Management of Threats and Errors in Normal Operations of Assistant Controllers

A thesis presented in partial fulfillment of the requirements for the degree of

Master
in
Aviation

at Massey University, Palmerston North
New Zealand

Timothy Kwan Chi Yeung

2007

Abstract

"To err is indeed human, so to err is normal."

Human errors are usually pronounced in accident or incident reports. Seldom does one pay enough attention to these errors during daily normal operations as these either go unnoticed or unreported for whatsoever the reasons may be. Therefore, the causes of these errors and also the system threats prevalent in the daily operations may not be fully contained. On the other hand, problematic situations that are successfully tackled by human skills are quite often treated as less important than they really are.

The job of an assistant controller (AC) is one of the important domains in air traffic management (ATM). The AC work together with air traffic controllers as team members and they do have direct and indirect contributions to the safe, orderly and efficient flow of air traffic. In this study, the threats, errors and potential undesired states occurring with AC during normal operations will be recorded by a methodology, which is new to Hong Kong Air Traffic Control (ATC). This methodology, called Normal Operations Safety Observation (NOSO), is built on the Threat and Error Management (TEM) framework. The results will generate a broad outline on what sorts of threats, errors and undesired states an AC can be facing during normal operations. The relative frequencies of occurrence of these conditions will be presented separately in tables and figures. The AC's potential vulnerabilities and capabilities to cope with these threats, errors and undesired states will be discussed together with a suggested ranking. It is envisaged that an analysis of the data collected will aid the development and evaluation of safety defence measures in ATM and further support the applicability of this data collection methodology in other ATM operations and subsequent researches.

KEYWORDS:- Normal Operations Safety Observation, Threat and Error Management, Safety Management, Air Traffic Control

Acknowledgements

This research could not have been completed without the help and support of many people. It is a pleasure of mine to express my gratitude to the following:-

Thesis Advisors

Dr. Hans-Juergen Hoermann
Senior Scientist Human Factors
German Aerospace Center
Institute of Aerospace Medicine
Sportallee 54a
22335 Hamburg, Germany
Germany
+49-40-51309642
hans.hoermann@dlr.de

Dr. Andrew Gilbey
School of Aviation
Massey University
Turitea Campus
Palmerston North
New Zealand

Professional Advisors

Mr. Peter Pui Kong Leung
Senior Operations Officer
Civil Aviation Department
Air Traffic Control Complex
Hong Kong International Airport
Hong Kong

Mr. David Kwok Wai Cheung
Senior Quality Assurance Manager
Civil Aviation Department
Air Traffic Control Complex
Hong Kong International Airport
Hong Kong
Executive Vice-President Asia Pacific
International Federation of Air Traffic
Controllers' Associations

I am obliged to the Hong Kong Civil Aviation Department for its support in granting me the approval to conduct this research in the Hong Kong Air Traffic Control Centre and for the approval of two-month's leave associated with data collection. I would also like to express my gratitude to Massey University and the Hong Kong Polytechnic University for their academic support. Most importantly, I wish to thank my family for their patience with my four-year Master Degree studies.

There are two gentlemen who are advocates of aviation in the Hong Kong Special Administrative Region and New Zealand respectively. They have put forward dedicated efforts in the establishment of this locally run Master Degree of Aviation course. Their names, which should be remembered by all the students of this course, are as follows:-

Professor Kee Ying Fung, Hong Kong

Professor Graham J F Hunt, New Zealand

Above all, my heartfelt thanks to those participating assistant controllers who have to remain anonymous for confidentiality. They allowed me to conduct the research while they were on their job. The success of this research relies heavily on their trust and participation. Without their kind assistance, there is no way that the research would yield a successful completion.

"Thank you"

The research undergoes an ethical consideration from Massey University that the research strictly follows the Code of Ethical Conduct for Research (Massey University, 2006).

Table of Contents

List of Figures

List of Tables

Chapter One: Introduction

The nuclear industry, medicine and aviation are professions that are, in general, managed by highly skilful professionals. On the practical sense, these personnel are required to work in a high-risk environment and errors are not always forgiving or easily forgotten.

On April 26, 1986 at 01:24 a.m., two explosions took place in Reactor 4 of the Ukrainian Nuclear Power Plant in Chernobyl (Medvedev, 1990). The accident, resulting in a vast environmental radioactive pollution and unknown number of attributed deaths, is considered as the worst accident in the history of nuclear industry. The accident itself was caused by networks of causation that Dörner (1996) considers them to be mistakes of cognition.

Medicine might be mistakenly treated as less significant when only a single patient, given a hit-and-miss treatment, is considered. It changes one's thinking when the number of deaths (44,000) due to medical errors is found to exceed the number people who got killed because of vehicle accidents (43,458), breast cancer (42,297) or AIDS (16,516) (Kohn, Corrigan & Donaldson, 1999).

Aviation is no exception: 70–80% of all aviation accidents are, to a certain extent, attributable to human errors (Shappell & Wiegmann, 1996). Continuous attempts are made to overcome human errors by either automation or regulation. However, incidents and accidents still occur from time to time so long as attention is only focused on retrospective analysis. Although incidents and accidents are infrequent events and they take up only a small fraction in an ATM operation, they do draw a lot of attention. The rest are normal operations that are embedded with a mixture of events comprising two extremities, namely the good and the bad. The former is treated as normal or sometimes heroic performance, whereas the latter is from peccadilloes to errors resulting from not paying sufficient consideration and more often then not, the subsequent absent-mindedness. Errors in fact can generate knowledge. This knowledge can either enhance one's skill or reveal the system's deficiencies and defectiveness. Without a deep understanding of human behaviour and clear identification of this dichotomy, the effort on implementing safety measures is becoming less effective and the problems of human error will continue to remain unresolved.

1.1 The "Swiss Cheese" Model of Defences

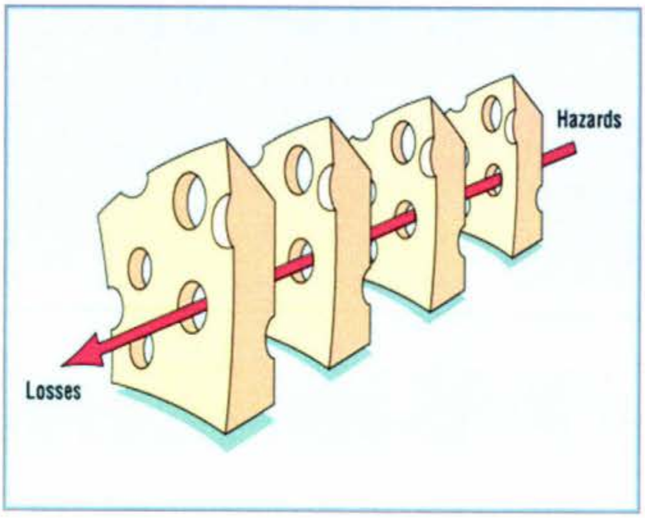


Figure 1.1 **Reason's Swiss-cheese Model (Adapted from Reason, 2000)**

Reason's (1990) Swiss-cheese model, which is shown in Figure 1.1, highlights the interactions of human behaviour and safety defences that can lead to the breakdown of complex systems under certain conditions. The holes in the first cheese layer are failures that are usually identified by incident/accident investigators. Remedial actions such as training and/or new procedures are subsequent layers implemented to prevent recurrence and are of reactive in nature. The holes in the other layers, though not considered as primary factors in the incident/accident, still exist and can possibly contribute to future incidents/accidents. They are potential accident precursors under different circumstances and it is just a matter of time and conditions before an accident will occur. Proactive actions are efforts to block more holes. Normal Operations Safety Survey (NOSS) (International Civil Aviation Organization [ICAO], 2005; Maurino & Ruitenberg, 2004) can be regarded as one of such actions as it will reveal essential data to enhance safety levels before an incident/accident happens.

1.2 ATM Vulnerabilities and Strengths

In the context of ATM, all the holes represent areas which can be tapped for valuable

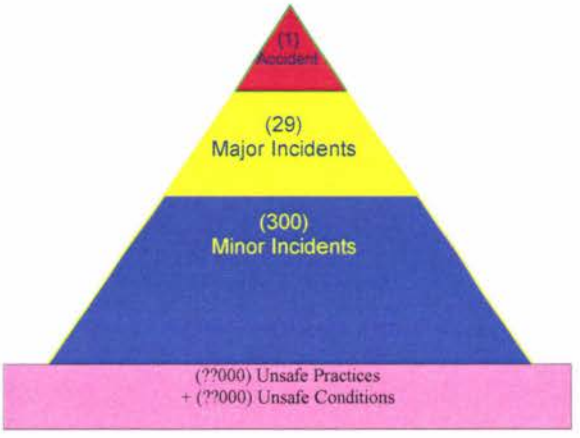


Figure 1.2 **Heinrich Pyramid**
(Adapted from Heinrich et al, 1980)

safety data that enable ones to identify the weaknesses in the ATM systems so that safety measures can be improved or further developed. Conventionally, the sources of these safety data are derived from retrospective means, which are the outcomes of incident/accident investigation and data from confidential safety reporting system. However, these are passive means to collect safety information in a safety management system. Although proactive measures such as Surveillance by Stream Supervisors, Annual Proficiency Check, Refresher Training and Medical Examination are in place, they can only provide some "snapshots" of the ATM personnel's performance and problems can only be fixed in retrospect. Besides, the voice and radar data recordings can only provide pertinent information on how incident/accident occurred but may not be able to explain why it has occurred. Without a full picture, these data and measures are less effective and inconclusive. Even occasionally, a false indication of healthy conditions by the effect of "angel performance" (FAA, 2006) is perceived when ATM personnel are under examination. In the application of the sequence 1–29–300 (Heinrich, 1959) to accident causation, Heinrich suggests that 300 minor incidents will lead to 29 major incidents and over time to one accident – 1-in-300 rule. These figures do not include unknown number of unsafe practices and conditions underlying the pyramid, as illustrated in Figure 1.2 (Heinrich, Petersen & Roos, 1980), that have gone either unnoticed or unreported. Furthermore, past research cited by ICAO (2006) that the accident to incident ratio is 1:600, that is even a worsened figure than the previous one. On the other hand, information on daily operations of successful problem-solving techniques, such as how ATM personnel tackle threats (e.g., similar callsigns) and errors (e.g., miscommunication), has seldom received attention. These are often regarded as norms. Thus, the strengths as well as weaknesses that Air Navigation Service Provider (ANSP) used to reinforce its safety margins to prevent performance degradation are actually intertwined.

1.3 Line Operations Safety Audit (LOSA)

The concept of collecting safety data from daily operations in aviation can be traced back to 1991. A human factors research project sponsored by the Federal Aviation Administration (FAA) was conducted by the University of Texas at Austin. A methodology called LOSA was developed to monitor the normal line operations of flight crews. As of February 2007, 30 airlines (of which 4 conducted LOSA the second time), had conducted LOSA which included around 6,000 flights (Merritt, 2007). Over 39,500 threats, errors and undesired aircraft states have been identified and recorded. LOSA has since become a formal process of safety data collection method and is endorsed by the International Civil Aviation Organization (ICAO). In fact, an ICAO manual has been published as guidance material for airlines (ICAO, 2002). In general, the methodology requires that trained observers occupy the jump seat during normal scheduled flights to collect safety-related data from the departure to the arrival gate. The data collected are classified, kept strictly confidential and non-punitive. This is one of the key reasons pilots are willing to participate in this program. All these data, after analysis, would provide airlines with invaluable safety information on nine key aspects (FAA, 2006) such as threat in operating environment and operations, training, procedures, equipment designs, pilots' performance and other organizational considerations.

LOSA is underpinned by the TEM concept that daily performance of flight crews are recorded and scrutinized subsequently to produce a representative picture of flight crew operation. LOSA, originating from the University of Texas research on complex operations (FSF, 2005), is considered also applicable to ATC by the International Federation of Air Traffic Controllers' Associations (Lauridsen, 2005; Wright, 2007). ICAO established a study group to implement a program to collect safety data during normal ATC operations in 2004. The program, Normal Operations Safety Survey (NOSS), is developed from the philosophy of LOSA with TEM as a framework. To date, 3 ANSPs – Airservices Australia (Knauer, 2005, 2007), Airways Corporation New

Zealand (Fallow, 2005, 2007) and Nav Canada (Down, 2005, 2007), have carried out trials on NOSS and presented their results in the First Global Symposium on TEM and NOSS in ATC Luxembourg in November 2005 and the Second Global Symposium on TEM and NOSS in ATC Washington, DC in February 2007. Their findings suggest that NOSS can equally be applied to the ATC domains.

1.4 The Objectives

This study introduces a new safety tool, which allows an ANSP to explore the threats and errors that take place in one of the ATM domains, the Assistant Controller (AC). The study will capture how the AC manages these situations under normal operations conditions and the details will be recorded on observation sheets. In this particular study, the LOSA methodology will be modified as Normal Operations Safety Observation (NOSO) to suit the platform of this study, that is the Hong Kong ATC environment. It is expected that such a method, not yet adopted in Hong Kong ATC, can be used as a means to collect information for safety enhancement. The study will produce fresh and unique data that may reflect a set of ATM's defences and vulnerabilities. The methods and findings could be used in future as indices of safety margins and safety monitoring purposes within that domain. On the other hand, these data can carry equal importance on every unit in the ATM system (e.g., training, evaluation, safety and quality, standards etc). In general, the strengths and weaknesses of the system within this domain will be discussed with the aid of other researches/references. The following areas form the objectives of this research:-

1. Identification of threats and errors in the ATM's operational environment;
2. Identification of threats and errors from within the ATM's operations;
3. Identification of design problems in the human-machine interface;
4. Identification of the quality and usability of procedures;
5. Understanding of AC's shortcuts and workarounds; and
6. Establishment of preliminary safety margin references.

Chapter Two: Literature Review

2.1 Human Errors

Apart from sabotage, it is believed that incident/accidents are caused by either mechanical failures or human errors and in rare cases, both. The former will be the task of an engineer who reveals the mechanical fault in the aftermath of an incident/accident and subsequently gives out new safety measures such as improved hardware together with new procedures. However, this does not solve the problem completely, as it has to be noted that the human errors account for more than 80% of the overall causes (Hudson, 2000), as such, human errors are still the most challenging but interesting area to look into.

This research comes in contact with various kinds of human errors and therefore, one has to understand the traits of human errors. However, the term "Human Errors" is far too complicated to be deciphered although many people have different interpretation/ understanding which are subject to arguments. Amongst all the reasoning, Hollnagel (2001) states four arguments to elucidate the concept of human errors. The first argument from semantics spells out three indications on human errors. They are

(i) the erroneous action which constitutes the cause of the observed outcome;
(ii) the event or action itself irrespective of the consequential outcome or not; and
(iii) the outcome of the action that can have more than one latent consequence.

This argument is further supported by Amalberti's (1996 cited in Hollnagel, 2001) five categories of human actions. These five categories are that

(i) actions for which the actual outcome matches the expected outcome even though there is possibility of having different outcomes;
(ii) incorrect actions having been detected and corrected, deliver the same expected outcome;
(iii) one is unable to correct incorrect actions that have not been detected;
(iv) the system may not allow certain incorrect actions to be corrected if it is not provided with a recovery function; and
(v) the last category is more complicated, as incorrect actions, though being recognized and allowed the discretion to change are usually ignored because

one always decides not to action after an educated assessment; that will be classified as an error if the outcome is consequential.

These arguments not just give light to the researcher to determine AC action in binary distinction between correct actions and errors but also provide insight into their effectiveness of actions against outcome.

Another argument from philosophy is backward causation that refers to cause-and-effect relation bounded by conditions of priority in time and contiguity in space and time. It is recognised that this relation cannot provide the real interpretation especially when under a complex environment. Falsely associating a cause with an effect is obviously exacerbated by Representativeness (similarity), Availability (or judgmental) and Adjustment and Anchoring (Tversky & Kahneman, 1982). Representativeness Heuristic means causality is determined on the basis of similarity between cause and effect. Availability Heuristic means causality is derived from biases which are due to the retrievability of instances (i.e. salience), effectiveness of a search set (i.e. arbitrary searching), imaginability (i.e. evaluation based on constructing instances), and illusory correlation (i.e. assume things are correlated when they are not). Quite often, one is susceptible to the hindsight bias (Fischhoff, 1982) (also known as "I-knew-it-all-along" effect) in Availability Heuristic that one with the knowledge of past experience is used to predicting outcome in the future. Adjustment and Anchoring means a judgment under uncertainty will start with an initial reference point (anchor) and adjust this point insufficiently to reach a conclusion; which can lead to either overestimation or underestimation. Although there are significant drawbacks in backward causation, due consideration should be given to the benefit of hindsight in terms of lessons learnt as in the findings of NOSO.

The third argument from logic focuses on a stop point where the searching for causes should be ended. Once a cause has been revealed with the association of a system structure or system function (e.g., people, procedures, etc), the direction and depth of the analysis will be subject to resources such as time and sufficient information as well as the context of the cause. The stop point is also liable to evolutionary change as when one's knowledge and experience accumulate in light of time and future happenings. Every methodology has its own constraints and limitations; therefore, NOSO methodology is somewhat a way of looking at human activities from another perspective that one should endeavour to reap the maximum benefit.

The last argument from practice addresses the problem when human errors components are classified in different categories or codings. The classification scheme or coding method should be independent of the skills and experience of the raters who are going to use it. Otherwise, it will be necessary to establish an inter-rater agreement among the raters. On the other hand, the concepts and categories have to be well defined so that there is no ambiguity when events are put to discussion. Having said that, argument may arise when experts of different fields speak authoritatively of their area of interest. This may not necessarily be a bad thing in the case of different people speaking different languages and that of data cleaning of NOSO. People can widen their knowledge by considering different points of view involved in NOSO (e.g., subject matter expert, supervisor, AC and even the NOSO observer).

There may not be a meticulous conclusion on defining human errors as they are often referred to as observable outcome. Instead of saying human errors, one should consider human performance an explanation for a system failure or to be fair, system recovery/mitigation in the context of threat and error management. On the other hand, the vigilance and "smart" actions from human on saving a day shall not be neglected as human prevents the accident from happening in many instances. For example, pilots exercised superior airmanship in the Sioux City accident (Job & Tesch, 1996) that miraculously saved 184 people on a DC-10. The focus on human performance should be confined to the dimensions of "what", "when", "where" "why" and "how" of both attributes so that these human performances are becoming more predictable, detectable and eventually manageable. These are the genuine safety values that any method of analysis of observation, like NOSO, is trying to provide.

2.2 Human Performance Models

Under the concept of the SHELL model (Edwards, 1988; Civil Aviation Authority, 2002), human behaviour is very much influenced by the components that interact with them and that gives out the end-product – human performance.

2.2.1 The Causes of Error – Rule-based, Skill-based and Knowledge-based

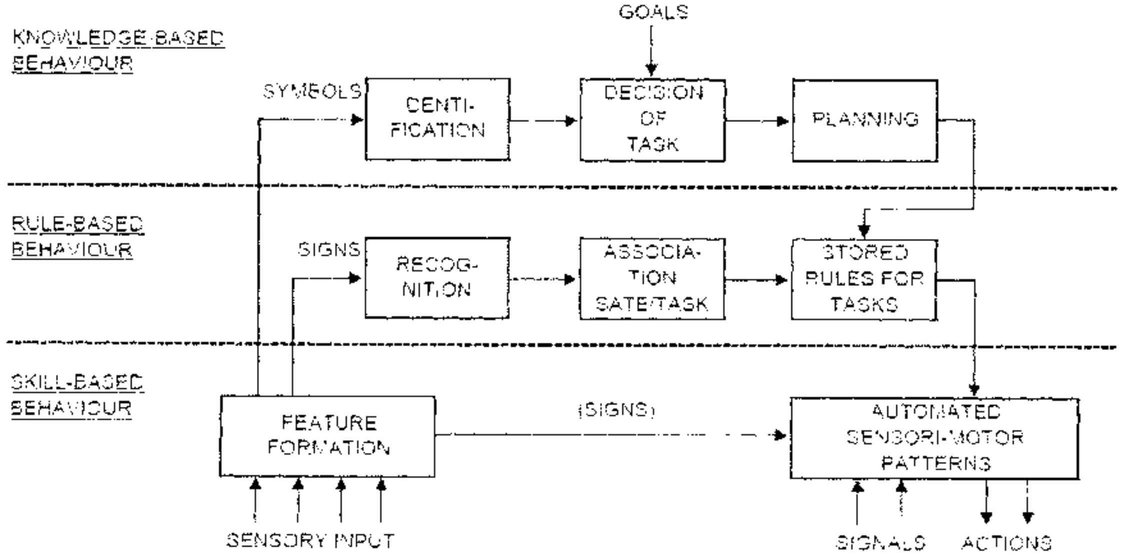


Figure 2.1 **Three Levels of Human Performance (Adapted from Rasmussen, 1983)**

The role of human in a complex workplace environment is so important that one must need to understand how human behaviour interacts with an environment. As defined by Rasmussen (1983) and later elaborated by Reason (1990) and Strauch (2002), there are three typical levels of human performance and associated errors (Figure 2.1):- skill-based, knowledge-based and rule-based. In relation to this research, skill-based performance refers to certain routine work that the AC's perform daily. Their skills are acquired from training and experience. Therefore, their actions are prompt and highly automated without conscious control (e.g., attending to intercom telephone call when it rings). The skill-based errors are mainly errors of execution (or slips), for example, forgetting to turn off the telephone after communication. Rule-based performance is more advanced than skill-based in terms of the amount and/or level of training and the attention of the AC. The most distinctive difference between skill-based and rule-based performance is that the former is purely a voluntary action in which the AC is not able to describe or reason what knowledge is being put to use, while with the latter the AC's action is based on the know-how and the rule(s) employed for that particular situation. For example, putting a tick on the strip after information been transferred. Rule-based error is usually associated with the application of wrong rule(s) or inappropriate procedure(s) to a situation that is not fully recognised or comprehended by the AC. For example, putting a tick on the strip with a black (instead of green) pen after information been transferred. Knowledge-based performance occupies the highest cognitive level when compared with the skill-based and rule-based performances. It operates in an unfamiliar situation in which the AC faces no know-how or available rule(s)/procedure(s) gained from previous experience. The situation that the AC needs to handle is to analyse the novel problem with knowledge and experience in situation management or one's creative strategy (e.g., sudden equipment failure situation). The successful mitigation will become new experience and knowledge for the AC while failure in handling the problem will become a knowledge-based error which is mainly an inability to apply existing knowledge to new situations. This may be due to deficiency in analysis (e.g., failing to respond effectively to a sudden equipment failure situation).

