34</td>
<td>Question 36</td>
<td>Question 26</td>
</tr>
<tr>
<td>Question 43</td>
<td>Question 52</td>
<td>Question 30</td>
<td>Question 35</td>
</tr>
<tr>
<td>Question 42</td>
<td>Question 53</td>
<td>Question 32</td>
<td>Question 24</td>
</tr>
<tr>
<td>Question 46</td>
<td>Question 20</td>
<td>Question 21</td>
<td>Question 50</td>
</tr>
<tr>
<td>Question 29</td>
<td>Question 37</td>
<td>Question 54</td>
<td>Question 39</td>
</tr>
<tr>
<td>Question 51</td>
<td>Question 31</td>
<td>Question 22</td>
<td></td>
</tr>
<tr>
<td>Question 47</td>
<td>Question 33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 28</td>
<td>Question 49</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Question 25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

These four groups were defined by identifying naturally occurring breaks in higher agreement sequence by respondents in Study 4, while being mindful of the need to have approximately 25% of the action statements represented in each group (see Table 9.1). By including items from each of the four levels of higher agreement identified as a result of Study 4, it was possible to explore the agreement hierarchy for these items in another form. That is, the responses to the questionnaire gave an indication of preference for selected items (and subsequently the underlying action statements). While it was not possible to include all the combinations of support (agreement) levels for the action statements from Study 4, it was possible to achieve a representative number of combinations of items from differing levels of support (agreement) from Study 4.
Table 9.2

Action Statement Representation by Item in the Questionnaire (Appendix O)

<table>
<thead>
<tr>
<th>Construct components</th>
<th>Number of Action Statements</th>
<th>Required Number of Items</th>
<th>Achieved Number of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-Preparation</td>
<td>4</td>
<td>40</td>
<td>38</td>
</tr>
<tr>
<td>Planning</td>
<td>6</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Strategy Building</td>
<td>6</td>
<td>60</td>
<td>61</td>
</tr>
<tr>
<td>Implementation</td>
<td>12</td>
<td>120</td>
<td>121</td>
</tr>
<tr>
<td>Monitoring Progress</td>
<td>8</td>
<td>80</td>
<td>84</td>
</tr>
<tr>
<td>Self-Assessment</td>
<td>4</td>
<td>40</td>
<td>36</td>
</tr>
</tbody>
</table>

Using the method detailed above, the inclusion of items representing the action statements (regarding management of flight) was completed in accordance with the ratio of the action statement distribution used in Study 4 (see Appendix K). That is, the action statements were represented according to the number of action statements grouped under the construct components of self-preparation (action statements = 4 = 10% of total), planning (action statements = 6 = 15% of total), strategy building (action statements = 6 = 15% of total), implementation (action statements = 12 = 30% of total), progress monitoring (action statements = 8 = 20% of total) and self-assessment (action statements = 4 = 10% of total) (see Appendix K). The psychometric questionnaire composition is detailed in Table 9.2 above. The number of items included to represent each construct component (i.e., self-preparation etc.) was very close to that required by the number of action statements which represent each construct component. The relative emphasis on construct components (see Appendix K) was maintained in the questionnaire (see Appendices L & O).

Figure 9.1 summarises the procedure employed in this component of Study 5 to develop the 100 questions for the questionnaire.

40 action statement $\Rightarrow$ data review $\Rightarrow$ 404 items $\Rightarrow$ Application of support hierarchy $\Rightarrow$ 100 questions

Figure 9.1: Process used to construct the 100 questions for the questionnaire
9.5.5 Results

Using the guidelines outlined in the procedure, an questionnaire was developed with the following characteristics:

- Questions 1-60 of the questionnaire (see Appendix O) were constructed by selecting one item from each of four groups of this ranked list (see Table 9.1).

- Questions 61-70 of the questionnaire (Appendix O) incorporated one item derived from the questions which were most highly supported in Study 4, together with three statements derived from the questions which were least supported in Study 4 (see Table 9.1).

- Similarly, questions 71-80 of the questionnaire (see Appendix O) incorporated one item derived from the most highly supported questions and three from questions with lower mid range support (see Table 9.1).

- Questions 81-90 of the questionnaire (see Appendix O) contained one item derived from those with upper mid range support and three with lower mid-range support from Study 4 (see Table 9.1).

- The last group of ten questions (91-100) of the questionnaire (see Appendix O) contained item derived from those questions which were most highly supported in Study 4 (see Table 9.1).

These items were finalised using the guidelines suggested by authors in the field (e.g., Anastasi & Urbina, 1997; Gregory, 1996; Murphy & Davidshofer, 1994) (see pages 172 & 173). The first version of the questionnaire (see Appendix O) was the result of this sub-section of Study 5.
The core question for the questionnaire was designed to elicit a high priority (most likely to perform) response and a low priority (least likely to perform) response. This approach is similar to the approach of some personality tests (e.g., the OPQ [Saville & Holdsworth, 1994]) where respondents are required to indicate statements that are most like themselves and least like themselves. With respect to the management of flight items which each question proposed, respondents were asked to indicate the items which they were most likely to perform and least likely to perform before and during a flight. The unfamiliar route scenario (that proposed the context for the questionnaire) in order to circumvent aspects of performance which would result from different levels of experience (e.g., automaticity) on a particular route. The core question designed to elicit these responses was:

As a captain required to operate on an unfamiliar route, I would be

- [ ] most likely to..........
- [X] least likely to..........

9.5.6 Discussion

The results of Study 4 have shown that there are specific actions which experienced Captains perceived that novice airline pilots could adopt in order to develop command management of flight skills. These actions were, in most cases, a distillation by multiple research participants of many differing interpretations of the management of flight theme. The data that contributed to these action statements were drawn from Studies 1, 3 and 4. Having consolidated these data for the questionnaire in Study 5, focus group members revisited the action statements from Study 4 and expanded on them by attributing the supporting activities from Studies 1, 3 and 4 to develop the items for the questionnaire.

9.5.7 Conclusions

Qualitative data from Studies 1, 3 and 4 provided the material that was used to construct the questionnaire (see Appendix O). Further, it was possible to construct the questions
and the items of the questionnaire according to the guidelines suggested by researchers in the field. Further, it was possible to assemble the items for this questionnaire in a way that presented subjective priority choices to the respondents. The priority of choices was established by using the high agreement support hierarchy (see Table 9.1) from Study 4.

9.6 Component 2 - Pilot study of the questionnaire

9.6.1 Aim

The aim of this second sub-section of Study 6, the pilot study of the questionnaire, was to review the viability of the 100 questions developed in the preceding stage of Study 5 so that the questionnaire could be confidently presented to a much larger group of respondents as part of a later sub-section of this study.

9.6.2 Participants

A group of five pilots was involved in the pilot study. These personnel were all training pilots and, as a result of this experience, all had been exposed to the issues surrounding initial Captain training and the apparent vagaries of the selection processes. Four of these personnel were Captains and the fifth was a First Officer (co-pilot) who had been appointed to a training position. Experience on all types of aircraft operated by the airline of study was represented in this group. Participation was voluntary.

9.6.3 Procedure

The five participants assembled to complete the questionnaire (Appendix O) and then to give written and verbal feedback on aspects of the questionnaire. A copy of the questionnaire (see Appendix O) was given to each participant to complete. The participants were briefed on the purpose of their participation (to help fine-tune the items and questions in the questionnaire for wider distribution). Then they were told to complete the questionnaire following the instructions attached to the questionnaire. The
responses were anonymous. To facilitate the provision of feedback regarding the questionnaire, a second questionnaire similar to the Examinee Feedback Questionnaire (EFeQ) (Nevo, 1992 and cited by Gregory, 1996) was constructed to provide immediate and anonymous post-test feedback from the pilot study (see Appendix N). This questionnaire addressed issues such as:

- administration conditions;
- clarity of instructions;
- requirements of answer recording;
- perceived suitability of the psychometric tool;
- perceived difficulty of the psychometric tool;
- difficulty of choice;
- vocabulary usage; and
- ipsative tool format.

Participants were asked to review the questions concerning feedback before commencing work on the questionnaire so that the feedback questions could, in part, be answered as completion of the questionnaire proceeded. The feedback regarding the questionnaire was used to stimulate the subsequent plenary discussion to refine the questionnaire administered a larger group of respondents. This discussion facilitated debate on the responses so that all aspects of the questions could be considered by all pilot study respondents. Pertinent points from this discussion were noted.

In summary, the process of the review of the questionnaire in the pilot study was completed using the following procedure:

1. participants completed the initial version of the questionnaire (see Appendix O);
2. participants responded to the feedback questionnaire during completion of the questionnaire (see Appendix N);
3. focus group (comprising the five participants) was convened to discuss the feedback in more detail; and
4. Written and verbal feedback from the pilot study participants was used to fine-tune the questionnaire.

9.6.4 Results

With respect to the feedback from the pilot study participants, the results can be reviewed in three sections:

- feedback which was used to undertake editorial changes to the questionnaire items;
- because the next target participant group (line Captains) was approaching research saturation, feedback was used to assess whether the study should be continued in the proposed form; and
- feedback which was used in fine-tuning the questionnaire.

The results from the five participants’ responses to questions 7 through 11 of the feedback questionnaire (see Appendix N) are detailed in Table 9.3. The First Officer did not respond to Q9 and Q10 of the feedback questionnaire (Appendix N), since he had no airline command experience. Editorial changes were suggested to items in Questions 11, 13, 19, 23, 29, 34, 38, 43, 54, 58, 64, 68, 76, 82, 84, 93, and 96. For example, the original item 82c was: define errors in terms that I can deal with and was changed to: identify actions required to correct errors, after the feedback was reviewed (see Appendix O). These changes were effected during plenary discussion with the respondents after they had completed both the psychometric questionnaire and the feedback questionnaire. Consensus was reached on each queried item during the plenary discussion and the revised version of these queried items appears in Appendix O.
Table 9.3
Pilot Study Frequency of Responses to the Questions Relating to the Suitability of the Questionnaire (Appendix N)

<table>
<thead>
<tr>
<th>Question</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. The instructions for completion were clear and unambiguous</td>
<td></td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>8. The method of recording answers was convenient and unambiguous</td>
<td>1</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. The questionnaire was a fair exploration of Captain attributes</td>
<td></td>
<td></td>
<td>3</td>
<td>1*</td>
</tr>
<tr>
<td>10. The questionnaire format was suitable for exploring Captain attributes</td>
<td>1</td>
<td>1</td>
<td></td>
<td>2*</td>
</tr>
<tr>
<td>11. The difficulty of the questionnaire was appropriate</td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>

*Note: There was a missing response to Q9 and Q10 because the First Officer who participated did not have any experience as a Captain.

Responses to questions 9 (the questionnaire was a fair exploration of Captain attributes), 10 (the questionnaire format was suitable for exploring Captain attributes), and 11 (the difficulty of the questionnaire was appropriate) indicated that, if the study was continued, the proposed form was appropriate since there was general agreement with these proposals (see Table 9.3). Similarly, responses to questions 7 (the instructions for completion were clear and unambiguous) and 8 (the method of recording answers was convenient and unambiguous) indicated general agreement (see Table 9.3). Written qualitative comments (e.g., *Dot point the instructions*) were used to fine-tune the presentation and completion detail.
9.6.5 Discussion

During the plenary discussion, all of the pilots who participated in the pilot study suggested that the research should progress to the next stage ("There is nothing like this in the system. We need to see where this might lead" [PS3]). However, these pilots unanimously concluded that the questionnaire (100 questions) that they answered was too long and that a shorter questionnaire (they all agreed that 60 questions was long enough) should be developed ("This has taken over an hour to complete. Forty-five minutes is long enough" [PS1]). These pilot respondents also agreed that, since the number of respondents to the pilot study was limited to five, it would be desirable to collect more data before deciding which questions to exclude ("Get some line people to do the test" [PS2]).

Generally, the respondents to this pilot study found that the proposed psychometric questionnaire was a reasonable way to proceed, albeit that further refinements were required to make the questionnaire more user friendly and meaningful. Sufficient feedback (written and verbal) was collected to enable the suggested changes to be made. Importantly, consensus across the pilot study participants was reached on all of the proposed changes.

9.7 Component 3 - Administration of the questionnaire to a group of experienced line Captains

9.7.1 Aim

The aim of the third sub-section of Study 5 was to administer the questionnaire to a larger group of experienced line Captains at the airline of study with the view to: (a) establishing a criterion by which the size of the questionnaire could be reduced to 60 questions (as suggested by respondents to the pilot study); (b) identifying the responses which the respondents considered to be most appropriate; and (c) establishing a level of internal consistency.
9.7.2 Participants

The participants for the third sub-section of Study 5 included 46 captains who flew the line permanently. This group consisted of 45 males and one female and all were over 40 years of age. The Fleet Managers recruited the participants in this group. The Fleet Managers decided upon selection criteria that related to perceived day-to-day operating performance (operates reliably without unwarranted recourse to head office for advice) and records of performance in recurrent training (a good average standard for the five exposures a year over the time of their Captaincy). These criteria (i.e., demonstrated line and training performance) identified Captains according to their perceived ability to achieve the best possible outcome for each flight under their command, even when faced with difficult situations. Fifteen Captains from each of the four fleets were identified.

9.7.3 Materials

A paper version of the questionnaire was used and participants recorded their answers directly onto the questionnaire. The core question and an example from the 100 questions contained within this questionnaire follow:

As a captain required to operate on an unfamiliar route, I would be:

- most likely to...........
- least likely to...........

41. a. make excuses for my performance
    b. be on the lookout for mistakes
    c. maintain control of the crew by withholding information
    d. recognise and use my strengths
9.7.4 Procedure

Having identified the 60 potential respondents, the questionnaire was mailed directly to the potential respondents. This despatch of the questionnaire and the subsequent retrieval of the questionnaire were completed by the secretariat to the Fleet Managers so that the anonymity of the respondents was preserved. A personalised letter seeking the cooperation of the respondents in the data collection was despatched with each questionnaire (see Appendix M). The Fleet Manager secretariat made the questionnaires available to the researcher once they had been returned via the internal company mail service and de-identified. The researcher entered the data into a database at the work site. A frequency count of both the most likely and least likely responses to each item in each question was conducted for each response. The Delphi method was then applied.

The Delphi method of problem solving was pioneered within the RAND Corporation (Helmer, 1963). This methodology aims to produce a collective human intelligence (incorporation of ideas from multiple sources through a series of refinement stages) about a topic (Linstone & Turoff, 1973). This is achieved by creating a systematic approach (such as serialised questionnaires) that facilitates the inclusion of individual expert contributions and allows an assessment of group judgement, while maintaining a degree of anonymity. According to Helmer (1963), this participative (inclusive) approach produces credible results while focussing attention on the issues, minimises the ‘follow the leader’ syndrome, and creates equal opportunity for all involved. In short, the Delphi method aims to “obtain the relevant intuitive insights of experts and use their informed judgements as systematically as possible” (Ziglio, 1996, p. 4).

The research methodology in the current study (Figure 4.1) bears similarities to the Delphi method (multiple opportunities for participant input). The process of questionnaire development within this study relied heavily on the principles which underpin the Delphi method (particularly the use of participant feedback) to produce the final form of the questionnaire. This process of contribution, review and revision by subject matter expert respondents was used to modify and adjust the proposed
questionnaire in order to generate the final version of the questionnaire for data collection and analysis.

Since all of the items in the psychometric tool originated from action statements (behaviours and activities) upon which there was a degree of agreement (i.e., no rejection, only varying levels of agreement) by respondents in Study 4, levels of agreement of responses might also be seen as a reasonable method of establishing a hierarchy within the questions. The ipsative format of the questionnaire rendered data that were receptive to the application of the level of agreement criterion for the inclusion or exclusion of questions in the final form of the questionnaire (which, in turn, conforms to the Delphi methodology). Therefore, a level of agreement criterion was used to reduce the number of questions in the final form of the questionnaire. A 75% level of agreement was applied, since this level of agreement was found to meet the aims of the third subsection of Study 5 (i.e., the 75% level of agreement criterion reduced the number of questions, and identified the most consistent answers to the reduced number of questions).

A number of questions containing no item that met the 75% agreement criterion (i.e., these questions contained items upon which the experienced line Captains indicated least agreement) were inserted. These were Q52 to Q60 and were inserted to determine the levels of agreement by other groups of pilots compared to the experienced line Captains who expressed low levels of agreement on these questions.

9.7.5 Results

A total of 46 responses out of 60 was received. The numbers of responses received to the questionnaire distributed to experienced line Captains from the four different aircraft fleets are recorded in Table 9.4 below.
Table 9.4

Responses by Line Captains to the Questionnaire

<table>
<thead>
<tr>
<th>Type</th>
<th>Number of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>B747-400</td>
<td>13</td>
</tr>
<tr>
<td>B747-300</td>
<td>6*</td>
</tr>
<tr>
<td>B767-200/300</td>
<td>14</td>
</tr>
<tr>
<td>B737-300/400</td>
<td>12</td>
</tr>
<tr>
<td>Missing</td>
<td>1</td>
</tr>
<tr>
<td>TOTAL</td>
<td>46</td>
</tr>
</tbody>
</table>

*this group had a reduced time to respond

Due to rostering commitments, the distribution of the questionnaire to the B747-300 fleet participants was delayed. These participants had a reduced time frame to complete the questionnaire. Consequently, the number of responses received from this group was lower than from the other three fleet groups. The respondents recorded their preferences according to the example below:

As a captain required to operate on an unfamiliar route, I would be

√ most likely to...........

× least likely to...........

41. a. make excuses for my performance

b. be on the lookout for mistakes

c. maintain control of the crew by withholding information

d. recognise and use my strengths

The frequency counts for the *most likely to perform* items for each question are recorded in Appendix P. Appendix Q details the frequency of responses on the *least likely to perform* scale. By applying the 75% agreement criterion, 61 items of high agreement were identified. Of this number, 18 of the items were *most likely to perform responses*
and 43 were least likely to perform items. These 61 items were contained within 51 questions because of agreement equal to or greater than 75% on both the most likely and least likely scales in 10 questions (i.e., Q8, Q26, Q28, Q32, Q33, Q37, Q40, Q42, Q94 & Q95 of Appendix O). That is, items that produced at least 75% agreement to both the most likely and the least likely probes were selected by the 46 respondents in 10 questions (see Appendix R). These 51 questions are the first 51 questions of Appendix S and were used to establish the criterion (75% agreement) score of 61 (i.e., the total number of items contained within the 51 questions where the experienced line Captains achieved 75% agreement).

Further analysis of the responses to these 51 questions using the four hierarchical groupings (most support, upper mid-support, lower mid-support, and least support) of responses from Study 5 (see Table 9.1) was then carried out with regard to the construction protocol (i.e., selecting items from all or some of the four hierarchical groups to form a question) as outlined in the procedure for this component of Study 5 (9.6.4). For example, Question 1 of the refined questionnaire contained the following items that were derived from the action statements (see Appendix K) indicated in the parentheses:

1. a. assume that the operation will not go as planned
   (derived from Q27: developing alternatives to cover things which may not go to plan and which had received upper mid-support)

   b. pay less attention to the efficiency of the operation
   (derived from Q23: using safety, passenger comfort, schedule and efficiency criteria to plan and which had received lower mid-support)

   c. initiate actions without communicating reasons to others
   (derived from Q41: avoiding the use of information as power and which had received least support)

   d. anticipate periods of high workload
   (derived from Q45: maintaining tactical situation awareness of other traffic, weather, aircraft performance, workload, etc. and which had received most support)
Table 9.1 indicates the action statements (and their levels of support in Study 4) from which the items in the 51 questions of the final questionnaire used in Study 5 were drawn. The results of the analysis conducted on this basis for the 51 selected questions that met the 75% level of agreement criterion are reported in Table 9.5 below.

A total of nine questions wherein every item elicited a low level of agreement by the experienced line Captain group was added to the 51 high level of agreement questions. This enabled a comparison between levels of agreement by other groups of pilots and experienced line Captains on questions where the experienced line Captains exhibited low levels of agreement. These were Questions 7, 21, 22, 29, 43, 47, 84, 85 and 99 of the original (100 question) questionnaire (Appendix O). The highest level of agreement by the experienced line Captains for any item in any of these questions was 40%. By comparing levels of agreement between the experienced line Captain groups and other groups on these nine questions, the consistency of priority choices across the groups could be considered. If, for example, all other groups had recorded >75% agreement on all the questions where the experienced line Captains exhibited low agreement, further investigation would be warranted.

Table 9.5

Analysis of Item Responses According to the Levels of Support from Study 4 of Questions Meeting the 75% Agreement Criterion.

<table>
<thead>
<tr>
<th>Most supported</th>
<th>Upper mid-range support</th>
<th>Lower mid-range support</th>
<th>Least supported</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Most likely to perform</strong></td>
<td>10</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td><strong>Least likely to perform</strong></td>
<td>7</td>
<td>6</td>
<td>9</td>
</tr>
</tbody>
</table>
9.7.6 Discussion

The distribution of the items that met the 75% agreement criterion (43 least likely items and 18 most likely items) (see Table 9.5) indicates that respondents more frequently identified those items that they were least likely to perform compared to those items that they were most likely to perform. That is, there was more agreement demonstrated by respondents on items which they were least likely to perform. Given that all of the items are drawn from action statements for which there was only varying levels of agreement (no disagreement) in Study 4, the most likely/least likely choice may be an expression of a prioritisation of activities represented by the item, rather than an outright rejection of the item.

With respect to questions 91 to 100 of Appendix O (the original Study 5 questionnaire of 100 questions), where all items were drawn from the most highly supported action statements identified in Study 4, five of these questions are represented in the first 51 questions of the refined questionnaire containing 60 questions (see Appendix S). That is, discrimination between items that were all drawn from the most highly supported action statements from Study 4 was possible for half of the questions (i.e., Q91, Q93, Q94, Q95, & Q98) (see Appendix R). The apparent importance of all items in the last ten questions of Appendix O (as indicated by the high level of support in Study 4) did not appear to make the task of item differentiation any more difficult than in the first 60 questions where one item was drawn for each of the four levels of support (Table 9.1). Since the questionnaire was constructed so as to reduce the impact that guessing might have on the results, it seems that the respondents were able to prioritise their activities even when offered choices of activities of very similar desirability.

9.7.7 Conclusion

When offered a fixed choice of items, experienced Captains appear to be able to identify items that are least important or most important to perform (i.e., they can prioritise their activities) with a degree of consistency (i.e., >75% agreement). This notion has been
supported in both Studies 4 and 5 (see Tables 8.7, 8.8, & 9.1 and Appendices P & Q). Excluding the 9 questions (questions 52 to 60) that were added in order to source data concerning low levels of agreement, the final iteration of the questionnaire is, to a degree, consistent and, thereby, internally reliable.

9.8 Component 4 - Administration of the final iteration of the questionnaire to other defined groups of pilots

9.8.1 Aim

The aim of the last sub-section of Study 5 was to administer the questionnaire to a number of groups of pilots in order to compare the consistency of the responses of the experienced airline Captain group with the consistency of the responses of the other groups of pilots. That is, the ability of the questionnaire to discriminate between groups of pilots from various backgrounds would be tested.

9.8.2 Participants

The last group of participants comprised personnel from two sources: applicants for pilot positions with the airline of study, and personnel enrolled in tertiary aviation-related studies. Personnel from these two sources were further categorised into different groups according to their experience and employment status (i.e., student pilots, commercial pilots who were yet to apply to an airline, pilots who had applied to an airline but who had been unsuccessful, airline co-pilots, and airline Captains) so that their responses to the questionnaire could be compared.

The applicants for pilot positions at the airline of study were from a variety of aviation backgrounds and had differing levels of experience as pilots within the industry. For example, direct entry pilots are those who meet at least the basic academic and flying experience criteria. This group (n = 44) included a number of co-pilots (n = 23) from an airline which failed and who had been given employment priority by the airline of study.
The remaining direct entry pilots \((n = 21)\) were from either military or general aviation backgrounds. Another group, the cadet pilot applicants \((n = 15)\), generally had less than 100 hours total piloting time, but had undergone testing (at the airline of study) to ascertain the likelihood that they would successfully complete commercial pilot training. However, no airline job guarantee was given to these applicants.

A further group of participants in the final sub-section of Study 5 was drawn from a cohort of 217 aviation university students. These university students are not necessarily pilots and if they were pilot trained, their experience and job aspirations were varied. However, all the respondents who participated in the study were pilots. Four sub-groups were identified so that comparisons across the groups could be made. Those who were airline Captains, those who were airline co-pilots, those who were pilots but had not yet applied to an airline, and those who had applied to an airline for a piloting position but had been unsuccessful (see Table 9.6).