2.2.2 The "Wolf or Sheep" Violation

Rasmussen did not address an important but intractable human attribute – violation. It is part of human performance that Helmreich (2000) and Helmreich and Musson (2000) consider as a type of error that is developed from a culture of non-compliance and perceptions of impregnability. Therefore one will deliberately deviate from what they consider poor procedures. However, Reason (1990) has a different philosophy on violation. He considers there is insufficient connotation to explain perverse behaviours especially when it comes to classification of human behaviour during accident investigation (e.g., Chernobyl and Zeebrugge disasters). Same belief is noted in other professions, like medicine. Barber (2002) states that errors occur mainly from one's internal processing, in other words, they have the intention to get the job done but violation is more motivational and variegated in spite of the fact that the outcome is not necessarily a bad event. Although there is no unanimous opinion on the distinction between error and violation, the outcome of any doctrine is the same that the rule(s) or procedure(s) is/are not observed by human; and, there is either a severe breakdown in system or status quo without any notable change. On the other hand, Hudson, Verschuur, Parker and Lawton (2002) consider violation other than slip, lapse and mistake as a human error. They look at the problem of violation in great depth and identify three types of problematic procedures that violation will take place. They also divide the violators into four groups animating them as "sheep", "wolf", "sheep in wolf's skin" and "wolf in sheep's skin". Finally, they suggest five types of violations that can cause serious outcome especially when they happen together with errors. Therefore, they recommend some remedies for violation problems.

The purpose of this research is not to discover *who* is the "wolf" and who is the "sheep", but instead, its aim is to uncover the types of errors as well as threats. How the AC would cope with these problems both successfully and unsuccessfully are the main concern. The participating AC is only an agent to provide such information. The focus is on the system rather than the people themselves. Although the taxonomy of these aforesaid human behaviours can be grouped into different categories, they are, in general, all unsafe acts that can lead to severe incident. Furthermore, the way the AC deviates from the norm is prudently analysed. This is what the threat and error management framework attempts to illustrate.

2.3 The Impact of Levels of Experience on Human Performance

In general, one's knowledge and skills on performing a task will enhance as time goes by. Therefore, it is a common knowledge that those with more experience (e.g., experts) can perform better than the ones with less experience (e.g., novices). This phenomenon is best described by Kasarskis, Stehwien, Hickox, Aretz and Wickens (2001) who show that experts are having better eye-scanning strategies as they have shorter dwells on everything that give them more time in surveillance on their tools and environment. Also, it is noted that experts are able to extract information from their peripheral vision by selective seeing and hearing while the novices do not have such attributes. The level of experience in this study is the number of years of experience in ATC/AC duty of those AC being studied. It is expected that their threat and error management skills can reflect the relationship between levels of experience and performance.

2.4 Workload and Task Complexity

Human performance is driven by many limiting factors that some of these are observable and measurable (e.g., number of transfers in a minute), but some are not transparent such as internal factors (e.g., emotional) that are independent of the level of expertise. Among all these factors, workload is considered the greatest limitation in capacity in an ATM system and it is believed that complexity is one of the most significant elements in the limits of workload (Majumdar & Polak, 2001). Eurocontrol (2004) recollecting numerous past theoretical/empirical researches on ATC complexity and workload identifies 108 and 47 indicators of complexity and workload respectively. These indicators widen the scope and understanding of task complexity in connection with workload although some of the indicators (e.g., visual saccade rate) cannot be measured in some data collection methods such as NOSO. The distinction between workload and complexity is context specific and interrelated with each other closely. Workload and task complexity are directly related to threats and errors. They are often seen in incident/accident reports (Civil Aviation Department, 2004). However, this phenomenon, often treated as common knowledge, always gives the impression that only high workload and complex situation can give rise to errors. Dismukes, Young and Sumwalt (1998) point out that errors may not necessarily be generated from demanding situations, rather they can be set off by interruptions and distractions. Norman and Shallice (1986) supplement that some tasks requiring multiple demands very often exceed human capacity although human can perform multi-task with some limitations. All these actions require conscious attention even if automation is in place. These can still go wrong; and it becomes prominent for tasks that need highly cognitive requirements.

2.5 Threat and Error Management (TEM)

TEM is a conceptual framework for elucidating human performance in many complex operations, shown by the flowchart in Figure 2.2. It explains how human factors play their role in a dynamic working environment, the interaction between humans and the complexities of their operation domain. An example of AC operation is presented in paragraph 2.5.1 to facilitate the understanding of the TEM model. The framework comprises three main elements, threats, errors and undesired states together with their respective consequences. They are defined in accordance with ICAO (2005) but with terms modified for the subject of this research on AC as follows:-

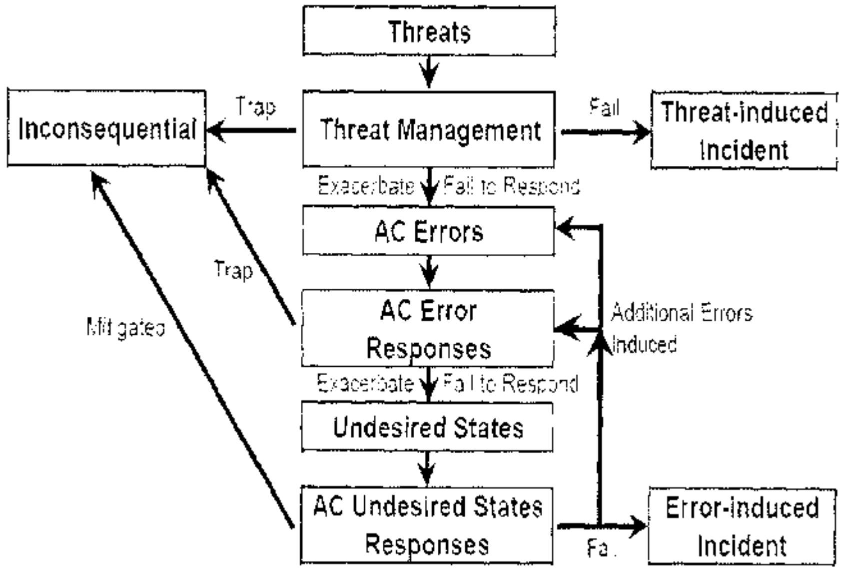


Figure 2.2 **Threat and Error Management Model (Adapted from ICAO, 2005)**

(i) Threats

Events or "external" errors that occur beyond the influence of the AC but must be managed to maintain the margins of safety (e.g., equipment failures increased operational complexity).

(ii) Errors

Actions or inactions by the AC that lead to deviations from organizational or AC's intentions or expectations (e.g., slips and lapses).

(iii) Undesired States

Operational conditions where an unintended traffic situation results in a reduction in margins of safety (e.g., wrong information passed to adjacent control unit).

2.5.1 Hypothetical Scenario

To facilitate the explanation of the TEM model, a hypothetical scenario is created for exemplification in the next paragraph. The events in this scenario occur from time to time in the AC operations. Events treated as threats, errors and undesired state are known to ATM personnel. Since they are not sufficiently acknowledged, awareness is used to being implicit. TEM model translates this awareness from implicit to explicit. As such, ATM personnel become more cognitive to the events (ICAO, 2005). The three major elements in the TEM model are parenthesized in front of the events for illustration as follows.

Instead of doing self-briefing, [Error] the morning shift AC who arrived early took over from the overnight watch AC so that they could take the shuttle departing in two minutes' time. As such, the handover/takeover was carried out in quite a rush and a controller gave a strip of flight ABC123 to the AC to effect a transfer to the next area control centre (ACC), [Threat] the strip was due for transfer as the controller was late in assigning flight level; the handover AC did not carry out the action of transfer. While the handover/takeover was taking place, there were two calls from other ACC and the handover AC just quickly told them Hong Kong ACC would return their calls. The handover AC left immediately after finishing the briefing. [Threat] The AC did not call the two ACC as two colleagues came to chat on the football match last night. The chat lasted for two minutes. [Error] The strip was left unattended at the AC workstation for approximately 8 minutes as the AC was busy receiving transfer messages from other ACC. [Threat] The controller informed the AC that there were significant weather deviations south of the terminal area boundary due to an approaching typhoon; he instructed the AC to inform the adjacent ACC that Large Scale Weather Deviation procedure would become effective immediately. The AC suggested that the adjacent ACC might ask for a postponement as they needed to inform downstream ACCs. The controller concurred and gave the AC a time due to become effective half an hour later. [Undesired state] An ACC called and asked for traffic information approaching their airspace boundary. The AC then realized that he had not yet transferred flight ABC123. [Threat] He then passed the flight details immediately and the ACC read back the transfer with a wrong flight level. This was spotted and corrected by the AC. The flight was five minutes from the transfer of control point. The AC apologized to the ACC for the late transfer.

There were 4 threats, 2 errors and 1 undesired state in the aforesaid scenario. Some threats could lead to error and even to undesired state if not properly mitigated. The above example is just one of the many types of Threat-Error-Undesired State relationship. It may not easily be visualized that threat can lead directly to incident. For example, equipment failure (a threat) can lead to traffic disruption (an undesired state). Also, error can lead to additional error. For example, a late transfer is an error itself but the AC can make mistake(s) on passing the flight details to the receiving ACC; if the AC does not cross-check the readback from the receiving ACC, then the mistake the AC makes will become an additional error and the outcome can become an undesired state as well.

Chapter Three: Method

3.1 Participants

AC are ATM personnel who assist the Area and Approach Controllers in the provision of air traffic services (ATS). They handle and process large volume of flight data with the aid of advanced database system and communication devices. They also liaise with adjacent ATC units (e.g., Manila ATC) and internal ATS units (e.g., Aerodrome Control), for the exchange of Transfer-of-Control messages, co-ordination and flight level assignments, airspace restrictions and any other pertinent matters related to flight safety. They also assist the supervisor/manager to carry out special duties such as alerting notification. Their job is varied and their workload is quite significant during peak period and/or adverse weather conditions. They primarily work in the air traffic control centre with their workstations located in-between the controller (either radar controller or procedural controller) and the flight data operator. As a matter of fact, AC are regarded locally as the persons who have the certificate of AC that allows them to carry out AC duties. They, in fact, did not have such a certificate on day one when they joined the ATM; they would receive AC training after in service for some years. Therefore, their experience in ATC as a whole is longer than that in AC alone.

There are over 80 ATM personnel with AC qualification. However, some of them have been engaged in other administrative duties for years and seldom perform AC duties. The research study is focused on daily normal AC operations; the AC being observed must be current in their skills and conversant with book knowledge. By such reckoning, at the time of conducting the research, there were 71 AC actively involved in daily operations; a cohort of 24 AC was randomly selected for this study on a voluntary basis. In addition to the AC refusing to be observed, the following AC were not included in this study:-

(i) AC being supervised or under re-validation;

(ii) AC supervising a trainee;

(iii) AC not currently in practice:-

AC who have not performed AC duties for more than 30 days; and/or those who worked less than 6 hours a month in any AC position; and

(iv) AC involved in ATC incident within three months of the observation.

The observation will terminate if there is serious incident (e.g., no transfer occurring in the relevant AC sector).

3.1.1 The AC Sectors

There are six working positions, which are AC North, AC Macao, AC East, AC South, AC West and AC Combined (night mode) in different shifts. Each participant is studied once at each position by the observer from shift start to shift end in four different shifts:- morning, day, afternoon and overnight. Two observations are carried out on each position per shift and these are summarized in Table 1.

Table 1

Observation Program

Position / Sector	Shift*	Observation
ACE / East	am1	Two observations on each (Total: 24 observations)
ACE / East	pm1	
ACS / South	am2	
ACS / South	pm2	
ACW / West	am1	
ACW / West	pm1	
ACN / North	am2	
ACN / North	pm2	
ACM / Macao	day	
ACE / Combined	night	
ACW / Combined	night	
ACH / Combined	night	

* am1: 7:45am-3:00pm pm1: 2:30pm-10:00pm day: 9:50am-6:00pm
am2: 8:00am-4:00pm pm2: 3:50pm-12:00pm night: 9:45pm-8:00am

3.2 Materials

3.2.1 NOSO Observation Forms

During the observation, the activities of AC are recorded in seven specially-designed NOSO Observation Forms (see Appendixes A1 to A7). For the purpose of confidentiality, these forms are designed so that it will be hard for anybody to trace the participant and the date of observation. A brief description of each the observation form is in Table 2:-

Table 2

Description of NOSO Observation Forms

Observation	Functions of Observation Form
Observation Demography	It records basic information of the observation such as AC position, observation period, duration of observation and remarks; the remarks are generally for some events which do not belong to any other observation forms. Years of experience in ATC and in AC can be sensitive elements; therefore they are not listed and used directly in the data analysis.
Handover and Takeover	It records the details of handover/takeover; missing items will be recorded. The observed performance is marked with scale in the Threat and Error Countermeasures worksheet.
General Operations	It is a description of the events (threats, errors and undesired states) in details. The observed performance is marked with scale in the Threat and Error Countermeasures worksheet.
Threat Management	The observed threats are described and coded. Linkage to other operations and errors are given. Threat management is noted. The observed performance is marked with scale in the Threat and Error Countermeasures worksheet.
Error Management	The observed errors are described and coded. Linkage to other operations and threats are given. Error response and its outcome are stated. Error management is noted. The observed performance is marked with scale in the Threat and Error Countermeasures worksheet.
Undesired State Management	The observed undesired states are described and coded. Linkage to other threats and errors are given. Undesired state response and its outcome are stated. Undesired state management is noted. The observed performance is marked with scale in the Threat and Error Countermeasures worksheet.
Threat and Error Countermeasures	The performances on eleven operational aspects of the observation are classed into four scales from 1 to 4 (Table 3). Those not being observed are given a value of "5" and it is not used in averaging.

The performance marker scales on the Threat and Error Countermeasures worksheet are listed in Table 3.

Table 3

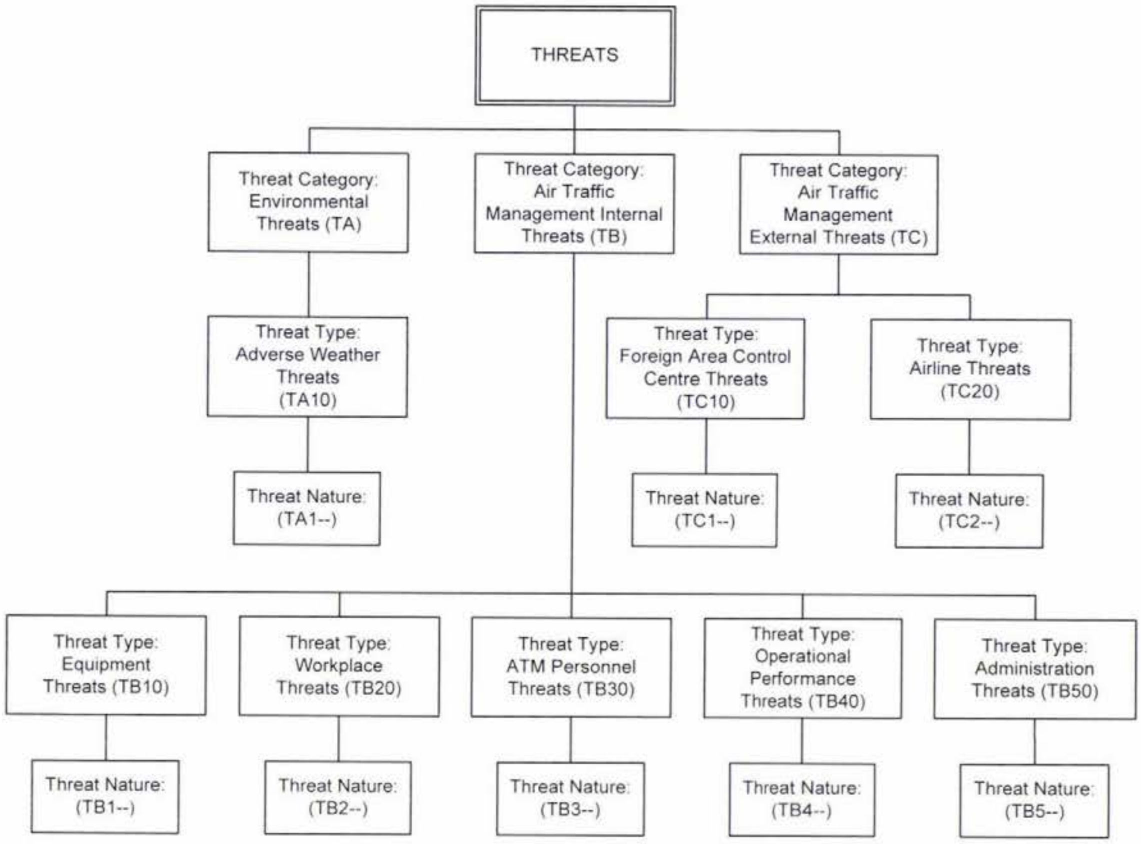
Performance Marker Scales

Scale	Category	Performance
1	Poor	Observed performance had safety implications
2	Marginal	Observed performance was barely adequate
3	Good	Observed performance was effective
4	Outstanding	Observed Performance was truly noteworthy
5	Not Observed	No activity was noted

3.2.2 NOSO Codebook

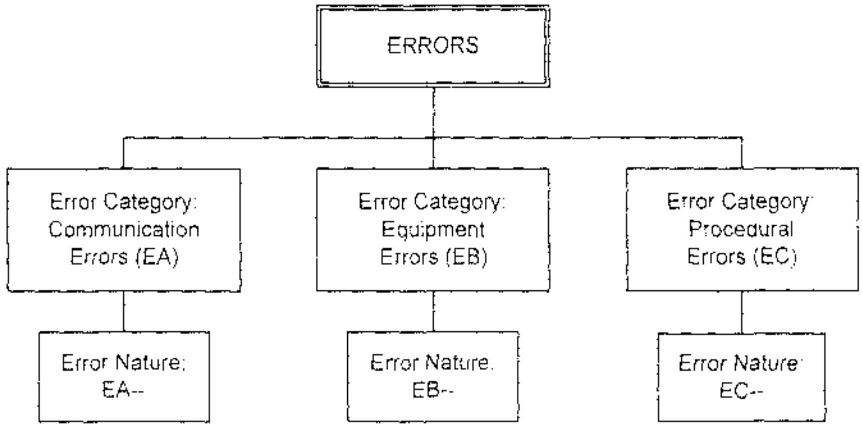
It is important to have a coding system that can describe every event precisely and concisely so as to facilitate data analysis. The NOSO Codebook is based on a collection of inputs from the AC, supervisors and some known incidents. They are mainly breakdowns of many minor events that took place in previous failures. These minor events are equipment failure, procedural problems and human factor issues. It has to be noted that those threats, errors and undesired states are collected from the NOSO only and are by no means exhaustive. Appropriate codes are assigned to different events. Wallace, Ross, Davies, Wright and White (2002) emphasize that these codings are reliable enough as to render them valid even after a period of time. Wallace et al. further stipulate the importance of having a logical and coherent hierarchy so as to make each code mutually exclusive. As such, there is minimum overlapping of codes and observers register the correct code during observation.

The NOSO Codebook contains all the possible categories, types and natures of threats, errors and outcome of undesired states (Appendixes B1 to B3). Category, Type and Nature form the hierarchy for threats. Category and Nature form the hierarchy for errors. Category and Outcome form the hierarchy for undesired states. Those threats, errors and undesired states that cannot be categorised during NOSO are grouped as "Others" as appropriate. The coding system is summarized in figures 2.3, 2.4 and 2.5.



Key: TA1--: TA101-TA106, TA199
TB1--: TB101-TB107, TB199
TB2--: TB201-TB207, TB299
TB3--: TB301-TB308, TB399
TB4--: TB401-TB407, TB499
TB5--: TB501-TB504, TB599
TC1--: TC101-TC117, TC199
TC2--: TC201, TC202, TC299
See Appendix B1 for details

***Figure 3.3* NOSO Coding System (Threat)**



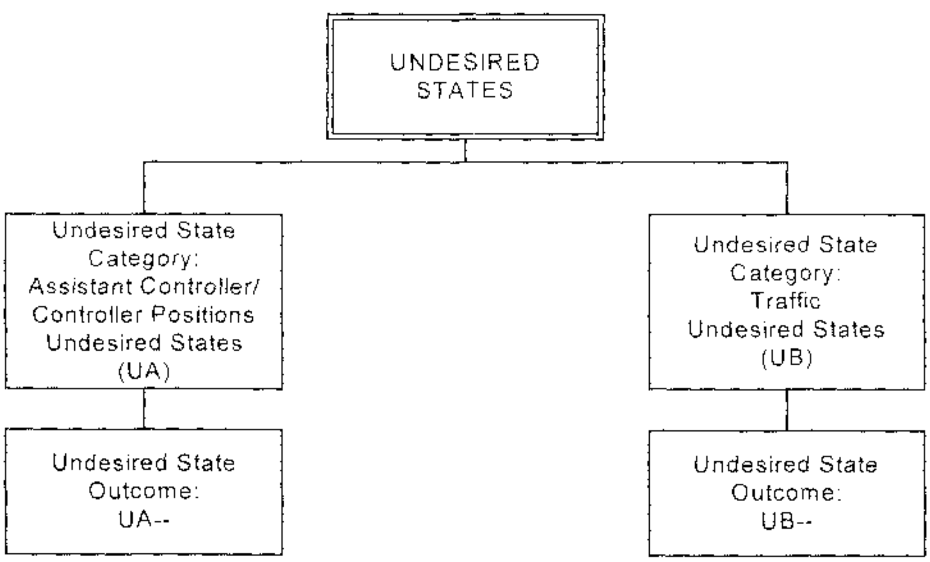
Key: EA--: EA01-EA15, EA99

EB--: EB01-EB05, EB99

EC--: EC01-EC29, EC99

See Appendix B2 for details

Figure 3.4 **NOSO Coding System (Error)**



Key: UA--: UA01-UA09, UA99

UB--:UB01-UB06, UB99

See Appendix B3 for details

Figure 3.5 **NOSO Coding System (Undesired State)**

3.2.3 NOSO Database

A NOSO Database is created using Microsoft Excel software (Appendixes C1 to C5). There are totally five worksheets for Demography, Threat Management, Error Management and Undesired State Management. All the observation events are coded and transcribed into these worksheets. A Threat and Error Countermeasures worksheet, summarizing the observed performance grading from 'poor' to 'outstanding', is also contained in the Excel workbook. Hyperlink is created for some pertinent fields for ease of reference and tracing. With appropriate Excel formulae, these worksheets can produce pie charts, bar charts and graphs for presentation and analysis purposes.

3.2.4 Information Sheet and Consent Form

Apart from ethical requirements, each participating AC is given an information sheet (Appendix D) to elucidate the purpose of this research study. Questions and answers as well as a short briefing of threat and error management concept are conducted with the AC. They are also giving means of contacting the researcher which include telephone and email. Once the participating AC understands the purpose of the research, they are then given a consent form (Appendix E) and being advised that they can withdraw anytime without having to give a reason. After the researcher receives the consent form, a date will be scheduled without the knowledge of the participating AC so that the researcher (hereafter, the observer) can monitor them at their workstations.

3.3 Procedures

There are six stages in the NOSO program. The first four stages are the core stages of the research which includes two 2-week reviews; while the last two stages are the Report Writing and Presentation of Results. Subject to manpower, the duration of NOSO can all be programmable but the six stages must be conducted sequentially.

3.3.1 Stage One: Preparation

Support from the management and the union were essential in addressing the confidentiality and non-disciplinary issues. Approval to conduct this research in the Hong Kong Air Traffic Control Centre (ATCC) was sought from the Hong Kong Civil Aviation Department. Concurrent with this report, Hong Kong Air Traffic Controllers' Association had decided to remain "neutral" because their statutes did not allow facilitation of any research work. However, the Executive Committee of the Association had given its moral support for this study.

Informal meeting and correspondence were to be held and exchanged with the ATC managers, the supervisors, training officers and veteran ATC personnel to elucidate the purpose of the study. On the other hand, an individual briefing for each of the volunteers was given to explain the purpose of this study and provided with questions-and-answers; the NOSO Information Sheet and Consent Form were also given to the AC under consideration together with a copy of the research proposal in newsletter format. It was very important to emphasize on the method of confidential data collection and non-punitive assurance to all the participants; otherwise, the study results would become unreliable without their understanding and trust. Pressure would not be given to those who declined to participate in the study and no questions would be asked about the reasons for refusal. Furthermore, the name of any participant was not mentioned at any stage of the study including this research report.

A comprehensive literature review was carried out to enrich the knowledge and understanding in identifying/recording the threats and errors that would take place during the observation. To get more insight into the subject of TEM, the observer attended the Third ICAO-IATA TEM Conference in 2005 and a TEM course run by Cathay Pacific in 2006. Additionally, in order to enable the observer to familiarise the job of an AC, arrangement was made for the observer to sit next to some experienced AC during live AC operations for two weeks. This also served as an advanced notice of NOSO to all the AC.

NOSO Observation Forms are designed at this stage and they are being tested by hypothetical scenario to calibrate any shortcoming in the observation forms.

Participating professional advisors, strictly observing the disciplines of this research, monitored the complete data collection process, in particular, the observer's conduct, so as to ensure the NOSO process was properly conducted.

3.3.2 Stage Two: Data Collection

For every observation, the observer arrived half an hour earlier than the AC report duty time so that the observer could familiarize himself with the handover materials current for that day. Also, the observer walked around the ATCC to detect any abnormality (e.g., adverse weather conditions, staff shortage, and incorrect information on the handover board). For the benefit of this study, the observer observed the AC position at which the participant was carrying out their duties and recorded the activities on a small notepad during the observation period. All the observations were transcribed into the observation forms during the AC's break time and after signing off. In order not to give any stress to the AC being observed in this study, the observer adopted a way of "*fly on the wall*". That meant the observer remained at arm's length behind the participant with the use of a long cable for his headset and sat on a high chair for better view where disturbance was kept to a minimum. Therefore, the observer would avoid talking to the participant or anyone in the workplace during the observation.

All observations were recorded in the observation forms. The threats, errors and undesired states identified in the observation forms were posted to Excel worksheets (Appendixes C1 to C5) designed for these purposes.

3.3.2.1 2-Week Review (for Stages One and Two)

The difficulties encountered in these two stages were to be documented for future enhancement in the methodology.

3.3.3 Stage Three: Data Cleaning

Personnel/Subject Matter Experts from different sections (e.g., training, examiner, supervisor, management) were invited to cross-check the collected data to ensure that its integrity and accuracy were in conformity with current manuals, policies, rules and procedures and that the events recorded by the observer were correctly categorized and interpreted.

3.3.4 Stage Four: Data Analysis

NOSO data were carefully studied to reveal trends and patterns of undesirable operations and operational practices that were noteworthy. Subject to these areas of trends and patterns, possible enhancement could be formulated to improve the current operations.

The selection of statistical tools has to be very cautious. Both Pearson Correlation and Spearman Rank Correlation are widely used for measuring the degree and direction of linear relation between two variables. In this study, there were two kinds of variables – independent variables and dependable variable. AC from different shifts, working at different positions and their experience in ATC/AC would be classified as the independent variables; while threats, errors and undesired states, would be classified as the dependent variables. For confidentiality, the use of the exact number of years of experience in the analysis was avoided. Therefore, it was appropriate to use the Spearman rank correlation in the statistical analysis in the data analysis.

3.3.4.1 2-Week Review (for Stages Three and Four)

The difficulties encountered in these two stages were to be documented for future enhancement in the methodology. This review also served as an extension for Data Analysis period if that stage was longer than expected due to the huge amount of data.

3.3.5 Stage Five: Report Writing

The NOSO process was summarized and the overall findings were presented in the thesis report. Comparisons of data collected from different sectors and shifts were made to reveal if extra attention was needed in certain areas. The report further addressed the identified issues and recommended action plans for thorough consideration. Furthermore, all the processes in the NOSO methodology were then reviewed and documented. Once the report of NOSO was compiled, it would be presented in the Aviation Research Conference held within the Hong Kong Polytechnic University. At the same time, a summary of the overall results of this research would be sent to the participants who had indicated their interest and methods of delivering the report in the Consent Form (Appendix E).

3.3.6 Stage Six: Presentation of Results

Although Presentation of Results should not be part of the research report, this was important in NOSO. All the information in the research report should be shared and discussed with the operational AC to bring up their alertness on threats and the possible consequences, the common errors, the techniques and ways to avoid these threats and errors; the undesired states were shared as part of lessons learnt. Everyone could contribute as well as share their ideas and past experiences on safe operations. Also, the NOSO methodology could be further fine-tuned through discussion.

Chapter Four: Results

The first two objectives of this research are to identify the threats and errors in /from within the ATM'S operational environment/operations. They are successfully achieved by considering a number of different threats and errors collected for this study. These threats and errors together with associated undesired states are grouped and summarized into different categories. The occurrences of threats/errors/ undesired states and their linkages are expressed in percentages. Relationships between years of experience and number of errors, years of experience and different types of errors, and different shifts/AC sectors and number of threats/errors are compared and tabulated in the following sections.

4.1 NOSO Fact Sheet (1) – General Overview

4.1.1 NOSO Observation Forms

240 pages of NOSO observation forms (Appendixes A1–A7) were used in recording the 24 observation sessions.

4.1.2 Summary of Data Collected

The total observation took 115 hours 57 minutes (excluding break time) involving 162 handover/takeover and 399 recorded events (excluding handover/takeover). The information recorded on the observation forms before and after Data Cleaning Stage is summarized in Table 4.

Table 4

Summary of NOSO Data in the NOSO Observation Forms

Threat	Error	Undesired State
	Before Data Cleaning	
287	234	4
	After Data Cleaning	
286	224	3

After Data Cleaning Phase, it was found that 1 threat was duplicated, 10 errors were not considered AC errors and 1 undesired state was mixed up with another undesired state and they were removed from the NOSO database. In general, there were 2.5 threats per observation hour (or 1 threat in every 24 minutes), 1.9 errors per observation hour (or 1 error in every 31 minutes) and 1 undesired state every 38 hours.

4.2 NOSO Fact Sheet (2) – Overview on Threats, Errors and Undesired States

4.2.1 Overview on Threats

Table 5

List of Threats recorded in NOSO

Threat Code	Threat Nature	Different Observations	Occurrences	
TA105	Enroute weather	7	20	7.0%
TB102	Speech processing equipment	2	2	0.7%
TB104	Computer event	1	2	0.7%
TB106	Electronic filing system	1	1	0.3%
TB107	Inter-area speech circuit	2	2	0.7%
TB201	Noise	7	8	2.8%
TB203	Lighting	1	1	0.3%
TB205	Briefing note error	2	2	0.7%
TB208	Mobile phone	7	8	2.8%
TB306	Supervisory action	4	4	1.4%
TB307	Internal visitor	8	9	3.1%
TB308	Incomplete/unclear instruction from controller	3	5	1.7%
TB312	Poor team interaction	2	2	0.7%
TB313	Controller error	11	16	5.6%
TB315	Flight data operator error	9	12	4.2%
TB317	Other ATM personnel error	2	3	1.0%

Table 5 (continued)

Threat Code	Threat Nature	Different Observations	Occurrences	
TB318	Distraction from controller	2	2	0.7%
TB320	Distraction from flight data operator	2	2	0.7%
TB322	Poor handwriting	1	1	0.3%
TB399	Other ATM personnel threats	1	1	0.3%
TB401	Combining sectors/positions	8	9	3.1%
TB402	De-combining sectors	2	3	1.0%
TB403	Non-standard level	3	3	1.0%
TB404	Similar/confusing/uncommon callsign	4	4	1.4%
TB405	Incomplete handover/takeover	7	10	3.5%
TB406	Problem aircraft	2	2	0.7%
TB407	CASEVAC/medevac/ambulance Flight	1	1	0.3%
TB503	Transport event	1	1	0.3%
TB504	Staff shortage	2	2	0.7%
TC101	Non-standard phraseology	1	1	0.3%
TC102	Readback error	13	21	7.3%
TC103	No readback	7	8	2.8%
TC106	Flow control	12	23	8.0%
TC107	Airspace restriction	1	1	0.3%
TC108	Missing/incomplete/incorrect information	4	7	2.4%
TC109	Wrong transfer	9	12	4.2%
TC110	Insufficient separation	2	2	0.7%
TC111	Potentially late transfer	5	7	2.4%
TC112	Late transfer	8	23	8.0%
TC113	Poor English	7	9	3.1%
TC114	Poor quality in communication	2	3	1.0%

Table 5 (continued)

Threat Code	Threat Nature	Different Observations	Occurrences	
TC115	Macao runway change	3	3	1.0%
TC116	Speak too fast	1	1	0.3%
TC117	Complicated coordination/message	2	2	0.7%
TC201	Flight plan matters	12	25	8.7%

Table 5 showed all threats which were identified in NOSO. Some threats occurred repeatedly in the same observation while some threats occurred commonly in different observations. Collectively speaking, all these threats belong to 45 types of threat nature.

4.2.2 Overview on Errors

Table 6

List of Errors recorded in NOSO

Error Code	Error Nature	Different Observations	Occurrences	
EA01	No readback	2	3	1.3%
EA02	Incorrect readback given	11	14	6.2%
EA04	Incorrect coordination/transfer not detected	3	3	1.3%
EA05	Wrong callsign used	4	4	1.8%
EA06	Non-standard phraseology	2	2	0.9%
EA09	Incomplete/incorrect information given/received during transfer	6	6	2.7%
EA10	Do not understand/partially understand incoming message/instruction	4	4	1.8%
EA11	Incomplete/incorrect information [except transfer] passed to other sector/ACC	11	17	7.6%
EA12	No coordination	2	2	0.9%

Table 6 (continued)

Error Code	Error Nature	Different Observations	Occurrences	
EA13	Incomplete/incorrect coordination	2	2	0.9%
EA14	Wrong transfer	2	2	0.9%
EB01	Wrong computer input	2	2	0.9%
EB02	Communication system manipulation error	14	24	10.7%
EB04	No fault-reporting	1	1	0.4%
EB05	Incomplete/wrong equipment setup	1	1	0.4%
EC01	Wrong strip marking	2	2	0.9%
EC02	No strip marking	5	7	3.1%
EC04	Wrong strip delivered to controller	1	1	0.4%
EC05	Printed strips with wrong information not spotted/actioned	4	7	3.1%
EC07	No visual scan of flight progress strip board	2	2	0.9%
EC08	No cross-checking correctness of information on the strip/transfer slip	5	12	5.3%
EC13	Do not open position	2	2	0.9%
EC14	Confusing handwriting	4	7	3.1%
EC15	No self-briefing prior to takeover	2	2	0.9%
EC17	Incomplete/wrong briefing to takeover watch	7	9	4.0%
EC18	Failure to make occupancy record	2	2	0.9%
EC19	Do not sign Daily Manning Record	2	2	0.9%
EC20	Do not sign on equipment	24	24	10.7%
EC21	Unaware of airborne BEKOL departure	4	6	2.7%
EC22	Unfamiliar with published procedures/operational instructions	7	10	4.4%
EC23	Inattentive to duty	4	4	1.8%
EC24	No handover	2	2	0.9%

Table 6 (continued)

Error Code	Error Nature	Different Observations	Occurrences	
EC25	Do not request transfer	4	5	2.2%
EC26	Mishandling of transfer slip	1	1	0.4%
EC27	Incorrect routeing input in the FDP not spotted	1	1	0.4%
EC28	Do not check EFS message	1	1	0.4%
EC29	Misread EFS message	1	1	0.4%
EC99	Other procedural errors	24	28	12.4%

Table 6 showed all errors which were identified in NOSO. Again, some errors occurred repeatedly in the same observation while some errors occurred commonly in different observations. There were 38 types of errors in the 24 observations.

4.2.3 Overview on Undesired States

There were only three cases of undesired states as shown in Table 7; this figure could not reflect whether the AC operation was robust or not. Discussion is made on this subject in next chapter.

Table 7

List of Undesired States recorded in NOSO

Undesired State Code	Undesired State Outcome	Different Observations	Occurrences
UA01	Radar label displayed without required information	2	2
UB06	Late transfer	1	1

4.2.4 Overview on Threat and Error Countermeasures

Appendix C5 was a summary of threat and error countermeasures of 24 participants. Four participants were not involved in item 1 (Flight Progress Strip Management); the corresponding averages did not take into account of such value.

4.3 NOSO Fact Sheet (3) – Explorations on Threats, Errors and Undesired States

4.3.1 Explorations on Threats

Table 9

List of Threat Category

Threat Category	Occurrences	Percentage
Environmental Threats	20	7.0%
Air Traffic Management Internal Threats	118	41.3%
Air Traffic Management External Threats	148	51.7%

All the recorded threats could be found in the NOSO Codebook (Appendix B). It included numerous types of threat under these three categories (Table 9). Each category had its own particular characteristics and was branched out into different types and natures of threats; different strategies were needed to resolve those threats.

The majority of threats occurred in the "General operations" (Table 10) that made up a major portion of all the observation periods.

Table 10

Linkage of Threats to Operations

Phase of Operation	Occurrences	Percentage
Handover	4	1.4%
Takeover	13	4.5%
Opening position	2	0.7%
Closing position	9	3.1%
None of the above *(General operations)*	258	90.2%

As per the threat and error management model (which was shown in Figure 2.2), threat can lead to error if it is not managed properly or failure of detection exists. It was highlighted in Table 11 that 22% of threats could give rise to errors although none of these errors led to the consequential event. In this study, it was discovered that threat did not lead to any undesired state without transiting the error management stage. The mechanism of how these threats could lead to error without being mitigated was to be reasoned.

Table 11

Linkage of Threats to Errors

Relation between Threat and Error	Occurrences	Percentage
Number of Threats linked to Errors	63	22.0%
Number of Threats not linked to Errors	223	78.0%

It was noted that more than half (56.3%) of threats managed by AC (which was shown in Table 12), 43.7% of threats still resided in the systems of which 63 of them (which was shown in Table 11) caused errors. These figures posted a concerning message to the AC operations that the understanding/alertness of the impact of threat was insufficient and the defence capability had to be strengthened. On the other hand, how these threats could be managed was also important as this research was not just focused on the adverse sides of threat, but also on threats which were being managed by AC successfully.

Table 12

Threat Management by AC

Threat Management	Occurrences	Percentage
Number of Threats not being managed *(either lead to errors or undesired states)*	125	43.7%
Number of Threats being managed	161	56.3%

4.3.2 Explorations on Errors

All the recorded errors could be found in the NOSO Codebook (Appendix B). It included numerous types of errors under these three categories (which were shown in Table 13). Each category had its own particular characteristics and was branched out into natures of errors; different strategies were needed to resolve those errors.

Table 13

Category of Errors

Error Category	Occurrences	Percentage
Communication Errors	60	26.7%
Equipment Errors	28	12.4%
Procedural Errors	137	60.9%

According to Table 14, 60 out of 225 errors belonged to Intentional Non-compliance that meant 26.7% of all errors made by the AC were due to disregarding of rules and procedures. The highest percentage was found in Communication Errors meaning that a high tendency of Intentional Non-compliance occurred in this category. The problem of Intentional Non-compliance should be dealt with in two ways, namely, either in culture aspects or drawback of rules and/or procedures.

Table 14

Percentage of Intentional Non-compliance in Different Categories of Errors

Category of Error	Intentional Non-compliance	Total Occurrences	Percentage of Intentional Non-compliance
Communication Errors	24	60	40.0%
Equipment Errors	2	28	7.1%
Procedural Errors	34	137	24.8%

The majority of errors occurred in the "General operations" (which was shown in Table 15) but notably, 21.3% occurred in the "Handover", "Takeover", "Opening position" and "Closing position"; these areas involved errors arising from the interactions between AC in exchanging information. Similar to threats, errors could influence the AC's performance on mitigating other errors and assisting error recovery.

Table 15

Linkage of Errors to Operations

Phase of Operation	Occurrences	Percentage
Handover	10	4.4%
Takeover	31	13.8%
Opening position	3	1.3%
Closing position	4	1.8%
None of the above *(General operations)*	177	78.7%

It was shown in Table 11 that 63 threats linked with errors but Table 16 showed that 66 errors were linked to threats. Threat could induce not just one error but more than one. Thus the impact of threat should not be downplayed. On the other hand, the occurrence of a high percentage (70.7%) of errors could not be explained by threats. They were "made" by the AC themselves and could become a safety concern in areas of weakness.

Table 16

Linkage of Errors to Threats

Relation between Threat and Error	Occurrences	Percentage
Number of Errors linked to Threats	66	29.3%
Number of Errors not linked to Threats	159	70.7%

71.6% of errors were not discovered (which was shown in Table 17) and remedied by any ATM personnel and they in turn did not cause any additional errors (which was shown in Table 18) or undesired states (which was shown in Table 19); this revealed that those errors could be absorbed by the AC operations which might be a robust system within the contextual conditions present during that particular observation; on the other hand, some areas might need a feedback loop or crosscheck gate to block the errors passing through as they still could cause additional errors and/or undesired states.

Table 17

Error Discovery by Personnel

Personnel	Occurrences	Percentage
Nobody	161	71.6%
Controller	7	3.1%
Flight data operator	12	5.3%
Other Assistant Controller	1	0.4%
Supervisor	1	0.4%
Others (NOSO observers, other ACC personnel)	43	19.1%

Three undesired states were recorded in the NOSO and they were not serious ones. The other inconsequential outcomes were errors either being mitigated by the AC or being compensated by the system.

Table 18

Outcome of Errors

Outcome	Occurrences	Percentage
Inconsequential	222	98.7%
Additional error	0	0.0%
Undesired state	3	1.3%

4.3.3 Explorations on Undesired States

Undesired state is a remote case. In this research, there were altogether three undesired states which were shown in Table 19 and all these originated from threats which were not properly mitigated by the AC and these threats in turn became undesired states.

Table 19

Linkage of Undesired States to Threats/Errors

Relation of Undesired States and Threats/Errors	Occurrences
Number of Undesired State linked to Threats	3
Number of Undesired State linked to Errors	0

Two cases had been detected and managed by the AC but in one case the AC was not aware of the happening and failed to respond (which was shown in Tables 20 & 21). None of them was consequential (which was shown in Table 22).

Table 20

Undesired State Management

Response	Occurrences
Detected	2
Failed to response	1

Table 21

Undesired State Discovery by Personnel

Personnel	Occurrences
Assistant Controller	2
Controller	0
Supervisor	0
No one	1
None of the above	0

Table 22

Outcome of Undesired States

Outcome	Occurrences
Inconsequential	3
Additional error	0

4.4 NOSO Fact Sheet (4) – Relationship between AC Positions and Threats, Errors, Undesired States

Each of the AC position per shift was observed twice. The 1st and 2nd observations were conducted with separate participants. There were different working periods in the three night shifts and these periods were slightly different in different teams but in general, the night shift could be divided into four periods:-

(i) the first period being a sectorised mode when all three AC positions were manned. Once it was after 11pm, it would become a combined mode with two AC or in some slack period one AC;
(ii) the second period being after 12:30am that the ACW worked until 3:30am;
(iii) the third period being after 3:30pm that the ACE worked until 7:00am; and
(iv) the fourth period being the ACH worked in-between the period of the second period and the third period.

There was no hard and fast period as it is subject to team to team and traffic volume.

4.4.1 Relationship between AC Positions and Threats

It was noted that ACE sector bore the highest average number of threats (2.78) particularly on ACE sector pm-shift with an average of 3.22 and ACH night-shift bore the lowest threat (2.00).

Table 23

AC Positions versus Average Number of Threats

		Average Number of Threats per hour per shift			
Sector	Shift	1st observation	2nd observation	Average (per sector per shift)	Average (per sector)
ACE	am	2.48	2.21	2.35	2.78
ACE	pm	2.99	3.45	3.22	
ACS	am	2.92	0.84	1.88	2.23
ACS	pm	2.72	2.45	2.58	
ACW	am	2.39	1.98	2.18	2.41
ACW	pm	2.22	3.04	2.63	
ACN	am	3.25	2.84	3.05	2.53
ACN	pm	1.15	2.87	2.01	
ACM	day	3.35	1.44	2.40	2.40
ACE	night	1.42	3.43	2.43	2.43
ACW	night	3.31	1.74	2.53	2.53
ACH	night	1.84	2.16	2.00	2.00

4.4.2 Relationship between AC Positions and Errors

Again, it was noted that ACE sector bore the highest average number of errors (2.34) and the ACE sector am-shift bore a highest average of 3.08. The ACW night-shift bore the lowest average of error.