**Table 9.6**

**Groups of Respondents Enrolled in Tertiary Aviation Related Studies**

<table>
<thead>
<tr>
<th>Respondent classification</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airline Captains</td>
<td>19</td>
</tr>
<tr>
<td>Airline co-pilots</td>
<td>20</td>
</tr>
<tr>
<td>Pilots yet to apply to airlines</td>
<td>22</td>
</tr>
<tr>
<td>Unsuccessful airline applicants</td>
<td>6</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>67</strong></td>
</tr>
</tbody>
</table>

The pilots enrolled in university studies who reported that they had not been successful in gaining employment with an airline \((n = 6)\) were considered with the direct entry applicants for pilot positions at the airline of study who were not successful in gaining employment \((n = 20)\). Regardless of how they were grouped for analysis, there were 67 participants drawn from pilots enrolled in tertiary aviation studies, 44 direct entry pilots
from various backgrounds, and 15 applicants for cadet pilot positions, giving a total of 126 participants in this component of Study 5.

9.8.3 Materials

A paper version of the latest iteration of the questionnaire was used and participants recorded their answers directly onto the questionnaire. The SPSS database was used for data processing.

9.8.4 Procedure

All participants responded voluntarily to complete the questionnaire. The tertiary students received their questionnaire through the university’s distance education system and returned them by post in a pre-addressed envelope. The questionnaire was distributed to all of the 217 university students. Applicants for pilot positions at the airline of study were asked to complete the questionnaire as an adjunct to the normal applicant testing. It was made quite clear to the pilots applying for piloting positions that the answers that they provided would have no influence on their employment prospects.

For the purpose of analysis, the direct entry pilots were distributed across several sub-groups. That is, while the group (n = 44) was considered as a whole, the members of this group who were co-pilots from airline B were also considered separately (n = 23), and the members of the direct entry group, who were not successful in gaining employment (n = 20), were grouped with the six University students who reported that they had been unsuccessful at an airline selection process to give a group of 26.

9.8.5 Results

Each respondent who completed the questionnaire received a score of between 0 and 61. This score was a result of comparing the choices of items that each respondent made with the 61 items chosen by >75% of the experienced line Captain group (i.e., the criterion
score). If a respondent chose the item with which >75% of the experienced line Captain group agreed, a score of 1 was recorded for that question. If a respondent did not choose the item with which >75% of the experienced line Captain group agreed, then a score of 0 was recorded for that question.

For the purpose of analysis, the data from the eight diverse groups of pilots were compared. This grouping was accomplished using the following criteria: type of piloting experience (airline or non-airline); success at an airline selection process; and position in the airline crew structure (i.e., Captain or co-pilot). It was assumed that a valid questionnaire based on the perceptions of experienced airline Captains concerning management of flight would be expected to expose differences between the experienced airline Captain group and the other groups since the questionnaire was highly contextual. The groups were:

- the experienced line Captains from the airline of study (N=46);
- the airline Captains from the university student cohort (N=19);
- the airline co-pilots from the university student cohort (N=20);
- the university students who had not yet applied to an airline (N=22);
- the co-pilots from airline B who applied to the airline of study (N=23);
- the applicants to the airline of study who were seeking cadetships (N=15);
- the applicants to an airline who were unsuccessful for a variety of reasons (N=26); and
- the applicants to the airline of study other than those seeking cadetships (direct entry) (N=44).

Tables 9.7 and 9.8 report the questions where the various groups responded with >75% agreement on either the most likely to perform and the least likely to perform scales.
Table 9.7

The Questions where at least 75% Agreement was Evident in the Responses of Each Group for the *Most Likely* to Perform Activities.

<table>
<thead>
<tr>
<th>Experienced line Capts</th>
<th>Uni Capts</th>
<th>Uni copilots</th>
<th>Uni yet to apply</th>
<th>Airline B copilots</th>
<th>Cadet-ship applicants</th>
<th>Un-successful applicants</th>
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Table 9.7
The Questions where at least 75% Agreement was Evident in the Responses of Each Group for the Most Likely to Perform Activities (cont’d).

<table>
<thead>
<tr>
<th>Experienced line Capts</th>
<th>Uni Capts</th>
<th>Uni copilots</th>
<th>Uni yet to apply</th>
<th>Airline B copilots</th>
<th>Cadet-ship applicants</th>
<th>Un-successful applicants</th>
<th>Direct entry applicants</th>
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Table 9.8
The Questions where at least 75% Agreement was Evident in the Responses of Each Group for the Least Likely to Perform Activities.

<table>
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<th>Experienced Line Capts</th>
<th>Uni Capts</th>
<th>Uni copilots</th>
<th>Uni yet to apply</th>
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Table 9.8

The Questions where at least 75% Agreement was Evident in the Responses of Each Group for the *Least Likely* to Perform Activities (cont’d).

<table>
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<th>Experienced Line Capts</th>
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<th>Uni copilots</th>
<th>Uni yet to apply</th>
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Table 9.8
The Questions where at least 75% Agreement was Evident in the Responses of Each Group for the Least Likely to Perform Activities (cont’d).

<table>
<thead>
<tr>
<th>Experienced Line Capt</th>
<th>Uni Capts</th>
<th>Uni copilots</th>
<th>Uni yet to apply</th>
<th>Airline B copilots</th>
<th>Cadetship applicants</th>
<th>Unsuccessful applicants</th>
<th>Direct entry applicants</th>
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The means and standard deviations for the scores (which were obtained using the method described in the results for this sub-section) were calculated for each group. A one-way ANOVA was then conducted (F(7,208) = 9.1, p<0.001). The means and standard deviations are recorded in Table 9.9.

The mean score for the 8 groups which were considered are significantly different (F(7, 208) = 9.1, p<0.001). A post-hoc Tukey’s (overall p = 0.05) test indicated that the mean score for the experienced line Captain group was significantly higher than the mean score for all other groups, except the university student Captains and the university student Co-pilots. Further, the mean score for the cadetship applicants was significantly lower than the means for the experienced line Captains, the University student Captains, the
University student Co-pilots and the University students who are yet to apply to an airline. There is no evidence of a significant difference between any of the other groups (see Table 9.9).

Table 9.9
Means and Standard Deviations for all Questions with >75% Agreement for the Eight Groups of Respondents to the Questionnaire

<table>
<thead>
<tr>
<th>Line Capts</th>
<th>Uni Capts</th>
<th>Uni Co-pilots</th>
<th>Uni Yet to Apply</th>
<th>Airline B Co-pilots</th>
<th>Cadetship Applicants</th>
<th>Un-successful Applicants</th>
<th>Direct Entry Applicants</th>
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<tr>
<td>N</td>
<td>46</td>
<td>19</td>
<td>20</td>
<td>22</td>
<td>23</td>
<td>15</td>
<td>26</td>
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<tr>
<td>Mean</td>
<td>51.91</td>
<td>49.84</td>
<td>49.3</td>
<td>47.63</td>
<td>46.82</td>
<td>42.6</td>
<td>46.0</td>
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<tr>
<td>sd</td>
<td>3.56</td>
<td>2.69</td>
<td>4.65</td>
<td>4.53</td>
<td>5.16</td>
<td>5.1</td>
<td>6.39</td>
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Note: The variance of these means are not significantly different from each other using Levene’s test (p = .12).

9.8.5 Discussion

This analysis has focussed largely on group responses, rather than those of individuals. This is consistent with research question 14 (If such an instrument is administered to experienced Captains, will their responses exhibit any consistency?) which was addressed in component 3 of Study 5, question 15 (Will pilots who are not in an airline exhibit the same consistency in their responses as Captains in the airline of study?) and question 16 (Will pilots of other airlines exhibit the same consistency in their responses as the Captains in the airline of study?).

Notably, there was sufficient consistency in the responses from the experienced line Captains at the airline of study (as defined by the >75% agreement criterion) to facilitate comparisons across the various identifiable pilot groups who completed the refined questionnaire (see Appendix S). Further, there was only one instance where >75%
agreement was achieved by another pilot group on a question item which was drawn from questions where the experienced line Captain group had recorded <75% agreement (item 57a [maintain an overview of all relevant information]) (see Table 9.7). This suggests that, in general, higher levels of agreement on any item by all participants were restricted to the 61 items where the experienced line Captain group exhibited >75% agreement.

However, there were some differences in the way that the various groups of respondents answered the questions. For example, several groups (university student Co-pilots, university students yet to apply to an airline, airline B Co-pilots, unsuccessful applicants to the airline of study, and applicants for Cadet Pilot positions at the airline of study) achieved >75% agreement on a most likely response to Q1 (Q1d, anticipate periods of high workload) (see Table 9.7), whereas the airline of study experienced line Captain group and the university Captain group did not. While the reasons for this different perception cannot be determined from the data, it is curious that there was less agreement to the most likely to perform item among the experienced Line Captains at the airline of study compared to non Captain groups of pilots to whom the workload which command brings is an unknown factor.

Co-pilots from airline B also exhibited some differences to the experienced Line Captain group at the airline of study. The co-pilots from airline B achieved >75% agreement on nine (most likely) questions upon which the experienced Line Captain group did not (i.e., Q1d, Q20c, Q23b, Q25a, Q34a, Q38a, Q41d, Q42c, & Q47a) (see Table 9.7). Conversely, the experienced Line Captain group from the airline of study achieved >75% agreement on eight (most likely) questions where the co-pilots from airline B did not (Q3b, Q8c, Q16b, Q18c, Q19b, Q22d, Q33a & Q41c) (see Table 9.7).

The experienced Line Captain group exhibited more consistency of responses to questions relating to planning for contingencies (Q8c [think about the worst case scenarios] and Q19b [make contingency planning an integral part of my operation]) and questions which reflect initial and continuing mental modelling (Q41c [build a realistic expectation of the flight to reduce surprises] and Q22d [keep the big picture in focus])
than did the co-pilots from airline B. Conversely, the co-pilots from airline B exhibited more consistency of responses to questions relating to focussed error detection (Q20c [review all activities in order to detect error] and Q23b [be on the lookout for mistakes]) and the consideration of all available information (Q38a [initially accept that all information may influence the flight] and 42c [remain open minded]) than the experienced line Captain group. The possibility that these differences in response agreement are representative of cultural as well as experience differences between the two groups would require further exploration.

The results of this study appear to provide the basis for future research in the development of selection tools at the airline of study. In particular, the ability of this data to support future developments in selection processes is of note. This assertion is made as a result of the data reported in Table 9.9. The questionnaire (see Appendix S) elicits some significant differences in the mean agreement scores between the groups. With the exception of Captains and Co-pilots enrolled in University aviation studies courses, all of the means varied significantly from the experienced line Captain group.

The airlines of employment of the university Captains and Co-pilots were not recorded in order to preserve anonymity. However, given the enrolment distribution at the university from where the participants were recruited, each of these groups of respondents probably contained representatives from the airline of study, airline B, and overseas airlines. For example, of the 39 airline-employed pilots who responded, six reported that they currently lived (and presumably worked) outside Australia. The observation can be made that, overall, non-homogeneous groups of airline Captains and Co-pilots responded in a similar way to the experienced Line Captains from the airline of study. This raises the question of the effect of university education on the behavioural preferences of pilots. The possibility that such education is effective in developing desirably consistent behaviours in a way similar to vocational experience and training is certainly raised and could be an area of future research.
9.8.6 Conclusions

The prototype questionnaire met the objectives of this study. In the first instance, using the data from previous studies, it was possible to construct such a questionnaire following the guidelines proposed by previous research (see section 9.2). Therefore, research question 13 (Is it possible to construct a psychometric instrument using the completed research?) can be answered in the affirmative. The time taken to complete the original questionnaire (100 questions) was criticised and the number of questions was reduced in the final instrument. The final form of the questionnaire did not attract any adverse comment from participants during the course of the study. On a first trial, the prototype instrument was found to be able to discriminate between the reference group and some other groups from which data were collected.

Given the outcomes reported above, the construction of a vocationally-oriented psychometric test should be possible. The ipsative format appears to present two avenues for sourcing comparative data from individuals and groups. While not explored here because of the limited number of respondents, normative data could be collected to enable a standard tens (sten) scoring for individuals.

Having established an acceptable consistency of response (agreement level) for the forced choice, individual responses by prospective Captain trainees could be compared for consistency with the responses of the experienced Captains. This comparison could add detail to a gap analysis and the training needs of the prospective Captain trainees could be more clearly defined as a result. More likely though, this process has the potential to identify individuals who prioritise their activities most like the majority of experienced Captains within a given organisation. While it was not possible in this study to gather data from prospective trainee Captains within the airline of study, this internal validation process would be a desirable next step in any continuing research. The data from the co-pilots from airline B indicates a potentially different focus by these pilots when compared with the experienced Line Captains at the airline of study. Just how
similar co-pilots at the airline of study are to the co-pilots at airline B is a question yet to be answered.

Any instrument developed from this research should not be viewed as *stand alone*, but rather as a potential enhancement to existing selection processes. The output of such an instrument could have several uses in any selection process (e.g., initial intake or upgrade training allocation). For example, it could be used to drive the interview segment of a multi-faceted selection process. This proposed development would require the collection of normative data across the entire Captain cohort at the airline of study and a further research project to validate response differences which might be expected between the Captain cohort and other pilots (e.g., co-pilots at the airline of study and applicants for piloting positions at the airline of study).
CHAPTER 10

Discussion

10.1 Introduction

The present research project has explored the management of flight function of the piloting role from numerous perspectives. The manner in which the individual studies have contributed to the overall goal was outlined in Chapter 1 and will be expanded upon in this chapter. Further, the validity and the reliability of the present research will be investigated. Subsequent to a discussion on the relationship between the findings of the present research and the contemporary literature on self-regulation, the possible avenues of future research will be proposed.
10.2 Exploring the aim of the research

The approach to Cognitive Work Analysis (CWA) proposed by Rasmussen (1986) suggests that behaviour is shaped by domain constraints (e.g., the dynamic nature of the operating environment). Further, Vicente (1995) advances the proposal that the accommodation of constraints facilitates the completion of unanticipated tasks. However, in the view of some authors (e.g., Hutchins, 1995), the work completed by operators within a domain (such as aviation) is primarily mediation (intervention) to mitigate the impact of failure within any of the areas of risk (i.e., safety, passenger comfort, schedule and efficiency of operation). Therefore, while the constraints of the aviation domain might influence both pilot behaviour and the completion of unanticipated task by the pilot, the mediation role of the pilot in the mitigation of risk remains a high priority function which management of flight skills must accommodate.

The risks associated with aviation are derived from an analysis of the product that is delivered to the customer. Generally, the definition given to the product sub-set by McKnight (1992) is representative of a hierarchal decomposition namely: safety, customer service, schedule, public relations and economy. This sub-set is acknowledged by policy statements at the airline of study as the generic tasks associated with the management of flight. These generic tasks underpin all cognition and behaviour which operators would be expected to exhibit in the execution of their duties. These generic tasks are also presumed to encompass the driving philosophies for the actions that are designed to fulfil the operational requirements which they generate.

Attempts to capture the essence of performance in non-technical areas of airline pilot operations have resulted in tools such as the Line/LOS Instrument (Helmreich et al. 1991). Further, the numerous ranked lists of CRM elements identified by Flin and Martin (1998) fail to account for some of the fundamental requisites of expertise. For example, Gott et al. (1991) and Ye (1991) propose that problems and associated knowledge require the application of structure as well as content and control mechanisms. Thus far, CRM topics have generally not defined elements such as structuring in their treatment of problem solving. Further, CRM development has identified required skill sets as separate
content and control mechanisms (e.g., decision making, teamwork and communication) without providing the framework of an identified structure that more closely resembles the human approach to the task of managing a flight. However, some authors (e.g., Spence & Brucks, 1997) contend that structuring as a prerequisite to problem solving is important.

If, as Spence and Brucks (1997) report, experts are superior in handling unstructured but structurable problems, it can be deduced that experts either recognise structure or initiate the structuring of any situation with which they are confronted. To do this, they would need an established framework that has the capacity to enable the comprehension and reasoning required within the context of the current operating environment. This contextualisation accounts for much of the time budget of experts encountering novel situations (Federico, 1995). Further, solutions and required actions tend to be generated by heuristics (Spence & Brucks, 1997) and pattern matching (Klein, 1993).

These views support the notion that the identification of a practical and robust framework, which facilitates cognition and behaviour within the Captain’s work domain, would be of value. The nature and extent of such a framework (i.e., a construct of management of flight) would also be of interest, particularly to facilitate training. While the stimulus for this research originated from a vocational need at the airline of study, the aim of defining a management of flight construct appears to be consistent with the views of many authors (e.g., Hunter & Burke, 1995). As well as fulfilling a need at the airline of study (where failure of Captain training programmes by trainees was largely attributed to a lack of management of flight skill), the definition of a construct that enables the ability of operators to manage flights within a real time dynamic environment may have a more general application within the domain (e.g., adding value to selection processes).

10.3 The research methods and their outcomes

The desire to achieve internal validity and reliability through triangulation guided the methods employed in the conduct of this research project. Triangulation was achieved
through the convergence of data collection methods (reliability) and sources of information (validity). This amounts to a verification of the research process. Figure 10.1 gives an overview of the research process employed in the present research project.

![Diagram of research process]

Figure 10.1 - Model of the research process employed in the present research project

With respect to reliability, Salkind (1997) proposes synonyms like dependable, stable, trustworthy, predictable and faithful when considering this term. McBurney (1998) takes the view that reliability is simply a measure of how well the research was conducted and whether it would give the same results when next conducted in the same way. Further, according to McBurney (1997), reliability can be tested by examining the components of the research methodology to ascertain whether they all amplify the research topic (i.e., management of flight definition). However, reliability can exist without validity (Salkind, 1997).

Validity refers to the truthfulness, accuracy, authenticity, genuineness, and soundness of the research (Salkind, 1997). Therefore, while a piece of research might be dependable
(reliable), it might not be authentic (valid). A consensus on the methods of treating traditional topics such as reliability and validity has not been reached. However, the issues of reliability and validity can be approached through a discussion of the research process that has been used in the present study (Creswell, 1994).

The present research took place within the context of an operating airline: a 'real world' situation. This research environment yielded vocationally-typical language and discourse. The real world situation, coupled with vocationally-oriented language and discourse are important requisites of qualitative research according to Smith et al. (1995). The probability that this research environment produced emic (insider) views is high and grounded the research (Strauss & Corbin, 1990). This process enhanced the validity of the research since the data can be considered as highly authentic.

The progressive nature of the data collection and analysis (see Figure 10.1) facilitated an in-depth understanding (truthfulness) of the perceptions surrounding management of flight at the airline of study and generated an action research methodology, since advancement along the research continuum was data-driven (Charmaz, 1995). The unrestrictive nature of this research programme facilitated the discovery of the realities of the context as perceived by the participants (Punch, 1994). This process contributed to the establishment of validity, since the outcomes enhanced truthfulness (Salkind, 1997) and generated a correspondence with reality from the participants' point of view (McBurney, 1997).

The role of the researcher was contributory to the grounded outcomes of the present research. By being immersed in the interplay between the data collection and the analysis, the researcher contributed to the grounding of the research (Strauss & Corbin, 1990). Moustakis (1990) proposes that induction results from researcher immersion in the setting, and the gaining of insight through incubation of ideas and increasing an awareness of the contextual setting. This researcher immersion facilitated contextual associations and partisan results (Altheide & Johnson, 1994), thus ensuring that the outcomes were highly relevant to the development of a better understanding of the
concept of management of flight within the airline of study. Authentic research outcomes are more likely in this circumstance and, thereby, support claims of validity (Salkind, 1997).

Further, Fielding and Fielding (1986) claim that single measures of a social phenomenon are fallible, and that a research methodology which uses triangulation as its core design criterion will be less fallible. According to Janesick (1994), the essence of triangulation is multiple methodologies, data sources and investigators. The present research project sourced data using questionnaires, verbal reports, focus groups and interviews. This mixed-method approach, using multiple data sources, produced a consistency of outcomes by way of the definition of management of flight and, thereby, rendered the outcomes reliable (Salkind, 1997).

Data were analysed from 288 responses by check and training Captains from the airline of study, 263 line Captains from the airline of study, 30 First Officers from the airline of study, 23 Second Officers from the airline of study, 59 applicants for pilot positions at the airline of study, and 67 pilots who were enrolled in aviation-related tertiary studies. Content validity was enhanced because, in most instances, contextual experts (i.e., experienced Captains) were used as the data sources (Salkind, 1997). The investigators included the primary researcher, SMEs and training Captains from the airline of study.

The depth of the methods used in the present research project conforms to accepted qualitative methodology. This research programme contained several examples of participants being involved in both the process of data collection and the process of analysis. This style of research where, to any extent, the researched are also, in part, the researchers, has also been defined as action research, a type of co-operative inquiry (Heron, 1996). Action research has the ability to empower participants through participation in both the experience of the research at hand and in decisions about the outcomes and future shape of the research programme. If, as Heron (1996) contends, truth is a local consensus about a sophisticated construct relative to a given group and a given time and place, then action research (which actively involves the group members)
contributes to the definition of truth and, according to Salkind (1997), truthfulness is an indicator of validity.

The data collection methods elicited data from SMEs and practitioners in a progressive and repeatable way (reliability) and arrived at a perceptual consensus (which contributes to validity) as to how flight is managed by experienced Captains at the airline of study. The convergence of data collection methods rendered the research process internally reliable. The sources of data were representative samples of pilots at the airline of study and, in the last study, of pilots who were not yet employed by the airline of study. These respondents provided qualitative data that added validity to the research outcomes. Consequently, it can be argued that this research project achieved high levels of internal reliability and validity by virtue of the thoroughly grounded nature of the research and the use of triangulation as the core design criterion.

10.4 Overview of the results of the research

10.4.1 Study 1

The rationale supporting the initiation of the present series of studies highlighted the need to explore the possibility that existing induction selection processes at the airline of study are not reliable as predictors of success at the Captain training level. This was revealed by a preliminary examination of the selection outcomes for good and poor performers in Captain training programmes during Study 1. Study 1 also identified and organised the performance markers currently used by personnel responsible for Captain training and checking. Having identified the command readiness markers in use at the airline of study, a framework was devised to organise these markers and, thereby, facilitate their use by all personnel.

The strategies employed in this study included open coding to identify the separate markers in use, frequency distribution to establish the most supported markers, and axial coding to facilitate the grouping of markers according to function. A 5 point Likert scale was also employed to assess the degree of agreement by respondents with the
understanding of overall performance (including the management of flight function) derived during this study (see Table 5.9). Standard deviations were then calculated.

The preliminary examination of the results of the application of existing test batteries employed by the organisation revealed that these tests do not necessarily predict long-term performance (i.e., at the Captain training level). That is, poor and good candidates for Captain training may not be discriminated on any of the dimensions tested during selection. The possible consequences of this preliminary review for the industry worldwide cannot be ignored, since the types of tests examined within the airline of study are typical of those used throughout the aviation industry. Further research is required to determine the extent to which the results of this preliminary review are supported.

Several core themes emerged from the process of open and axial coding of responses. For example, the notion that mental models supported normal and adverse operations was proposed. The perception of participants in Study 1 was that the development of these models relied on numerous generic and vocational attitudes and processes (e.g., preparing, maintaining SA, WCS planning, & safety culture). The respondents who were canvassed for an opinion on the model of performance as defined by the list of markers (which included mental models) and that was proposed in Study 1 generally agreed that the list of markers was an accurate representation of the required Captain (management of flight) performance (with a mean of 4.45 on a 5 point Likert scale).

Mental models were perceived to be integral to management of flight performance by Captains. What was not established was the extent of the modelling carried out by these SMEs (Captains). Study 1 did not solicit comment on whether whole production cycles, or only segments thereof, were subject to modelling. If the view of Serfaty, MacMillan, Entin and Entin (1997) is accepted, mental models are used in dynamic environments to recognise situation similarities (through schemata in long term memory), explore unfolding situations (by asking the right questions) and optimise the application of the plans developed (through matching to the mission).
Aviation folklore has always maintained that good performers stay ‘ahead of the aircraft’. In terms of the present discussion, the ability to mentally represent segments of the flight in advance of execution is vitally important to management of flight performance. Study 1 incorporated visualisation as a reported marker of management of flight performance. For the experienced aviator, visualisation might very well include previous experience as the basis for the representation. In Study 1, the safety culture marker identified by respondents was verified as contributing to the development of a mental model. That is, the safety element of risk was included as a consideration integral to the development of mental models of the operation.

The coding of responses to Study 1 resulted in the item ‘decisive’ being included as one of the markers of management of flight performance. This coding was representative of the intent of respondents and highlights the ability to select alternatives, rather than the process by which the alternatives were developed. The incorporation of decisiveness in the management of flight performance model considered in Study 1 highlights a possible difference between management of flight and CRM.

Seamster et al. (1997) and Zachary (1999) contend that the allocation of cognitive resources to decision making impacts upon performance. Vancouver (2000) cites Stevenson, Busemeyer and Naylor (1990) as arguing that problem solving relates more to the ‘construction’ of alternatives than the ‘selection’ of alternatives (which is the domain of decision making). CRM training at the airline of study has emphasised the desirability of constructing alternatives. However, with respect to decision making, the training Captains who provided data in Study 1 seem to be more interested in the decision implementation, rather than alternative construction.

The emphasis on the use of markers was considered a possible dimension for comparison amongst training Captains. Anecdotal feedback from Captain training candidates on the variability of the standard of training and the variability of assessment criteria supported this approach. To that end, the emphasis that policy makers and training managers place on the use of identified markers was compared to the emphasis on markers amongst
training and checking captains. In this regard, some differences in marker emphasis between the policy makers and the training and checking personnel were evident.

Practitioner feedback on the markers identified as representing effective management of flight performance (command readiness performance model) derived as part of Study 1 was reviewed for acceptance and useability at varying levels. Subsequently, the usefulness of the command readiness management of flight performance model to the organisation was also assessed. However, the list of markers describing management of flight performance derived in Study 1 was seen by participants as too complex and impractical for in flight use. An examination of an accepted, less complex and more easily understood concept was considered necessary. Study 1 revealed that SA was used by practitioners as a marker of command readiness (research question 1) and thus could be the concept that was needed. Further, Study 1 raised the prospect that a level of SA of the immediate situation (tactical SA) and of the whole operation (strategic SA) were identifiably different but were both required for effective management of flight (research question 2 and research question 3). Therefore, it was considered that, if aspects of SA could be found to be reliable indicators of overall performance, then a useful long-term criterion would have been identified.

10.4.2 Study 2

The second study set about the task of establishing an organisational understanding of SA because, as well as there being several interpretations of SA and its possible predictive capabilities reported in the literature, the results of Study 1 indicated that a more encompassing perception of SA might be held at the airline of study. Accordingly, the cultural understanding of SA within the airline of study could be quite different to other reported expressions of SA. Consequently, the general correspondence of the organisational model of SA to reported models of SA would be low.

The challenge for this study was to devise and implement a research process, which would represent most concepts of SA and enable feedback from a large enough group of
respondents to establish an organisational understanding of SA. Focus groups were facilitated to gather individual and group intelligence on the topic of SA understanding. With focus group member agreement, the convenor analysed the results, identified themes, derived an expanded and composite organisational definition, and presented this output to a larger group of pilots for consideration.

Study 2 found that the organisational understanding of SA was strategically-focused as well as tactical in nature since there was no significant disagreement with the organisational definition (*Within the context of airline operations, flight crew can develop and maintain Situational Awareness by the continuous acquisition, retention, analysis and application of knowledge of events, conditions, data and variables*) and amplification of SA across the novice/expert continuum (Appendix D). Since the model proposed was strategic in nature, it could be claimed that the less experienced respondents (Second Officers) were as strategically focused and reflective as the SMEs (experienced Captains) who participated since there were no discernable differences in the results from the two groups.

The lack of significant disagreement with the organisational definition gives an indication that research question 4, which sought to establish a relationship between strategic SA and metacognition, might be answered in the positive. The perception that the model of SA (strategic) proposed in Study 2 was a reasonable expression of the understanding of SA within the airline of study also indicates that, within the airline of study, SA is perceived as less algorithmic and more reflective in nature (i.e., less like a problem solving exercise and more like a process of continuous review). If the organisational understanding of SA is continuous by nature, the relationship between this version of strategic SA and algorithmic problem solving is weaker than the relationship between tactical SA and algorithmic problem solving. Therefore, research question 5, which proposed that tactical SA is more closely related to algorithmic problem solving than strategic SA, is answered in the affirmative.
In Study 2, practitioners were asked to reflect on an organisational concept of SA, which contained references to mental models. The results indicated a perception that mental modelling was used less as a method of retaining knowledge and data (83% inclusion rate) than as an aid for analysing knowledge and data (90% inclusion rate). Mental modelling was perceived by the sample in Study 2 to be more useful in dynamic situation analysis than in the less dynamic process of knowledge structuring. With the exception of rehearsal (which only received 86% support), the activities associated with the construction of functional models of expectation before flight was high (>95% support).

Within the organisation where the research was conducted, other means of representing data and knowledge were perceived to be used. Chunking, association, and prioritised lists were the methods most frequently included for representing knowledge and data that was thought to be required in the development of SA (>90% inclusion rate). The relationship between these latter methods of knowledge and data representation and mental models was not explicitly explored. However, no evidence that they would not contribute to mental model construction was forthcoming.

Since the organisational understanding of SA was clearly more strategic in nature than the approach developed by Endsley (1988), the results of Study 2 refocussed the thrust of the research on the work domain, rather than individual tasks. The additional dimensions identified in Study 2 were significant in that it was perceived that reflection was used as a directive mechanism for the development and maintenance of SA. The way that predictions were used to reassess and replan the operation clearly expanded the purpose of SA development and maintenance. Goal review was also perceived to be a part of SA production. This finding alone answers research question 6, which sought to establish whether good performance relies on the presence of strategic SA, since it signals the use of overview skills as integral, rather than apart from normal SA practices and signals the importance of strategic SA to management of flight performance.

Within the cohort of study, SA was perceived to have a production cycle (the whole flight) focus. Therefore, it was apparent that, within the airline of study, SA might be part
of a larger, management of flight performance-controlling construct. In essence, SA may not exist as a ‘stand alone’ construct, but be subsumed by, and integral to, a more expansive construct. For example, pilot management of flight performance may be as dependent on metacognitive activities such as goal orientation, monitoring and self-efficacy as it is on tactical SA. This possibility was the impetus for Study 3.

10.4.3 Study 3

Study 3 was initiated to consider the process whereby pilots develop, implement and track their mental model of the task at hand. Once this had been completed, it was possible to assess similarities between this process and higher level constructs of human performance. As a consequence, further definition of pilot management of flight performance resulted. Essentially, the aim of this study was to identify the principal themes of activity that expert pilots (Captains) engage to manage the risks involved in flying a high capacity jet aircraft between city pairs.

A total of fifteen semi-structured interviews with expert line (N=7) and check (N=8) Captains was included in this analysis. The scenario of a call out (limited notice of a flying duty) to operate an unfamiliar sector was set. The transcriptions and notes of the interviews were then examined for recurring, common themes of activity. Personnel who agreed to participate in this process were made aware that the material would be used to advance the research regarding the definition of management of flight performance within the airline of study.

The inductive analysis process identified several activity themes. Activity control mechanisms and the role of automaticity in this activity process were examined. To this end, interview records were examined for evidence of routine behaviours and the part that they play in the management of flight. The process used by the participants to control task execution was also examined for the maturity of its self-initiating (metacognitive) properties. Further, the approach used in Study 3 recognised that the development of management of flight expertise occurs over time and through experience from a laboured and unsophisticated approach to an automatic and comprehensive ability.
The analysis of the data in Study 3 also revealed a concerted effort by experienced captains to develop a representation of a hitherto unfamiliar production cycle. *Flying the sector in one's mind* was a typical pre-flight representational requirement expressed by interviewees. While there are aspects of rehearsal involved here as well, the strong need to be *ahead of the operation* (as expressed by another respondent) indicates the level and importance of mental representation to the perceived probability of success.

The recurring themes that resulted from Study 3 were found to reflect similarities with the construct of self-regulation. A principal derivative of this construct appears to be the development and adaptation of mental models of the task to hand. In these respects, research question 7 (Do experienced Captains use an identifiable process to develop mental models of a proposed flight?) and research question 8 (What processes do experienced Captains use to adjust these mental models to cope with a changing operational environment?) are answered in the affirmative in that, an underlying process for the development and modification of task models has been identified from analysis of the interviews. Further, in Study 3, this umbrella construct was reported as having a *self-learning* facet integral to its functioning. Therefore, research question 9 (How do pilots learn from an aviation experience?) would appear to be answered by this revelation.

Having identified the recurring themes, which were perceived to support management of flight by SMEs, the activities which are integral to each theme that was identified needed to be defined before the construct could be considered in its entirety. The need to identify activities, which qualify the recurring themes, was the catalyst for Study 4.

10.4.4 Study 4

The expansion of the recurring themes into action statements was the first goal of this study. Once this had been completed, some refinement through exposure and feedback was accomplished. The resulting format was then tested for acceptability within the airline of study by canvassing the opinions of a large sample of Captains.
Through an inductive process, it was possible to compile an action statement list (totaling 40) using the identified themes from Study 3 as sub headings. A questionnaire was developed and was distributed to 317 line captains. Respondents were asked to indicate their agreement regarding the inclusion of the action statements presented in a routine designed to aid novice airline pilots develop management of flight expertise. This format was developed to bypass the automated approach that airline Captains appear to have developed to management of flight. The reliability of this data was tested using Cronbach’s alpha. Additional questions to gather information on the attitude ofCaptains to the management of flight expertise of First Officers were included in this questionnaire.

The results were analysed to determine the consistency of the perceptions of Captains to First Officers’ management of flight expertise and to the activities represented by the action statements associated with each of the themes. The identification of the factors that were perceived to underpin the ability of First Officers to manage without intervention was a goal of this analysis.

The perception of Captains canvassed in Study 4 reflects actions associated with good management of flight performance. The analysis of the frequency data from Study 4 indicated that Captains who perceive that First Officers can manage flight without intervention also perceive that First Officers are organised and structured in their approach to sector flying and maintain both tactical and strategic SA. Further, there was general agreement with the construct that was proposed and the supporting actions for each theme contained within the construct (i.e., actions concerning self-preparation, planning, strategy building, implementation, progress monitoring and self-assessment). The ten most favoured action statements and the ten least favoured action statements were examined to explore their metacognitive nature. Feedback on the embodying construct was also analysed. Based on the results of this study, it was possible to identify a profile of pilot management of flight that would be associated with high performance.
Within the construct of management of flight proposed in Study 4, the implementation stage contained many behaviours hitherto associated with CRM such as communication, information processing, decision making, conflict resolution and efficacy behaviours. All of these behaviours or activities attracted a relatively high frequency of agreement amongst respondents. While the allocation of action statements reflecting CRM behaviours across the construct was not restricted to the implementation of strategies stage, this phase of the construct contained the largest concentration of such action statements.

Where CRM-type behaviours appeared in other areas, for instance, workload (Q28 of Appendix K) and error management (Q30 of Appendix K) as integral to strategy building, they too could be viewed as specialised, rather than general within the context of this construct of management of flight. Further, the nature of the construct which emerged from Study 4 seems to indicate that aspects of the development and maintenance of tactical and strategic SA are facilitated by so called CRM-type activities during the implementation phase of management of flight.

The agreement which resulted from Study 4 reflected on the originating construct (self-preparation, planning, strategy building, implementation, progress monitoring, and self-assessment) as much as the individual action statements which support facets of the originating construct. This framework, which it is argued approximates self-regulation is, in itself, a substantial strategic mechanism because it provides a framework for the performance of the management of flight function. Experienced line Captains perceive that this strategy could be used by novices to develop mastery of the domain-generic tasks. In particular, the planning, strategy building, implementation, progress monitoring and self-assessment cycle can be used in a sequential or randomised fashion to review and attain mission goals through adaptive inference (alteration of the personal self-regulatory approach). This flexibility represents a further embodied strategy pertaining to self-regulation (Zimmerman, 2000).
In summary, the similarity between the underlying construct, which facilitates management of flight, and self-regulation was pursued in Study 4. Research question 10 aimed to identify the activities that support competent management of flight performance by airline Captains. Consequently, a construct of management of flight was developed and presented to a large group of participants who generally supported the concepts related to management of flight which were presented. Thus, research question 16, which asked whether support for the concepts of management of flight which were presented to the Captain cohort was evident, was answered in the affirmative.

The data derived from this study confirmed a perception that experts in this context (experienced Captains) believe that novices (co-pilots) can develop management of flight expertise through the consistent and frequent application of the proposed routine (i.e., actions concerning self-preparation, planning, strategy building, implementation, progress monitoring and self-assessment). That is, SMEs perceive that the knowledge of activities which support competent management of flight performance by airline Captains stimulates the acquisition of command competence in the management of flight (research question 11).

While the development of training tools as a result of Studies 1 through 4 was not an aim of this research, the potential of any outcomes of this completed research to improve the selection process at the airline of study was considered at the outset. Accordingly, Study 5 was initiated to explore the contribution that the research outcomes of Studies 1 through 4 might be capable of making to the selection process at the airline of study.

10.4.5 Study 5

Having assembled large amounts of data concerning the perceptions of the management of flight performance profiles from competent Captains, the possibility of constructing a psychometric questionnaire based on these perceptions was addressed. Using the ipsative approach to psychological testing, the management of flight activities and behaviours identified thus far were used to construct a prototype ipsative questionnaire. Support for
the concepts (action statements) contained within the management of flight function developed in Study 4 was evident in the outcomes of Study 4. These action statements were then expanded into representative items. These items were identified from the qualitative data collected in Studies 1, 3, and 4. They were assembled into a multiple-choice format of 100 questions each containing four choices. The choices were assembled with regard to the levels of agreement with the action statements in Study 4 (from which the individual items for each question were drawn) Thus, as research question 13 asked, it was possible to construct a psychometric instrument using the completed research. This instrument was designed to establish the activities considered most and least important to respondents when trying to optimise the management of flight outcomes in the role of Captain.

Following the administration and analysis of the 100 questions contained within the prototype ipsative questionnaire to 46 experienced line Captains, 51 questions were identified wherein the consistency of responses (>75% agreement) was considered such that they could be administered for comparison to other groups of pilots. The >75% agreement demonstrated in the responses from the 46 experienced line Captains satisfied research question 14 which asked if any consistency would be exhibited if such a questionnaire was administered to experienced Captains. A modified ipsative questionnaire containing the 51 questions which elicited high levels of agreement across the experienced line Captain group was then administered to applicants for pilot positions with the airline of study and a group of University students enrolled in tertiary aviation related studies (some of whom were from other airlines). From the application of the ipsative questionnaire to the groups of pilots who were not employed by the airline of study, it was apparent that some pilots who are not in an airline did not exhibit the same consistency in their responses as Captains in the airline of study (research question 15). Further, pilots from another airline (airline B) did not exhibit the same consistency in their responses as the Captains in the airline of study (research question 16).

The results of the administration of the questionnaire to the groups of pilots showed some significant variations in the responses across the various groups when compared to the
responses of the experienced line Captain group at the airline of study. The reasons for these variations are not readily apparent from this research. However, the contribution of notions of self-regulation to management of flight expertise has been investigated during this series of studies. Therefore, further discussion of the relationship between self-regulation and the management of flight aspects of the piloting role is warranted.

10.5 Self-regulation and management of flight aspects of the piloting role

In summarising the contributions to their *Handbook of Self-Regulation*, Boekaerts, Pintrich and Zeidner (2000) propose that “self-regulation involves cognitive, affective, motivational, and behavioural components that provide the individual with the capacity to adjust his or her actions and goals to achieve desired results in light of changing environmental conditions” (p. 751). Boekaerts et al. (2000) go on to interpret this generic definition as containing goal setting, steering, strategic, feedback and self-evaluation processes. Such a view widens the debate on the management of flight considerations of pilot performance and suggests that any research in the management of flight area should explore the relevance of specific and generic aspects of this interpretation of self-regulation. Self-regulation, as a higher level cognitive strategy (if not the highest), must be considered in this context.

Boekaerts et al. (2000) highlight several forms of interaction between self-regulation and the environment (i.e., the domain of study). The first consideration involves matching people to the environment. This process assumes that the need for effective self-regulatory skills has been identified as a domain requirement. However, most airlines have more applicants than jobs available. Aviation has been seen as an attractive and a desirable vocation since humans first took to the air. Boekaerts et al. (2000) contend that self-selection is the next environmental/self-regulation interaction. That is, people choose domains of employment (self-selection) as well as employers hiring employees within the employment domain (selection). If it was possible to assess the self-regulatory skills of all technically qualified personnel, then, the selection processes for airline employment would be enhanced considerably.
The last group of interactions between self-regulation and the environment proposed by Boekaerts et al. (2000), who cite the work of Hettma and Kenrick (1992), involves the modifying effects of persons on the environment and the environment on persons. This has probably been the interaction upon which the industry has relied to overcome shortcomings in the selection process. The position of Hettema and Kendrick (1992) is that individuals will modify their work environment to suit their skills. Unfortunately, the aviation environment is not sufficiently flexible to allow the modification of the environment by the individual. Accordingly, persons will be unable to change the work domain to match their skill set. The statistics which prompted this research (high failure rates of First Officers in Captain training programmes) testify to the inability of the environment to transform all mismatched individuals.

Certainly, this ‘osmotic’ process (trial and error or on-the-job learning) cannot be relied upon to produce the desired personal ‘command ready’ profile (i.e., exhibition of all the affective, cognitive and behavioural activities that are required to command an aircraft within the airline of study). The task remains one of getting the desired individual profile clearly identified and building selection tools (initial and pre-Captain training) to match. In the meantime, if the construct is validated, current employees need to be educated in the knowledge, skills and attitudes associated with self-regulation. This research has commenced that process by raising an awareness of the perceived application of the self-regulation construct to the management of flight aspects of the piloting role.

10.6 Recent perspectives concerning self-regulation

Zimmerman (2000) describes self-regulation as self-generated thoughts, feelings and actions that are planned and adapted cyclically to the attainment of personal goals. This notion is similar to that of Boekaerts et al. (2000) who contend that self-regulation is a composite construct that relies on metacognitive knowledge and skill, together with the activation of motivational and emotional processes which facilitate behavioural monitoring and control. Shapiro and Schwartz (2000) emphasise the intentional nature of
self-regulation, which is fundamental to their understanding that systems are self-regulated when the whole system can be seen to intentionally regulate the interaction of its parts or sub-systems.

The theme of intentional (goal-oriented) regulation is pursued by Pintrich (2000) who explores goal establishment in two dimensions: mastery and performance. Pintrich (2000) concludes that mastery goals (learning a skill) are more likely to contribute positively to self-regulation than to performance goals (executing the learned skill well). Mastery acts as a proximal regulator of more distal outcome goals (Zimmerman, 2000). Dweck and Leggett (1988) found that mastery goals contribute positively to self-efficacy (judgement of competence to perform the task) by defining task value to the individual and, thereby, generating interest. This view of the influence of goals on self-regulation is consistent with the thoughts of Vancouver (2000) who contends that the desired state of the task must be internally represented (modelled) to facilitate self-regulation. This would require forethought. This self-motivated aspect of self-regulation would entail task analysis, goal setting and strategic planning (Zimmerman, 2000).

Vancouver (2000) holds that the notion of self-regulation is the result of two core paradigms, cybernetics (which rely on parallel nested systems) and decision making (together with problem solving which are serial processes). The parallel (automated) processes upon which the cybernetic paradigm relies are cyclical in nature in that feedback to the system will generate adjustment in operating performance (Zimmerman, 2000). Self-regulated individuals continually adjust their goals and their choice of strategies as a result of their self-regulation (Schunk & Ertmer, 2000; Zimmerman, 2000). Further, Shapiro and Schwartz (2000) contend that feedback from the task is amplified if the individual operates in the intentional (conscious), rather than automatic (unconscious) self-regulation mode. Importantly, Zimmerman (2000) stresses the importance of context in defining the processes (of planning, strategy building, etc.) which are then applied in a cyclical fashion to achieve self-regulation. This is particularly the case when the reflective aspects of self-reflection (the originator of feedback) are considered. For example, Zimmerman (2000) proposes two dimensions to self-reflection: self-judgement
(What did I do?) and self-evaluation (How did my actions compare with the requirements?). While self-judgement is exclusively causal, self-evaluation implies a comparison to standards, be they collaborative, normative or personal in nature.

Several concepts of self-regulation interventions support this cyclical view of the maintenance of self-regulation. In the more abstract, Shapiro and Schwartz (2000) propose that intention begets attention. Purposive direction (attention and action) results and is the key to continued self-regulation, stimulated through continuous inward refocussing of attention (mindfulness). The forethought (planning), monitoring (comparing what is happening with what should be happening), control (acting) and reflective (feedback) processes derived from the work of Zimmermann (1998), and proposed by Pintrich (2000) as the controlling construct for cognition, motivation and behaviour produce a contextual cycle which maintains regulation. Zimmerman (2000) holds that forethought precedes performance which, in turn, is evaluated through self-reflective processes (Kanfer and Ackerman, 1989). Schunk and Ertmer (2000) agree with this proposition and suggest that self-regulation is highly dependent on self-efficacy (judgement of confidence to perform the task) in the goal setting, self-monitoring and self-evaluation phases of self-regulation. The self-regulation interventions taught at the University of Texas and explored by Weinstein, Husman and Dierking (2000) are explicit in their support of a cyclical approach to self-regulation of learning. The steps which the University of Texas course proposes are:

1. Setting a goal
2. Reflecting on the task and one’s personal resources
3. Developing a plan
4. Selecting potential strategies
5. Implementing strategies
6. Monitoring and formally evaluating the strategies and one’s progress
7. Modifying the strategies if necessary
8. Summatively (cumulatively) evaluating the outcomes to decide if this is a useful approach for future similar tasks or if it needs to be modified or discarded for future use (p. 742).

Weinstein et al. (2000) also discuss the process of learning or attaining the state of self-regulation and suggest that if the interventions listed above are employed in this order on a cyclical basis, a state of automated self-regulation can be achieved. Demetriou (2000) cites the work of Kopp (1982) who examined the development of general self-regulation in humans. Although this work refers to childhood self-regulation development, the learning of self-regulation progresses through the modulation of arousal states and reflexes, control of behaviour initiation, self-control of behaviour modification through remembered information to self-regulated planfulness and strategy use to initiate, modify and control behaviour.

Zimmerman (2000) also proposes a four-stage learning process beginning with observation which induces major features (behaviours). This is followed by an emulation phase that involves practice of aspects of behaviour. Self-control or procedural application of behaviours is then implemented in the next stage. Finally, a state of conditional adaptation or self-regulation is achieved when persons apply the interventions listed by Weinstein et al. (2000).

10.7 Comparing research outcomes to recent literature

The goal of this research was to galvanise the numerous opinions on command readiness into a practical management of flight performance profile that could be used on a day-to-day basis as a training and assessment tool as well as being developed into a selection tool. The propositions and results of the present research can be considered against recent literature regarding self-regulation.

Study 1 concluded that existing selection tools were incapable of consistently matching the ‘people’ to the operational ‘environment’, since good and poor performers in Captain
training programmes exhibited no significant differences on selection tests. Therefore, in order to understand why this is happening, further dimensions of pilot command performance had to be explored. Furthermore, Study 1 showed that check and training Captains exhibited little consistency in their use of markers to assess command readiness. However, the high frequency of the use of SA as a marker provided a useful starting point. Most of the constructs of SA which have retained favour are by nature, repetitive and cyclical. For example, Endsley (1988) suggested that the perceive, comprehend, project construct of SA requires continuous application to be useful. This characteristic of a possible construct of Captain management of flight performance remained a focus of the remaining studies.

The perception of respondents in Study 2 was that an expanded and cyclical version of SA was probably operational within the airline of study (i.e., SA is developed by the continuous acquisition, retention, analysis and application of knowledge of events, conditions, data and variables). The semi-structured interviews of Study 3 with experienced captains revealed a number of recurring activity themes (self-preparation, planning, strategy building, implementation, progress monitoring, self-assessment) which were perceived to be consciously applied as demanded by the situation (depending on familiarity). Although not explicitly cyclical, respondents indicated that the activity areas were revisited as required, suggesting some repetition of actions associated with each theme. These recurrent themes reflected the elements of the construct of self-regulation. The contextual construct which appeared to be consistent with self-regulation and which was explored in Study 4, requires a cyclical application to cope with review and change in the operating environment (Pintrich, 2000; Shapiro & Schwartz, 2000; Weinstein et al., 2000; Zimmerman, 2000).

During the axial coding of the 48 markers identified in Study 1, the existence of unconscious and conscious (covert and overt) activities was considered. The concept of consciousness might be similar to that of intentionality proposed by Shapiro and Schwartz (2000), since an operator (pilot) would probably view conscious activity as intentional. Studies 2 and 3 also reveal the sometimes intentional nature of activity by the
practitioner. The metacognitive nature of management of flight performance began to become more apparent through the exhibition of a component of intentionality in the management of flight performance.

The implication for the activities investigated in Studies 2, 3 and 4 (and relating to the expanded view of SA and concepts of self-regulation) is that many seem to be self-generated. This view of self-generation of action is highlighted by Q42 of Study 4 where there was high frequency of agreement with the notion that persons in command of aircraft must ‘accept responsibility for driving the flight to the most successful conclusion possible’. In essence this activity area requires the acceptance of responsibility and the understanding that as the Captain, the individual must initiate (self-generate) actions to produce the most favourable outcome with regard to all the prevailing circumstances. As a result, performance within the work domain is perceived to rely heavily on intentional activities.

Study 4 sought comment regarding the motivational aspects (intentional nature) of self-regulation since the self-preparation action statements included reference to motivational levels. According to Shapiro and Schwartz (2000), this is an aspect of self-regulation that facilitates behavioural monitoring and control and, consequently, if motivation is deficient or shallow, performance at the monitoring and control levels may be reduced (Corno, 1993). After reviewing contemporary literature, Pintrich (2000) suggests that mastery goals (skill acquisition/task completion) appear to be more effective as motivators, as opposed to performance goals (aiming for a high standard of task execution/surpassing others), which seem to promote a less strategic approach to the task (Bouffard, Boisvert, Vezeau, & Larouche, 1995).