Table 24

AC Positions versus Average Number of Errors

Sector	Shift	Average Number of Errors per hour per shift		Average (per sector per shift)	Average (per sector)
		1st observation	2nd observation		
ACE	Am	3.72	2.44	3.08	2.34
ACE	Pm	2.24	0.96	1.60	
ACS	am	1.75	4.21	2.98	2.21
ACS	pm	1.98	0.89	1.43	
ACW	am	1.52	1.32	1.42	1.59
ACW	pm	1.78	1.74	1.76	
ACN	am	2.64	1.78	2.21	2.32
ACN	pm	0.96	3.89	2.43	
ACM	day	1.84	0.72	1.28	1.28
ACE	night	2.12	2.22	2.17	2.17
ACW	Night	1.17	1.55	1.36	1.36
ACH	Night	1.32	2.70	2.01	2.01

4.4.3 Relationship between AC Positions and Undesired States

Table 25

AC Positions and Shifts versus Occurrence of Undesired States

Sector	Shift	Occurrence
ACM	Day	1
ACE	AM	2

There were only three cases of undesired states (which were shown in Table 25); it was not vindicated to claim there was any relationship between years of experience in ATC/AC and the undesired states. The undesired states had to be studied case by case to address the causation.

4.5 NOSO Fact Sheet (5) – Listing of Years of Experience in ATC/AC and Number of Errors

Table 26

Years of Experience in ATC/AC versus Number of Errors

Years of Experience (ranked) in		Number of Errors in the whole session	Average Number of Errors per hour
ATC	AC		
1	3	11	2.22
2.5	5	12	2.12
2.5	5	8	1.78
4	7	5	0.96
5	1	5	1.32
6	2	6	1.17
7.5	5	6	1.32
7.5	8	11	0.89
9.5	9	5	0.96
9.5	11	18	3.72
11	10	19	3.89
12	16	4	0.72
13	14	12	2.24
14	13	10	1.78
15	12	10	2.70
16	17	8	1.98
17	15	5	2.44
18	18	13	2.64
19	20	8	1.75
20.5	19	11	1.84
20.5	21	8	1.55
22	22	7	1.52
23	23	8	1.74
24	24	15	4.21

4.6 Statistical Analysis (1) – Years of Experience in ATC/AC versus Number of Errors

The scatter graphs generated from Table 25 showed the possibility of a positive correlation between the two variables. It was expected there was an association between the experiences in ATC/AC and the number of errors.

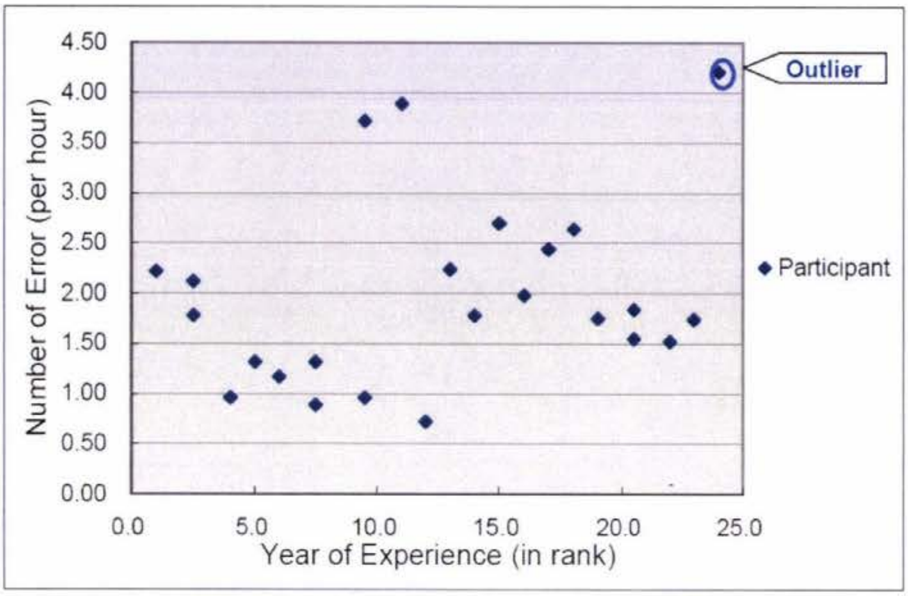


Figure 4.1 – **Scatter Graph to show the Years of Experience in ATC with Number of Errors**

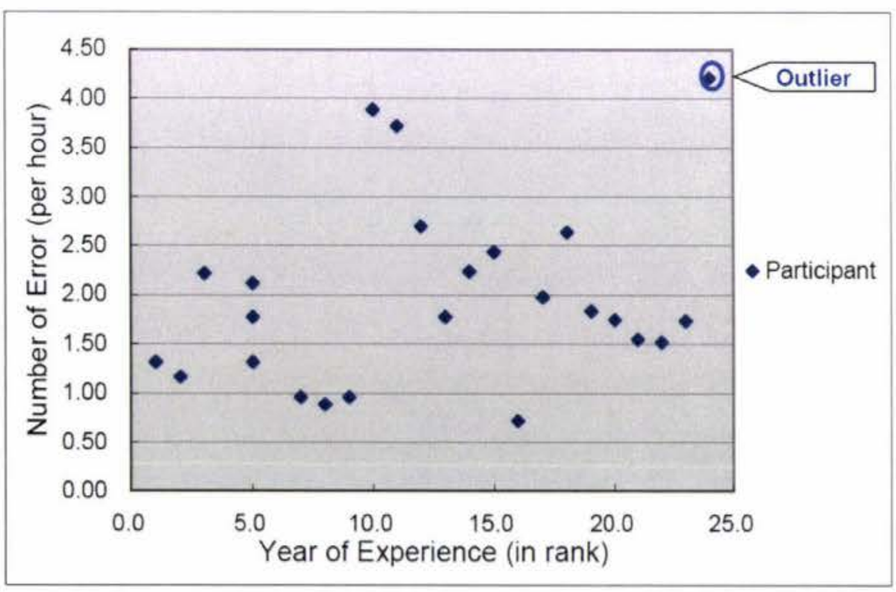


Figure 4.2 – **Scatter Graph to show the Years of Experience in AC with Number of Errors**

4.6.1 Outlier

Data collected (Figures 4.1 & 4.2) highlighted that the variables were not randomly distributed; it was expected the data would show a consistent relationship but not necessarily a linear relationship. A datum in Figures 4.1, 4.2 and 4.3 was substantially different (largest) from all other values in the data set, in other words, it significantly deviated from the trend in the scatter plots. For the sake of a robust data continuity, it had to consider that datum was possibly an outlier (Gravetter & Wallnau, 2007; McCall, 1970) which could have a significant influence on the correlation (which was shown in paragraph 4.6.2). To avoid misinterpretation of the relationship between the two variables, the statistics, hence, involved the suspected outlier and produced two results for comparisons.

4.6.2 Spearman Rank Correlation Test on Experience of AC versus Errors

The experience of the AC in ATC, measured in years and the corresponding number of errors per hour were rank ordered and a Spearman rank correlation test was used to compare the ranks. A correlation for the data (excluding the suspected outlier) revealed that experience of AC in ATC and number of errors were not related, $r = +.178$, $n = 23$, $p < .05$, one tail. A correlation for the data (including the suspected outlier) revealed that experience of AC in ATC and number of errors were not related, $r = +.277$, $n = 24$, $p < .05$, one tail. The latter result was raised to over 50% and it was considered an outlier and was rejected from subsequent analysis (except for the event studies in Chapter 5 and Appendixes G, H & I).

The same statistical method was used for the experience of the AC in AC duty. A correlation for the data (exclude the suspected outlier) revealed that experience of AC in AC duty and number of errors were not related, $r = +.162$, $n = 23$, $p < .05$, one tail. A correlation for the data (include the suspected outlier) revealed that experience of AC in AC duty and number of errors were not related, $r = +.262$, $n = 24$, $p < .05$, one tail. The latter result was raised to over 60% that it was considered an outlier and was rejected from subsequent analysis (except the event studies in Chapter 5 and Appendixes G, H & I).

4.6.3 Two Groups of AC – Kai Tak and Chek Lap Kok

As a matter of fact, there are two groups of AC in the AC population. One group of AC is Kai Tak group (i.e. AC being trained and became rated in Kai Tak Airport). The other group of AC is Chek Lap Kok Group (i.e. AC being trained and became rated in Chek Lap Kok Airport). Kai Tak Airport became decommissioned as when the new airport – Chek Lap Kok Airport opened in July 1998, all the AC received conversion training on the new systems that included new equipment and new procedures. It is noteworthy that there were two patterns of trend in Figure 4.3. Incidentally, these patterns belonged to the two aforesaid groups of AC. The Kai Tak Airport group (brown line) and the Chek Lap Kok Airport group (green line) all showed that the less experienced ones committed more errors than the more experienced ones in each group. The Kai Tak group seemed to have committed more errors than the Chek Lap Kok group.

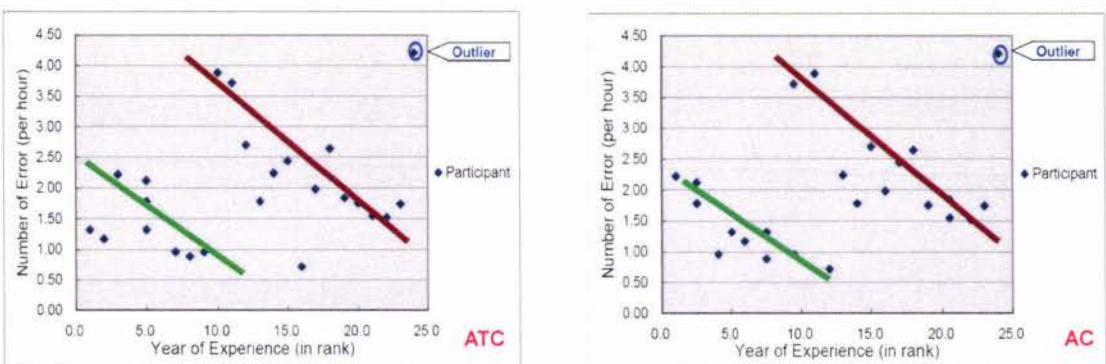


Figure 4.3 **– Scatter Graphs to show the Years of Experience in ATC/AC with Number of Errors**

4.6.4 Mann-Whitney *U*-test on the Two Groups of AC

The recorded errors, measured in number of errors per hour, and the years of experience in ATC/AC of the AC were rank ordered; a Mann-Whitney *U*-test was used to compare the ranks for these two groups of AC of which $n = 9$ AC in Kai Tak versus the $n = 14$ AC in Chek Lap Kok. The results indicated significant difference between the two groups of AC, $U = 27.5$, $p < .05$, with the sum of the ranks equal to 72.5 for the AC in Kai Tak and 203.5 for the AC in Chek Lap Kok.

4.6.5 Spearman Rank Correlation Test on Experience of AC versus Errors in the Two Groups of AC

Spearman rank correlation was used to show if there was a consistent relationship in each of these two groups of AC. There was only a small difference in r for years of experience in ATC/AC versus number of errors (paragraph 4.6.2). The focus was put on the years of experience in AC duty.

The experience of the AC for the two groups of AC, measured in years and the corresponding number of errors per hour were rank ordered. Spearman rank correlation test was used to compare the ranks. A correlation for the data revealed that the experience of AC (Chek Lap Kok group) in AC duty and number of errors were not related, $r = -.300$, $n = 9$, $p < .05$, one tail. A correlation for the data revealed that the experience of AC (Kai Tak group) in AC duty and number of errors were significantly related, $r = -.699$, $n = 14$, $p < .05$, one tail.

4.6.6 Other Considerations

There are other factors that may influence this relationship between the years of experience in ATC/AC and number of errors. Some factors that could be confounded with years of experience may include:-

- Some AC were more conversant with the job than the others as they were in fact rostered for AC positions more frequently during the month before the observation.
- Traffic volume and complexity of each observation varied on a day to day basis.
- These data were derived from different AC sectors and shifts.

Although it was not discovered that a strong correlation existed between years of experience and the number of errors, further analysis was used to test if there was any relationship between years of experience in ATC/AC and different types of errors (skill-based errors, rule-based errors, knowledge-based errors and violation).

4.7 Statistical Analysis (2) – Years of Experience in ATC/AC versus Different Types of Errors

Different types of errors and violations were covered in Chapter Two. Table 27 below present these different types of errors which are skill-based errors, rule-based errors, knowledge-based errors as well as violations together with years of experience in ATC/AC which were being rank ordered.

Table 27

Ranks for Years of Experience in ATC/AC and Number of Different Types of Errors

Years in ATC ranking	Years in AC ranking	Rank (per hour)			
		Skill-based	Rule-based	Knowledge-based	Violation
1.0	3.0	21.0	9.0	10	8.0
2.5	5.0	19.0	9.0	10	8.0
2.5	5.0	7.0	19.5	21	8.0
4.0	7.0	2.0	14.0	10	8.0
5.0	1.0	10.0	3.5	10	17.5
6.0	2.0	12.0	3.5	10	8.0
7.5	8.0	7.0	3.5	10	8.0
7.5	5.0	5.0	9.0	10	17.5
9.5	11.0	22.0	9.0	10	8.0
9.5	9.0	4.0	14.0	23	21.0
11.0	10.0	23.0	9.0	21	23.0
12.0	16.0	3.0	3.5	10	8.0
13.0	14.0	17.0	3.5	10	21.0
14.0	13.0	7.0	19.5	10	8.0
15.0	12.0	18.0	14.0	10	17.5
16.0	17.0	13.0	19.5	10	17.5
17.0	15.0	20.0	14.0	10	8.0
18.0	18.0	16.0	19.5	10	8.0
19.0	20.0	9.0	19.5	10	8.0
20.5	21.0	1.0	23.0	10	8.0
20.5	19.0	14.0	14.0	21	21.0
22.0	22.0	15.0	3.5	10	8.0
23.0	23.0	11.0	19.5	10	8.0

4.7.1 Spearman Rank Correlation Test on Experience of AC versus Number of Different Types of Errors

The experience of the AC in ATC/AC, measured in years and the corresponding number of unsafe acts (skill-based/rule-based/knowledge-based errors and violations) per hour. was rank ordered and a Spearman rank correlation test was used to compare the ranks. The results on different unsafe acts were indicated in Table 28. A correlation for the data revealed that the experience of AC in ATC/AC and number of different types of error were not related.

Table 28

Correlation Matrix for Years of Experience in ATC/AC and Different Types of Errors

	Experience in	
	ATC	AC
Skill-based errors	+.018	−.028
Rule-based errors	+.127	+.153
Knowledge-based errors	+.289	+.342
Violations	+.164	+.095

$n = 23$

All coefficients are not significant ($p > .05$, one-tailed)

4.7.2 Spearman Rank Correlation Test on Experience of AC versus Number of Different Types of Errors on the Two Groups of AC

The two groups of AC (which can be inspected in Figure 4.3) were compared with the Spearman rank correlation test to see if there was any correlation between years of experience in AC and different types of errors in the two different groups of AC. Tables 29 and 30 were transposed from Table 27; they were years of experience in AC versus different types of errors in the two groups of AC. Again, Spearman rank correlation was used in the statistical test.

Table 29

Ranks for Years of Experience in AC and Types of Errors (Chek Lap Kok Group)

Year in AC ranking	Skill-based per hour rank	Rule-based per hour rank	Knowledge-based per hour rank	Violation per hour rank
1	5	2	4.5	8.5
2	6	2	4.5	4
3	8	5.5	4.5	4
5	7	5.5	4.5	4
5	3.5	9	9	4
5	2	5.5	4.5	8.5
7	1	8	4.5	4
8	3.5	2	4.5	4
9	9	5.5	4.5	4

Table 30

Ranks for Years of Experience in AC and Types of Errors (Kai Tak Group)

Year in AC ranking	Skill-based per hour rank	Rule-based per hour rank	Knowledge-based per hour rank	Violation per hour rank
1	3	6.5	14	12
2	14	4	12.5	14
3	12	6.5	6	9.5
4	4	11	6	4.5
5	11	2	6	12
6	13	6.5	6	4.5
7	2	2	6	4.5
8	7	11	6	9.5
9	10	11	6	4.5
10	8	6.5	12.5	12
11	5	11	6	4.5
12	1	14	6	4.5
13	9	2	6	4.5
14	6	11	6	4.5

From Tables 29 and 30, both the Kai Tak and Chek Lap Kok groups had the following respective r values in Table 31 for different types of errors:-

Table 31

Correlation Matrix for Year of Experience in AC and Different Types of Errors for Kai Tak Group and Chek Lap Kok Group

	Experience in AC	
	Kai Tak[1]	Chek Lap Kok[2]
Skill-based errors	–0.279	–0.071
Rule-based errors	+0.365	+0.392
Knowledge-based errors	–0.071	+0.367
Violation	–0.434	–0.046

[1] $n = 14$

[2] $n = 9$

All coefficients are not significant ($p > .05$, one-tailed)

A correlation for the data revealed that the experience of AC in AC duty and number of different types of error were not related in both groups.

4.8 Statistical Analysis (3) – Relationship between Different Shifts/AC Sectors and Number of Threats/Errors

There were four conditions the research would examine:-

(i) relationship between different shifts and threats;

(ii) relationship between different AC sectors and threats;

(iii) relationship between different shifts and errors; and finally; and

(iv) relationship between different AC sectors and errors.

The number of subjects in each condition was shown in Tables 32, 33, 34 and 35.

Although the workstations of AC and AC's job functions were in the similar fashion in different shifts and AC sectors, it was believed that certain shifts and AC sectors were more susceptible to threats and errors. This had to be proven by comparing the independent variables (Shifts – AM, PM & Day and AC sectors – East, South, West, North & Macao) and dependent variables (recorded threats and errors); the overnight shift was not considered in the analysis (2) and (4) as the AC positions did not have fixed working period and also the AC were in many occasions, assisted by another AC in terms of sectorisation or acting as "an extra pair of eyes". The Macao sector (with day shift only) was not considered in this analysis as there were only two observations made and that did not qualify for the statistical method which would be dealt with in the next paragraph.

The statistical analysis tended to be conservative in these cases as only a tendency of the conditions would be looked into. Besides, due to the rather small sample size available, it was decided to use non-parametric statistics throughout the thesis. As such, the Kruskal-Wallis test was used to compare all these variables.

4.8.1 Relationship between Different AC Sectors and Threats

After ranking the individual threats, a Kruskal-Wallis test was used to evaluate the differences among the four sectors (which were shown in Table 32). The outcome of the test indicated no significant differences among the four sectors on threats, X^2 = 1.389 (3, n = 16), p > .05.

Table 32

AC Sectors versus Threats being converted into Ordinal Data Ranks

Sectors			
ACE	ACS	ACW	ACN
4	1	3	2
8	7	5	10
13	9	6	11
16	12	14	15

Note. n = 16

The same statistical test was used to examine the other three relationships in the following paragraphs.

4.8.2 Relationship between Different Shifts and Threats

After ranking the individual threats, a Kruskal-Wallis test was used to evaluate differences among the three shifts which were shown in Table 33. The outcome of the test indicated no significant differences among the three shifts on threats, $X^2 = 1.094$ (2, $n = 22$), $p > .05$.

Table 33

Shifts versus Threats being converted into Ordinal Data Ranks

Shifts		
Am	pm	night
1	2	3
6	9	4
8	11	5
10	13	7
12	15	20
14	17	21
16	18	
19	22	

Note. $n = 22$

4.8.3 Relationship between Different AC Sectors and Errors

Table 34

AC Sectors versus Errors being converted into Ordinal Data Ranks

Sectors			
ACE	ACS	ACW	ACN
2.5	1	4	2.5
11	7	5	8.5
12	10	6	13
14	16	8.5	15

Note. $n = 16$

After ranking the individual errors, a Kruskal-Wallis test was used to evaluate the differences among the four sectors which were shown in Table 34. The outcome of the test indicated no significant differences among the four sectors on errors, $X^2 = 1.825$ (3, $n = 16$), $p > .05$.

4.8.4 Relationship between Different Shifts and Errors

Table 35

Shifts versus Errors being converted into Ordinal Data Ranks

	Shifts	
AM	PM	Night
5.5	1	4
7	2.5	5.5
10	2.5	8
11.5	9	14
17	11.5	15
18	13	19
20	16	
22	21	

Note. $n = 22$

After ranking the individual threats, a Kruskal-Wallis test was used to evaluate the differences among the three shifts which were shown in Table 35. The outcome of the test indicated no significant differences among the three shifts on errors, $X^2 = 1.831$ (2, $n = 22$), $p > .05$.

4.8.5 Summary of the Kruskal-Wallis Test

The Kruskal-Wallis test on all the four situations above got the same outcome that indicated no significant differences among the threats (or errors) in different shifts or different AC sectors; this might be due to insufficient data for the test as there were only four data in some cases illustrated by Tables 32 and 34.

Chapter Five: Discussion

5.1 Overview of Findings

It was presented in Chapter Four that there were 14 findings in the NOSO. After Data Cleaning, there were 286 threats, 224 errors and 3 undesired states (p. 27). Out of the different threats, errors and undesired states, 45 types of threats, 38 types of errors and 2 types of undesired states (pp.28–32) were identified. ATM External Threats (51.7%) (p. 33) scored the highest percentage of types of threat and Procedural Errors scored the highest percentage of types of error (60.9%) (p. 35). Of all the threats, 43.7% of threats were not managed by AC (p.35) and the highest percentage of Intentional Non-compliance was noted in Communication Errors (p. 36). On the other hand, the AC were not aware of 71.6% of all the errors (p. 37), whereas 98.7% of the total errors were inconsequential (p. 38). ACE sector of pm shift bore the highest average threats (p. 40) and ACE sector of am shift bore the highest average errors (p. 41). With the aid of statistical analysis, the years of experience in ATC/AC were not related to the number of errors except for the Kai Tak group, it was shown the more experienced AC made fewer errors than the AC with less experience (pp. 44–46). There was no significant relationship between years of experience in ATC/AC and different types of errors (skill-based, rule-based, knowledge-based and violation) (p. 48). There was also no significant relationship between AC Sectors/shifts and threats/errors (pp. 50–53). Finally, an outline of threat management, error management, and undesired state management (Appendixes F, G, H and I) was compiled to highlight each threat, error and undesired state for perusal.

5.2 Analysis of Findings (1) – in General

All these findings suggest threats are ubiquitous and they are hazards or unsafe conditions which affect human performance during normal operations at any time. On the other hand, errors are those actions either induced by threats or created by human as unsafe acts. It supports implicitly a concept (Heinrich, 1959) that minor incidents (3 undesired states) are made up of numerous unsafe practices (224 errors) and unsafe conditions (286 threats).

The Cheese model (Reason, 1990), again, was in action in an undesired state. For example, a transfer of flight information was not conducted in time because of poor ergonomic design of departure display and lack of alarm on departure [latent failure – organisational influence], lack of team role (no prompt from controller and/or flight data operator) [active failure – workplace factors] and distraction from supervisory action [active failure – poor supervision].

The same undesired state was spelled out very well under the TEM framework. The AC poorly handled the threat caused by the supervisor. That diverted his attention for monitoring the departure display which was unsuitably installed in his work station (another threat). Another threat was the controller error with which the AC should be reminded of any departure for exit point BEKOL. The AC was finally aware of the departure when he regularly checked the departure list right in front of him. His routine checking prevented him from an even more severe undesired state – no transfer.