Mastery of the task (of managing a flight) was the dominant theme of the research conducted in Studies 3 and 4 (i.e., executing an unfamiliar task and describing a routine to enable mastery of management of flight by novice airline pilots). The construct upon which comment was sought in Study 4 was presented as an intervention capable of leading to mastery of the task. Clearly, even the procedural application of the proposed
management of flight routine (actions associated with self-preparation, planning, strategy building, implementation, progress monitoring and self-assessment) should be able to help direct cognition, allow the user to adapt behaviour to achieve the goal, and provide a positive level of self-efficacy. Pintrich (2000) maintains that these activities are indicators of mastery goal focus (in this case, management of flight).

Vancouver (2000) contends that an accurate internal representation (i.e., a mental model) of the desired state is necessary to control the outcomes of our actions (i.e., self-regulate) through decision making processes (Stevenson et al., 1990). The notion of mental models was explored during Studies 1 through 4. Several of the markers identified in Study 1 relate to the development of mental models. Study 2 explored the mechanisms by which the retention of knowledge and data (internal representation) is achieved. Further, Study 2 elicited comment on the activity of comparing the existing state to the required state as integral to the analysis phase of SA. The results of Study 3 indicated that knowledge acquisition and structuring were perceived to be essential to task completion. Finally, the results of Study 4 indicated that goal understanding, knowledge acquisition, planning and strategy building were perceived to be integral to the developed construct of self-regulated management of flight. The themes identified in Study 3 and explored in Study 4 are consistent with Zimmerman’s (2000) view of self-regulation, since these activities would require forethought resulting in an internal representation of the desired state being formulated (Stevenson et al., 1990).

The concept of management of flight which was derived as an outcome of Study 4 comprises a series of activities or actions which, when applied in sequence or parallel, will likely generate a state which is regulated and is adjusted by feedback from both the operation and the individual charged with controlling the outcome of the operation (Zimmerman, 2000). Aspects of the proposed construct (e.g., continuous questioning of self, flight status and others) imply conscious feedback generation which involves some form of reflection (Shapiro & Schwartz, 2000). Thus, the construct derived in Study 4 is dependent on a cybernetic approach (control and communication of feedback on performance). Further aspects of feedback, such as self-judgement and self-evaluation
(Zimmerman, 2000), are integral to the self-regulation cycle and are evident in the construct proposed in Study 4 with the inclusion of notions such as performance review and feedback generation activities (Appendix K, Q51: regularly reviewing all aspects of their performance, and Q52: generating accurate and honest feedback for themselves).

The process of feedback generation facilitates the cyclical nature (Schunk & Ertmer, 2000; Shapiro & Schwartz, 2000; Winne & Perry, 2000; Zimmerman, 2000) of self-regulation. The concept of management of flight proposed in Study 4 appears to be consistent with Pintrich’s (2000) view that cognition, motivation and behaviour are controlled by purposive forethought, monitoring, control and reflective activities. The similarity between the cyclical interventions put forward by Weinstein et al. (2000) and the description of management of flight generated by the present research is striking since both propose components pertaining to self-preparation, planning, strategy building, implementation, monitoring with the view to making changes as required, and self-assessment. The prospect that domain transfer may be possible cannot be ignored (e.g., education to aviation) to enhance pilot management of flight skills.

When compared to Kopp’s (1982) concept of childhood self-regulation development (modulation, control, self-control, and self-regulation) and Zimmerman’s (2000) four stage process of learning to self-regulate (forethought, volitional control, self-reflection, self-regulation), the results of this research suggest the notion that management of flight (command self-regulation) can be learned and that this prospect should be investigated. In part, the participants in Study 4 supported this proposal since the questionnaire from which the data was drawn was presented as a tool for establishing a routine from which novices could develop management of flight expertise. The failure of command training programmes within the airline of study suggests that the complexity of activities, which are ascribed to management of flight within this domain, might require targeted learning, rather than reliance on socialisation to achieve the required level of self-regulation. However, this will first require a programme to train the trainers, trainees and examiners.
10.8 The identification and the management of the possible limitations of this research

While it was necessary for the initiation and advancement of this research, the highly contextual nature of the research process is viewed as a possible weakness. Participants in this research were a defined group, who were predominantly Captains (a limited number of First and Second Officers contributed to Studies 2 & 5) within a largely international air carrier. A limited number of the Captains were engaged in short sector flying of one to three hours duration over land with a useable airport almost always in close proximity. The bulk of respondents were Captains flying long (6 to 14 hour) sectors on international operations over water or remote areas of the world with limited access to desirable alternate airports.

The performance profile for Captains engaged in long and short sector flying may be different since the contingent demands of the task are perceived to be different. At first glance, this research may have lacked the ability to discriminate between the relative complexities of long and short sector flying. Furthermore, because the research was so contextually-based, the ability to generalise the results is limited. Even if other contexts could be seen to exhibit similarities, the transportability of outcomes may be difficult to support empirically.

If the cultural and contextual differences between long and short haul pilots influence production cycle activities, the final result would be skewed in favour of long-haul participants, since the respective respondent ratio was approximately 3 to 1 throughout the research. This outcome would need to be reviewed, particularly with respect to Study 4. The responses from short-haul and long-haul pilots would need to be identifiable at this level. This demographic information was collected and the comparison was made between the two groups. However, the results failed to reveal any significant differences between the responses from short-haul Captains and the responses from long-haul Captains. This lack of difference indicated that the proposed construct of management of flight was as acceptable to short-haul Captains as it was to long-haul Captains.
Undertaking a research project where the researcher is totally devoid of personal ideas of possible outcomes is very difficult. As Wolcott (1990) observes, the temptation to pronounce ‘what ought to be’ rather than ‘what is’ continues to introduce bias. This temptation could be exacerbated by the apparent resistance to change, which an organisation exhibits, and the agenda of the researcher in facilitating this change. Unless thoroughly applied and validated, qualitative research methods could act as a vehicle for meeting such agendas since inductive analysis renders an interpretation (by the researcher) of the data. While interaction between the researcher and the phenomenon is essential to the determination of outcomes (Guba & Lincoln, 1994), the degree of researcher involvement in the contextual setting of this research might also translate into a possible limitation with respect to validity of the research.

However, in order to examine the function referred to as management of flight as comprehensively as possible, a broad-based approach to the collection of qualitative data was adopted. In order to effect a high quality triangulation, as many participants as possible and manageable were approached to contribute when qualitative data was sought. This expansive qualitative process was also designed to minimise the possibility of researcher bias. For example, Study 1 canvassed 165 possible respondents, while Study 2 was offered to 120 participants having first collected comment from about 60 focus group participants. Study 3 was an exception with only 15 interviews being completed. Upon completion of Study 5, and having adhered to the research model that was developed, over 800 opinions had contributed to the shape of the final management of flight construct. The mixed-method approach that was employed facilitated the incorporation of a large number of differing opinions and comments from multiple and oft times differing groups of participants, thereby minimising the influence of the researcher and ensuring high quality triangulation.

Further, the nature of voluntary participation in research also brings advantages and disadvantages. The respondents wish to have their views recorded, while the no less valid view of those who do not respond goes unrecorded. The degree to which the organisation
is perceived as generative (i.e., a ‘learning organisation’) will influence the individual in his/her decision to respond or not respond (Westrum, 1995). If the perception amongst potential respondents is that the individual cannot make a difference and is never heard by the management, then any attempt to elicit input by management or others (perceived to be management aligned) will not be an overwhelming success. Consequently, the outcomes will probably be skewed to an indeterminable degree.

This may have been the case with this research, since the research could be seen to be supported by a management structure which, rightly or wrongly, is perceived by some prospective respondents as ‘non-listening’, bureaucratic and, consequently, deficient in the generative arena. Further, participant scepticism has also been flagged as an issue in the process of establishing ownership of the results. The view that a research programme sponsored by organisational management alone would do little to allay these attitudes was taken from the outset. Therefore, the inclusion of the representative labour organisation as a sponsor was necessary. Fortunately, there was only a single union involved. Representatives of this body were included in discussions on research direction and target audiences as the research progressed. This representative reported back to the union’s Committee of Management on a regular basis. Joint signatories from the highest level of organisational management and the labour union were secured for covering sponsorship letters (see Appendices J and M) to allay scepticism and encourage responses. The response rate that was achieved in each study was relatively high and indicates that this mechanism of universal sponsorship was quite effective (see Table 1.1).

In summary, the return rates were sustained throughout the programme of research because the topic was of concern and of interest to most participants and, bipartisan support (management and union) for the research was evident to participants. The response rates seemed to indicate a sense of general involvement of the Captain cohort (see Table 1.1). All of these factors support the notion that a substantive (contextually applicable) outcome has resulted from this research project, and that this outcome aligns broadly with the general theories of self-regulation described in the literature.
10.9 Research Summary

The nature of the research restricts any general claims, since it would be inappropriate to
generalise the results to other domain settings. At best, the results should be seen as
contextual perceptions. While this position does not render the results any less valid for
the participant group (and participant perceptions of command readiness were the
catalysts for commencing the research), the ability to generalise the findings may not be
possible. Having considered the research questions, the outcomes of the individual
studies, and the relationship of the research to recent topical literature, the results of this
research can be summarised as follows:

1. SA is perceived to exist at both the goal-driven strategic level and the data-driven
tactical level;
2. Captains perceive that First Officers demonstrate good tactical SA and, also perceive
that First Officers are less likely to maintain strategic (overview) SA;
3. Captains perceive tactical SA as a highly favoured indicator (amongst others) of
command readiness;
4. Captains perceive that both tactical and strategic SA must be present to render good
management of flight performance;
5. The themes identified in Study 3 are indicative of a construct of self-regulation and
are perceived to be useful in developing effective contextual management of flight
skills (Study 4);
6. SA in all its forms is perceived to be subsumed by the umbrella construct of self-
regulation; and
7. It was possible to construct an ipsative questionnaire, which demonstrated a potential
ability to identify the desired traits and skills of Captains in respondents.

The main implication of these findings is that when there are aspects of the self-
regulation construct that are not demonstrated, there is a perception that management of
flight performance will not be optimal. The construct of self-regulation is perceived by
participants to define management of flight performance within their operating context.
The contextual perception of self-regulation exists at two levels: the concept level (the construct components of self-preparation, planning, strategy building, implementation, progress monitoring and self-assessment) and the action level (the action statements which support the construct components). Further, cyclical processes that operate in series or parallel when required, are perceived to be evident at both levels. Such is the perceived nature of command management of flight performance in this piloting context.

10.10 Future Research

Within the originating context (the airline of study), the definition of management of flight (in the form of an ipsative questionnaire) could be tested and validated against current methods used to assess the potential of First Officers to pass Captain training. This process needs to occur at both the initial selection and at the command training approval stages so that normative data can be gathered. Once this process of internal validation has been completed, these data can then be used to address external validation. The external validation process would continue the development and refinement of tools capable of contributing to an understanding of the strengths of individuals with respect to their role as Captains of airliners.

Globally, the outcomes of this research have the potential to support future research into several areas of pilot performance that are related to management of flight. To propose some directions in this respect, it will be necessary to explore a possible validation and adaptation of this research. The ever changing human/machine interface and the design and implementation of human and computerised systems to achieve the goal of safe air travel on a global scale is of concern to aviation designers, manufacturers, and operators.

Figure 10.2, the aviation domain-oriented functional model of self-regulation proposed in Chapter 8, is a prototype of such a design/operating/performance model. Its strength may well be its simplicity. This prototype, and any of its derivatives, is yet to tested empirically. However, through the cyclical nature of their planning, implementation, monitoring and assessment phases, concepts of self-regulation propose that the self-
regulating human will engage in activities which modify the adopted course of action to meet the changing needs of the operational environment (see Figure 10.2). The incorporation of an identifiable stage of intervention, once the need has been established, has yet to be clearly defined.

Figure 10.2: Aviation domain-oriented functional model of self-regulation
The present research project suggests that the construct of self-regulation supports individual pilot management of flight performance within the airline of study. The robustness and applicability of this construct to other aspects of the piloting role appear less obvious. That is, the increasing role of automation in flight operations does not seem to be addressed by the outcomes of this research. Historically, there has been a consistent move towards total automation with each new generation aircraft. The events of September 11th 2001 will conceivably provide added impetus to the drive towards fully automated, remote controlled flight capability. Given the existing technology, this is an achievable goal. The role of the pilot will change in a dramatic way should this come to pass. Conceivably, the pilot will be required to operate in parallel with flight control systems, rather than as a serial part of the system.

A model for flight control which adequately supports the human/automation interface would simplify the challenges which remote controlled automated flight would bring. Significantly, once validated through further studies, the findings of this research could possibly be used to develop selection criteria, set training curricula, train pilots, observe and assess their performance. Depending on the level of redundancy ascribed to the pilot in such a system, the model suggested in Figure 10.3 could also define human intervention and, in particular, the extent to which the pilot would be allowed to input to flight decision making.

The clear definition of this intervention stage in the proposed model is pivotal to the viability of Figure 10.3 as a vehicle for understanding the human role in automated flight at any level of sophistication. For example, if the height lock on the simplest of autopilots or the traffic separation computer on a more complex autopilot is not achieving the goal, then the attending operator (pilot) must intervene. Of course, software could be developed to trigger automated intervention. Ultimately, software could be developed to cope with all conceivable flight variables. The adoption of this technology then becomes a matter of acceptability to the travelling public.
It is hard to imagine that the progression to *pilotless* flight will be made in one leap. Integral to an intermediate position will be the provision of a seat at the decision making table for the pilot (flight operator). An essential part of such a proposition will be that the pilot maintains an overview of the flight and considers the variables as they present. Only then will the pilot be fully equipped to take part in decisions which will affect the outcomes of the flight. In effect, if Figure 10.2 and Figure 10.3 are successfully tested, Figure 10.3 would be representative of the management of a flight where the operator (pilot) works with sophisticated automation. The automated systems and the pilot will fulfil most of the functions inherent in Figure 10.3 concurrently and work together at the intervention point to effect required changes.

**HUMAN and/or AUTOMATED SYSTEMS**

![Diagram](image)

Figure 10.3: A model of the human to automated systems interface
Figure 10.3 proposes a flexible approach to flight control in that, in the extreme cases, flight will be totally controlled by the human or totally controlled by automated systems. Today's reality is that, while humans remain finally responsible for flight control (management), the drift from total human control to automated control has begun and, for historical reasons, may accelerate. If validated, the proposed model (Figure 10.3) could also cater for failures, which necessitate a reversion in either direction. That is, failures that require more human control, or failures that require more automated control.

The research questions which spring from the extension of the research completed during this exploration of the perceptions of competent airline Captain management of flight performance pertain to all facets of flight operations now, and into the future, namely:

- Can the perceptions regarding management of flight revealed in this research be validated?
- Can the findings of this research be incorporated into training development, observation, and assessment of performance of humans in the cockpit?
- Can the findings of this research be used to develop selection instruments to assist with the identification of personnel capable of fulfilling the changing human role in flight operations?
- Are the findings of this research applicable to the human to automated systems interface?
- Can the findings of this research be applied to automation design into the future?
## Appendix A

Comparison of selection test results

<table>
<thead>
<tr>
<th>Measure</th>
<th>Poor Performer Range</th>
<th>Good Performer Range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( N=18 )</td>
<td>( N=20 )</td>
</tr>
<tr>
<td>IQ</td>
<td>108 to 122</td>
<td>107 to 125</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>13\textsuperscript{th} to 34\textsuperscript{th} %ile</td>
<td>6\textsuperscript{th} to 98\textsuperscript{th} %ile</td>
</tr>
<tr>
<td>Verbal: Concepts:</td>
<td>16\textsuperscript{th} to 84\textsuperscript{th} %ile</td>
<td>11\textsuperscript{th} to 73\textsuperscript{th} %ile</td>
</tr>
<tr>
<td>Reasoning:</td>
<td>5\textsuperscript{th} to 89\textsuperscript{th} %ile</td>
<td>2\textsuperscript{nd} to 95\textsuperscript{th} %ile</td>
</tr>
<tr>
<td>Spoken:</td>
<td>8\textsuperscript{th} to 82\textsuperscript{nd} %ile</td>
<td>6\textsuperscript{th} to 99\textsuperscript{th} %ile</td>
</tr>
<tr>
<td>Written:</td>
<td>59\textsuperscript{th} to 86\textsuperscript{th} %ile</td>
<td>4\textsuperscript{th} to 97\textsuperscript{th} %ile</td>
</tr>
<tr>
<td>Numerical:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reasoning:</td>
<td>27\textsuperscript{th} to 95\textsuperscript{th} %ile</td>
<td>27\textsuperscript{th} to 96\textsuperscript{th} %ile</td>
</tr>
<tr>
<td>Critical reasoning:</td>
<td>27\textsuperscript{th} to 95\textsuperscript{th} %ile</td>
<td>8\textsuperscript{th} to 95\textsuperscript{th} %ile</td>
</tr>
<tr>
<td>Spatial:</td>
<td>18\textsuperscript{th} to 86\textsuperscript{th} %ile</td>
<td>29\textsuperscript{th} to 99\textsuperscript{th} %ile</td>
</tr>
<tr>
<td>Mechanical:</td>
<td>39\textsuperscript{th} to 89\textsuperscript{th} %ile</td>
<td>8\textsuperscript{th} to 79\textsuperscript{th} %ile</td>
</tr>
<tr>
<td>Diagrammatic:</td>
<td>4\textsuperscript{th} to 93\textsuperscript{rd} %ile</td>
<td>21\textsuperscript{st} to 98\textsuperscript{th} %ile</td>
</tr>
<tr>
<td>Personality:</td>
<td>poor to high overall</td>
<td>poor to good overall</td>
</tr>
</tbody>
</table>
Appendix B

FEEDBACK ON IDENTIFIED CAPTAIN ATTRIBUTES

I have _____ years experience as an Airline Captain.

Please consider each statement and record a response according to the following table. Written expansion of your answers would be helpful.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>DISAGREE</td>
<td>DISAGREE</td>
<td>NEUTRAL</td>
<td>AGREE</td>
<td>AGREE</td>
</tr>
<tr>
<td>STRONGLY</td>
<td>SLIGHTLY</td>
<td>SLIGHTLY</td>
<td>STRONGLY</td>
<td></td>
</tr>
</tbody>
</table>

1.____ All the identified markers are useable in defining the role of Captain.

2.____ The underlying concepts of Table 5.9 are appropriate

3.____ The groupings in Table 5.9 are practical.

4.____ The definition which Table 5.9 (or similar) offers will assist in the training and checking of Captains.

5.____ Terminology used in Table 5.9 is clear and explanatory.

6.____ Adequate training is given to Trainers & Trainees in all facets of Tab 5.9

7.____ Given supporting documentation, I would use Table 5.9 (or similar) as a reference in my Training & Checking duties.

8.____ Table 5.9 (or similar) has the potential to match the expectations of the trainees with those of the system.

9.____ Table 5.9 (or similar) will make it easier to identify areas of strength & weakness in Trainees.

10.____ Trainees could use Table 5.9 as a self preparation tool.
Appendix C

Summary of qualitative comment by respondents to the questionnaire detailed in Appendix B:

- Simplify the language used or provide education
- Final form of Table 5.9 should be idiot proof
- More consultation required before final form of Table 5.9 is decided
- Final form of Table 5.9 should be issued to all pilots so that all are aiming at the same goal posts
- Attributes as recorded could be used in a building block fashion during time as copilot
- Some of the identified attributes are identifiable during the selection process
- Reworking of the attribute groupings may be required
- This format may be too complex or less than optimum
- Overlap between groups exists in more than one area
- Table 5.9 would be a good aid but too complex for day to day use
- Table 5.9 is a good checklist for performance
- Ownership has been established by the development method
- Table 5.9 is more applicable to training than checking
- An expanded version of Table 5.9 is required to be put into use
- Table 5.9 is excellent as it is simple and logical
- Word picture examples need to be given to expand on terminology
- Underlying concepts need to be explained more fully
- Training will be required in attribute recognition
- Formalise these aspects of training
- It is regrettable to have to acknowledge that the system does not provide training in all areas
- Give detailed examples in supporting documentation
- Table 5.9 could intimidate trainees
- Table 5.9 could be used as the basis for an advanced command training checklist
- Publish guidelines for everybody
- A more user friendly format is required
- Useful as an explanation aid for trainees
- Trainees who need it most may not be able to identify this need themselves
- Use Table 5.9 in pre-command courses
- If aware of Table 5.9, trainees may role play too much
Appendix D

Within the context of airline operations, flight crew can develop and maintain Situational Awareness by the continuous acquisition, retention, analysis and application of knowledge of events, conditions, data and variables.

54. Do you agree with the basic concept expressed by this statement? (a) Yes (b) No

Consider the qualifications attributed to each of the four components of this concept and cross out those with which you do not agree.

55. Acquisition
   (a) perceive (b) question (c) listen
   (d) share (e) vigilance (f) recency
   (g) overall experience (h) sensitive (i) systematic
   (j) continuous (k) disciplined (l) delegate

56. Retention
   (a) memorise (b) concrete (c) associations
    (e.g. diagrams) (e) use of imagery (i.e. (e.g. speed/thrust)
    (d) prioritised (i.e. most important (f) use of mental models (i.e. representations of objects
    first) sharp images of their properties)
    (g) vocalisation (i.e. (h) repetition (i) mnemonics
    say to yourself) (i) grouping into
    (j) grouping into (k) rote learning (l) structured plan (e.g. left to
    manageable chunks right or beginning to end)

57. Analysis
   (a) deduce (b) categorise (c) assess
   (d) sift (e) prioritise (f) actual V required
   (g) potential (h) internal and (i) mental models
   (j) compare with external influences (k) understand (l) consider implications
   previous experience
   (m) cross-check validity

58. Application
   (a) predict (n) resolve ambiguity (c) control
   (b) overview (d) timely (f) safety
   (e) timely (g) reassess (i) remodel
   (h) reassess (j) efficiency (l) worst case scenarios
   (k) efficiency (m) beyond obvious (o) normal and non-normal
   (n) present and future
   (p) revise plan
Appendix E

Generic Interview Questions – Study 3

1. You have just been called out to rescue an aeroplane and passengers that is stranded in Bogata and take it to Buenos Aires. How you are going to approach this unusual task?
2. Picture yourself going out to the aeroplane to operate the service. How are you going to implement this plan you have put together? What would be some of the things you would do?
3. You have never met the crew before. What are some of the words you might say to them to establish the right environment?
4. The aeroplane is cranked up and you are under way. What are some of the things that occupy your mind and time while you are flying down to Buenos Aires?
5. How do you keep track of the progress of the flight?
6. Describe some of the strategies you would use to tackle this unknown sector.
7. Are there any parts of the local culture that might generate a reaction from you and the way you would do business on this flight?
8. For instance, the South American region doesn’t have a good record for CFIT. Why do you think this is?
9. How do you think air traffic control contributes to the problems of the region?
10. You have landed in Buenos Aires. Is there anything you would do at that stage as the final part of the flight?
11. How would you assess your own performance?
12. How do you react to disparities between your perception of your performance and the perception of others of your performance?
13. How much and what kind of effort do you find that you still have to apply to your job?
14. If you were to define the Captain’s responsibilities, what facets of the operation would you say he or she is responsible for?
15. With respect to first officers, how would you pick a person who you thought had what it takes to make Command?
16. Are there any other things that you might see in a co-pilot that indicates that he or she is a good candidate for Command?
17. Is there anything else you would want to add?

Thank you.
Appendix F

Example of semi-structured interview used for data gathering in Study 3

GB: You have just been called out to rescue an aeroplane that is in Bogata and take it to Buenos Aeries, I want you to tell me how you are going to approach that task.

Int: Okay Graham, there is obviously a number of questions I have to ask myself, given that I have never operated over there before and know nothing about Bogata. I know where Buenos Aeries is. There would be a lot of preparation I would need to do, for me to feel comfortable doing the sector. First, physically I would want to know about the airport of Bogata, the elevation, the runways where the aircraft is going to be parked, things like flight planning: How they are going to get to me? Any likely performance problems? - that is just concerning Bogata itself. Why is the aircraft in Bogata? Has there been a mechanical problem? Has there been some other problem? Am I going to operate under an MEL, ATP? Is there likely to be any operational restriction, etc? I would want to look at the route the sector. What sort of safety heights are involved and the implications concerning that. I am not sure how long the sector will be, all these things. Obviously it is unlikely I am going to be a heavyweight, but it is going to impinge on three engine, two engine performance on the flight. Then I would want to look at Buenos Aeries - once again the layout, airport, parking, how we are going to be handled, what sort of arrival, etc. I don’t want to be going there cold trying to find places on a map.

GB: Could you please explain what “cold” is. What does “cold” mean?

Int: “Cold” is no preparation. Not knowing. For instance, the first time I went to Tokyo, knowing, I had a mental picture in my mind where the airport was, where the navigation aids around Tokyo, where likely holding pattern are. So I had a mental picture of where I am coming from, and where I am likely to be going to, so when I am cleared to a position, I am not picking up the chart to try to work out how I am
going to get there. So it’s a matter of having some awareness of where things are with reference to an airport. So it is the preparation. Knowing basically where things are.

GB: Could you explain that awareness level that you are looking for a little bit better for me? What level of awareness?

Int: I am not going to have an intimate knowledge, given that I have not done that route before. I would not have seen it before, but I would want to know, as I said, where the airport is with reference to the city, where other airports are with reference to that airport. In other words, in the worst case scenario, where else can I go? What are my options? That is the level of awareness I am taking about. In other words, I don’t want to be scrambling. I don’t want to be having to prove things top of my head in an area with which I am not familiar. I can do that in London, because I know the area much more intimately, I can cope. I know where Stansted is, I know where Manchester is, I know where Gatwick is. I have a good mental picture. So this is the level of awareness I am talking about. Having a good mental picture so that I have options. I don’t want to be going in there with one hand tied behind my back.

GB: You have developed this level of awareness you talked about, what is the next step?

Int: Now I would need more specific information. At sign on, I would go and talk to Flight Planning, because they should have an idea of what we are going to do. So I would talk to them, this is even if I am to get a copy of the flight plan. I would go and see route qualifications, given that these are two airports we don’t normally operate into. I would expect they would have some information which they normally put together in a package for this sort of operation, and it would have things like airport characteristics, terrain and also find out if they have any typographical charts, if not, certainly an airways chart that I can take with me. But I would expect to have a package available in the normal scenario, that I can take with me. I am assuming that this is going to be a two man crew, I would ask him what he knows about it. Has he been to South America? He might be an ex Air force guy, operated an ad hoc VIP charter. At least what information he has. Has he been there before. Given the time
constraints we are under, we are going to get across to check in. We are not going to delay an aircraft, even if they have not got the information immediately available. Could they fax it to the hotel? On the way across, I would spend time looking at the information on the aircraft on the flight deck, in the countries I have not operated to, just familiarising myself with any difference with things that I would normally expect to. So look at the text. There obviously would not be any information chart-wise on the airport, because we don’t normally go there. Talk to the people on the crew, just to see even if they have visited the city, either one. We have done charters in the past. If you don’t ask, you don’t know. And then having done all that, then it would be matter of waiting to actually arrive in Bogota to be able to continue the chase. On arrival in Bogata, the airport is going to be the best place to try and locate some information. Talk to whoever the local airline is. There is a good chance that the local airline would operate that sector on a regular basis and there would be someone there you can at least talk to. What can I expect on departure? What can I expect on arrival? Even talking to ATC. What clearance do you normally give? Are there any unusual restrictions for that departure?

GB: Why are you building this expectation?

Int: Because I don’t know anything about this operation. I want to have a level of preparedness. There are going to be surprises anyway, but I want to try and anticipate some of those surprises. I would rather try and have as few surprises as possible in a day.

GB: Could you operate that sector without any of this preparation?

Int: You probably could. But it would be, if nothing went wrong, you would get away with it. But on this level of ad hoc operation, things tend not to go according to plan. You don’t have your local people. Strangers refuelling us, strangers handling us. You have to expect the unexpected. The more things I know, the more likely I will be able to deal with them at the time.
GB: Now just picture yourself going out to the aeroplane to operate the service, how are you going to implement this plan you have put together? What would be some of the things you would do?

Int: When I get to the airport, obviously one of the first things I would want to do is meet the crew. That is important on any flight - where all the crew members at least know what I look like, and the FO, and all the crew, at least they can put a face to the voice over the PA - meet the crew. If we are on the bus together going out to the airport, I would probably have brief word. I am not a great believer in chatting too long, but introduce myself, tell them what I knew of what we are going to do today. Often the CSM (Customer Service Manager) has more information that I do, and ask him what he can tell me of what he knows about the operation: number of passengers, who would be handling us, who is the Qantas agent looking after us. Obviously we would need Qantas back up to do all these things, and often the CSM will have the information. Their support is quite good from their office here in Sydney. Once we get to the airport, it is going to be things like, firstly, where do we put our bags, all the basic things, where is flight planning? They should have the information, as I had asked that information to be faxed to me in the hotel. Still it's a matter of finding it at a strange airport, making sure that everyone is aware of where they are going and what we are trying to do. In other words keeping everyone together so we are not losing people in this strange environment. The FO and I go to Flight Planning. At that point I would have given him as much information as I had as the things we discussed. Under the circumstances, I would probably elect to fly the sector. It is not that I'm a selfish person, but I like to fly. It is a one sector thing, it is a strange airport, I would probably elect to do that.

GB: What is the advantage in that?

Int: Firstly, it is giving, keeping people in their best roles. In other words, the FO is the best person probably to give support. The Captain will give the best support he can. Obviously it is often better when someone who is used to being in that role. When I am operating a sector, I am probably better in my most comfortable role in running
the show. Flight planning, as I said, we would have as much information as we could, but it is still going to be limited. Things like checking NOTAMS would require extra time and care to do. This is one case probably where I would be making an effort to leave on time, but in the back of my mind knowing that it’s probably not going to happen, only close, mainly because everything is unfamiliar.

**GB:** Would you purposely slow it down, because of that?

**Int:** I don’t know about purposely slowing it down, but I would look at things more carefully. I would not deliberately try to slow it down, but not to let things slip through which unless you are absolutely sure what you are letting slip through. I would be probably quite conservative in my fuel order, once again only because I don’t know what plans are at the other end. From the weather point of view, forecast is forecast, that is only because I don’t know what holding is going to be, how good ATC is, are you going to be stuffed around, are you likely to get to the level you want. I would be on the conservative side, not ridiculously so, but I would have a pad to give myself those options. Having done that, I would hope at that point, that there would be some sort of Qantas rep there, a manager from some other point whom I can talk to, who can point me in the direction of the aircraft. On the aircraft, firstly talk to the CSM re: the flight time, giving the flight time, and other details, weather is fine or whatever on route and for arrival, whether there is likely to be a short a taxi. Having talked to him see if I can find the engineer, to make sure we don’t have any other unknown problems there, aircraft is ready to go operating normally, and then get about doing the check and getting on the road.

**GB:** Is it important that the rest of the crew have an input to the operation?

**Int:** In what regard?

**GB:** In any regard that they think that they need to.
Int: Yes, it is. Obviously, if you have Spanish speakers on board, they could be a great help in the communication situation. Can I communicate? I would assume the engineer would speak English, but if I have got a Spanish speaker who can interpret for me, that is going to make my life easier, to make everything run so smoothly. Yes, it is important to find out, and communicate as much a possible, but in this case it is a resource, all these people who have skills who can contribute particularly say in a new environment.

GB: How do you set up that environment?

Int: Well in the first place, it is when meeting the crew. You would soon find out if there is a Spanish speaker, when you first meet and have a chat before departure, in the hotel lobby. You will pick up things, if only with people you may have seen before, and that is creating a bond. People will go an extra mile for you if they respect you and like you and everyone is not going to like you, but you are creating an environment where you give it the best chance to happen. And that is also where you often pick up the Spanish speakers, and other things which can be useful if not right at the moment but you can store away for use at sometime down the track.

GB: With crew that you have never met before, what are some of the words you might say to them to establish this environment?

Int: Well, when I first meet them, I am a great believer in introducing myself by Christian name. I don’t put myself on a pedestal. I already have the trappings of power, I have the four bars. Then what I need to do is create an environment where they are comfortable in being able talk to me. Putting myself close to their level, in their mind. Given the 16 people in the crew, you are not going to spend a lot of time, if I have not met before - just how long you are going to fly, how have they enjoyed Bogota, have you been there before? Then if they have any information, then they are likely to offer it.
GB: So you have got the aeroplane cranked up and you are under way, what are some of the things that occupy your mind and time while you are flying down to Buenos Aeries?

Int: On the way, given that things are going according to plan, and I must say that I would anticipate that the plan is going to be a fairly accurate reflection of what we are doing given the information available to us. I would be now more concentrating given that I am happy with the actual minute to minute running of where we are, what we are doing, I would be now thinking about the arrival. I would have already if possible briefed myself as comprehensively as possible on the airport. I would be thinking about obviously the weather, what runway I am going to be using, what kind of approach that is likely to entail, and also in the worst case scenario, where else can I go, and how I am going to get there, and I would always want to know what my options are, particularly before I commence to descend. Once you have commenced descending, you often lock yourself into a landing at a destination. So that sort of thing, you can plan, and that is information you have already. So, mainly thinking about your arrival, physically getting on the ground, after you are on the ground, where am I going to go, how am I going to taxi there. Before I start to descend, could I talk to anyone, to let them know we are coming, where we are going to park, who is going to meet us. Once again that housekeeping stuff.

GB: How do you keep track of the progress of the flight?

Int: Well, I keep track - I always have a mental 2 minutes ahead and 400ks ahead type of operation in that regard. On the progress page (FMS), I keep an eye on that as well, as far as it makes sense, if the arrival time, and the fuel on arrival doesn’t make sense, normally on a short flight it is not too bad, because it doesn’t always reflect your arrival time and fuel.

GB: Will you have any strategies to tackle this unknown sector?
Int: I don’t think that I will be doing anything much more differently as far as strategy than I would do normally. I think half the battle in this sort of operation is to try and keep it as normal as possible, doing the things in the same way that you always do. I think that, in itself, builds in a texture by doing it the same way. Yes, I would be aware that time would probably be an issue, because of my guess that the South American mentality may be a case in point, but I am not going to be getting uptight about the fact that departure time is coming close and still no load sheet, the passengers are not all on board. I believe in this situation, you have to accept a certain amount of inevitability that it is not going to go the way you like it to. But in other regards, I very much try and keep it as simple and as normal as possible.

GB: Are there any other parts of that local culture that might generate a reaction from you and the way you do business in this form?

Int: Only so far as what I have mentioned where normally time is quite important to me. I am very aware of time. This is one where I would make sure that the time issue is not one of my major constraints. In other words, stay relaxed and stay aware. It is too easy to get up tight, to narrow down, to get fixated on something and miss something which is much more important. I know it has happened to me before, where you get fixated on a particular thing, where time is a classic one where you are pushing to get things done, and you miss something which turns out to be much more important.

GB: South American region doesn’t have a good record for CFIT for instance, why do you think that is?

Int: I would assume it comes out of situational awareness. They don’t know where they are.

GB: Who are “they”?

Int: The local pilots. Given that CFIT mostly, apart from the recent one in the case of American Airlines, most instances appear to have been local pilots operating in IFR. I
would suggest that the reason that they hit these hills is because they are somewhere other than actually where they thought they were.

GB: Do you think air traffic control could contribute to this big problem?

Int: They possibly could. With my little experience I have had in Mexico for instance, it is a very laid back system of air traffic control, but ultimately air traffic control doesn’t fly you into the hill. They can clear you to do anything. They can clear you to a particular safety height, but it is up to you accept that clearance. I don’t believe that ATC in that respect, where you can fob off responsibility for that sort of incident. One more thing, one thing that ATC can contribute to is a situation where they try to rush you and cut corners, reduce separation and set you up, but if you are prepared to go along with it, where you try to operate the aircraft in the corners of the envelope.

GB: Do you see this filtering of instruction as the Captain’s role, or the crew’s role?

Int: I think it is the crew’s role. I think it is very much a part of the job to filter information and it is very important that both the FO and Second Officer, if you have one or two, that you are hearing exactly the same thing. It is too easy to hear something, because you already have an idea in your head to assume that they mean the instruction is this. It happens all too often. Yesterday for instance going to Melbourne, I asked the FO, in one case talking to the Company, to ask a particular question, he then asked the question but in a way which had no bearing on what I wanted. But that is what he heard. One the return journey, we were behind a 767, and we were about 15 miles behind and overtaking slowly, so I said to the FO, "Would you ask ATC if they would like us to reduce speed slightly now, so as not to affect the arrival.” So then he said “Would you like us to slow up now to reduce our holding?” I said, I never said anything about holding, then ATC would say “What holding are you expecting?” This is the sort of interpretation you have to make sure when ATC give instruction that you are both clear. I think it is important that the Captain sets the tone to the level that he and the crew are happy with. It is no good if
the Captain is running at 100 miles an hour and the crew can run only at 60. Once again, you got to set a level at which everyone can reasonably meet.

GB: So you have landed in Buenos Aeries, is there anything you would do at that stage as the final part of the flight?

Int: I always talk to the crew after we actually shut down and discuss anything I have learned. Something unexpected. We can plan so much, but there would be always something which is going to be out of left field. So I would ask, was there anything you noticed with the communication when you talked to ATC? Did they do things that you thought were unusual? As I said, a little bit of debrief after we have shut down, just from the point of view of saying, why were we surprised by that, or it all really worked just as we thought, I was really happy with that sector, and ATC was much better than I expected them to be, they were not laid back, etc.

GB: Would you assess your own performance?

Int: Once again, I think it is important you do that. I have always, when I debrief myself to the crew, once again, whether it is in front of the FO or two or three others, always say things like, that approach was a little sloppy, or I knew I was a bit tired, but I didn’t push myself hard enough. So yes, I think it is critical for the Captain as the leader of the team should say “I wasn’t happy with that part of the sector” or “I was happy with the way they worked” and invite any other comments about my performance. And often someone would comment on it.

GB: Do you ever find a disparity between your view of reality and what other people see? Are you ever surprised by comments?

Int: Mostly not. No, I think I am fairly hard on myself. By and large, I tend to be quite hard in assessing my own performance, and often not surprised by outside comments.

GB: Do you find that you still have to put a fair bit of effort into aviation?
Int: More so. There are things which become easier, but certainly the flying, I have got to work as hard or harder than when I was 30 or 31. But now I really have to work hard to get the result I want, and even then, I often don’t meet my expectations or demands on myself.

GB: Do you think general co-pilots understand that?

Int: Probably not. I think that they think that the longer you fly, they expect it to be easy almost. I think you can make it look easier by looking relaxed, but underneath, certainly in my case, I have to work harder now on the straight flying side. But on the route flying, things do become easier. I am happy in the environment.

GB: If you were to define the Captain’s responsibilities, what facets of the operation is he/she responsible for?

Int: He is responsible for the entire operation in the broader sense, however, you have to delegate a lot of the responsibilities, like loading of the aircraft, cabin service, and the crew rest. I am not going to go back there and toss and turn worrying about what is happening at the front. So you have to be able to delegate that responsibility to that FO and be happy that he can do it. Now if I can’t trust him to do that, I am not going to go off in the first place. If I am not happy with what he is doing, then I will stay there. But I take the responsibility personally, whether it be talking to the engineers, catering with regard to what is advertised, etc. I take that responsibility in the fullest sense. The safety, the comfort, etc.

GB: You are looking at a co-pilot. How would you pick a person who you thought had what it takes to make Command?

Int: It is an attitude. It is preparation. That to me is one of the first signs.

GB: What do you mean by preparation?
Int: Flight Planning that he is offering things. For instance, it is no good if he can read a NOTAM unless it means something to him. It is no good if he is looking at a NOTAM for Jakarta and not knowing where the runway is. So if he had good route knowledge, and it becomes evident not particularly in the first sector, but if you are doing it three or four times, it becomes more and more evident. He offers things, once given that opportunity for input, then the good guys do, in a way which is easily acceptable by the Captain. They will generally fly pretty well. Ability to communicate, to talk, to mix. That is an important part of this job. one that has been overlooked a lot. It is no good having the best pair of hands in the world, the best preparation, if you can’t get the best out of your crew. In other words, create an environment where people are happy to contribute.

GB: It used to happen when we first joined.

Int: Yes, it used to happen. I don’t think it worked particularly well. But you learned to offer things in a way, so that the Captain thought it was his idea. You become a bit diplomatic in the way you suggest things.

GB: Are there any other things, which you might see in a co-pilot which indicates that they are a good candidate for Command?

Int: As I said it is an overall expression that you develop. It is the way they conduct themselves. Having a good knowledge of even the aircraft, if you get a problem, even the ability to say, doesn’t it work like this, and this. In other words, they obviously put the time into the books, shows an interest and maturity, and willingness to contribute. I can’t put a finger on a particular thing, but it is an overall impression you get. His conduct, appearance, his knowledge, his flying, and it is the whole package. After I fly with him two or three times, I would know if he can make it to command or not.

GB: Would communication include to be able to accept suggestions from you?
Int: I think it is an important thing. If there is a failing at all, a reluctance to accept criticism, I find is a common feature. Too many F/Os have got those. You can couch criticism as constructively and as well managed as you like, too many won’t or can’t accept it. The ones who will obviously have the maturity to be able to look at it in the way it is presented. I have to be able to equally take the criticism. The FO are not too critical, but they ask questions like “Why did you do it that way?” Criticism is a two way street. You got to be able to take it as well as give it.

GB: That has been great. Thank you very much.
Appendix G

Discussion paper on command management

Preamble.

Achievement of an airline command continues to elude many applicants. Part of the problem may be that the goal, in the form of job description and specification, has been inadequately defined. This document is an attempt to establish performance indicators and thereby clarify the goal definition.

The Goal Defined.

In organisational terms, the captain of an aircraft must be seen as the front line risk manager. This person alone is charged with the authority to determine the final disposition of aircraft under his/her command. This ability to call a halt to the operation or decide on an alternative course of action translates into management of risk. The effort required to manage risk will occupy cognitive capacity or space.

This risk space has been traditionally occupied by four identifiable risks, namely SAFETY, CUSTOMER COMFORT, SCHEDULE and ECONOMY. The risk in these operational facets can be described as ‘a risk of failure which will adversely affect the survival of the organisation at large’. Airline captains must continue to demonstrated the capacity to manage these risks at a level which ensures the best organisational outcome.

The ‘Swiss cheese’ conceptualisation of organisational safety demonstrates the need to close as many holes as possible in the performance of airline captains. In the organisational sense, this concept of imperfection applies to the other identified risks.

How is this done?

There are two dimensions to this required performance, the cognitive and the behavioural. Because cognition is not observable, judgements of performance are largely made on exhibited behaviours although questioning protocols have a place,
especially in training. Generally, in this context, behaviours are the result of natural attributes, training, experience and culture.

Deficiencies in any of these areas will result in less than desired performance. To date there has been strong reliance on natural attributes and experience to instil the required culture, with training being largely limited to stick and rudder skills and desired behaviours through CRM. Cognitive processes, the essence of risk space management, if developed, have been a result of osmosis.

Culture

Because of its underlying influence, the concept of culture should be explored first. Culture can be briefly described as beliefs, values and attitudes. The difference between desired culture and exhibited culture represents a performance degradation.

Cultural development can be categorised in three stages:

• pathological, where the fear of being caught drives behaviours;
• bureaucratic, where rules and regulations shape behaviours; and
• generative, where responsibility is shared and failures are treated as learning experiences.

Culture influences responses in risk management. The airline captain will manage risk in accordance with his/her perception of national and organisational culture. That is, his/her interpretation of these cultures. It is very difficult for individuals to ignore established culture. Culture will shape responses to all risk.

It may follow that departments within an organisation develop mature cultures in particular areas of risks as a result of their perceived primary role. The inconsistency of cultural maturity is one of the many challenges facing the airline captain. However, the airline captain must come to grips with the inextricable link between operational and commercial culture. While the hierarchy detailed above is valid, managing risk in one area stimulates responses in other areas by default.
Cognitive Process

Contrary to the belief of some, airline captains are mere mortals with a limit to their cognitive capacity. If risk is to be managed successfully, a system of managing demand on this finite resource must be developed and used by each captain. By controlling the availability of cognitive resources in this way, there will always be space to assess the risk associated with any proposed course of action or behaviour.

This notion of multi-tasking implies a degree of automaticity. Complex systems such as the modern airliner cannot be managed without some unconscious and seemingly automatic actions. This operational state can be a result of experience or conscious cognitive organisation. The command trainee will rely more on the latter. A structured system of acquiring data and information pre-flight must be in place.

This process will yield a data/information dense mental representation of the sector/s to be flown. Probably, the best results will be achieved if the sector is reduced to manageable sections and information assembled and sequentially structured for each section. This puts in place a default model of the flight which can be mobilised to control the operation if cognitive space is squeezed, especially if it has been rehearsed pre-flight.

There are two standards of default model, the prototype and the executive models. The prototype (developed largely pre-flight) will need to be adjusted as the operation progresses and missing, updated, conflicting or novel information comes to hand. One of the problems here for the inexperienced is the inability/failure to turn the inbound data stream into information, to make it meaningful. For example, wind speed at destination is useless unless direction of the wind and runway is also known.

The prototype will become the executive model only after all changes to accommodate the latest information have been made. This is why the operator needs to reflect on the goals of the flight from time to time to make sure that they are being achieved in the best possible fashion. The executive model will, by design, be developed to a point well down track if not all the way to destination (and/or on to an
alternate!). In this way, the operation can be ‘kept on track’ in times of high cognitive workload.

When missing, updated, conflicting or novel information is detected, the potential impact of the information will have to be assessed so that the representation being used to drive the operation can be adjusted in the most appropriate way. This response can involve any or all of the following:

- noting the information;
- making an inquiry of other crew members or an agency for clarification;
- devising a tactic to accommodate short term impacts; or
- changing or developing new strategies to realise the long term goals of the operation.

This sequence defines a hierarchy of responses. Incorporation of the most suitable response will ensure the most successful result in the form of risk management. Achievement in this regard will require varying degrees of conscious control on the part of the operator. In the airline context, such responses are unlikely to be automatic. This self-regulation of the use of cognitive capacity relies heavily on individual abilities to self-check progress and assess each situation in the unfolding scenario.

The process of self-checking is facilitated by reflective ability. This ability to mentally stand to one side of the operation and assess progress in an uninvolved fashion is vital to successful cognitive management. It is this ability which will enable critical redirection of the operation to take place. Simple statements or thoughts such as ‘What are we trying to achieve here?’ have the powerful effect of refocussing effort towards the established risk management goals.

It is this reflective ability which also enables maximum learning from each experience. Being able to openly come to grips with facets of the operation, which would be better done a different way, is invaluable if personal reflection identifies the topic. Such a process can only operate in a ‘no jeopardy’ environment.
Implementation

This is the overt dimension of the whole process. These are the behaviours which can be observed and assessed by others. This is the exhibition of resource management. The tenets of CRM are predominant at this stage of the operation. This is where commitment to the system and the environment which encourages and facilitates the involvement of each crew member to the limit of their expertise is demonstrated.

The use of good CRM technique cannot be demonstrated without first having:

- a firm grip on the risk management objectives of command;
- an embedded generative culture underlying all risk spaces; and
- a developed process to control cognitive resources regardless of demand.

Implementation can only be executed after processing. Further, it is during this processing stage that the method of implementation will be decided. Once having decided upon what needs to be done, how it will be done can be initiated. The underlying principle of CRM which dictates that all resources will be utilised in the most appropriate way to ensure safe and efficient flight will guide implementation.

This cultural aspect of CRM is influential in getting the job done. The practice of CRM techniques will have rendered many of these methods automatic. To varying degrees, such techniques will be employed unconsciously. Operators are obliged to self-check their use of good CRM methods.

Summary

If the developed argument is accepted as more or less valid, then the case has been made to incorporate competencies and behaviours covering all these aspects of command performance in any system which is established to assess this role. Further, training should be given to trainees and trainers on this material.
Competence Definition and Associated Behaviours

Demonstrate risk management by:

Managing events according to the established risk hierarchy
Adhering to SOPs in all areas of risk
Understanding the expectations of our customers
Managing the impact of events in one area of risk on other areas of risk
Generating an atmosphere of safety and security
Maintaining appropriate oversight of desired organisational outcomes
Managing recovery from failures areas of risk
Not developing limiting personal action thresholds for risk management

Contribute to a generative culture in all areas of risk by:

Accepting accountability and responsibility for personal performance
Using reflective processes to learn from experiences
Affirming the inextricable link between safety and service
Contributing to fixing the problem as well as dealing with the symptoms
Welcoming new ideas and reviewing them thoroughly
Treating messengers as co-workers, not the enemy
Encouraging others to adopt a generative approach
Not using information as personal power

Maintain control of cognitive capacity by:

Recognising your own cognitive limitations
Knowing when SOPs, operational variations & risk management are likely to compete for cognitive space
Using a durable detailed structure to acquire knowledge pre-flight
Developing a sophisticated prototypical mental representation of the sector pre-flight
Rehearsing every known detail of the sector pre-flight
Analysing all inbound information
Determining the potential impact of inbound information
Adjusting prototype of sector according to determined impact of inbound information
Developing executive model well into the future of the sector
Self-checking current situation against sector goals and devising suitable responses
Reflecting on personal performance and making adjustments for future use

_Implement your plan by_: 

Establishing an open operating environment by inviting input from all other crew members under all allowable circumstances at first meeting
Giving the input from other crew members proper consideration
Stating clearly the operational goals and other requirements you may have
Attending to flight path control within tolerance at all times
Adhering to SOPs since non-compliance generates crew stress
Observing applicable rules and regulations at all times
Recognising and resolving conflict rather than escalating the problem
Communicating appropriate information to crew members concerned
Distributing workload in a prioritised, timing-conscious and unambiguous fashion
Initiating a crew decision making process when required & clearly stating the decision
Properly evaluating all decisions and proposed courses of action
Recognising the need for and giving coaching/mentoring when appropriate
Using common assertiveness techniques only when required
Conducting open reflection on personal and crew performance & agreeing on outcomes
Clarifying ambiguity as soon as recognised and by what ever means possible
Communicating with passengers in an honest and informative fashion
Summary

Only four competencies have been identified herein, with many indicative behaviours attached to each. In short, airline captains need to be competent in risk space management, cultural understanding, control of cognitive capacity and implementation of plans. The debate on this conceptualisation will be worthwhile.