5.3 Analysis of Findings (2) – in Details

The threats, errors and undesired states and their relationship with each other and other factors (e.g. years of experience, shifts, sectors) were discussed in the following paragraphs.

5.3.1 Threats

Three threats were at the high percentages (which was shown in Table 5), they were the "late transfer" (8%), "flow control" (8%) and "flight plan matters" (8.7%). The most common threat was "readback error" (incoming) which occurred with 13 participants. However, attention should not only be just placed on the frequency or number of occurrences but also on the possible threat-induced consequences. It would be invaluable if these threats (and errors) could be linked up with past incidents for references and retrospective analysis (Sträter & Van Damme, 2004) so that a wider perspective in understanding incidents as well as prospective assessment of human behaviour in a system could be sought.

5.3.2 Errors

The errors shown in Table 6 occurred most frequently were "Communication system manipulation error" (10.7%), "Do not sign on equipment" (10.7%) and "Other procedural errors (e.g., monitor the distress frequency)" (12.4%). However, the high percentage occurrence of the third one (i.e. Other procedural errors) should not bear any significance in the discussion, as it only indicated procedures that were commonly practised but not listed in the NOSO Codebook, yet. Other than "Other procedural errors", the most common error was "Do not sign on equipment" which occurred with 24 participants. Attention should not be just placed on the frequency or number of occurrences but also on the severity of the error and its possible consequence if not being captured and resolved.

5.3.3 Relationship between Years of Experience and Errors

The results of years of experience (r) in ATC/AC versus different types of errors showed that they (except years of experience in AC versus skill-based error that had a nearly zero value) all had a weak positive correlation between the two sets of data. After comparing the r values from the Critical Values for Spearman rank correlation, the weak positive and negative correlation of the two sets of variables in the population were considered as by chance. No significant conclusions could be drawn from the results, except that there were tendencies of positive correlation between the years of experience in ATC/AC and the number of different types of errors. Although the more experienced person should commit fewer errors than those with less experience, at least in terms of skill-based errors.

There was no linear relationship in the population between the years of experience in AC and the number of errors in both the Chek Lap Kok and Kai Tak groups. In other words, the weak correlations between those sets of variables in the population were by chance only in this study sample; however, some of the r figures were close to the critical values and there would be valuable outcomes if the corresponding r were compared between the two groups of AC. Again, although the results in Table 31 were not statistically significant, there were still tendencies that both the Kai Tak group and Chek Lap Kok group had positive correlation that the more experienced AC tended to make more rule-based errors. Besides, the more experienced AC tended to make more knowledge-based errors than the less experienced AC in the Chek Lap Kok group. The more experienced AC tended to make less skill-based error than the less experienced AC in the Kai Tak group and there was similar fashion in violation within that group. This phenomenon gave food for thought on why there were such differences and trends in these two groups of AC.

With the three levels (skill-based, rule-based and knowledge-based) of human behaviour distinguished by Rasmussen (1983), the ANSP can define the training objectives for different groups of ATM personnel such as novice AC versus expert AC, different natures of task (e.g., routine work or novel situations).

5.3.4 Performance Markers

The average scale for all the performance markers was from 2.6 to 3.2 out of 4.0 and attention should be first placed on "Post-handover Support", "Scanning" and "Flight Progress Strip Management" as all these aspects scored the lowest scale (2.6). There was a moderately good average scale in "Teamwork" (3.2) representing that there was quite a harmonized team function. The range of average performance markers was from 2.5 to 3.3 in all the 24 observations with the overall average scale of 2.82 which was very close to the Good category. Having said that, these figures did not bear any safety implications of the organization implicitly and explicitly. Instead, all these figures as well as the figures of threats and errors should act as indexes or references for targets of improvement when an ANSP considers that a thorough review on the AC operation was necessary. Subject to resources and duration required to implement further safety measures (e.g., training, consolidation of new procedures), another NOSO should be carried out to confirm the effectiveness of all these efforts as well as revealing new safety considerations. On the other hand, these figures can be used as benchmarking figures for groups of AC during their initial training.

5.3.5 Areas of Attention

Particular attention is placed on four types of operation (which were shown in Tables 10 and 15) – "Handover", "Takeover", "Opening position" and "Closing position" which made up about 10% of the total threats and about 21% of the total errors. Despite this comparatively small percentage, these types of operation are considered the most vulnerable parts of the operations as they can influence the AC's performance on mitigating errors and assisting in error recovery. A checklist and best practices can avoid significant portions of these safety issues. Research conducted by Voller, Glasgow, Heath, Kennedy and Mason (2005) and Turner (2001) show that detailed discipline on checklist and some best practices can address the issues on those four types of operation.

Two errors were pointed out by the observers (which were shown in Table 17) to the AC to remind the AC and/or controller to carry out certain actions; otherwise, the situations would have developed into undesired states during observation. This seems a violation to the "fly-on-wall" principle of being an observer. However, in NOSO, all the observations were taken under live traffic. Errors that could cause serious consequences were pointed out by the observer for purely safety reason and this was carried out but in a tactful manner. It is worthwhile to note that the responses from AC and/or controller on the two aforesaid events were gratefully accepted by them.

Tables 11, 12, 16, 18–20 and 22 show that the TEM framework in action. Following the critique on the first NOSO, it is anticipated that the number of occurrences in the linkage between threats and errors should reduce in the second NOSO after two to three years of implementation of new rules or procedures. However, one might consider the measures of rectifying the defeats in the system taken after the first NOSO as ineffective if the results of the second NOSO were not satisfactory, or there might have been many changes in procedures taking place in-between the two NOSO.

Statistical analysis showed that ACE bear the highest average number of threats and errors in the morning shift and afternoon shift respectively, whilst the ACH night shift carried the lowest average number of threats and ACW night shift carried the lowest average number of errors. These figures were not mainly caused by the amount of traffic. They were presented with the intention to provide the ANSP with a priority to allocate resources when implementing safety measures. In other words, ACE sector is an area justified for the earliest attention when the ANSP is looking into all these AC positions. Nevertheless, statistical analysis showed that there was no significant relationship between different shifts/AC sectors and threats/errors. It seemed the high average number of threats and errors in ACE sector have to be investigated by further researches.

It was discovered accidentally that there were two groups of AC (which was shown in Figure 4.3) in the sample with one group becoming rated at Kai Tak Airport and another group becoming rated at Chek Lap Kok Airport; they all showed the same trends that the more experienced AC committed less errors than the less experienced ones. It was interesting to note that the Kai Tak group comparatively committed more errors than the Chek Lap Kok group. It could be argued that the latter group retained two sets of knowledge – one for Kai Tak Airport and another for Chek Lap Kok Airport; the transition from old airport to new airport did not favour this group of AC. It throws light on the transition training for new knowledge (e.g., new equipment), new working environment (e.g., new working position) and procedures (e.g., automation). A long transition training period is highly recommended for future major changes.

5.3.6 Events on Threat Management, Error Management and Undesired State Management

All the events of threat, error and undesired state were recorded in NOSO Observation Forms. The events extracted from Threat Management Worksheet (Appendix A4), Error Management Worksheet (Appendix A5) and Undesired State Management Worksheet (Appendix A6) were compiled into a simpler format as presented in Appendixes G, H, and I. All duplicated and similar events were put together into one entry. Abbreviations and codes used in those Appendixes are interpreted in Appendix F.

5.3.6.1 Threat Events

All the threats encountered by the AC were either managed or mismanaged (or unawareness). The unawareness, actions and inactions taken against these threats are listed in Appendix G with preliminary analysis and comments.

Environmental Threats Summary (TA)

These were mainly traffic that deviated around bad weather. Although it is not uncommon to have bad weather, it usually requires lots of non-standard messages and non-standard coordination. Very often such messages are not relayed properly or even mistaken due to language problems (Cushing, 1994; Dietrich, 2004).

Air Traffic Management (ATM) Internal Threats Summary (TB)

These were some threats which could not be fixed. In other words, they were hard to resolve. For example, it is hard to contain internal visitors (staff on break) who may cause distraction to operational staff, although supervisory action can always intervene with such an activity. Besides, equipment malfunction, a by-product of automation also tested the ATM personnel to exercise their vigilance on spotting these problems rather than being taken over by surprise due to complacency (Kirwan, 2005). In this research, an action-trigger alarm (visual or audio) was not in place to supplement human deficiency and together with poor ergonomic design (Stanton, 1994; Sommerich, 2005)) ended up with a number of late transfers to another ACC. Other than machine problems, errors created by controller became threats to the AC, or vice versa. It has to be resolved by a robust team function so that these threats and errors can be detected and mitigated. Notwithstanding, many threats can still be mitigated by administrative measure (e.g., reinforce supervisory monitoring).

Air Traffic Management (ATM) External Threats Summary (TC)

External threats can very often be mitigated by negotiations with adjacent ANSP or other flight information region such as negotiations on flow control restriction, danger area activation, no readback from other ACC. However, many of these causes can also be softened by internal briefing/training and some alert functions in the system (e.g., warning on wrong flight plan information).

5.3.6.2 Error Events

All the errors were either resolved or unresolved by the AC (or other ATC personnel).

The outcomes of these errors are listed in Appendix H.

Communication Errors Summary (EA)

Communication errors were mainly hearback errors, readback errors, incorrect/incomplete information and poor understanding of English.

Equipment Errors Summary (EB)

These were the slips in data entry and equipment setup.

Procedural Errors Summary (EC)

The errors of this nature were various. There were mixes of slips, lapse, mistakes and violation. Some need training while some need supervisory monitoring/ cross-checking. A good team function was noted so that quite a number of errors was resolved although a large number of less critical errors had still gone unnoticed.

5.3.6.3 Undesired State Events

Three cases of undesired state were recorded; with the benefit of hindsight (Dekker, 2006), these cases should be treated as lessons learnt and one should develop measures to prevent recurrence of similar events (Appendix I).

Assistant Controller/Controller Positions Undesired States Summary (UA)

The outbreak of these events was mainly from AC's assumption and heavy workload due to runway change.

Traffic Undesired States Summary (UB)

This was a system weakness indicating that a breakdown in teamwork functions. A lesson learnt briefing and alert functions in the system could have avoided such an undesired state.

5.4 Limitations of NOSO

As confidentiality is the keystone of the NOSO, all the data are kept anonymous. The statistical tools, being used in analyse the data, has to be conservative in nature. Therefore, Spearman correlation using rank order instead of Pearson correlation using actual figure was employed to determine the relationship between the variables (e.g., years of experience in ATC/AC versus number of average errors), although the latter statistical tool can produce a more realistic correlation.

Unlike the LOSA conducted by Klineet (2005) with participation of the LOSA Collaborative, airlines management, university, pilot union, pilot and aviation human factor experts, NOSO does not have such collaborative supports from different parties at this stage. It was considered as a personal academic pursuance with only limited support from different sources such as the approval from the Hong Kong Civil Aviation Department and the staff (the AC) on a voluntary participation basis. Full practical support from the Hong Kong Air Traffic Controllers' Association in terms of physical participation was not available due to union's policy on personal research work.

Due to limited resources in terms of manpower, the amount of work (e.g., the six stages of NOSO) on NOSO becomes huge for a single researcher. Therefore, 66 weeks for the completion of the NOSO is far less than ideal as far as the time factor is concerned. With more resources, attempts can be made on other high level objectives as stated in ICAO (2002) as follows:-

- (i) Degree of transference of training to the operational area;
- (ii) Baseline for organisational change; and
- (iii) Rationale for allocation of resource.

Organization culture is another consideration in NOSO. As stated before, there were 71 qualified for NOSO research. Fifty AC was invited in person by the observer and 32 AC accepted to participate in the research. The refusal implied that many AC did not want to be monitored at work partly because of embarrassment when they made mistake which was being discovered (and recorded). Although it was clearly stated on in the Information Sheet (Appendix D) on the issues of confidentiality and non-punitiveness, the AC still might not trust the observer or the organization. Therefore, a proper protocol has to be agreed between the management and the union so as to reinforce the two issues.

5.5 NOSO in the Future

Statistical analysis shows some results are very close to the critical values (e.g., –.434 in the correlation between years of experience in AC and violation in Kai Tak group in Table 31). A further research on a larger number of participants, using the NOSO methodology (with the participation of other parties, e.g. the union) or the like, might present a better picture and indicate that one variable affected the other. A study focusing on a specific AC sector and shift, for example, ACE with the same number of participants should provide a better and more fruitful result on the AC performance within that sector and shift.

With some modifications (e.g. formats of the observation forms), NOSO can be used to collect safety data on other ATM positions, for example, aerodrome control tower, approach control and area control. Some overseas ANSP (e.g., Australia) are actually evaluating similar methodology (e.g. NOSS).

On the other hand, NOSO (or NOSS) can be a touchy methodology in a place with poor reporting culture. It would be difficult to collect safety data with such methodology in an organization with "blame culture" rather than "just culture" (Marx, 2001). Since safety data on the normal operations are so useful to an organization, the NOSO methodology can be further modified to collect data on "good performance" (e.g., good technique on problem-solving) only so that such methodology after being modified, could be easily accepted by ATM personnel until such time, the ATM personnel are ready to accept a more complete methodology.

5.6 Summary

The NOSO methodology used in this research is supported by the fulfillment of the objectives of NOSO.

Threats, errors and undesired states were identified and recorded in the ATM's operational environment and from within the ATM's operations by means of NOSO.

The errors, which were skill-based, rule-based and knowledge-based, were attributed to the AC's performance, violations were recorded to the effect that some AC did not follow the rules and/or procedures deliberately. These violations were just exactly what Hudson et al. (2002) described as *"seeing the opportunities"* that some AC found their way (violation) provided by system, for example, lack of supervision. All these are negative aspects on the performance of AC and they always draw the attention of people concerned. However, under the framework of the Threat and Error Management, there can be many other novel situations that the AC use their problem solving skills or initiative to cope with successfully. These professional skills can be unique and transferable to others, but they are not being discovered and made public. Therefore, the community of AC is not benefited. The events of threat, error and undesired state that were tackled by the AC during the NOSO study present AC's shortcuts and workarounds. Besides, they throw light on many aspects that include design problems in human-machine interface, quality and usability of procedures. All these events are recorded in brief narratives (Appendixes F, G, H & I). It is highly desirable that such information will be considered for use in training (e.g., scenarios in simulator exercises), safety study (e.g., the weaknesses as well as strength of the AC operation). Most importantly, the introduction of NOSO methodology as a proven methodology to be used as means of data collection to supply safety data to the ANSP for safety management.

Chapter Six: Conclusion

Threats and errors are unwanted elements in an ATC system as they compromise flight safety and have to be identified and properly managed by ATM personnel. The way these problems and their outcomes are tackled depends on many overt or subtle factors. All in all, they are important indicators of the safety conditions of the ATM system and they provide advance warnings of potential problems as LOSA does.

NOSO is not NOSS nor is intended to replace NOSS that is under study by ICAO and currently has to satisfy the requirements in ICAO preliminary document (ICAO, 2005) as far as concurrent with the prevalent concern. NOSO is a methodology modified from LOSA and it carries conditions and requirements that meet the local conditions, or at least, meet the situations at the time of this research having limited resources. NOSO may be used to explore further on the methodology of collecting safety data that can provide the ANSP with useful and meaningful data of their system.

The value of NOSO is supported by its findings. This methodology, together with supports from the management, union, a shared vision of achieving safety and a high level of mutual trust among ANSP's personnel, can be a proactive and effective means of collecting safety data from real-time operations. An ANSP can use the Triangulation method (Guion, 2002) to analyze the data from annual proficiency check and incident investigation to produce more validated and credible evaluation results. The ANSP can then use this validated information to decide its safety margins and/or undertake remedial actions, such as the need to review existing procedures, fortify training standards to rectify problematic areas as well as to promulgate good practices so as to improve the situations and ultimately further enhance safety.

Finally, NOSO methodology should not be limited to AC. It could be used in other domains of ATC such as aerodrome controller and radar controller. Therefore, this methodology may form a basis for future research.

Bibliography

Barber, N. (2002). *Should we consider non-compliance a medical error?* Quality and Safety in Health Care;11:81-84. Retrieved April 30, 2006, from http://qshc.bmj.com/cgi/content/full/11/1/81

Civil Aviation Authority (2002). *Fundamental human factors concepts* (1st ed.). Retrieved December 2, 2004, from http://www.caa.co.uk/docs/33/CAP719.PDF

Civil Aviation Department. (2004). *Report on the accident to Boeing MD11 B-150 at Hong Kong International Airport on 22 August 1999.* Hong Kong: H. K. SAR Government.

Dekker, S. (2006). *The field guide to understanding human error.* Aldershot (UK) and Burlington, VT: Ashgate.

Cushing, S. (1994). *Fatal words: communication clashes and aircraft crashes.* The University of Chicago Press: Chicago & London.

Dietrich, R. (2004). Determinants of effective communication. In R. Dietrich & T. M. Childress (Eds.). *Group interaction in high risk environment* (pp. 185-205). Aldershot (UK) and Burlington, VT: Ashgate.

Dismukes, K., Young, G., & Sumwalt, R. (1998). Cockpit interruptions and distractions: Effective management requires a careful balancing act. *ASRS Directline, 10,* 4-9. Retrieved September 12, 2006, from http://asrs.arc.nasa.gov/d irectline_nf.htm

Dörner D. (1996). *The logic of failure: Why things go wrong and what we can do to made them right* (pp.28-35). Metropolitan Books: New York.

Down, G. (2005). *Threat and error management training for air traffic control officers.* Presented at the International Civil Aviation Organization and Eurocontrol, First Global Symposium on Threat and Error Management (TEM) and Normal Operations Safety Survey (NOSS) in Air Traffic Control. Luxemburg. 9 to 10 November 2005. Eurocontrol and ICAO. Retrieved December 22, 2005, from http://www.icao.int/ANB/humanfactors/LUX2005/Greg_Down TEM%20Training %20for%20ATCOs.ppt

Down, G. (2007). *NOSS: The trials at NAV CANADA*. Paper presented at the 2nd ICAO Global Symposium on Threat and Error Management (TEM) and Normal Operations Safety Survey (NOSS) in Air Traffic Control. Washington, DC 7 to 8 February 2007. Retrieved March 2, 2007, from http://www.icao.int/ANB/human factors/noss2/NavCanada.ppt

Edwards, E. (1988). Introductory overview. In E. L. Wiener & D. C. Nagel (Eds.), *Human factors in aviation* (pp. 3-26). San Diego, CA: Academic Press.

Eurocontrol (2004). *Cognitive complexity in air traffic control: A literature review.* EEC Note N. 0404. Project COCA – COmplexity and CApacity. Brussels, Belgium: Eurocontrol.

Fallow, P. (2005). *NOSS: The trials at Airways New Zealand.* Paper presented at the International Civil Aviation Organization and Eurocontrol, First Global Symposium on Threat and Error Management (TEM) and Normal Operations Safety Survey (NOSS) in Air Traffic Control. Luxemburg. 9 to 10 November 2005. Eurocontrol and ICAO. Retrieved December 20, 2005, from http://www.icao.int/ANB/humanfactors/LUX2005/Paul_new_Airways%20Trial%20 Brief.ppt

Fallow, P. (2007). *NOSS: The trials at Airways New Zealand.* Paper presented at the 2nd ICAO Global Symposium on Threat and Error Management (TEM) and Normal Operations Safety Survey (NOSS) in Air Traffic Control. Washington, DC 7 to 8 February 2007. Retrieved March 15, 2007, from http://www.icao.int/ANB/human factors/noss2/AirwaysNewZealand.ppt

Federal Aviation Administration (FAA). (2006). *LOSA Advisory circular.* April 27, 2006. The University of Texas Human Factors Research Project. Retrieved May 20, 2006, from http://homepage.psy.utexas.edu/Homepage/Group/HelmreichLAB/Publications/Misc/AC%20120-9011.pdf

Fischhoff, B. (1982). For those condemned to study the past: Heuristics and biases in hingsight. In D. Kahneman, P. Slovic & A. Tversky (Eds.). *Judgement under uncertainty: Heuristics and biases* (pp. 335-351). Cambridge University Press. 1982.

Flight Safety Foundation (FSF). (2005). Line operations safety audit (LOSA) provides data on threats and errors. *Flight Safety Digest.* February 2005. Retrieved December 17, 2005, from http://www.flightsafety.org/pubs/fsd_2005.html

Gravetter F. J., & Wallnau L. B. (2007). *Statistics for the behavioral sciences* (7th ed.). USA: Thomson Learning, Inc.

Guion L. A. (2002). Triangulation: Establishing the validity of qualitative studies [Electronic version]. University of Florida, Institute of Food and Agricultural Science. *IFAS Online publication FCS6014/FY394.* Retrieved January 6, 2007, from http://edis.ifas.ufl.edu/pdffiles/FY/FY39400.pdf

Heinrich, H. W. (1959). *Industrial accident prevention: A scientific approach* (4th ed., pp. 26-34). New York: McGraw-Hill.

Heinrich, H. W., Petersen D., & Roos N. (1980). *Industrial accident prevention: A safety management approach.* New York: McGraw-Hill.

Helmreich, R. L. (2000). *On error management: Lessons from aviation.* BMJ 2000; 320:781-785. Retrieved April 30, 2006, from http://www.bmj.com/cgi/content/full/320/7237/781

Helmreich, R.L., & Musson, D. M. (2000). *The University of Texas threat and error management model: Components and examples*. British Medical Journal online. Retrieved April 30, 2006, from http://www.bmj.com/misc/bmj.320.7237.781/

Hollnagel, E. (2001). The Elusiveness of "Human Error". In E. Hollnagel, & R. Amalberti. *The emperor's new clothes, or whatever happened to "human error"?* The 4th International Workshop on Human Error, Safety and System Development. Linköping, Sweden, June 11-12, 2001. Retrieved February 6, 2007, from http://www.ida.liu.se/~eriho/HumanError_M.htm

Hudson, P. T. W. (1998). *Bending the rules: Violation in the workplace.* Invited Keynote Address, Society of Petroleum Engineers, 1998 International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production. Caracas. June 1998. Retrieved April 30, 2006, from http://www.energyinst.org.uk/heartsandminds/docs/bending.pdf

Hudson, P. (2000). *Non-adherence to procedures: Distinguishing errors and violations.* Paper presented at the 11th Human Factors Symposium – Melbourne. Australia. 4 to 6 July 2000. Retrieved April 4, 2007, from http://www.crm-devel.org/resources/paper/Non%20Adherence%20to%20Procedures%20&%20Violations%20Hudson.PDF

International Civil Aviation Organization (ICAO). (2002). *Line operations safety audit (LOSA)*. ICAO Doc 9803 AN/761. ICAO, Montreal, Canada. Retrieved June 18, 2005, from http://www.icao.int/ANB/humanfactors/LUX2005/Info-Note-5-Doc9803alltext.en.pdf

International Civil Aviation Organization (ICAO). (2005) *Threat and error management (TEM) in air traffic control.* Preliminary Edition. ICAO, Montreal, Canada. Retrieved October 10, 2005, from http://www.icao.int/ANB/humanfactors/Introducing-Threat-and-Error-Management_final-Oct%2005.pdf

International Civil Aviation Organization (ICAO). (2006) *Safety management manual (SMM)* (1st ed., chap. 7). ICAO, Montreal, Canada.