This is a working document and as such represents only a starting point. It is anticipated that input will be sought from many sources before a final document is agreed. Feedback should be in writing and sent to the GMFOT.

May 18th, 1998
Appendix H

Questionnaire seeking feedback from subject matter experts

DISTRIBUTION:

Selected Subject Matter Experts

PREAMBLE:

Ladies and Gentlemen,

For some time now the development of a definition of management as we see it in Qantas has been under way. By analysing previous feedback and the approach of many experienced captains to the task of management, the attached representation has been produced.

It has two components. The first is the breakdown of the process into the segments of effort, planning, strategies, implementation, checking progress and self-assessment. The second comprises the ‘I’ statement indicators for each of the segments of the process.

More feedback is needed before any definitive conclusions can be drawn. The first step in that process is to seek comment from training personnel. To that end, would you please complete the questionnaire according to the instructions below and return the whole document to Box 138 QCC2 or c/o M148G.

Thanks,
INSTRUCTIONS:

✓ Review each statement
✓ Cross out those with which you do not agree or feel are repetitive
✓ Add statements which you believe have been left out or better define the requirements
✓ Number the six most important statements in each section (i.e., 1 to 6 in Effort, 1 to 6 in Planning, etc)
✓ Please think about the major headings (effort, planning, etc.) and give an opinion as to how adequately they define a process of management:

Circle the words which most nearly describe your opinion of the major headings:

Strongly Disagree  Slightly Disagree  Slightly Agree  Strongly Agree
**ACTIVITY STATEMENTS:**

**Effort**

---- I regularly research the requirements of command  
---- I identify the need for and complete self education (e.g., stress management)  
---- I recognise that major life events can degrade performance  
---- I acknowledge stress and seek help when required  

---- I put a lot of energy into planning for flight  
---- I aim to arrive at work fully prepared  
---- I use preparation to manage workload  
---- I find that aviation requires consistent application

**Planning**

---- I prioritise my planning on a safety, passenger comfort, schedule & economy basis  
---- I use a structure to collect data about the flight  
---- I use a comprehensive matrix to develop my operating plan  
---- I categorise gathered data into useable chunks  

---- I visualise components of the flight at the planning stage  
---- I rehearse the flight on the basis of what I know before reporting for duty  
---- I rehearse the updated version of each segment of the flight in advance  
---- I use rehearsal to manage mental workload  

---- I conceptualise many possible enroute scenarios  
---- I develop multiple useable outcomes for the flight  
---- I develop my mental representation of the flight to the 'ball park' level  
---- I extend my operating plan well ahead of the aircraft  

---- I collect data to enable contingency planning  
---- I am aware of the required contingency plans for each sector
I consciously record experiences to add depth to my contingency planning
I am seldom surprised by events enroute

Strategies

I develop strategies to manage every flight
I prioritise my need to attend to information entering the cockpit
I maintain awareness by actively developing understanding of events and information
I use strategies that have worked in the past

I think about the goals of the flight before reporting for duty
I maintain awareness of my limitations
I attempt not to rationalise poor personal performance
I acknowledge that I will make errors
I own my mistakes and manage them to achieve a satisfactory result

I look for ways to correct poor performance
I explore the possible long term effect of events on my flight
I look beneath the surface when analysing events
I apply most strategies consciously

I assess strategy application
I review alternative strategies
I control my reactions when critical events occur
I never assume that I have all the answers

I apply some strategies automatically to situations
I control time resources during the flight
I monitor the workload of co-workers
I identify important tasks and do them first
Implementation

----- I invite input from other crew members at first meeting
----- I give input from other crew members and passengers proper consideration
----- I state clearly the operational goals
----- I inform crew members of any additional requirements I might have

----- I use delegation to even out workload
----- I communicate appropriate information to all crew members
----- I ensure that flight crew share my mental representation
----- I initiate crew decision making processes as the preferred method
----- I communicate all decisions to crew members in a timely fashion

----- I facilitate an evaluation of all decisions
----- I recognise and resolve conflict rather than allow escalation
----- I react correctly to assertive behaviours of other crew members
----- I give coaching as required by other crew members

----- I conduct open reflection on crew performance and agree outcomes
----- I clarify ambiguity when recognised by any crew member
----- I keep passengers informed in an open and responsible fashion
----- I generate an atmosphere of safety and security

----- I treat messengers as co-workers, not the enemy
----- I do not use information as power
----- I accept responsibility
----- I encourage learning from degraded performance

----- I maintain focus on company goals
----- I develop sound reasoned argument before making judgements
----- I understand and maintain focus on the expectations of our customers
----- I manage product delivery failures
----- I do not agonise over events which I cannot control
Checking progress

---- I frequently check reality against my mental representation
---- I execute my plans in accordance with the established priorities (i.e., safety etc.)
---- I regularly update my developed contingency plans
---- I convert gathered data into useful information

---- I don’t wait for events to unfold before conceptualising new plans
---- I ensure that I comprehend all information entering the cockpit
---- I assess the need to replan whenever new information is detected
---- I note and inquire about events and then develop tactics or strategies as required
---- I check that I am focused on the appropriate priority (i.e., safety etc.)
---- I critically review the progress of the flight regularly
---- I maintain an overview of the goals of the flight
---- I consciously change plans to ensure that the goals of the flight are met

---- I drive the flight to the most successful outcome possible given all eventualities
---- I compare events with past experience to determine possible outcomes
---- I do not have a personal need to always be right
---- I ensure that I conform to the organisational values, beliefs and attitudes

---- I know what my employer expects of me
---- I am not afraid to ask for help
---- I review the effectiveness of strategies I use
---- I use situation awareness to manage workload
Self assessment

---- I regularly review my own performance
---- I compare my assessment of my performance with assessments made by others
---- I maintain an accurate assessment of my own performance
---- I don’t rely solely on assessments of my performance made by others

---- I act on feedback to improve my performance
---- I generate my own feedback by reflecting on my performance
---- I review each flight to enhance future performance
---- I accept that I am in control and must facilitate the desired outcomes
Appendix I

The forty action statements that were identified for inclusion in the command routine questionnaire were:

1. the ordering of personal life and the controlling of stress levels
2. self-control of motivation and energy
3. personal development of an understanding of command
4. maintenance of the necessary declarative knowledge
5. the gathering of all relevant sector intelligence
6. the structuring of gathered information into a useable form
7. the development of an expectation of any proposed flight
8. the construction of useful worst case scenarios
9. the use of the safety, passenger comfort, schedule, efficiency hierarchy
10. rehearsal of the flight in total or parts
11. the establishment of routines for managing finite resources
12. the optimisation of comfort and safety by having plans for turbulence & delays
13. anticipation of facets of the flight which may not go to plan
14. workload management by pace setting and unwarranted pressure management
15. acknowledgment of personal strengths and weaknesses
16. error recognition and management
17. acquisition of updated information and modification of the original expectation
18. inviting input from crew and giving input proper consideration
19. sharing all plans and intended actions with the rest of the crew
20. recognising and praising the abilities of others
21. using a decision making algorithm as a fail-safe mechanism
22. conflict and assertive behaviour recognition and management
23. keeping passengers informed in an open and honest way
24. the maintenance of an atmosphere of safety and securing
25. recovery of failures in customer product expectations
26. recognising the need for and seeking coaching when required
27. avoiding the use of information as power
28. avoiding deference of responsibility
29. checking what is actually happening against what should be happening
30. recognising that all information might impact the flight
31. maintaining awareness of other traffic, weather and workload
32. retaining an overview of mission goals
33. noting events, clarifying discrepancy & implementing tactics or strategies
34. reviewing contingency plans as they become useable
35. trapping and owning error
36. consciously questioning self and the flight status
37. reviewing personal performance
38. generating accurate and honest feedback
39. actioning feedback
40. asking others for feedback when personal efforts fail
Appendix J

June, 1999

Dear

Command management has received a great deal of attention in recent times. This major area of deficiency in command trainees continues to generate angst at the individual and the system levels. Just why seemingly consistent performance in the area at the First Officer level does not translate into similar Command performance has to be resolved.

Management as a skill has been very difficult to define. This results from the way in which skills are learned. All good managers probably started with a routine for approaching a sector and which developed into a highly automated process of management as a result of practice and experience. Experience also renders the ability to match a developing situation to a past event and effectively by-pass much of the reasoning which might otherwise be involved.

Coming to grips with a routine upon which management can be built will probably entail taking the automatic component out of the equation. In part, this can be achieved if one considers a sector which has never been flown before. This questionnaire should be approached in that light. Consider how you might approach such a sector to ensure that you would do your job to your usual standard.

Please review the entire questionnaire before completing any response. You are being asked to express your relative agreement with each component of the routine. The following scale is to be used:

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
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There are a few statements which precede the main routine questionnaire. This scale should also be used to express your opinion in the matters which they raise.

Your response to this questionnaire will provide important feedback in helping to determine how to develop effective and mature management skills. There is no intention or need to influence the way in which current Captains fulfil this important part of command. This feedback will also be considered when developing future pilot selection processes.

Please return as soon as possible together with any additional comments which you might have.

Regards,

Chief Pilot          President of Pilots’ Union
Appendix K

Please respond to the following statements in a way that reflects your personal experiences and beliefs.

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<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Slightly Disagree</th>
<th>Neutral</th>
<th>Slightly Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
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1. All Captains in all airlines believe that they are safe.
2. All Captains in all airlines exhibit consistently safe behaviours.
3. A flat cross-cockpit gradient contributes significantly to safety.
4. Poor situational awareness can cause poor management.
5. There are localised and overview aspects to situation awareness.
6. Lack of localised situation awareness is often demonstrated by aircrew in other airlines.
7. First Officers generally have good localised situational awareness.
8. First Officers are prone to lose sight of the big picture.
9. Accidents and incidents are a result of poor management.
10. Younger pilots rely on technology for safety.
11. Inexperienced pilots rely on SOPs to manage.
12. First Officers are generally very organised and structured in their approach to sector flying.
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<tr>
<td></td>
<td>First Officers ask for critique on their management performance.</td>
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<td></td>
<td>First Officers can manage without intervention when they are PF.</td>
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Could a notice airline pilot start with the type of routine detailed below to develop personal command management expertise? Indicate your agreement with each statement.

**Prepare themselves by:**

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<td></td>
<td>having their life in order with stress levels low enough to maximise learning (in particular for command training)</td>
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<td>checking their motivational and energy levels (in particular for commencing command training)</td>
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<td>consciously developing a good understanding of the goals of airline command</td>
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<td></td>
<td>having the book knowledge required for command; and</td>
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**Plan before each sector by:**

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<td>gathering all possible knowledge and intelligence about each sector</td>
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<td>structuring this information in a useful way like phase of flight</td>
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<td>establishing expectations of the flight to minimise surprises</td>
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<td>1</td>
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<td></td>
<td>developing useful “what if” scenarios for each sector</td>
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<td>using safety, passenger comfort, schedule and efficiency criteria to guide their planning</td>
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<td>rehearsing the sector before going to work; and</td>
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**Build strategies for each sector by:**

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<td></td>
<td>devising actions to manage finite resources like fuel, pre-flight time, duty hours, etc.</td>
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</table>
26. 1 1+ 2 2+ 3 3+ 4  having turbulence and delay management plans which optimise comfort and safety

27. 1 1+ 2 2+ 3 3+ 4  developing alternatives to cover things that may not go to plan (e.g., altitude blockages)

28. 1 1+ 2 2+ 3 3+ 4  managing workload for all crew by delegating, setting the right pace, resisting pressure

29. 1 1+ 2 2+ 3 3+ 4  acknowledging their own strengths and weaknesses and using resource accordingly

30. 1 1+ 2 2+ 3 3+ 4  having an error recognition and management strategy; and

**Implement their plans and strategies by:**

31. 1 1+ 2 2+ 3 3+ 4  modifying developed expectations as current information is acquired and following this revised plan

32. 1 1+ 2 2+ 3 3+ 4  inviting input from crew at first meeting and resolving to give input proper consideration

33. 1 1+ 2 2+ 3 3+ 4  communicating detail to all crew to ensure everybody has the same expectations

34. 1 1+ 2 2+ 3 3+ 4  recognising, harnessing and praising superior knowledge and expertise in other crew members

35. 1 1+ 2 2+ 3 3+ 4  using the REFER decision making style where possible and overseeing the thorough application of GRADE

36. 1 1+ 2 2+ 3 3+ 4  recognising and managing both conflict within the crew and assertive behaviour by crew members

37. 1 1+ 2 2+ 3 3+ 4  informing passengers in an open and honest way

38. 1 1+ 2 2+ 3 3+ 4  maintaining an atmosphere of safety and security for all on board

39. 1 1+ 2 2+ 3 3+ 4  trying to recover failures in customer expectation delivery

40. 1 1+ 2 2+ 3 3+ 4  seeking coaching where a need is perceived and timing permits
Monitor flight progress by:

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<tr>
<td>43.</td>
<td>frequently checking what is happening and comparing that to what should be happening</td>
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<td>44.</td>
<td>initially treating all perceived information as it if could have an impact on the flight</td>
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<td>45.</td>
<td>maintaining tactical situation awareness of other traffic, weather, air traffic, workload, etc.</td>
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<td>46.</td>
<td>maintaining a strategic overview to ensure flight goals are achieved</td>
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<td>47.</td>
<td>noting events, asking questions if uncertain, developing tactics and changing strategies if required</td>
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<td>48.</td>
<td>reviewing contingency plans as they become operationally unusable</td>
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<td>49.</td>
<td>trapping, owing and managing error</td>
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<td>50.</td>
<td>continuously questioning self, the status of the flight and others to uncover discrepancy; and</td>
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Improve their own performance by:

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<tr>
<td>51.</td>
<td>regularly reviewing all aspects of their performance</td>
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<tr>
<td>52.</td>
<td>generating accurate and honest feedback for themselves</td>
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<tr>
<td>53.</td>
<td>acting on self feedback to modify attitudes, processing and actions, and</td>
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<tr>
<td>54.</td>
<td>asking for feedback from others when self assessment does not provide the answers</td>
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PLEASE RETURN VIA OCS TO: CMQ, 148G
Appendix L

Action statement/Item cross reference document
(Questions 15 to 54 in order)

Note 1: The number adjacent to an item (e.g., Q15, 02 02b Seek professional help if stressed) means that item 02 of Q15 was used as choice b in question 2 of the 100 questions in the prototype ipsative psychometric tool (Appendix W).

Note 2: The number after the action statement (e.g., Q15: having their life in order with stress levels low enough to maximise learning [147]) represents the number of respondents who indicated higher level support for the action statement.

Q15: having their life in order with stress levels low enough to maximise learning (147)

01 ..... Not fly stressed
02 02b Seek professional help if stressed
03 32d Recognise the symptoms of stress
04 29d Refuse the duty if my personal problems are too great
05 47d Successfully separate work from my private life
06 20b Accept a lower performance because of unfamiliarity
07 82b Use stress management techniques
08 ..... Be effected by higher stress levels
09 ..... Believe that mediation can relieve stress
10 56c Tolerate a little stress to enhance learning
11 11b Let stress influence my work

Q16: checking their motivational and energy levels (140)

01 14b Look forward to the challenge
02 02d Accept the duty without thinking about pay first
03 50d Recognise that this mission will require considerable application
04 81d Continue to want to learn about my job
05 26b Welcome the flight as a chance to learn
06 ..... Be bored by the type of work I do
07 38b Report for duty early
08 ..... Allow boredom to interfere with my work
09 71c Avoid the duty if it interferes with my lifestyle
10 85d Take more time than normal to complete routine tasks
11 78a Force myself to accept the duty
12 90c Question the fact that I started in aviation
Q17: consciously developing a good understanding of the goals of airline command (139)

01 89a Find out if my job entails extra responsibilities
02 78d Know what captains are trying to achieve
03 85b Develop a routine to cope with extra workload
04 15a Apply effort to analysing the job of captain
05 81d Ask other crewmembers what they would do
06 39c Take the opportunity to improve my command skills
07 03a Be aware of the need to understand airline command
08 27b Have a clear picture of my role in this circumstance
09 71d Resolve apparent ambiguities in my role in this operation
10 51c Learn about my role on this flight by asking others

Q18: having the book knowledge required for command (162)

01 14c Self-test my book knowledge
02 73a Attempt to commit all required information to memory
03 58d Prioritise topics for study
04 25a Know where to find required information
05 98d
06 47a Maintain an overview of all relevant information
07 36d Read and understand all pertinent amendments
08 03c Establish required depth of knowledge
09 91a Know approximate aircraft performance parameters for various conditions
10 69c Be systematic in acquiring knowledge
10 95d Self-direct knowledge acquisition

Q19: gathering all possible knowledge and intelligence about each sector (163)

01 35a Watch local and world newscasts
02 02a Discuss the proposed flight with peers
03 57d Review flight departure boards in the terminal
04 24b Read sector information before I need to use it
05 46c Note landing direction when around airports
06 00d
06 70d Discuss the proposed flight in a social setting beforehand
07 13b Use a gathering routine for sector information
08 72d Question despatchers for additional information
09 94a Develop understanding of maintenance in progress
10 97a Only discard sector information after I understand it
Q20: structuring this information in a useful way like phase of flight (144)

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Q21: establishing expectations of the flight to minimise surprises (135)

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Q22: developing useful what if scenarios for each flight (134)

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Q23: using safety, passenger comfort, schedule and efficiency criteria to plan (140)

01 ..... Put safety first at the planning stage
02 85c Consider passenger comfort in my planning
03 37d Meet safety requirements before efficiency at planning
04 49a Consider schedule last at the planning stage
05 78b Consider organisational goals at the planning stage
06 81c Put passenger comfort before safety
07 13d When planning, consider passenger comfort and efficiency after safety
08 90b Satisfy schedule constraints after passenger comfort
09 25d Make efficiency my last consideration at the planning stage
10 01b Pay less attention to the efficiency of the operation

Q24: rehearsing the sector before going to work (112)

01 14a Use arm chair flying to prepare for the flight
   69b
02 30b Rehearse motor skills required for the flight
03 46d Verbalise actions to rehearse
04 22d Visualise the flight in detail before work
   67d
05 54b Use rehearsal to develop my expectation of the flight
06 38c Practice actions required to complete the flight
07 62b Fine tune my work sequence by pre-flight rehearsal
08 06a Mentally fly the flight before duty commences
09 66c Dissect the flight step by step beforehand
10 65b Rehearse to stay ahead of the aircraft

Q25: devising actions to manage finite resources like fuel, pre-flight time, duty hours (130)

01 12a Establish crew duty limits
02 48a Develop options for managing available fuel
03 36a Avoid depletion of finite resources
04 77b Only accept adverse outcomes after all alternatives have been explored
05 84d Adjust the usage rate of fuel to achieve goals
06 74a Explore ways to best use finite resources
07 24a Prioritise goals and use finite resources accordingly
08 88d Manage finite resource usage
09 60b Monitor the depletion rate of finite resources
10 79c Respond decisively to impending depletion of finite resources
Q26: building turbulence and delay management plans which optimise comfort & safety (118)

01 12b Assess the probability of turbulence before the flight
02 44d Use knowledge of turbulence to plan the flight regime
03 62c Identify sources of possible departure delays
04 36c Track the time remaining to scheduled departure
05 52c Use a routine for turbulence penetration
   67b
06 04c Control pre-departure phase to make an on time departure
07 28d Minimise exposure to uncomfortably turbulent conditions
   68d
08 20a Interface assertively with ATC in order to avoid weather
09 64d Think laterally to minimise delays
10 60d Be mindful of the effect of delays on product delivery

Q27: developing alternatives to cover things which may not go to plan (147)

01 31a Expect my plan to have to be changed
02 55b Prepare several possible flight scenarios
03 46a Be flexible in my approach to changes
04 ..... Stay fluid
05 19c When required, implement an alternate plan
06 28a Be able to change tack quickly
07 81b Prepare for changes to my initial plan
08 ..... Think alternatives through
09 10b Develop several solutions to a problem
10 01a Assume that the operation will not go as planned

Q28: managing workload by delegating, setting the right pace, resisting pressure (154)

01 44b Complete most things myself
02 33a Accept that others have ability
   00b
03 96c Maintain a realistic view of my spare capacity
04 93d Avoid the one person band syndrome
05 22a Avoid overloading other crewmembers
06 80b Resist the temptation to speed things up
07 61b Establish task timeframes
08 55d Manage unwarranted pressure applied by others
09 92c Explore the needs of others when establishing work rosters
10 11c Avoid rushing to please others
Q29: acknowledging their own strengths and weaknesses and using resources accordingly (155)

01 30a Know my personal limitations
02 41d Recognise and use my strengths
03 93b Resist trying to justify inappropriate actions
04 08c Admit not knowing operational facts
05 96b Tap into the strengths of others
06 52d Establish the strengths of others
07 19b Accept that others may know more than me
08 99b
08 64b Let those who know the most exert the most influence
09 94b Think that I know enough to make the operation work
10 78c Remain open minded

Q30: having an error recognition and management strategy (137)

01 41b Be on the lookout for mistakes
02 05a Continuously scan for errors
03 17a Instigate the search for mistakes
04 76b Question my thinking as a way of detecting error
05 72b Continuously seek to identify omissions
06 82c Identify actions required to correct errors
07 53b Mitigate the effects of error by acting swiftly
08 86a Acknowledge the possibility of mistakes being made
09 89c Avoid rationalising error
10 29a Act to minimise the effects of mistakes

Q31: modifying developed expectations as more current information is acquired and following this revised plan (142)

01 ..... Recognise that the initial plan may need to be changed
02 54d Seek out the latest information
03 09a Resist the temptation to think that all is well
04 45c Maintain an active information gathering strategy
05 89b Repeatedly search for new information
06 27c Be prepared to change my plan
07 18b Resolve ambiguities in my initial plan
08 ..... Identify areas of missing information
09 ..... Recognise and incorporate new information
10 39d Amend and implement plans as required
11 ..... Act on the latest relevant information
Q32: inviting input from crew at first meeting and resolving to consider input (137)

01  42b  Give others permission to have their say  
02  76a  Commit to seriously consider all input  
03  18d  Regard all input as valuable  
04  72c  Avoid dismissing input out of hand  
05  30d  Require others to communicate detected error  
06  82d  Stress that uneasiness should generate input  
07  54c  Ask questions when others generate input  
08  06c  Set a tone which fosters participation  
09  86c  Require others to input when not in agreement  
10  89d  Discuss the use of language for providing input  

Q33: communicating detail to all crew to ensure everybody has the same expectation (132)

01  84c  Share all plans with crew  
02  46b  Brief crew before acting  
03  74d  Include all involved crew in briefings  
04  22b  Allow time for the discussion of plans  
05  88b  Ask for feedback on intentions  
06  34a  Provide optimum detail required for understanding  
07  77d  Make briefings meaningful  
08  79b  Acknowledge memory limitations when briefing  
09  10c  Ensure a common understanding is held by all crew  
10  58c  Determine the optimum time to brief  

Q34: recognising, harnessing and praising superior knowledge and expertise in other crewmembers (146)

01  83c  Allow those who know most to lead scenario resolutions  
02  54d  Explore the expertise of other crewmembers  
03  49d  Acknowledge demonstrated expertise in others  
04  58b  Tap into the knowledge and expertise of others  
05  40a  Encourage others to share their expertise  
06  04b  Give credit where credit is due  
07  13a  Generate opportunities for others to contribute to the operation  
08  22c  Encourage others who know more than me  
09  90d  Thank other crewmembers for their contributions  
10  .....  Ridicule the input of others
Q35: using an inclusive and structured decision making process where possible (114)

01 45a Consult other crewmembers before implementing any decision
02 05b Process all information as part of the decision process
03 62a Evaluate decisions before implementation
04 37a Use only my experience and knowledge to make decisions
05 65a Delegate decision making to others
06 13c Decide by consensus
07 69a
08 29c Allow all crew to participate in decision making
09 53d Employ the company approved decision making process
10 66a Analyse all information before making a decision
11 21b Revisit decisions to test their validity
12 67c