Job, M., & Tesch, M. (1996). *Air disaster* (Vol. 2, pp. 186-202*)*. Australia: Australia Aviation.

Kasarskis, P., Stehwien, J., Hickox, J., Aretz, A. & Wickens, C. (2001). *Comparison of expert and novice scan behaviors during VFR flight.* Paper presented at the 11th International Symposium on Aviation Psychology, Columbus, OH.

Kirwan, B. (2005). Developing human informed automation in air traffic management. In D. Harris & H. C. Muir (Eds). *Contemporary issues in human factors and aviation safety* (pp. 247-288). Aldershot (UK) and Burlington, VT: Ashgate.

Klinect, J. R. (2005). *Line operations safety audit: A cockpit observation methodology for monitoring commercial airline safety performance*. Unpublished doctoral dissertation, University Texas at Austin, United States.

Knauer, M. (2005). *NOSS: The trials at Airservices Australia*. Paper presented at the 2nd ICAO Global Symposium on Threat and Error Management (TEM) and Normal Operations Safety Survey (NOSS) in Air Traffic Control. Washington, DC 7 to 8 February 2007. Retrieved March 2, 2007, from http://www.icao.int/ANB/human factors/noss2/AirservicesAustralia.ppt

Knauer, M. (2005). *NOSS: The trials at Airservices Australia*. Paper presented at the International Civil Aviation Organization and Eurocontrol, First Global Symposium on Threat and Error Management (TEM) and Normal Operations Safety Survey (NOSS) in Air Traffic Control. Luxemburg. 9 to 10 November 2005. Eurocontrol and ICAO. Retrieved December 11, 2005, from http://www.icao.int/ANB/human factors/LUX2005/Markus_Knauer_Luxembourg.ppt

Kohn, L. T., Corrigan, J. M., & Donaldson, M. S. (1999). *To err is human: Building a safer health care system*. Washington, DC: National Academy Press.

Labour Department. (2002). *A health guide on working with display screen equipment* (1st ed.). Hong Kong: H. K. SAR Government.

Lauridsen, P. (2005). *IFATCA's perspective on TEM and NOSS.* Paper presented at the International Civil Aviation Organization and Eurocontrol, First Global Symposium on Threat and Error Management (TEM) and Normal Operations Safety Survey (NOSS) in Air Traffic Control. Luxemburg. 9 to 10 November 2005. Eurocontrol and ICAO. Retrieved December 11, 2005, from http://www.icao.int/ANB/human factors/LUX2005/Prebens_IFATCA%27s%20Perspective%20on%20TEM%20and%20NOSS.ppt

Majumdar, A., & Polak, J. (2001). *Estimating the capacity of Europe's airspace using a simulation model of air traffic controller workload* (pp. 4-7). Paper No. 01-3250. Presented at the 80th Annual Meeting of the Transportation Research Board. Washington, DC: Transportation Research Board. Retrieved January 20, 2007, from http://www.cts.cv.ic.ac.uk/documents/publications/iccts00190.pdf

Massey University (2006). *Code of ethical conduct for research, teaching and evaluations involving human participants.* Massey University. Revised 26/10/06. Retrieved April 4, 2007, from http://hu manethics.massey.ac.nz/massey/fms//Human %20Ethics/Documents/MUHEC%20Code%20October%202006.pdf

Maurino, D. E., & Ruitenberg, B. (2004). ICAO examining ways to monitor safety during normal ATS operations. *ICAO Journal, 59*(3), 14-16.

Marx, D. (2001). Patient safety and the "just culture": A primer for health care executives. [Electronic version]. *Medical Event reporting System for Transfusion medicine.* Retrieved April 4, 2005, from http://www.mers-tm.net/support/marx primer.pdf

McCall, R. B. (1970). *Fundamental statistics for psychology.* New York: Harcourt, Brace and World.

Medvedev, Z. A. (1990). *The legacy of Chernobyl* (1st ed.). USA: W. W. Norton & Co Inc.

Merritt, A. (2007). *The LOSA archive: The data and how it can be used.* Paper presented at the 2nd ICAO Global Symposium on Threat and Error Management (TEM) and Normal Operations Safety Survey (NOSS) in Air Traffic Control. Washington, DC 7 to 8 February 2007. Retrieved March 6, 2007, from http://ww w.icao.int/ANB/humanfactors/noss2/NOSS_Washington.ppt

Norman, D. J., & Shallice, T. (1986). Attention to action: willed and automatic control of behavior. In G. E. Schwartz, D. Shapiro, & R. J. Davidson (Eds.), *Consciousness and self-regulation, advances in research and theory* (Vol. 4, pp. 1-18). New York: Plenum Publishing Corporation.

Rasmussen, J. (1983). Skills, rules, and knowledge: Signals, signs, and symbols, and other distinctions in human performance models. *IEEE Transactions: Systems, Man & Cybernetics*, SMC-13, 257-266.

Reason, J. T. (1990). *Human error.* New York: Cambridge University Press.

Reason, J. T. (2000). Human error: models and management. *BMJ* 2000; 320:768-770. Retrieved May 4, 2005, from http://www.saferhealthcare.org.uk/NR/rdonlyres/2A5B3A09-87CA-47D2-B72F-4C2853A4E955/0/HumanErrorModelsAndManagement.pdf

Shappell, S. A., & Wiegmann, D. A. (1996). U.S. naval aviation mishaps 1977-92: Differences between single- and dual-piloted aircraft. *Aviation, space, and environmental medicine, 67*(1), 65-69.

Sommerich, C. M. (2005). General ergonomics principles. In J. Anshel, (ed.), *Visual ergonomics.* Boca Raton, USA: Taylor & Francis.

Stanton, N. (1994). A human factors approach. In N. Stanton, (ed.), *Human factors in alarm design* (pp. 1-10). UK: Taylor & Francis.

Sträter, O., & Van Damme, D. (2004). Restrospective analysis and prospective integration of human factors into safety management. In K-M. Goeters, (ed.), *Aviation psychology: Practice and research* (pp. 345-362). Aldershot, UK: Ashgate.

Strauch, B. (2002). *Investigating human error: Incidents, accidents, and complex systems* (pp. 3-28). Aldershot (UK) and Burlington, VT: Ashgate.

Turner, T. P. (2001). *Controlling pilot error: Checklists and compliance.* New York: McGraw-Hill.

Tversky, A. & Kahneman, D. (1982). Judgment under uncertainty: Heuristics and biases. In D. Kahneman, P. Slovic, & A. Tversky (Eds.). *Judgement under uncertainty: Heuristics and biases* (pp. 3-20). UK: Cambridge University Press.

Voller, L., Glasgow, L., Health, N., Kennedy, R., & Mason, R. (2005). Development and implementation of a position hand-over checklist and best practice process for air traffic controllers. In B. Kirwan, M. Rodgers, & D. Schäfer (Eds). *Human factors impacts in air traffic management* (pp. 25-42). Aldershot (UK) and Burlington, VT: Ashgate.

Wallace, B., Ross, A., Davies, J. B., Wright, L., & White, M. (2002). The Creation of a New Minor Event Coding System. *Cognition, Technology & Work, 4*, 1-8.

Wiggins, M. W., & Stevens, C. (1999). *Aviation social science: Research methods in practice.* Aldershot and Brookfield, VT: Ashgate.

Wright, D. (2005). *IFATCA's perspective on TEM and NOSS.* Paper presented at the 2nd ICAO Global Symposium on Threat and Error Management (TEM) and Normal Operations Safety Survey (NOSS) in Air Traffic Control. Washington, DC 7 to 8 February 2007. Retrieved March 7, 2007, from http://www.icao.int/ANB/humanfactors/noss2/IFATCA.ppt

NORMAL OPERATIONS SAFETY OBSERVATION - *Observation Demography*

Observation Number			**Form**		**of**	

AC Positions *(circle as appropriate)*

ACE	ACS	ACW	ACN	ACM	Night-1 (ACE)	Night-2 (ACW)	Night-3 (ACH)

Observation Period (UTC)		
2345 - 0700	0000 - 0800	0150 - 1000
0630 - 1400	0750 - 1600	1345 - 2400

Total Observation Duration

(excluding Break)

Year of Experience	
in ATC	**in AC**

Break Schedule Time Stamp (UTC)	
Start (hhmm)	End (hhmm)

Remarks:	Observation started:	Observation ended :

Appendix A2: NOSO Observation Form – Handover and Takeover

NORMAL OPERATIONS SAFETY OBSERVATION - *Handover and Takeover*

Observation Number			Form		of	

Handover and Takeover Watch

Narrative *Your narrative should provide a context. What did the AC do well? What did the AC do poorly? How did the AC manage threats, AC errors, and significant events? Also, be sure to justify your Threat and Error Countermeasures ratings.*

Handover / Takeover #1	Time Stamp (UTC)	Start:		Finish:	
Handover / Takeover #2	Time Stamp (UTC)	Start:		Finish:	
Handover / Takeover #3	Time Stamp (UTC)	Start:		Finish:	
Handover / Takeover #4	Time Stamp (UTC)	Start:		Finish:	

Appendix A3: NOSO Observation Form – General Operations

NORMAL OPERATIONS SAFETY OBSERVATION - *General Operations*

Observation Number			Form		of	

General Operations

Narrative *Your narrative should provide a context. What did the AC do well? What did the AC do poorly?*
How did the AC manage threats, AC errors, and significant events? Also, be sure to justify your Threat and Error Countermeasures ratings

[All times in UTC]

▶

Appendix A4: NOSO Observation Form – Threat Management

NORMAL OPERATIONS SAFETY OBSERVATION - *Threat Management*

Observation Number			Form		of	

Threat ID	Threat Description					Threat Management	
	Describe the Threat	Threat Code	Time Stamp (hhmm) UTC	Link to 1 - Handover 2 - Takeover 3 - Opening position 4 - Closing position 5 - No link	Link to error 1 - Yes (error code/ID) 2 - No	Threat managed 1 - Yes 2 - No	How did AC manage or mismanage the threat?
T1							
T2							
T3							
T4							
T5							
T6							

See the NOSO Codebook for Threat Codes

Appendix A5: NOSO Observation Form – Error Management

NORMAL OPERATIONS SAFETY OBSERVATION - *Error Management*

Observation Number		Form		of	

Error ID	Error Description						Error Response / Outcome		Error Management
	Describe the Error	Error Code	Intentional non-compliance 1 - Yes 2 - No	Time Stamp (hhmm) UTC	Link to 1 - Handover 2 - Takeover 3 - Opening position 4 - Closing position 5 - No link	Link to threat 1 - Yes (threat code/ID) 2 - No	Error detected by 1 - Nobody 2 - Controller 3 - FDO 4 - Other AC 5 - Supervisor 6 - Other	Error Outcome 1 - Inconsequential 2 - Additional Error 3 - Undesired State	How did AC manage or mismanage the error?
E1									
E2									
E3									
E4									
E5									
E6									

See the NOSO Codebook for Error Codes

Appendix A6: NOSO Observation Form – Undesired State Management

NORMAL OPERATIONS SAFETY OBSERVATION - *Undesired State Management*

Observation Number	

Form		of	

Undesired State ID	Undesired State Description				Undesired State Response / Outcome			Undesired State Management
	Describe the Undesired State	Undesired State Code	Time Stamp (hhmm) UTC	Link to 1 - Threat 2 - Error (enter code/ID)	AC Response 1 - detected 2 - fail to response	Solved by 1 - AC 2 - Controller 3 - Supervisor 4 - No one 5 - Other	Undesired State Outcome 1 - Inconsequential 2 - Additional error	How did AC manage or mismanage the undesired state?
US1								
US2								
US3								
US4								
US5								
US6								

See the NOSO Codebook for Undesired State Codes

NORMAL OPERATIONS SAFETY OBSERVATION - *Threat and Error Countermeasures*

Observation Number			Form		of	

Scale	1	2	3	4	
Performance	**Poor** Observed performance had safety implications	**Marginal** Observed performance was barely adequate	**Good** Observed performance was effective	**Outstanding** Observed Performance was truly noteworthy	

		Performance Markers	Scales
A	Pre-Takeover Self-briefing	Operationally relevant materials (e.g. Self Briefing Notes and Operational Instructions) were reviewed and were fully conversant	
B	Takeover	Listened attentively to all the information passed from the handover watch and raised question to clarify unclear handover items	
C	Handover	The handover was comprehensive, all pertinent information was passed to takeover watch accurately	
D	Post-Handover Support	After handover, AC stayed behind the takeover watch to ensure the takeover watch had clearly indicated having the full picture especially hand over a watch at busy period	
E	Monitor / Cross-check	AC actively monitored and cross-checked the work of other parties (Other ACC, Flight Data Operator and Controller) to detect threats to safety	
F	Scanning	AC utilized available resources to ensure his work was not prone to errors/mistakes and made necessary correction to recover faulty situation	
G	Workload Management	Operational tasks were prioritized and properly managed to handle primary AC duties	
H	Equipment Management	Equipment was properly managed to balance operational and / or workload requirements	
I	Flight Progress Strip Management	Flight progress strips were properly and promptly marked with appropriate strip markings	
J	Adaptability	AC was able to recognize and adapt to changing conditions with effective new action plan	
K	Teamwork	AC worked harmoniously with Flight Data Operator and controller and contributed every effort on routine task and problem-solving situation	

Average Scales: (A + B + C + D + E + F + G + H + I + J + K)		Remark:	

Appendix B1: NOSO Codebook – Threat

Threat Category:-

(TA) Environmental Threats

Threat Type:-

(TA10) Adverse Weather Threats

Threat Natures:-

(TA101) Typhoon

(TA102) Thunderstorm

(TA103) Turbulence

(TA104) Heavy rain

(TA105) Enroute weather

(TA106) Combination/multiple weather threats

(TA199) Other adverse weather threats

Threat Category:-

(TB) Air Traffic Management (ATM) Internal Threats

Threat Type:-

(TB10) Equipment Threats

Threat Natures:-

(TB101) Navaids maintenance

(TB102) Speech processing equipment

(TB103) Handset/headset

(TB104) Computer event

(TB105) Printer event

(TB106) Electronic filing system

(TB107) Inter-area speech circuit

(TB199) Other equipment threat

Appendix B1 (Continued) : NOSO Codebook – Threat

Threat Type:-

(TB20) Workplace Threats

Threat Natures:-

(TB201) Noise

(TB202) External visitor

(TB203) Lighting

(TB204) Air-conditioning

(TB205) Briefing note error

(TB206) Manual/Reference material error

(TB207) Procedure

(TB208) Mobile phone

(TB299) Other workplace threat

Threat Type:-

(TB30) ATM Personnel Threats

Threat Natures:-

(TB301) Non-standard phraseology from controller

(TB302) Non-standard phraseology from another assistant controller

(TB303) Non-standard phraseology from flight data operator

(TB304) Readback error from other ATM personnel

(TB305) No readback on pertinent information by other ATM personnel

(TB306) Supervisory action (e.g., vague instruction)

(TB307) Internal visitor (e.g., staff on break)

(TB308) Incomplete/unclear instruction from controller

(TB309) Incomplete/unclear instruction from other assistant controller

(TB310) Incomplete/unclear instruction from flight data operator

(TB311) Incomplete/unclear instruction from other ATM personnel

(TB312) Poor team interaction

(TB313) Controller error

(TB314) Controller [under training] error

(TB315) Flight data operator error

(TB316) Flight data operator [under training] error

(TB317) Other ATM personnel error [other than TB313 to TB316]

(TB318) Distraction from controller

(TB319) Distraction from other assistant controller

(TB320) Distraction from flight data operator

(TB321) Distraction from other ATM personnel

(TB322) Poor handwriting

(TB399) Other ATM personnel threats

Threat Type:-

(TB40) Operational Performance Threats

Threat Natures:-

(TB401) Combining sectors/positions

(TB402) De-combining sectors

(TB403) Non-standard level

(TB404) Similar/confusing/uncommon callsign

(TB405) Incomplete handover/takeover

(TB406) Problem aircraft

(TB407) CASEVAC/medevac/ambulance flight

(TB499) Other operational performance threat

Threat Type:-

(TB50) Administration Threats

Threat Natures:-

(TB501) Roster event

(TB502) Shift change

(TB503) Transport event

(TB504) Staff shortage

(TB599) Other administration threat

Appendix B1 (Continued) : NOSO Codebook – Threat

Threat Category:-

(TC) Air Traffic Management (ATM) External Threats

Threat Type:-

(TC10) Foreign Area Control Centre (ACC) Threats

Threat Natures:-

(TC101) Non-standard phraseology

(TC102) Readback error

(TC103) No readback

(TC104) Communication equipment failure

(TC105) No communication contact

(TC106) Flow control (e.g., due to weather)

(TC107) Airspace restriction (e.g., due to gun-firing)

(TC108) Missing/incomplete/incorrect information

(TC109) Wrong transfer (e.g., wrong callsign, estimate, etc)

(TC110) Insufficient separation

(TC111) Potentially late transfer

(TC112) Late transfer

(TC113) Poor English (e.g., pronunciation, misunderstanding)

(TC114) Poor quality in communication (e.g., IASC)

(TC115) Macao runway change

(TC116) Speak too fast

(TC117) Complicated coordination/message

(TC199) Other foreign ACC threat

Threat Type:-

(TC20) Airline Threats

Threat Natures:-

(TC201) Flight plan matters (e.g., non-standard route, wrong level)

(TC202) Diversion

Appendix B1 (Continued) : NOSO Codebook – Threat

(TC299) Other airline threat

Appendix B2: NOSO Codebook – Error

Error Category:-

(EA)	Communication Errors

Error Natures:-

(EA01)	No readback
(EA02)	Incorrect readback given
(EA03)	Incorrect readback not detected
(EA04)	Incorrect coordination/transfer not detected
(EA05)	Wrong callsign used
(EA06)	Non-standard phraseology
(EA07)	Missed call
(EA08)	Late coordination
(EA09)	Incomplete/incorrect information given/received during transfer
(EA10)	Do not understand/partially understand incoming message/instruction
(EA11)	Incomplete/incorrect information [except transfer] passed to other sector/ACC
(EA12)	No coordination
(EA13)	Incomplete/incorrect coordination
(EA14)	Wrong transfer
(EA15)	Inappropriate conversation
(EA99)	Other communication error

Error Category:-

(EB)	Equipment Errors

Error Natures:-

(EB01)	Wrong computer input
(EB02)	Communication system manipulation error
(EB03)	No computer input
(EB04)	No fault-reporting
(EB05)	Incomplete/wrong equipment setup
(EB99)	Other equipment error

Appendix B2 (Continued): NOSO Codebook – Error

Error Category:-

(EC) Procedural Errors

Error Natures:-

(EC01)	Wrong strip marking
(EC02)	No strip marking
(EC03)	Incomplete strip marking
(EC04)	Wrong strip delivered to controller
(EC05)	Printed strips with wrong information not spotted/actioned
(EC06)	No cross checking of printed strips against transfer slip
(EC07)	No visual scan of flight progress strip board
(EC08)	No cross-check correctness of information on the strip/transfer slip
(EC09)	No separation check
(EC10)	Late transfer
(EC11)	Overlook separation check
(EC12)	Flight plan not updated
(EC13)	Do not open position
(EC14)	Confusing handwriting
(EC15)	No self-briefing prior to takeover
(EC16)	Incomplete self-briefing prior to takeover
(EC17)	Incomplete/wrong briefing to takeover watch
(EC18)	Failure to make occupancy record
(EC19)	Do not sign Daily Manning Record
(EC20)	Do not sign on equipment
(EC21)	Unaware of airborne BEKOL departure
(EC22)	Unfamiliar with published procedures/operational instructions
(EC23)	Inattentive to duty
(EC24)	No handover
(EC25)	Do not request transfer
(EC26)	Mishandling of transfer slip
(EC27)	Incorrect routeing input in the FDP not spotted
(EC28)	Do not check EFS message