Q36: recognising and managing both conflict within the crew and assertive behaviour by crew members (137)

01 52a Respond supportively to assertive behaviour by others
02 72a Establish the needs of other parties in conflict situations
03 82b Take the time to resolve conflicts by process
04 40b Commit to addressing the concerns of others
05 76d Recognise the signs of developing conflict
06 04d Be alert for the signs of assertion and conflict
07 28c Tune into the feeling behind the spoken word
08 71a Use authority to deal with assertion and/or conflict
09 86b Recognise increasing urgency in assertive behaviour
10 16b Focus on others in conflict situations

Q37: informing passengers in an open and honest way (143)

01 44a Lie to passengers
02 37c Always tell passengers the truth
03 17d Treat passengers’ knowledge of flying with respect
04 08b Keep passengers well informed
05 44c Inform passengers of change as soon as possible
06 53a Apologise for outcomes over which I have no control
07 26a Withhold information from passengers
08 88c Give passengers plausible explanations of events
09 44b Use emotive language in communications with passengers
10 44b Mislead passengers on purpose
Q38: maintaining an atmosphere of safety and security for all on board (161)

01  97b  Appear calm at all times
02  37b  Talk to passengers in a confident tone
03  48b  Keep all crewmembers informed
04  15b  Avoid down playing threats posed by poor weather
05  68b  Resist the temptation to embellish situations
06  04a  Avoid speculation about possible outcomes of the flight
00c
07  92d  Engage passengers by smiling
08  26a  Hurry when completing normal duties
09  74c  Maintain order in task completion
10  59c  Consider the safety implications of any proposed action

Q39: trying to recover failures in customer expectation delivery (102)

01  48c  Maintain customer needs in focus
02  56b  Create opportunities to check customer satisfaction
03  66b  Monitor customer satisfaction
04  08d  Regularly communicate with customers
05  32b  Support customer expectations for a consistent product
06  68c  Contribute to the recovery of failures in customer service
07  63c  Activate the company system to recover customers
08  24d  Assist other crewmembers in customer recovery
09  40c  Assign a high priority to customer satisfaction
10  16a  Formulate plans to recover dissatisfied customers

Q40: seeking coaching where a need is perceived and timing permits (123)

01  58a  Acknowledge the benefits that coaching can bring
02  02c  Choose a good time and place to request coaching
03  18a  Identify specific areas where I need coaching
04  61c  Be prepared to be coached by others
05  42a  Accept that others may assess my coaching need
06  50b  Resolve to find ways to improve
07  26c  Solicit coaching from others
64a
08  34b  Be receptive to advice
09  10d  Follow up on topics raised during coaching
10  70b  Incorporate validated improvements into my task routines
Q41: avoiding the use of information as power (128)

01 57c Withhold information from others
02 17c Embarrass others by withholding information
03 09c Control crew by limiting information flow
04 41c Maintain control of the crew by withholding information
05 61a Claim that I know everything
06 33d Insist that I am always right
07 63d Leave cockpit crew out of the information loop
08 25b Revel in knowing something that others do not
09 49b Share information confidentially with selected crewmembers
10 01c Initiate actions without communicating reasons to others

70c

Q42: accepting responsibility for driving the flight to the most successful conclusion possible (157)

01 39a Never defer responsibility
02 50c Ensure that I receive all flight information
03 17b Accept that I am the final arbiter
04 93a Blame others rather than accept responsibility
05 96a Verbalise shortcomings of personal actions
06 28b Initiate actions to make the operation work

98a
07 66a Assert authority when needed
08 06b Take unpopular decisions regardless of other pressures
09 76c Avoid decisions based on feelings
10 95a Expect others to do things that I would not do

Q43: frequently checking what is happening and comparing that to what should be happening (159)

01 49c Know what should be happening
02 05c Develop an expectation of the flight
03 75a Search for ambiguities
04 27d Seek out missing information
05 91b Be prepared to get information restated
06 38d Follow up on incomplete information

99a
07 60c Establish what information is missing
08 94c Assume that everything is under control
09 67a Avoid untimely distractions
10 16c Enroute, use a routine to source information
Q44: initially treating all perceived information as if it could have an impact on the flight (118)

01 61a Ignore information which does not match my expectation
02 43d Actively process all inbound information
03 35b Discard inbound information without consideration
04 19d Test the relevance of acquired information
05 51d Discard information only when its relevance has been checked
06 27a Check the short and long term effects of information
07 03b Initially accept that all information may influence the flight
08 70a Establish which type of information may influence the flight
09 64c Rely on my experience to sift information
10 11a Use my expectation of the flight to sort inbound information

Q45: maintaining tactical situation awareness of other traffic, weather, aircraft performance, workload etc (163)

01 12d Maintain a plot of all traffic in close proximity
02 91c Routinely scan for weather
03 34c Strive to optimise aircraft performance
04 45b Monitor radio calls to/from other traffic
05 71b Assess the impact of other traffic on my flight
06 23d Initiate weather avoidance early
07 99c
08 56a Know the current safety height
09 96d Strive to use the least amount of fuel possible
09 95c Gain an advantage on competing traffic
10 01d Anticipate periods of high workload

Q46: maintaining a strategic overview to ensure that flight goals are achieved (155)

01 92a Prioritise flight goals
02 29d Act early to ensure that goals are achieved
03 99d
04 40d Keep the big picture in focus
04 77a Understand what is to be achieved
05 18c Make short term gains to achieve overall goals
06 65d Determine what can be realistically achieved
07 97d Take more fuel than legally required
08 51a Use available fuel to make operation work
09 91d Apply SOPs creatively to achieve goals
10 07d Establish operational bottom lines
Q47: noting events, asking questions if uncertain, developing tactics and changing strategies if required (154)

01 94a Identify events which could impact upon the flight
02 32c Clarify incoming information when required
03 43a Resolve ambiguities
04 21c Record incoming information
00a
05 98c Check the importance of all inbound information
06 95b Be prepared to seek more information
07 54a Act on considered information
08 62d Respond to new information with effective tactics
09 10a Devise strategies to meet long term goals
10 79d Strive to have operational restrictions lifted

Q48: reviewing contingency plans as they become operationally useable (146)

01 12c Think about the worst case scenarios
02 ..... Be aware of the proximate airports
03 30c Know the position of the nearest useable airport
04 48d Review approaches at contingency airports
05 21a Devise plans to cover several eventualities
06 03d Believe that contingency planning is necessary
07 84b Have a current useable contingency plan
08 33b Make contingency planning an integral part of my operation
09 57a Share my thoughts about contingencies with other crewmembers
10 ..... Brief contingency plans as they become operationally useable

Q49: trapping, owning and managing error (130)

01 47c Investigate any hint of error
02 84a Avoid procrastination over discovered error
03 23c Own up to my mistakes
04 74b Take the view that all error will be detected
05 88a Accept that error is inevitable on such a mission
06 35c Review all activities in order to detect error
07 77c Determine the best starting point for error correction
08 59b Generate an open communication environment
09 79a Manage error
10 11d Take decisive actions to mitigate the consequence of error
Q50: continuously questioning self, the status of the flight and others to uncover discrepancy (111)

01 31d Continuously look for things to do
02 47b Accept that flight outcomes depend on me
03 55c Search for things that I might have missed
04 15c Implement a scanning routine
05 63b Check the result of delegated work
06 23b Use a mental checklist to monitor flight progress
07 68a Recognise aspects of the flight which are not going to plan
08 65c Identify and resolve discrepancies
09 69d Entertain the probability that required activities will be omitted
10 07d Accept that omissions will need to be discovered

Q51: regularly reviewing all aspects of their performance (155)

01 98b Ascertain what I did not achieve
02 31b Know the required standard
03 09d Reflect on my performance
04 42c Generate time to review performance
05 20c Establish a performance review routine
06 53c Improve my performance at the first opportunity
07 93c Note improvements required for my next flight
08 97c Determine how things could have been done better
09 92b Be prepared to learn
10 63a Strive to do the perfect sector

Q52: generating accurate and honest feedback for themselves (144)

01 14d Rationalise my performance
02 05d Compare my performance to the required standard
03 35d Conduct a self-debrief after the sector
04 ...... Make a note of points for next time
05 23a Take every opportunity to refine my performance
06 59d Know the required standard
07 41a Make excuses for my performance
08 ...... Identify key areas for improvement
09 ...... Analyse my performance in a reasoned way
10 85a Generate areas for improvement after each flight
11 ...... Monitor my own standard
12 50c Assume that I have flown the perfect sector
Q53: acting on self feedback to modify attitudes, processing and actions (144)

01 36b Devise ways to improve my performance
02 51b Review areas for personal improvement before each flight
03 ..... Build improvement actions lists
04 15d Make notes on things that could be improved
05 24c Address problems identified through self-critique
06 ..... Employ prompts to activate improved actions
07 42d Limit improvement activity to flying skills
08 06d Strive to improve my performance on each flight
09 86d Develop a personal performance improvement plan
10 60a Build improvements into my flight routine

Q54: seeking feedback from others when self-assessment does not provide the answers (134)

01 83b Recognise that others may see thing differently
02 44a Accept that others may be more attuned to my performance than me
03 87c Draw word pictures to prompt input on my performance
04 08a Ensure that I fully understand what I am doing
05 20d Be very critical of my own performance
06 73c Ask others how I could improve
07 32a Initiate discussion on the performance by the crew
08 80d Persevere when trying to answer questions about my performance
09 56d Use observations made by others to improve my performance
10 75b Ask others to assess my performance
Appendix M

LETTER TO LINE CAPTAINS REQUESTING THEIR COOPERATION IN Completing the Selection Tool QUESTIONNAIRE

May, 2001

Dear

Enclosed you will find a questionnaire which has been developed as part of the effort to improve pilot selection processes. This development now requires some feedback from a limited number of Captains before it can be administered to pilot applicants. I seek your cooperation in this regard.

The questionnaire presently contains 100 questions and takes a little over 1 hour to complete. Your responses will be used to help identify approximately 70 questions which will be administered to pilot applicants on a trial basis. If this development is successful, the final product will assist with the identification of applicants who have the ability to approach a task in a way which is similar to that of an experienced Captain.

I would like to stress that there are no right or wrong responses to the questions and that your responses will remain anonymous. Further, all analysis of the responses will be at the group rather than the individual level.

It is important that you follow the instructions for completion even though you may have questions about the choices you have been offered. The development process will review all responses and will cull questions which prove to be unreliable because of the choices on offer.

Please return your completed questionnaire to the Executive Secretary on QCC2 by June 30th. Further, if you do not wish to complete the questionnaire, please return your copy as per the instructions above.

Sincerely,

General Manager or Manager BXXX Fleet Operations
Appendix N
AIRLINE CAPTAIN ATTRIBUTES
QUESTIONNAIRE
FEEDBACK FROM THE PILOT STUDY

1. The following activity statements were unclear and/or hard to understand (e.g., 24b):

........................................................................................................................................
........................................................................................................................................

2. The following activity statements are not applicable to the task (e.g., 24b):

........................................................................................................................................
........................................................................................................................................

3. The following activity statements are too similar to make a choice (e.g., 24a&b):

........................................................................................................................................
........................................................................................................................................

4. The following questions forced a choice with which I was not comfortable:

........................................................................................................................................
........................................................................................................................................

5. The following questions forced me to guess my responses:

........................................................................................................................................
........................................................................................................................................

6. I found that I was trying to double guess (i.e., answer according to my perception of what the researcher would like) responses to the following questions:

........................................................................................................................................
........................................................................................................................................

Please complete the questions overleaf by circling your level of agreement.
7. **The instructions for completion were clear and unambiguous.**

<table>
<thead>
<tr>
<th>Strongly</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8. **The method of recording answers was convenient and unambiguous.**

<table>
<thead>
<tr>
<th>Strongly</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9. **The questionnaire was a fair exploration of Captain attributes.**

<table>
<thead>
<tr>
<th>Strongly</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

10. **The questionnaire format was suitable for exploring Captain attributes.**

<table>
<thead>
<tr>
<th>Strongly</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

11. **The difficulty of the questionnaire was appropriate.**

<table>
<thead>
<tr>
<th>Strongly</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree</td>
<td></td>
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</tbody>
</table>

12. **Other comments:**

........................................................................................................
........................................................................................................
........................................................................................................
........................................................................................................
........................................................................................................
........................................................................................................
........................................................................................................
........................................................................................................
Appendix O

AIRLINE CAPTAIN ATTRIBUTES QUESTIONNAIRE

Instructions for completion:

- Record your fleet type and hours in command in the spaces provided.

  **Fleet type: ** ..................  **Hours in command: ** ..................

- This questionnaire contains 100 questions to which you are asked to respond. Each question contains four activity statements which relate to operating in command of a multi crew passenger aircraft.

- In each question, you are asked to identify the activity which you are most likely to complete and mark it with a tick. Secondly, in each question, you are asked to identify the activity which you are least likely to complete and mark it with a cross.

- **When completing this questionnaire, you will find it beneficial to think about receiving limited notice (1 day) to operate on a route which you have never flown before (e.g., Bogata to Rio de Janeiro).**

- The following example gives guidance as to how the questionnaire should be answered.

  As a captain required to operate on an unfamiliar route, I would be

  \[√\] most likely to...........

  \[✗\] least likely to..........

  1. a. be first off the aircraft at destination

  \[√\] acknowledge good performance by others

  c. lose sight of organisational goals

  \[✗\] ignore junior crewmembers

- If you wish to change a response, you will need to block out or erase the tick or cross already inserted and insert a new tick or cross.

- Although you must respond in both ways to each question, you must only respond once in each way to each question. Even if you believe that more than one statement applies, **you must finish with only one tick and one cross recorded for each question.**

- Work as quickly as you can to complete the questionnaire.

- Do not detach this instruction sheet from the questionnaire.
As a captain required to operate on an unfamiliar route, I would be

✓ most likely to...........

✗ least likely to...........

1. a. assume that the operation will not go as planned
   b. pay less attention to the efficiency of the operation
   c. initiate actions without communicating reasons to others
   d. anticipate periods of high workload

2. a. discuss the proposed flight with peers
   b. seek professional help if stressed
   c. choose a good time and place to request coaching
   d. accept the duty without thinking about pay first

3. a. be aware of the need to understand airline command
   b. initially accept that all information may influence the flight
   c. establish the required depth of knowledge
   d. believe that contingency planning is necessary

4. a. avoid speculation about possible outcomes of the flight
   b. give credit where credit is due
   c. control pre-departure phase to make an on-time departure
   d. be alert for signs of assertion and/or conflict

5. a. continuously scan for errors
   b. process all information as part of the decision process
   c. develop an expectation of the flight
   d. compare my performance to the required standard
As a captain required to operate on an unfamiliar route, I would be

✓ most likely to...........

× least likely to...........

6. a. mentally fly the flight before duty commences
   b. take unpopular decisions regardless of other pressures
   c. set a tone which fosters participation
   d. strive to improve my performance on each flight

7. a. organise my knowledge to improve recall
   b. establish operational *bottom lines*
   c. develop a prototype of the flight before work
   d. accept that omissions will need to be discovered

8. a. ensure that I fully understand what I am doing
   b. keep passengers well informed
   c. admit not knowing operational facts
   d. regularly communicate with customers

9. a. resist the temptation to think that all is well
   b. expect the unexpected
   c. control crew by limiting information flow
   d. reflect on my performance

10. a. devise strategies to meet long term goals
    b. develop several solutions to a problem
    c. ensure that a common understanding is held by all crew
    d. follow up on topics raised during coaching
As a captain required to operate on an unfamiliar route, I would be

✓ most likely to ..........

✗ least likely to ........

11. a. use my expectation of the flight to sort inbound information
    b. let stress influence my work
    c. avoid rushing to please others
    d. take decisive actions to mitigate the consequence of error

12. a. establish crew duty limits
    b. assess the probability of turbulence before the flight
    c. think about the worst case scenarios
    d. maintain a plot of all traffic in close proximity

13. a. generate opportunities for others to contribute to the operation
    b. use a gathering routine for sector information
    c. decide by consensus
    d. when planning, consider passenger comfort and efficiency after safety

14. a. use arm chair flying to prepare for the flight
    b. look forward to the challenge
    c. self-test my book knowledge
    d. rationalise my performance

15. a. apply effort to analysing the job of captain
    b. avoid down playing threats posed by poor weather
    c. implement a scanning routine
    d. make notes on things that could be improved
As a captain required to operate on an unfamiliar route, I would be

✓ most likely to..........

× least likely to..........

16. a. formulate plans to recover dissatisfied customers
    b. focus on others in conflict situations
    c. enroute, use a routine to source information
    d. utilise knowledge only if it is organised

17. a. instigate the search for mistakes
    b. accept that I am the final arbiter
    c. embarrass others by withholding information
    d. treat passengers’ knowledge of flying with respect

18. a. identify specific areas where I need coaching
    b. resolve ambiguities in my initial plan
    c. make short term gains to achieve overall goals
    d. regard all input as valuable

19. a. begin thinking about the flight before work
    b. accept that others may know more than me
    c. when required, implement an alternate plan
    d. test the relevance of acquired information

20. a. interface assertively with ATC to avoid weather
    b. accept a lower performance because of unfamiliarity
    c. establish a performance review routine
    d. be very critical of my own performance
As a captain required to operate on an unfamiliar route, I would be

✓ most likely to.........

✗ least likely to.........

21. a. devise plans to cover several eventualities
    b. revisit decisions to test their validity
    c. record incoming information
    d. run contingency plans in parallel with normal operations

22. a. avoid overloading other crewmembers
    b. allow time for the discussion of plans
    c. encourage others who know more than me
    d. visualise the flight in detail before work

23. a. take every opportunity to refine my performance
    b. use a mental checklist to monitor flight progress
    c. own up to my mistakes
    d. initiate weather avoidance early

24. a. prioritise goals and use finite resources accordingly
    b. read sector information before I need to use it
    c. address problems identified through self-critique
    d. assist other crewmembers in customer recovery

25. a. know where to find required information
    b. revel in knowing something that others do not
    c. assemble sector knowledge in a useable format
    d. make efficiency my last consideration at the planning stage
As a captain required to operate on an unfamiliar route, I would be

√ most likely to...........
× least likely to...........

26. a. withhold information from passengers
    b. welcome the flight as a chance to learn
    c. solicit coaching from others
    d. hurry when completing normal duties

27. a. check the short and long term effects of information
    b. have a clear picture about my role in this circumstance
    c. be prepared to change my plans
    d. seek out missing information

28. a. be able to change tack quickly
    b. initiate actions to make the operation work
    c. tune into the feelings behind spoken words
    d. minimise exposure to turbulent conditions

29. a. act to minimise the effects of mistakes
    b. refuse the duty if my personal problems are too great
    c. allow all crew to participate in decision making
    d. act early to ensure that goals are achieved

30. a. know my personal limitations
    b. rehearse motor skills required for the flight
    c. know the position of the nearest suitable airport
    d. require others to communicate detected error
As a captain required to operate on an unfamiliar route, I would be

✓ most likely to...........

✗ least likely to...........

31. a. expect my plan to have to be changed
    b. know the required standard
    c. use my expectation to assess flight events
    d. continuously look for things to do

32. a. initiate discussion on the performance by the crew
    b. support customer expectations for a consistent product
    c. clarify incoming information when required
    d. recognise the symptoms of stress

33. a. accept that others have ability
    b. make contingency planning an integral part of my operation
    c. rehearse contingency plans to fine tune detail
    d. insist that I am right

34. a. provide optimum detail required for understanding
    b. be receptive to advice
    c. strive to optimise aircraft performance
    d. explore the expertise of other crewmembers

35. a. watch local and world newscasts
    b. discard inbound information without consideration
    c. review all activities in order to detect error
    d. conduct a self de-brief after the sector
As a captain required to operate on an unfamiliar route, I would be

✓ most likely to ..........

✗ least likely to ..........

36. a. know when finite resources will be depleted
   b. devise ways to improve my performance
   c. track the time remaining to scheduled departure
   d. read and understand all pertinent amendments

37. a. use only my experience and knowledge to make decisions
   b. talk to passengers in a confident tone
   c. always tell passengers the truth
   d. meet safety requirements before efficiency at planning

38. a. use phases of flight to structure knowledge
   b. report for duty early
   c. practice actions required to complete the flight
   d. follow up on incomplete information

39. a. never defer responsibility
   b. recognise aspects of the flight which are not going to plan
   c. take the opportunity to improve my command skills
   d. amend and implement plans as required

40. a. encourage others to share their expertise
   b. commit to addressing the concerns of others
   c. assign a high priority to customer satisfaction
   d. keep the big picture in focus
As a captain required to operate on an unfamiliar route, I would be

✓ most likely to...........

✗ least likely to...........

41. a. make excuses for my performance
     b. be on the lookout for mistakes
     c. maintain control of the crew by withholding information
     d. recognise and use my strengths

42. a. accept that others may assess my coaching need
     b. give others permission to have their say
     c. generate time to review performance
     d. limit improvement activity to flying skills

43. a. resolve ambiguities
     b. use a sector plan to organise information
     c. know what should be happening next
     d. actively process all inbound information

44. a. accept that others may be more attuned to my performance than me
     b. complete most things myself
     c. inform passengers of change as soon as possible
     d. use knowledge of turbulence to plan the flight regime

45. a. consult other crewmembers before implementing any decision
     b. monitor radio calls to/from other traffic
     c. maintain an active information gathering strategy
     d. consider everything going to plan as a bonus
As a captain required to operate on an unfamiliar route, I would be

- √ most likely to...........
- × least likely to...........

46. a. be flexible in my approach to changes
     b. brief crew before acting
     c. note landing direction when around airports
     d. verbalise actions to rehearse

47. a. maintain an overview of all relevant information
     b. accept that flight outcomes depend on me
     c. investigate any hint of error
     d. successfully separate work from my private life

48. a. develop options for managing available fuel
     b. keep all crewmembers informed
     c. maintain customer needs in focus
     d. review approaches at contingency airports

49. a. consider schedule last at the planning stage
     b. share information confidentially with selected crewmembers
     c. know what should be happening
     d. acknowledge demonstrated expertise in others

50. a. ensure that I receive all flight information
     b. resolve to find ways to improve
     c. assume that I have flown the perfect sector
     d. recognise that the mission will require considerable application
As a captain required to operate on an unfamiliar route, I would be

✓ most likely to..........

✗ least likely to..........

51. a. use available fuel to make the operation work
    b. review areas for personal improvement before each flight
    c. learn about my role on this flight by asking others
    d. discard information only when its relevance has been checked

52. a. respond supportively to assertive behaviour by others
    b. organise information along a sector time line
    c. use a routine for turbulence penetration
    d. establish the strengths of others

53. a. apologise for outcomes over which I have no control
    b. mitigate the effects of error by acting swiftly
    c. improve my performance at the first opportunity
    d. employ the company approved decision making process

54. a. act on considered information
    b. use rehearsal to develop my expectation of the flight
    c. ask questions when others generate input
    d. seek out the latest information

55. a. analyse surprises to hone my expectation of similar flights
    b. prepare several possible flight scenarios
    c. search for things that I might have missed
    d. manage unwarranted pressure applied by others
As a captain required to operate on an unfamiliar route, I would be

✓ most likely to...........

✗ least likely to...........

56. a. know the current safety height
   b. create opportunities to check customer satisfaction
   c. tolerate a little stress to enhance learning
   d. use observations made by others to improve my performance

57. a. share my thoughts about contingencies with other crewmembers
   b. plan a go-around as well as a landing
   c. withhold information from others
   d. review flight departure boards in the terminal

58. a. acknowledge the benefits that coaching can bring
   b. harness the knowledge and expertise of others
   c. determine the optimum time to brief
   d. prioritise topics for study

59. a. establish which type of information may influence the flight
   b. generate an open communication environment
   c. consider the safety implications of any proposed action
   d. know the required standard

60. a. build improvements into my flight regime
   b. monitor the depletion rate of finite resources
   c. establish what information is missing
   d. be mindful of the effects of delays on product delivery
As a captain required to operate on an unfamiliar route, I would be

√ most likely to...........

× least likely to...........

61. a. ignore information which does not match my expectation
    b. establish task timeframes
    c. be prepared to be coached by others
    d. claim that I know everything

62. a. evaluate decisions before implementation
    b. fine tune my work sequence by pre-flight rehearsal
    c. identify sources of possible departure delays
    d. respond to new information with effective tactics

63. a. strive to do the perfect sector
    b. check the result of delegated work
    c. activate the company system to recover customers
    d. leave cockpit crew out of the information loop

64. a. solicit coaching from others
    b. let those who know the most exert the most influence
    c. rely on my experience to sift information
    d. think laterally to minimise delays

65. a. delegate decision making to others
    b. rehearse to stay ahead of the aircraft
    c. identify and resolve discrepancies
    d. determine what can be realistically achieved
As a captain required to operate on an unfamiliar route, I would be

✓ most likely to...........
✗ least likely to.........