Appendix B2 (Continued): NOSO Codebook – Error

(EC29) Misread EFS message

(EC99) Other procedural error

Error Category:-

(ED) Additional Errors

Error Nature:-

(ED01) Additional error(s) induced by previous error

(ED02) Additional error(s) induced by undesired state

Appendix B3 (Continued): NOSO Codebook – Undesired State

Undesired State Category:-

(UA) Assistant Controller/Controller Positions Undesired States

Undesired State Outcomes:-

(UA01) Radar label displayed without required information

(UA02) Radar label displayed with incorrect information

(UA03) Radar label displayed with insufficient information

(UA04) Traffic situation not being monitored

(UA05) Incomplete handover/takeover

(UA06) Equipment failure

(UA07) Position not opened

(UA08) Incomplete coordination

(UA09) Inaccurate information on the flight progress strip board

(UA99) Other controller position undesired state

Undesired State Category:-

(UB) Traffic Undesired States

Undesired State Outcomes:-

(UB01) Lack of separation assurance

(UB02) Required separation not ensured

(UB03) Airspace penetration

(UB04) No transfer

(UB05) Wrong transfer

(UB06) Late transfer

(UB99) Other traffic undesired states

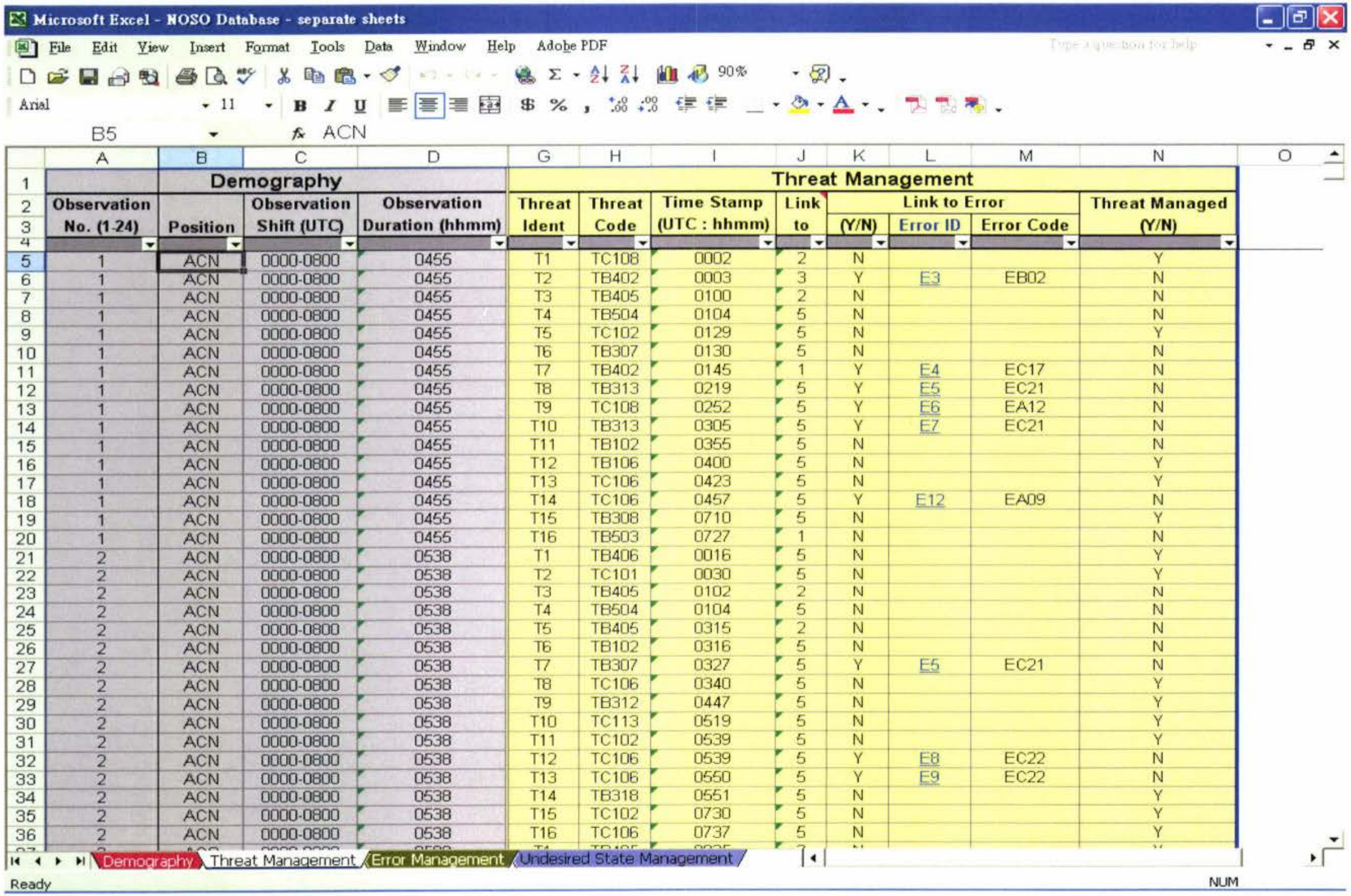
Microsoft Excel - NOSO Database - separate sheets

Observation No. (1-24)	Position	Observation Shift (UTC)	Observation Duration (hhmm)	A	B	C	D	E	F	G	H	I	J	K	Individual Average
Demography				**Summary of Threat and Error Countermeasures**											
1	ACN	0000-0800	0455	3	3	2	2	3	2	3	2	5	2	4	2.60
2	ACN	0000-0800	0538	3	2	3	4	4	3	3	3	5	3	3	3.10
3	ACS	0000-0800	0508	4	3	3	4	4	3	4	3	3	3	3	3.36
4	ACS	0750-1600	0403	3	3	3	2	2	3	3	3	2	3	3	2.73
5	ACE	2345-0700	0450	3	3	3	2	2	2	2	2	2	3	3	2.45
6	ACS	0750-1600	0429	3	3	3	3	3	3	3	3	2	3	4	3.00
7	ACE	2345-0700	0431	3	3	4	4	2	2	3	2	3	3	3	2.91
8	ACH-N	1345-2400	0348	3	3	2	2	2	3	3	3	2	3	3	2.64
9	ACE-N	1345-2400	0539	3	3	2	3	2	2	2	3	2	3	3	2.55
10	ACW	0630-1400	0430	3	3	3	2	2	1	3	3	2	2	3	2.45
11	ACW-N	1345-2400	0508	2	3	3	2	4	4	3	3	4	3	3	3.09
12	ACH-N	1345-2400	0342	3	3	2	2	3	2	3	3	3	3	4	2.82
13	ACE-N	1345-2400	0457	3	3	2	2	3	3	2	3	2	2	3	2.55
14	ACW-N	1345-2400	0510	3	3	3	3	3	3	2	2	3	3	3	2.82
15	ACM	0150-1000	0558	3	3	3	2	3	2	3	3	3	2	3	2.73
16	ACW	0630-1400	0436	3	3	3	4	3	3	3	3	3	3	3	3.09
17	ACW	2345-0700	0436	3	3	3	2	3	3	3	3	3	3	3	2.91
18	ACN	0750-1600	0512	3	3	3	3	3	2	3	3	5	3	3	2.90
19	ACW	2345-0700	0433	3	3	3	2	3	3	3	3	3	3	3	2.91
20	ACN	0750-1600	0453	1	3	3	2	4	2	3	2	5	3	3	2.60
21	ACE	0630-1400	0521	1	3	3	2	2	3	3	2	2	3	3	2.45
22	ACS	0000-0800	0334	3	3	3	2	2	2	2	2	2	3	3	2.45
23	ACM	0150-1000	0533	3	3	3	3	4	3	3	3	3	3	3	3.09
24	ACE	0630-1400	0513	3	3	3	4	4	4	3	3	3	2	4	3.27
				2.83	2.96	2.83	2.63	2.92	2.63	2.83	2.71	2.60	2.79	3.17	2.81
				Averages of each Performance Marker											

5 *Not counted in the above averages*

Demography / Threat Management / Error Management / Undesired State Management

Appendix C2: NOSO Database – Threat Management Worksheet



	Observation No. (1-24)	Position	Observation Shift (UTC)	Observation Duration (hhmm)	Threat Ident	Threat Code	Time Stamp (UTC : hhmm)	Link to	Link to Error (Y/N)	Error ID	Error Code	Threat Managed (Y/N)
5	1	ACN	0000-0800	0455	T1	TC108	0002	2	N			Y
6	1	ACN	0000-0800	0455	T2	TB402	0003	3	Y	E3	EB02	N
7	1	ACN	0000-0800	0455	T3	TB405	0100	2	N			N
8	1	ACN	0000-0800	0455	T4	TB504	0104	5	N			N
9	1	ACN	0000-0800	0455	T5	TC102	0129	5	N			Y
10	1	ACN	0000-0800	0455	T6	TB307	0130	5	N			N
11	1	ACN	0000-0800	0455	T7	TB402	0145	1	Y	E4	EC17	N
12	1	ACN	0000-0800	0455	T8	TB313	0219	5	Y	E5	EC21	N
13	1	ACN	0000-0800	0455	T9	TC108	0252	5	Y	E6	EA12	N
14	1	ACN	0000-0800	0455	T10	TB313	0305	5	Y	E7	EC21	N
15	1	ACN	0000-0800	0455	T11	TB102	0355	5	N			N
16	1	ACN	0000-0800	0455	T12	TB106	0400	5	N			Y
17	1	ACN	0000-0800	0455	T13	TC106	0423	5	N			Y
18	1	ACN	0000-0800	0455	T14	TC106	0457	5	Y	E12	EA09	N
19	1	ACN	0000-0800	0455	T15	TB308	0710	5	N			Y
20	1	ACN	0000-0800	0455	T16	TB503	0727	1	N			N
21	2	ACN	0000-0800	0538	T1	TB406	0016	5	N			Y
22	2	ACN	0000-0800	0538	T2	TC101	0030	5	N			Y
23	2	ACN	0000-0800	0538	T3	TB405	0102	2	N			N
24	2	ACN	0000-0800	0538	T4	TB504	0104	5	N			N
25	2	ACN	0000-0800	0538	T5	TB405	0315	2	N			N
26	2	ACN	0000-0800	0538	T6	TB102	0316	5	N			N
27	2	ACN	0000-0800	0538	T7	TB307	0327	5	Y	E5	EC21	N
28	2	ACN	0000-0800	0538	T8	TC106	0340	5	N			Y
29	2	ACN	0000-0800	0538	T9	TB312	0447	5	N			Y
30	2	ACN	0000-0800	0538	T10	TC113	0519	5	N			Y
31	2	ACN	0000-0800	0538	T11	TC102	0539	5	N			Y
32	2	ACN	0000-0800	0538	T12	TC106	0539	5	Y	E8	EC22	N
33	2	ACN	0000-0800	0538	T13	TC106	0550	5	Y	E9	EC22	N
34	2	ACN	0000-0800	0538	T14	TB318	0551	5	N			Y
35	2	ACN	0000-0800	0538	T15	TC102	0730	5	N			Y
36	2	ACN	0000-0800	0538	T16	TC106	0737	5	N			Y

Appendix C3: NOSO Database – Error Management Worksheet

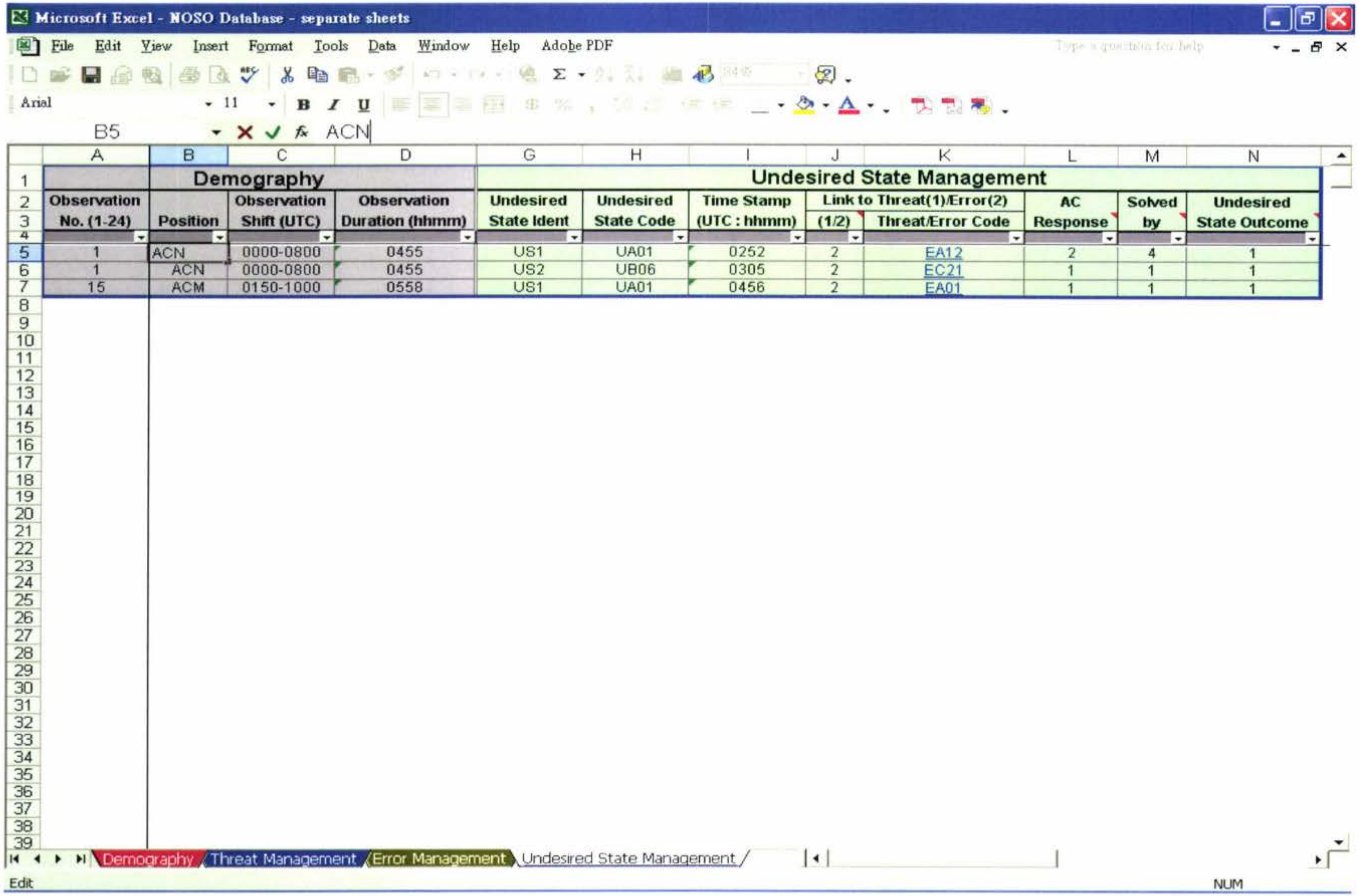
Microsoft Excel - NOSO Database - separate sheets

A1 Demography

Row	ography / Observation No. (1-24)	Demography Position	Observation Shift (UTC)	Observation Duration (hhmm)	Error Management Error Ident	Error Code	Intentional Non-compliance (Y/N)	Time Stamp (UTC : hhmm)	Link to	Link to Threat (Y/N)	Threat ID	Threat Code	Error Detected by	Error Outcome
5	1	ACN	0000-0800	0455	E1	EC99	N	0002	5	N			1	1
6	1	ACN	0000-0800	0455	E2	EC20	N	0002	2	N			1	1
7	1	ACN	0000-0800	0455	E3	EB02	N	0003	3	Y	T2	TB402	3	1
8	1	ACN	0000-0800	0455	E4	EC17	N	0145	1	Y	T7	TB402	1	1
9	1	ACN	0000-0800	0455	E5	EC21	N	0219	5	Y	T8	TB313	3	1
10	1	ACN	0000-0800	0455	E6	EA12	Y	0252	5	Y	T9	TC108	1	3
11	1	ACN	0000-0800	0455	E7	EC21	N	0305	5	Y	T10	TB313	6	3
12	1	ACN	0000-0800	0455	E8	EC17	N	0311	1	N			1	1
13	1	ACN	0000-0800	0455	E9	EC22	Y	0315	5	N			6	1
14	1	ACN	0000-0800	0455	E10	EC21	N	0455	5	N			3	1
15	1	ACN	0000-0800	0455	E11	EA11	N	0456	5	N			1	1
16	1	ACN	0000-0800	0455	E12	EA09	N	0457	5	Y	T14	TC106	1	1
17	1	ACN	0000-0800	0455	E13	EA14	N	0524	5	N			6	1
18	2	ACN	0000-0800	0538	E1	EC99	N	0000	5	N			1	1
19	2	ACN	0000-0800	0538	E2	EC20	N	0000	2	N			1	1
20	2	ACN	0000-0800	0538	E3	EC17	Y	0033	1	N			1	1
21	2	ACN	0000-0800	0538	E4	EA02	N	0230	5	N			1	1
22	2	ACN	0000-0800	0538	E5	EC21	N	0327	5	Y	T7	TB307	3	1
23	2	ACN	0000-0800	0538	E6	EC22	Y	0506	5	N			6	1
24	2	ACN	0000-0800	0538	E7	EB02	N	0528	5	N			6	1
25	2	ACN	0000-0800	0538	E8	EC22	Y	0539	5	Y	T12	TC106	1	1
26	2	ACN	0000-0800	0538	E9	EA11	N	0550	5	Y	T13	TC106	1	1
27	2	ACN	0000-0800	0538	E10	EA11	N	0747	5	N			1	1
28	3	ACS	0000-0800	0508	E1	EC99	N	0025	5	N			1	1
29	3	ACS	0000-0800	0508	E2	EC20	N	0025	2	N			1	1
30	3	ACS	0000-0800	0508	E3	EC22	Y	0040	5	N			1	1
31	3	ACS	0000-0800	0508	E4	EA11	N	0040	5	Y	T3	TC106	2	1
32	3	ACS	0000-0800	0508	E5	EC17	N	0132	1	N			1	1
33	3	ACS	0000-0800	0508	E6	EC99	Y	0227	5	N			1	1
34	3	ACS	0000-0800	0508	E7	EC08	N	0414	5	Y	T14	TB315	1	1
35	3	ACS	0000-0800	0508	E8	EC08	Y	0500	5	N			1	1
36	3	ACS	0000-0800	0508	E9	EC08	N	0520	5	Y	T15	TC201	3	1
37	4	ACS	0750-1600	0403	E1	EC99	N	0823	5	N			1	1
38	4	ACS	0750-1600	0403	E2	EC20	N	0823	2	N			1	1
39	4	ACS	0750-1600	0403	E3	EC05	N	0826	5	Y	T4	TC201	1	1
40	4	ACS	0750-1600	0403	E4	EC05	Y	0920	5	Y	T6	TB315	1	1
41	4	ACS	0750-1600	0403	E5	EA02	N	0921	5	N			6	1
42	4	ACS	0750-1600	0403	E6	EC25	N	1214	5	Y	T8	TC111	1	1

Demography / Threat Management / Error Management / Undesired State Management

Appendix C4: NOSO Database – Undesired State Management Worksheet



Microsoft Excel - NOSO Database - separate sheets

B5 ACN

Demography				Undesired State Management								
Observation No. (1-24)	Position	Observation Shift (UTC)	Observation Duration (hhmm)	Undesired State Ident	Undesired State Code	Time Stamp (UTC : hhmm)	Link to Threat(1)/Error(2) (1/2)	Threat/Error Code	AC Response	Solved by	Undesired State Outcome
1	ACN	0000-0800	0455	US1	UA01	0252	2	EA12	2	4	1
1	ACN	0000-0800	0455	US2	UB06	0305	2	EC21	1	1	1
15	ACM	0150-1000	0558	US1	UA01	0456	2	EA01	1	1	1

Demography / Threat Management / Error Management / Undesired State Management

Performance Markers			Observation number																								Average Scale
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
A	**Pre-takeover Self-briefing**	*Operationally relevant materials (e.g. Self Briefing Notes and Operational Instructions) were reviewed and were fully conversant*	3	3	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	1	1	3	3	3	2.9
B	**Takeover**	*Listened attentively to all the information passed from the handover watch and raised question to clarify unclear handover items*	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3.0
C	**Handover**	*The handover was comprehensive, all pertinent information was passed to takeover watch accurately*	2	3	3	3	3	3	4	2	2	3	3	2	2	3	3	3	3	3	3	3	3	3	3	3	2.8
D	**Post-handover Support**	*After handover, AC stayed behind the takeover watch to ensure the takeover watch had clearly indicated having the full picture especially hand over a watch at busy period*	2	4	4	2	2	3	4	2	3	2	2	2	2	3	2	4	2	3	2	2	2	2	3	4	2.6
E	**Monitor / Cross-check**	*AC actively monitored and cross-checked the work of other parties (Other ACC, Flight Data Operator and Controller) to detect threats to safety*	3	4	4	2	2	3	2	2	2	2	4	3	3	3	3	3	3	3	3	4	2	2	4	4	2.9
F	**Scanning**	*AC utilized available resources to ensure his work was not prone to errors/mistakes and made necessary correction to recover faulty situation*	2	3	3	3	2	3	2	3	2	1	4	2	3	3	2	3	3	2	3	2	3	2	3	4	2.6
G	**Workload Management**	*Operational tasks were prioritized and properly managed to handle primary AC duties*	3	3	4	3	2	3	3	3	2	3	3	3	2	2	3	3	3	3	3	3	3	2	3	3	2.8
H	**Equipment Management**	*Equipment was properly managed to balance operational and / or workload requirements*	2	3	3	3	2	3	2	3	3	3	3	3	3	2	3	3	3	3	3	2	2	2	3	3	2.7
I	**Flight Progress Strip Management**	*Flight progress strips were properly and promptly marked with appropriate strip markings*	5	5	3	2	2	2	3	2	2	2	4	3	2	3	3	3	3	5	3	5	2	2	3	3	*2.6
J	**Adaptability**	*AC was able to recognize and adapt to changing conditions with effective new action plan*	2	3	3	3	3	3	3	3	3	2	3	3	2	3	2	3	3	3	3	3	3	3	3	2	2.8
K	**Teamwork**	*AC worked harmoniously with Flight Data Operator and controller and contributed every effort on routine task and problem-solving situation*	4	3	3	3	3	4	3	3	3	3	3	4	3	3	3	3	3	3	3	3	3	3	3	4	3.2
		**** 20 observations only*** ***# Item I not counted***	# 2.6	# 3.1	3.4	2.7	2.5	3.0	2.9	2.6	2.5	2.5	3.2	2.8	2.5	2.8	2.7	3.1	2.9	# 2.9	2.9	# 2.6	2.5	2.5	3.1	3.3	

Appendix D: Information Sheet

Information Sheet

Normal Operations Safety Observation

This study is designed to explore the threats and errors that take place in Assistant Controller (AC) during normal shifts. It will collect information on threats that AC have to face in everyday operations, how these threats are managed, what errors may result from the threats and how AC manage these errors. All the collected information will be processed and analyzed to form a clear overview of the strengths and weaknesses of AC operations in regard to threats, errors and undesired states encountered by AC in normal operations.

You will be monitored for example, plug in at all times during the course of discharging your duty as an AC. You will not be questioned or commented on your performance by the observer during your work. Your observer will record data from your actions during your work. It has to emphasize that this study is neither a test nor validation on any particular subject; the main idea is to provide all ATC personnel robust information on threats, errors and undesired states so that we can work together to enhance the margins of safety.

The study period is between 4th June and 5th August 2006. Please note that you are under no obligation to complete this study and you may withdraw at any time. Your concern on confidential is fully recognized. The raw data collected from the survey will be carefully protected and de-identified; they will be properly destroyed after the study. In addition, the identity of all the participating ACs will be kept confidential and non-disciplinary.

Your participation in this study is a contribution to safety and thus is highly honored. If you have any questions, please do not hesitate to contact Timothy Yeung on:

Mobile : 9723 5444
E-mail : ac.noso@gmail.com

This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researchers(s) named above are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher(s), please contact Professor Sylvia Rumball, Assistant to the Vice-Chancellor (Ethics & Equity), telephone 0064 6 350 5249, email humanethics@massey.ac.nz

Appendix E: Consent Form

Consent Form

Normal Operations Safety Observation

I have been asked to participate in the research – Normal Operations Safety Observation conducted by Timothy Yeung, and I hereby give my free consent by signing this form. I also understand that:

The research project will be carried out as described in the Information Sheet, a copy of which is for my retention. I have read and understood the Information Sheet and allowed myself the opportunity to have all the questions answered to my satisfaction; furthermore,

My consent to participate is voluntary and I may withdraw from the study at any time. Incidentally I do not have to give a reason for the withdrawal of my consent.