66. a. assert authority when needed
   b. monitor customer satisfaction
   c. dissect the flight step by step beforehand
   d. analyse all information before making a decision

67. a. avoid untimely distractions
   b. use a routine for turbulence penetration
   c. revisit decisions to test their validity
   d. visualise the flight in detail before work

68. a. use a mental checklist to monitor flight progress
   b. resist the temptation to embellish situations
   c. contribute to the recovery of failures in customer service
   d. minimise exposure to uncomfortably turbulent conditions

69. a. decide by consensus
   b. use armchair flying to prepare for the flight
   c. be systematic in acquiring knowledge
   d. entertain the probability that required activities will be omitted

70. a. initially accept that all information may influence the flight
   b. incorporate validated improvements in my task routines
   c. initiate actions without communicating reasons to others
   d. discuss the proposed flight in social setting beforehand
As a captain required to operate on an unfamiliar route, I would be

✓ most likely to ..........

✗ least likely to ..........

71. a. use authority to deal with assertion and/or conflict
    b. assess the impact of other traffic on my flight
    c. avoid the duty if it interferes with my lifestyle
    d. resolve apparent ambiguities in my role in the operation

72. a. establish the needs of other parties in conflict situations
    b. continuously seek to identify omissions
    c. avoid dismissing input out of hand
    d. question despatchers for additional information

73. a. attempt to commit all required information to memory
    b. use every experience to refine expectations
    c. ask others how I could improve
    d. develop an initial response routine to activate contingency plans

74. a. explore ways to best use finite resources
    b. take the view that all error will be detected
    c. maintain a sequence in task completion
    d. include all involved crew in briefings

75. a. search for ambiguities
    b. ask others to assess my performance
    c. build a realistic expectation of the flight to reduce surprises
    d. automate responses to contingencies through repeated practice
As a captain required to operate on an unfamiliar route, I would be

√ most likely to ..........
× least likely to ..........

76. a. commit to seriously consider all input
   b. question my thinking as a way of detecting error
   c. avoid decisions based on feelings
   d. recognise the signs of developing conflict

77. a. understand what is to be achieved
   b. only accept adverse outcomes after all alternatives have been explored
   c. determine the best starting point for error correction
   d. make briefings meaningful

78. a. force myself to accept the duty
   b. consider organisational goals at the planning stage
   c. remain open minded
   d. know what captains are trying to achieve

79. a. manage error
   b. acknowledge memory limitations when briefing
   c. respond decisively to impending depletion of finite resources
   d. strive to have operational restrictions lifted

80. a. review my expectation at the formal planning stage
   b. resist the temptation to speed things up
   c. analyse the immediate return scenario
   d. persevere when trying to answer questions about my performance
As a captain required to operate on an unfamiliar route, I would be

✓ most likely to...........

× least likely to...........

81. a. continue to want to learn about my job
   b. prepare for changes to my initial plan
   c. put passenger comfort before safety
   d. ask other crewmembers what they would do

82. a. use stress management techniques
   b. take the time to resolve conflicts by process
   c. identify actions required to correct errors
   d. stress that uneasiness should generate input

83. a. continue to update information to plan for contingencies
   b. recognise that others may see things differently
   c. allow those who know most to lead scenario resolutions
   d. project thinking ahead of the aircraft

84. a. avoid procrastination over discovered error
   b. have a current useable contingency plan
   c. share all plans with crew
   d. adjust the usage rate of fuel to achieve goals

85. a. generate areas for improvement after the flight
   b. develop a routine to cope with extra workload
   c. consider passenger comfort in my planning
   d. take more time than normal to complete routine tasks
As a captain required to operate on an unfamiliar route, I would be

√ most likely to...........

✗ least likely to...........

86. a. acknowledge the possibility of mistakes being made
    b. recognise increasing urgency in assertive behaviour
    c. require others to input when not in agreement
    d. develop a personal performance improvement plan

87. a. recognise the need to organise sector knowledge
    b. develop a prototype of the flight before work
    c. draw word pictures to prompt input on my performance
    d. think that all will go to plan

88. a. accept that error is inevitable on such a mission
    b. ask for feedback on intentions
    c. give passengers plausible explanations of events
    d. manage finite resource usage

89. a. find out if my job entails extra responsibilities
    b. repeatedly search for new information
    c. avoid rationalising error
    d. discuss the use of language for providing input

90. a. assemble ideas about what should happen
    b. satisfy schedule constraints after passenger comfort
    c. question the fact that I started in aviation
    d. thank other crewmembers for their contributions
As a captain required to operate on an unfamiliar route, I would be

√ most likely to...........

× least likely to...........

91. a. know approximate aircraft performance parameters for various conditions
    b. be prepared to get information restated
    c. routinely scan for weather
    d. apply SOPs creatively to achieve goals

92. a. prioritise flight goals
    b. be prepared to learn
    c. explore the needs of others when building work rosters
    d. engage passengers by smiling

93. a. blame others rather than accept responsibility
    b. resist trying to justify inappropriate actions
    c. note improvements required for my next flight
    d. avoid the one-person band syndrome

94. a. identify events which could impact upon the flight
    b. think that I know enough to make the operation work
    c. assume that everything is under control
    d. develop an understanding of maintenance in progress

95. a. expect others to do things that I would not do
    b. be prepared to seek more information
    c. gain an advantage on competing traffic
    d. self-direct knowledge acquisition
As a captain required to operate on an unfamiliar route, I would be

✓ most likely to........

× least likely to........

96. a. verbalise shortcomings of personal actions
   b. tap into the strengths of others
   c. maintain a realistic view of my spare capacity
   d. strive to use the least amount of fuel possible

97. a. only discard information after I understand it
   b. appear calm at all times
   c. determine how things could have been done better
   d. take more fuel than legally required

98. a. initiate actions to make the operation work
   b. ascertain what I did not achieve
   c. check the importance of all inbound information
   d. know where to find required information

99. a. follow up on incomplete information
   b. accept that others may know more than me
   c. initiate weather avoidance early
   d. act early to ensure that goals are achieved

100. a. record incoming information
     b. accept that others have ability
     c. avoid speculation about possible outcomes of the flight
     d. note landing direction when around airports
APPENDIX P

MOST LIKELY

These are the questions ranked in order of maximum count of one answer.

'Answer' gives the response and 'max' gives the number of times that response occurred.

If two responses occurred equally, then the second response is given in tie.

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APPENDIX Q

LEAST LIKELY

These are the questions ranked in order of maximum number of participants who selected the same item as their least likely action.

‘Answer’ gives the item selected and ‘max’ gives the number of times that response was selected. If two responses occurred equally, then the second response is given in ‘tie’.

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APPENDIX R

A COMPOSITE LIST OF MOST LIKELY AND LEAST LIKELY QUESTION WHEREIN HIGH LEVELS (approx = or > 75\%) OF AGREEMENT WERE REPORTED

- First 18 questions are from Appendix AA (most likely) and appear in *italics*
- Last 43 questions are from Appendix AB (least likely)
- Questions marked with asterisk are common to both most likely and least likely data
- The refined questionnaire will contain the 51 questions wherein high agreement of answers was reported across the 46 responses

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Appendix S

AIRLINE CAPTAIN ATTRIBUTES QUESTIONNAIRE

Instructions for completion:

- Record:
  1. Your approximate total hours in command ...................
  2. Your approximate multi-crew hours ................ (command & co-pilot)

- This questionnaire contains 60 questions to which you are asked to respond.
- Each question contains four activity statements which relate to operating in command of a multi crew passenger aircraft.
- In each question, you are asked to identify the activity which you are most likely to complete and mark it with a tick. Secondly, in each question, you are asked to identify the activity which you are least likely to complete and mark it with a cross.

- When completing this questionnaire, you will find it beneficial to think about receiving limited notice (1 day) to operate on a route which you have never flown before (e.g., Bogata to Rio de Janeiro).

- The following example gives guidance as to how the questionnaire should be answered.

As a captain required to operate on an unfamiliar route, I would be

✓ most likely to...........

× least likely to...........

1. a. be first off the aircraft at destination
   ✓ acknowledge good performance by others
   c. lose sight of organisational goals
   × ignore junior crewmembers

- If you wish to change a response, you will need to block out or erase the tick or cross already inserted and insert a new tick or cross.

- Although you must respond in both ways to each question, you must only respond once in each way to each question. Even if you believe that more than one statement applies, you must finish with only one tick and one cross recorded for each question.

- Work as quickly as you can to complete the questionnaire.
- Do not detach this instruction sheet from the questionnaire.
As a captain required to operate on an unfamiliar route, I would be

✓ most likely to...........
× least likely to...........

1. a. assume that the operation will not go as planned
   b. pay less attention to the efficiency of the operation
   c. initiate actions without communicating reasons to others
   d. anticipate periods of high workload

2. a. discuss the proposed flight with peers
   b. seek professional help if stressed
   c. choose a good time and place to request coaching
   d. accept the duty without thinking about pay first

3. a. continuously scan for errors
   b. process all information as part of the decision process
   c. develop an expectation of the flight
   d. compare my performance to the required standard

4. a. ensure that I fully understand what I am doing
   b. keep passengers well informed
   c. admit not knowing operational facts
   d. regularly communicate with customers

5. a. resist the temptation to think that all is well
   b. expect the unexpected
   c. control crew by limiting information flow
   d. reflect on my performance
As a captain required to operate on an unfamiliar route, I would be

√ most likely to...........

× least likely to...........

6.  a. devise strategies to meet long term goals
    b. develop several solutions to a problem
    c. ensure that a common understanding is held by all crew
    d. follow up on topics raised during coaching

7.  a. use my expectation of the flight to sort inbound information
    b. let stress influence my work
    c. avoid rushing to please others
    d. take decisive actions to mitigate the consequence of error

8.  a. establish crew duty limits
    b. assess the probability of turbulence before the flight
    c. think about the worst case scenarios
    d. maintain a plot of all traffic in close proximity

9.  a. apply effort to analysing the job of captain
    b. avoid down playing threats posed by poor weather
    c. implement a scanning routine
    d. make notes on things that could be improved

10. a. formulate plans to recover dissatisfied customers
    b. focus on others in conflict situations
    c. enroute, use a routine to source information
    d. utilise knowledge only if it is organised
As a captain required to operate on an unfamiliar route, I would be

✓ most likely to...........

✗ least likely to...........

11. a. instigate the search for mistakes
   b. accept that I am the final arbiter
   c. embarrass others by withholding information
   d. treat passengers’ knowledge of flying with respect

12. a. interface assertively with ATC to avoid weather
   b. accept a lower performance because of unfamiliarity
   c. establish a performance review routine
   d. be very critical of my own performance

13. a. prioritise goals and use finite resources accordingly
   b. read sector information before I need to use it
   c. address problems identified through self-critique
   d. assist other crewmembers in customer recovery

14. a. know where to find required information
   b. revel in knowing something that others do not
   c. assemble sector knowledge in a useable format
   d. make efficiency my last consideration at the planning stage

15. a. withhold information from passengers
   b. welcome the flight as a chance to learn
   c solicit coaching from others
   d. hurry when completing normal duties
As a captain required to operate on an unfamiliar route, I would be

✓ most likely to...........

✗ least likely to...........

16. a. be able to change tack quickly
   b. initiate actions to make the operation work
   c. tune into the feelings behind spoken words
   d. minimise exposure to turbulent conditions

17. a. know my personal limitations
   b. rehearse motor skills required for the flight
   c. know the position of the nearest suitable airport
   d. require others to communicate detected error

18. a. initiate discussion on the performance by the crew
   b. support customer expectations for a consistent product
   c. clarify incoming information when required
   d. recognise the symptoms of stress

19. a. accept that others have ability
   b. make contingency planning an integral part of my operation
   c. rehearse contingency plans to fine tune detail
   d. insist that I am right

20. a. watch local and world newscasts
    b. discard inbound information without consideration
    c. review all activities in order to detect error
    d. conduct a self de-brief after the sector
As a captain required to operate on an unfamiliar route, I would be

√ most likely to...........

× least likely to...........

21. a. use only my experience and knowledge to make decisions
b. talk to passengers in a confident tone
c. always tell passengers the truth
d. meet safety requirements before efficiency at planning

22. a. encourage others to share their expertise
b. commit to addressing the concerns of others
c. assign a high priority to customer satisfaction
d. keep the big picture in focus

23. a. make excuses for my performance
b. be on the lookout for mistakes
c. maintain control of the crew by withholding information
d. recognise and use my strengths

24. a. accept that others may assess my coaching need
b. give others permission to have their say
c. generate time to review performance
d. limit improvement activity to flying skills

25. a. accept that others may be more attuned to my performance than me
b. complete most things myself
c. inform passengers of change as soon as possible
d. use knowledge of turbulence to plan the flight regime
As a captain required to operate on an unfamiliar route, I would be

✓ most likely to........

× least likely to........

26. a. consult other crewmembers before implementing any decision
b. monitor radio calls to/from other traffic
c. maintain an active information gathering strategy
d. consider everything going to plan as a bonus

27. a. be flexible in my approach to changes
b. brief crew before acting
c. note landing direction when around airports
d. verbalise actions to rehearse

28. a. develop options for managing available fuel
b. keep all crewmembers informed
c. maintain customer needs in focus
d. review approaches at contingency airports

29. a. consider schedule last at the planning stage
b. share information confidentially with selected crewmembers
c. know what should be happening
d. acknowledge demonstrated expertise in others

30. a. ensure that I receive all flight information
b. resolve to find ways to improve
c. assume that I have flown the perfect sector
d. recognise that the mission will require considerable application
As a captain required to operate on an unfamiliar route, I would be

✓ most likely to.......... 
✗ least likely to.......... 

31. a. apologise for outcomes over which I have no control
b. mitigate the effects of error by acting swiftly
c. improve my performance at the first opportunity
d. employ the company approved decision making process

32. a. act on considered information
b. use rehearsal to develop my expectation of the flight
c. ask questions when others generate input
d. seek out the latest information

33. a. know the current safety height
b. create opportunities to check customer satisfaction
c. tolerate a little stress to enhance learning
d. use observations made by others to improve my performance

34. a. share my thoughts about contingencies with other crewmembers
b. plan a go-around as well as a landing
c. withhold information from others
d. review flight departure boards in the terminal

35. a. acknowledge the benefits that coaching can bring
b. harness the knowledge and expertise of others
c. determine the optimum time to brief
d. prioritise topics for study
As a captain required to operate on an unfamiliar route, I would be

✓ most likely to...........

✗ least likely to..........

36. a. ignore information which does not match my expectation
   b. establish task timeframes
   c. be prepared to be coached by others
   d. claim that I know everything

37. a. strive to do the perfect sector
   b. check the result of delegated work
   c. activate the company system to recover customers
   d. leave cockpit crew out of the information loop

38. a. initially accept that all information may influence the flight
   b. incorporate validated improvements in my task routines
   c. initiate actions without communicating reasons to others
   d. discuss the proposed flight in social setting beforehand

39. a. use authority to deal with assertion and/or conflict
   b. assess the impact of other traffic on my flight
   c. avoid the duty if it interferes with my lifestyle
   d. resolve apparent ambiguities in my role in the operation

40. a. explore ways to best use finite resources
   b. take the view that all error will be detected
   c. maintain a sequence in task completion
   d. include all involved crew in briefings
As a captain required to operate on an unfamiliar route, I would be

✓ most likely to

✗ least likely to

41. a. search for ambiguities
   b. ask others to assess my performance
   c. build a realistic expectation of the flight to reduce surprises
   d. automate responses to contingencies through repeated practice

42. a. force myself to accept the duty
   b. consider organisational goals at the planning stage
   c. remain open minded
   d. know what captains are trying to achieve

43. a. continue to want to learn about my job
   b. prepare for changes to my initial plan
   c. put passenger comfort before safety
   d. ask other crewmembers what they would do

44. a. continue to update information to plan for contingencies
   b. recognise that others may see things differently
   c. allow those who know most to lead scenario resolutions
   d. project thinking ahead of the aircraft

45. a. acknowledge the possibility of mistakes being made
   b. recognise increasing urgency in assertive behaviour
   c. require others to input when not in agreement
   d. develop a personal performance improvement plan
As a captain required to operate on an unfamiliar route, I would be
✓ most likely to...........
× least likely to...........

46. a. assemble ideas about what should happen
   b. satisfy schedule constraints after passenger comfort
   c. question the fact that I started in aviation
   d. thank other crewmembers for their contributions

47. a. know approximate aircraft performance parameters for various conditions
   b. be prepared to get information restated
   c. routinely scan for weather
   d. apply SOPs creatively to achieve goals

48. a. blame others rather than accept responsibility
   b. resist trying to justify inappropriate actions
   c. note improvements required for my next flight
   d. avoid the one-person band syndrome

49. a. identify events which could impact upon the flight
   b. think that I know enough to make the operation work
   c. assume that everything is under control
   d. develop an understanding of maintenance in progress

50. a. expect others to do things that I would not do
   b. be prepared to seek more information
   c. gain an advantage on competing traffic
   d. self-direct knowledge acquisition
As a captain required to operate on an unfamiliar route, I would be

✓ most likely to...........

✗ least likely to...........

51. a. initiate actions to make the operation work
   b. ascertain what I did not achieve
   c. check the importance of all inbound information
   d. know where to find required information

52. a. organise my knowledge to improve recall
   b. establish operational *bottom lines*
   c. develop a prototype of the flight before work
   d. accept that omissions will need to be discovered

53. a. devise plans to cover several eventualities
   b. revisit decisions to test their validity
   c. record incoming information
   d. run contingency plans in parallel with normal operations

54. a. avoid overloading other crewmembers
   b. allow time for the discussion of plans
   c. encourage others who know more than me
   d. visualise the flight in detail before work

55. a. act to minimise the effects of mistakes
   b. refuse the duty if my personal problems are too great
   c. allow all crew to participate in decision making
   d. act early to ensure that goals are achieved
As a captain required to operate on an unfamiliar route, I would be

✓ most likely to...........

✗ least likely to...........

56. a. resolve ambiguities
   b. use a sector plan to organise information
   c. know what should be happening next
   d. actively process all inbound information

57. a. maintain an overview of all relevant information
   b. accept that flight outcomes depend on me
   c. investigate any hint of error
   d. successfully separate work from my private life

58. a. avoid procrastination over discovered error
   b. have a current useable contingency plan
   c. share all plans with crew
   d. adjust the usage rate of fuel to achieve goals

59. a. generate areas for improvement after the flight
   b. develop a routine to cope with extra workload
   c. consider passenger comfort in my planning
   d. take more time than normal to complete routine tasks

60. a. follow up on incomplete information
   b. accept that others may know more than me
   c. initiate weather avoidance early
   d. act early to ensure that goals are achieved
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PLEASE NOTE

The greatest amount of care has been taken while scanning this thesis,

and the best possible result has been obtained.
An investigation of the management of flight aspects of airline Captain performance

G. K. Beaumont

Doctor of Philosophy

2002

University of Western Sydney
I certify that the substance of this thesis has not already been submitted for any degrees and is not being currently submitted for any other degrees.

I certify that, to the best of my knowledge, any help received in the preparation of this thesis, and all sources used, have been acknowledged in the thesis.

Graham Beaumont
Abstract

A clear definition of pilot performance beyond manipulative skills remains a challenge. Attempts have been made to annunciate the cognitive and behavioural skill set which comprises this area of performance. Crew resource management (CRM) is one such effort which, while it has done much to identify pilot behaviours, has not translated easily into useable selection and general performance instruments. In particular, CRM research has not yet identified an umbrella construct which clearly and efficiently organises management of flight aspects of the airline piloting role. Such a construct would be useful in the training of pilots to automaticity in activities determined to contribute to sustained good performance in other than manipulative skills. In this present series of studies action research principles were employed throughout. Initially, markers that are used by airline check and training personnel in a specific airline to assess suitability for command were identified. Next, the organisational understanding of SA was explored and revealed a more strategic focus than the tactical approach adopted by preceding researchers. In a further study, this strategic focus was investigated through a series of semi-structured interviews with experienced airline Captains. In order to limit the reliance on automaticity, these captains were asked to consider an unfamiliar task. Recurring activity themes were then identified. When examined, these themes were found to approximate the proposed constructs of self-regulation. This concept was explored and defined in a further study which, through a repeated cycle of participant involvement, identified actions which were considered essential to the functionality of each of these recurring themes. These results were used as the foundation for a novel set of management of flight performance indicators for the organisation within which the research was carried out. Initial trials of an ipsative questionnaire derived from these action statements were carried out as the final study of this research.
Acknowledgements

This indulgence could not have been sustained without the support of my family. The understanding and tolerance of Helen, Tom, Amelia and Phoebe were the major factors which contributed to the completion of this work.

The research could not have been implemented without the shared vision and cooperation of key management personnel within Qantas. In particular Captain Ray Heiniger, Group General Manager Flight Operations and Chief Pilot, Captain Wayne Kearns, General Manager Flight Operations and Deputy Chief Pilot, and Captain Bob Small, General Manager Flight Operations Training, were instrumental in facilitating this project. As President of The Australian and International Pilots Association, Captain Colin Adams also contributed handsomely in this regard. Other management and union personnel too numerous to mention also contributed in valuable ways to this research project.

Hundreds of participants drawn from all ranks, but in particular the Captains, gave freely of their own time to ensure that the collected data met the quantity and quality standards required to advance this research. It was their contributions that ensured that this process of exploration reached a useful conclusion. In essence, this research and the outcomes belong to them.

The attention to detail and the guidance which I received from my supervisors enabled me to make sense of the voluminous amounts of data which came my way. Between them, Associate Professor Irene Henley, Dr Mark Wiggins and Dr Gaye Gleeson brought a comprehensive range of academic and practical skills to this project, and the final form is in no small part due to their expertise and encouragement.

Miles and Huberman (1984) point out that “no amount of evidence can prove me right and no amount of evidence can prove me wrong” (p. 242). This research has not been about proof, but has been about giving expression to that which has come so naturally to most, yet continues to elude many. Thanks to their involvement, we do have a better idea of how Captains in this airline achieved and continue to maintain management of flight competence.
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### Abbreviations

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<td>A300</td>
<td>Airbus mark 300 type aircraft</td>
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<td>AC</td>
<td>Advisory Circular</td>
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<td>ACRM</td>
<td>Advanced crew resource management</td>
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<td>AIPA</td>
<td>Australian and International Pilots Association</td>
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<td>ANOVA</td>
<td>Analysis of variance</td>
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<td>AOC</td>
<td>Air Operator's Certificate</td>
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<td>APU</td>
<td>Auxiliary power unit</td>
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<td>AQP</td>
<td>Advanced Qualification Programme of pilot training</td>
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<td>ASRS</td>
<td>Aviation Safety Reporting System</td>
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<td>ATC</td>
<td>Air traffic control</td>
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<td>ATP</td>
<td>Authority to proceed</td>
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<td>ATSB</td>
<td>Australian Transport Safety Bureau</td>
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<td>B707</td>
<td>Boeing mark 707 type aircraft</td>
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<td>B747-300</td>
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<td>CDM</td>
<td>Critical decision making method of cognitive task analysis</td>
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<td>CFIT</td>
<td>Controlled flight into terrain</td>
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<td>ci</td>
<td>Confidence interval</td>
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<td>CNN</td>
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<td>CSM</td>
<td>Customer Service Manager (Purser, Lead Flight Attendant)</td>
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<td>CTA</td>
<td>Cognitive task analysis</td>
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<td>CVR</td>
<td>Cockpit voice recorder</td>
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<td>Cognitive work analysis</td>
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<td>Decision making</td>
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FAA  Federal Aviation Administration
FMAQ  Flight management attitudes questionnaire
FMS  Flight management system
F/O  First officer
GAO  General Accounting Office of the United States
GMFOT  General Manager Flight Operations Training
GPS  Global positioning satellite system
GRADE  Gather, review, analyse, decide and evaluate (DM acronym)
HF  Human factors
IFR  Instrument flight rules
IQ  Intelligence quotient
LC  Line Captain
LTC  Line training Captain (route trainer)
LLC  Line/LOS checklist
LOFT  Line oriented flight training
LOS  Line operational simulation
LTC  Line training captain with route training qualification
MEL  Minimum equipment list
N  Number of cases
NASA  National Aeronautics and Space Administration
NDM  Naturalistic decision making
nm  nautical mile
NOTAM  Notices to airmen/women
OR  Odds ratio
PA  Public address
P or p  Probability
pos  Position
PROB  Probability
prob  Probability
PS  Pilot study respondent
Q  Question
QA  Quality assurance
QAR  Quick access recorder
REFER  DM style which requires reference to other crew members
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<td>Situation awareness global assessment technique</td>
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<td>SART</td>
<td>Situation awareness rating technique</td>
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<td>SCC</td>
<td>Senior check captain</td>
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<td>SME</td>
<td>Subject matter expert</td>
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<td>S/O</td>
<td>Second officer</td>
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<td>Standard operating procedure</td>
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<td>Self-regulation</td>
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<td>Senior training captain with simulator training qualification</td>
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<td>Total air temperature</td>
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