Signature: ______________________ Date: / / 2006

I wish to receive a summary of the overall results of this research. Please send a summary to me at the address below on completion of the study.

Name: ______________________

Address: ______________________

____

or E-mail: ______________________

The format of this consent form is modified from:
Aviation Social Science: Research Methods in Practice, Ashgate, 1999.

This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researchers(s) named above are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher(s), please contact Professor Sylvia Rumball, Assistant to the Vice-Chancellor (Ethics & Equity), telephone 0064 6 350 5249, email humanethics@massey.ac.nz

Appendix F: Abbreviations and Codes used in Threat Management, Error Management and Undesired State Management

Abbreviation:-

ACM Assistant Controller Macao

AFTN Aeronautical Fixed Telecommunications Network

AIC Aeronautical Information Centre

APS Approach Control Supervisor

ATA Actual Time of Arrival

ATCC Air Traffic Control Centre

ATD Actual Time of Departure

CDC Clearance Delivery Controller

CFRC Central Fault Reporting Centre

COD Coordinator

CVSM Conventional Vertical Separation Minimum

DTG Date Time Group

EFS Electronic Filing System

ER En-route Procedural Sectors

ESU Area Control Supervisor

ETA Estimate Time of Arrival

FDO Flight Data Operator

FDPS Flight Data Processing System

FPL Flight Plan

FSS Flight Service Supervisor

HK Hong Kong

HOW Handover

IASC Inter-Area Speech Circuit

ISS Information Support System

kts knots

LSWD Large Scale Weather Deviation

PLC Planner/Controller

R/T Radio Telephony

RNP Required Navigation Performance

RVSM Reduced Vertical Separation Minimum

SID Standard Instrument Department

SMR Surface Movement Radar

SPE Speech Processing Equipment

SSR Secondary Surveillance Radar

TFP Tower FSO (Data)

TOW Takeover Watch

Aircraft Type:-

A319

A333

B773

Navigational Aid:-

LKC

Reporting Point:-

BEKOL

DOTMI

ENVAR

KAPLI

NOMAN

SIERA

Appendix G – Threat Management

Threat Code	Threat Description	Threat Management	Analysis And Comment
TA105	i) Unknown traffic deviated into HK due weather.	i) The AC was barely able (e.g., hesitant intonation) to relay the message to the radar controller though the information relayed was correct.	i) The AC should be able to cope with such a coordination. It should be considered to include poor weather conditions in the HOW board and HOW/TOW briefing to enhance the preparedness.
	ii) An ACC informed the AC that traffic deviating left of track due to weather.	ii) The AC relayed the message correctly to the ER verbally but wrote down a wrong reporting point on the transfer slip was not presented to the controller.	ii) The transfer slip, bearing wrong information, was not presented to the controller.
	iii) Large Scale Weather Deviation in force.	iii) The AC handled the message of cancellation of LSWD. He/she acknowledged and accepted the request of LSWD cancellation from an ACC without the approval of the controller or supervisor.	iii) The message from the ACC was a clarification on whether the LSWD could be cancelled but the AC misunderstood that it was a confirmation message of cancellation of LSWD.

Threat Code	Threat Description	Threat Management	Analysis And Comment
TA105	iv) Traffic deviating around weather.	iv) The AC hardly grasped the ACC's message on the traffic deviating around weather although it was clearly stated by the ACC.	iv) The AC was not ready for unusual message(s). The pre-TOW briefing should include weather information to improve alertness.
TB102	The voice volume of Macao Tower IASC link was exceptionally high and making everybody uncomfortable.	The AC immediately turned the volume switch to an acceptable level; but then turned it back to a higher volume for other IASC links.	The AC adopted a tolerant and temporary measure to react to the problem which should be reported to the supervisor for permanent fixing.
TB104	FDPS generated strips with illogical sector times.	Both the controller and AC were not aware of the illogical sector times. The observer pointed out the wrong estimate to the controller who then instructed the AC to effect a revised transfer.	Deficiency in the FDPS that could not be fixed if the database was not changed.
TB106	The display of the EFS was frozen.	The AC reported to CFRC to get the problem fixed.	The action of fault reporting was correct and prompt.
TB107	i) IASC voice link volume was low.	i) The AC informed the adjacent ACC and requested them to check their equipment.	i) The adjacent ACC refused to check their equipment. The threat could not be managed.

Threat Code	Threat Description	Threat Management	Analysis And Comment
TB107	ii) Incoming voice tone was weak.	ii) The AC requested the adjacent ACC to speak louder.	ii) The AC was aware of the problem and asked for clarification. The action was correct.
TB201	i) Noise created by vacuum cleaner.	i) The noise stopped after 10 minutes.	i) Unavoidable threat.
	ii) Noise created by ESU and APS on HOW/TOW during shift change.	ii) The noise lasted two minutes and stopped when the HOW/TOW finished.	ii) Noise created by the shift change seemed unavoidable, but speech volume could be reduced by the speakers.
TB203	City main power interruption, the ATCC lighting was reset to default lighting intensity setting.	The AC was not distracted by the power supply interruption.	The AC's response to the sudden power failure was calm.
TB205	i) An expired restricted area notification message was on the self-briefing board but there was an updated one in the AC position.	i) The AC was not aware that the restriction area notification message had expired.	i) The FSS did not update the briefing note; however, the updated information was at the AC position. There should be a proper action list for such message delivery.
	ii) Missing item on the briefing note.	ii) LKC was off due flight check; such information was missing on the briefing note and the AC only received the information during TOW.	ii) The FSS did not update the briefing note. That missing item was covered by proper HOW briefing. There should be a proper action list for such message delivery.

Threat Code	Threat Description	Threat Management	Analysis And Comment
TB208	i) Radio interference caused by mobile phone.	i) The AC's mobile phone was in vibration mode; the AC neither returned the call nor turned off the mobile phone.	i) Everyone should switch off their mobile phone before entering the centre.
	ii) Mobile phone rang.	ii) The AC forgot to switch off his/her mobile phone which rang right after TOW.	ii) Appropriate sign already provided right at the ATCC's entrance. It was a matter of culture.
TB306	i) Supervisor imposed a restriction to other ACC but did not put the AC and controller in picture.	i) The AC did not have full picture of the restriction so he/she was confused when coordinating the time requirement with other ACC.	i) The supervisor did not organize and present the message to relevant parties properly. That could induce error to operational staff.
	ii) The ESU ordered sectorisation while HOW/ TOW was taking place.	ii) The inopportune order of sectorisation complicated the HOW/TOW process.	ii) The supervisor should order the sectorisation before or after the HOW/TOW process.
TB307	i) A colleague who was having a break came to chat about non-operational matter.	i) The AC chatted with the colleague and did not notice that a BEKOL departure was airborne. The COD did not voice out the transfer but the FDO did.	i) The threat was not managed; the supervisor should have prevented such internal visitor staying in the centre for non-operational purpose. Teamwork in this case avoided the error.

Threat Code	Threat Description	Threat Management	Analysis And Comment
TB307	ii) Two colleagues were arguing about operational matter at a control position nearby creating noise for five minutes.	ii) The AC was not distracted by the noise.	ii) The supervisor should have prevented such non-essential discussion.
	iii) A colleague who was having a break came to chat on non-operational matter with other colleagues.	iii) The AC chatted with the colleague and did not notice that there was a BEKOL departure airborne.	iii) The threat was not managed; staff on a break should not cause distraction in the operational area. The supervisor should have prevented such an internal visitor staying in the centre.
TB308	i) Complex and unclear instruction from controller.	i) The AC did not understand the whole message and only carried out part of it though it did not cause any consequential effect to the overall situation.	i) All messages should be concise and precise to avoid confusion.
	ii) Unclear instruction from controller.	ii) The ER passed a strip to the AC without any instruction; the AC had to clarify with the ER for his/her intention.	ii) The controller assumed the AC knew his/her intention.

Threat Code	Threat Description	Threat Management	Analysis And Comment
TB312	i) COD passed a message to the AC who was occupied with the IASC. Also COD asked the AC to relay a complicated message.	i) The AC was barely able to relate such a complicated message.	i) The COD should not interrupt the AC while the AC was occupied with the IASC unless urgent. The COD, who had the pictures, should pass the complicated message to another ACC himself as it could take a long time to put the AC in the full picture.
	ii) The FDO was not attentive as far as teamwork was concerned..	ii) The FDO was occupied with personal matter on the phone that the AC had to solve the problem by himself/herself.	ii) Poor teamwork.
TB313	i) The COD did not advise BEKOL departure airborne.	i) The AC did not notice that there was a BEKOL departure airborne. The FDO reminded the AC of the BEKOL departure.	i) Poor ergonomic design. The AC needed to raise his head to check if there was any BEKOL departure from time to time. Although there would be departure message in the EFS, the message would come up to the display sequentially with other messages such that there would be time delay for prompting the AC of such departure. There should be an effective prompt (e.g., alarm) for the BEKOL departure.

Threat Code	Threat Description	Threat Management	Analysis And Comment
TB313	ii) Controller error.	ii) The ER did not cock an outbound strip which was not yet transferred. The AC also did not notice such a flight was not transferred to another ACC. The flight was 20 minutes from the boundary.	ii) Seemingly, both the controller and AC did not notice such a pending transfer; the observer prompted the AC to remind the controller of the non-transferred traffic.
	iii) COD was still not aware of a BEKOL restriction (i.e. 10-minute flow control)	iii) Although the AC was advised by the ACC that 10 minutes was required between BEKOL departures, the AC continued the transfer with 8 minutes apart.	iii) As separation would be infringed and both the AC and controller did not notice the error, the observer had to remind the AC of such a separation oversight and told the AC to inform the controller in turn.
	iv) Controller was not conversant with the restriction imposed by other ACC and asked the AC to request slot time.	iv) The AC advised the controller that such a restriction was being replaced.	iv) Vigilance saved an error.
	v) The controller was inattentive to work because of chatting.	v) The AC raised up the voice to draw the controller's attention to an approval request from an ACC.	v) The action got an effective response.

Threat Code	Threat Description	Threat Management	Analysis And Comment
TB313	vi) A pair of ENVAR traffic to Seoul 11 minutes apart but the following traffic was faster (B773 following A333) and no speed control was imposed by the controller.	vi) The AC reminded the controller who liaised with another ACC to resolve the catching up situation.	vi) Controller's error was saved by AC's vigilant performance.
TB315	i) Missing strip marking.	i) The AC did not detect the missing strip marking.	i) Missing strip marking was not spotted by both the controller and AC for the whole session. The scanning behaviour was poorly executed.
	ii) FDO error.	ii) Absence of strip marking spotted by the AC.	ii) Good fault finding technique.
	iii) FDO error.	iii) The AC was aware of the wrong strip marking by FDO: the direction of arrow was wrong but the AC did not order a new set of strips with the correct direction of arrow.	iii) The AC should avoid this let go attitude on error.

Threat Code	Threat Description	Threat Management	Analysis And Comment
TB317	AIC issued a confusing AFTN message on the cancellation of all DOTMI restrictions without quoting any DTG.	The AC had a current DOTMI restriction so the AC queried AIC on the validity of that message and found out that message was meant to replace a previous restriction.	Correct action in clarifying an ambiguous message.
TB318	The COD talked to the AC on non-ATC matter while the AC was doing a transfer.	The AC disregarded the distraction from the COD and concentrated on the transfer.	The response to the distraction was correct.
TB320	i) The FDO dined next to the AC.	i) No one intervened such dining activities.	i) Food could produce smell which caused distraction or even discomfort. Eating in the centre should be banned.
	ii) Distraction from FDO during HOW.	ii) The HOW was intermittently interrupted by FDO who was chatting with the AC about non-operational matter.	ii) The AC should ignore the FDO's interference through chatting by a positive gesture.
TB322	Controller received a transfer for the AC; however, the handwriting was illegible on the transfer slip.	The AC then confirmed the transfer details with the ACC.	Correct action in clarifying a transfer; it was a correct attitude to clarify something when there was a doubt.

Threat Code	Threat Description	Threat Management	Analysis And Comment
TB399	The HK runway had been changed 20 minutes ago, but the runway-in-use sign board was showing the previous runway-in-use.	The AC noticed the runway change and informed the controllers who changed the runway-in-use sign board.	The observant AC spotted the error.
TB401	i) High workload due to combining sectors.	i) The workload built up quickly from incoming calls of other ACCs. The AC had to defer the callers by telling them to call back. The AC's workstation was overwhelmed by strips, transfer slips and non-stop IASC calls.	i) The AC was well behind of traffic, assistance was required from either the controller or sectorisation was to be in place.
	ii) Workload built up due to sector combination.	ii) The AC was too occupied to cross-check the controller's oversight on revised transfer.	ii) High workload pulled down an error barrier – the AC in this case. Supervisor should have provided manpower or supervision to resolve the workload.
	iii) Unnecessarily combined positions.	iii) The AC followed the instruction of the FSS to additionally man the FDO position due to staff re-deployment. Workload was moderate then.	iii) The FSS did not assess the traffic situation comprehensively before making the decision of combining positions.

Threat Code	Threat Description	Threat Management	Analysis And Comment
TB401	iv) No HOW for combined sector.	iv) The AC did not ask for HOW items.	iv) It seemed it was a norm for a brief or even no HOW as there were couples of similar events.
TB402	i) The AC received a HOW from the other AC; the AC moved over and set up new position for sectorisation.	i) The AC was not aware the BUZZ function was not switched on in the SPE. The FDO reminded the AC that the BUZZ function was off.	i) The threat of opening position was not managed that equipment was not properly set up. A checklist might facilitate the HOW/ TOW process.
	ii) De-combining sectors.	ii) The AC forgot to HOW two items to another AC; but the AC noticed that the two missing items eight minutes later.	ii) The threat of de-combining sectors was not managed that gave rise to error. A checklist could avoid the missing items in the HOW briefing.
TB403	i) Non-standard level offered by an ACC.	i) The AC checked the flight progress strip board and did appropriate marking and transfer.	i) Very cautious on accepting non-standard items.
	ii) The AC was instructed to request non-standard transfer level from an ACC.	ii) The AC received approval from the ACC and revised the transfer; however, the action of transfer was not completed because tick was missing.	ii) It had to be very cautious to accept or approve non-standard procedures and also routine checking had to be maintained while exercising extra caution.

Threat Code	Threat Description	Threat Management	Analysis And Comment
TB404	Unusual/similar callsigns.	The AC asked the ACC to say again in order to copy the callsign correctly.	Threat was mitigated by "say again" requesting for confirmation and clarification.
TB405	i) Missing item in the briefing during TOW.	i) The HOW AC did not brief what runway was in-use; however, the runway-in-use signboard displayed the current runway-in-use.	i) A signboard could provide information on missing item in the HOW provided it was updated. A checklist should be provided and then followed by every AC in the HOW/TOW process.
	ii) Incomplete HOW/TOW.	ii) The AC was not briefed that one of the IASC links was not manned.	ii) Same as above, a checklist should be provided to ensure completeness in HOW/TOW process.
	iii) Incomplete HOW from the relief AC.	iii) The AC accepted the brief HOW.	iii) The threat was not managed. The relief AC should go through considerable items in the HOW, preferably follow a checklist.
	iv) A quick HOW from the relief AC "continued".	iv) The AC accepted the HOW and did not ask any question.	iv) Instruction should be issued to remind all AC to conduct comprehensive HOW/TOW process for every HOW/TOW.
TB406	i) An outbound returned to HK due to technical reason.	i) The AC carried out proper and prompt notification and relevant form completed.	i) The AC was very conversant with returned flight procedure.

Threat Code	Threat Description	Threat Management	Analysis And Comment
TB406	ii) Aircraft with technical problem.	ii) The AC did not fully understand the text pertaining to the nature of the problem conveyed by the IASC message. As such, the nature of the problem of the flight was not copied.	ii) The AC could ask the ACC to speak slowly and if required, asked the ACC to spell out the nature of problem.
TB407	Medevac flight.	The FPL indicated the flight would not enter either AC sector.	Non- essential information was not screened properly by previous watch AC.
TB503	Tight schedule of staff transportation.	The AC quickly went through the HOW and then left immediately.	The AC would have to wait half an hour for the next shuttle bus. The AC would have to wait for half an hour for the next bus if he/she missed the 3:30pm bus.
TB504	Staff shortage due to staff sickness without replacement.	The AC had to work in combined mode until such time another AC was available to split the combined position.	The threat could not be managed by the AC. Whether the AC was aware of his/her limit or not, he/she should be provided with an AC-rated flight data operator to render assistance if team resources permitted.
TC101	An ACC did not use standard phraseology. The AC did not understand.	The AC did not understand the message and asked for say again to clarify the message.	Threat was mitigated by "say again" requesting for confirmation and clarification.

Threat Code	Threat Description	Threat Management	Analysis And Comment
TC102	Another ACC wrongly read back a callsign and estimate in a transfer.	The AC spotted the readback error	Attentiveness and vigilance saved a possible readback error.
TC103	i) No readback from an ACC.	i) The AC did not ask the ACC to read back the level.	i) This was not a mandatory requirement on readback but highly recommended if workload permitted.
	ii) No readback from an ACC.	ii) The AC asked the ACC to read back a callsign.	ii) Asked for readback if in doubt.
TC106	i) Guangzhou ACC informed HK to cancel the flow control restriction.	i) The AC carried out notification. He/she informed CDC that "BEKOL restriction cancelled"; that phrase was not precise enough and could even be misleading.	i) The AC should use "cancel BEKOL restriction message no. xxx" instead.
	ii) Flow control restriction from an ACC.	ii) Although the AC carried out proper notification actions, one of the restriction items was not clarified. The ER noticed the vague item and instructed the AC to clarify that item with Guangzhou ACC.	ii) This highlighted very often the AC was just a mouth piece although in many cases the AC could spot the vague information. Only the experienced AC would query and clarify otherwise vague information for the benefit of the controller who would really be interested in having proper information.

Threat Code	Threat Description	Threat Management	Analysis And Comment
TC106	iii) An ACC passed a time slot to HK departure for Beijing with reason.	iii) The AC related the message to the COD but the AC did not mention the reason (due weather).	iii) The AC should ensure all the relevant information on the flow restriction sheet was passed to the appropriate party.
	iv) An ACC passed a BEKOL flow control restriction.	iv) The AC carried out the notification actions correctly and promptly.	iv) The AC was conversant with the procedure and that made the job very handy.
	v) Flow control restriction from an ACC. The aerodrome being flow was vague for example, Shanghai 10 minutes flow.	v) The AC did not ask for the reason of the flow control although the AC clarified the details of the flow restriction and carried out proper notification actions. No one requested the reason for the flow control.	v) Again, the AC could only function as a mouth piece. With more experience and attentiveness, the vague information could be recognised.
TC107	Danger area active.	The AC reminded the ER of a danger area that could affect KAPLI traffic.	This was not an uncommon situation; it occurred more or less every evening around the same time.
TC108	i) An ACC only read back the BEKOL transfer but did not acknowledge the approval request on low level crossing at BEKOL.	i) The AC clarified with the ACC.	i) Readback on level was very important; therefore, it gave food for thought on treating the readback as a mandatory requirement in view of this situation.

Threat Code	Threat Description	Threat Management	Analysis And Comment
TC108	ii) Incorrect information from another ACC.	ii) The AC detected and clarified with the ACC on a wrong SID.	ii) The AC could apply book knowledge when performing the job.
	iii) Macao Tower did not pass pertinent information on departure.	iii) The AC assumed the ACM had such pertinent information and did not verify with ACM and relayed the information to the controller directly.	iii) The threat was not managed and it led to an undesired state. The AC should relay pertinent information through proper communication channel.
TC109	i) Wrong transfer estimate in a transfer from an ACC.	i) The AC queried the illogical transfer estimate and the ACC passed a revised transfer estimate.	i) The AC's vigilance identified the error created by other ACC.
	ii) Wrong transfer level from other ACC.	ii) The AC did not spot the error and passed the transfer slip to the FDO for processing. A minute later, the ACC revised the transfer level.	ii) The AC failed to check the accuracy of information on receiving transfer. Extreme care to be exercised when it comes to pertinent information such as flight level.
	iii) Wrong transfer level.	iii) An ACC transferred a CVSM flight at F350; the AC spotted the wrong level and advised the ACC to transfer it at a correct level.	iii) The AC's vigilance identified the error created by other ACC. This error could give rise to a separation problem.

Threat Code	Threat Description	Threat Management	Analysis And Comment
TC110	An ACC transferred two arrivals with insufficient time separation	The AC reminded the ACC to provide sufficient separation.	The AC's vigilance identified the error created by other ACC.
TC111	i) Potentially-late transfer.	i) The AC should have requested transfer from Sanya ACC.	i) There was not sufficient alert for the AC to chase up for transfer from another ACC. A warning signal for example, blinking might help.
TC111	ii) A pending inbound with estimated time over the boundary 20 minutes from SIERA but there was no transfer from the ACC.	ii) The AC noticed that and asked the FDO to contact company for latest information.	ii) The action was correct but would be perfect if the AC could ring up the ACC concerned to request transfer.
TC112	i) Late transfer from other ACC.	i) The AC neither reminded that ACC to transfer promptly nor asked the FDO to expedite processing that transfer.	i) A reminder can sometimes alert other ACC and also the AC was in lack of priority.
	ii) Late transfer from an ACC.	ii) The AC received the late transfer and passed the transfer slip to the FDO immediately for strip printing.	ii) The action was quick and effective.
TC113	i) Poor English pronunciation of "Squawk" vs "Squall".	i) The AC requested Zhuhai ACC to say again a few times	i) "Say again" could always make clear the context of the message.

Threat Code	Threat Description	Threat Management	Analysis And Comment
TC113	ii) Poor understanding of English.	ii) The AC spoke slowly to Guangzhou ACC and rephrased the enquiry in simple English.	ii) Good tactics.
TC114	Poor quality in voice link.	The AC copied wrongly ATIS identification from Macao Tower, which noticed the wrong readback and corrected the AC.	That threat could only be managed if the AC asked Macao Tower to speak up, or asked them to say again for confirmation.
TC115	Macao runway change.	The AC changed all the SID to new runway SID, revised all those being transferred to another transfer point and ACC, but the AC entered a wrong SSR code in a Macao departure.	A slip in typing in a high workload situation.
TC116	An ACC spoke very fast in a transfer.	The AC barely copied the transfer details but did not tell the ACC to speak slowly.	A reminder to the ACC requesting them to speak slowly could avoid wrong copying of messages.
TC117	i) Neighbouring ACCs IASC failure, HK acted as a relay station for ACC messages.	i) The AC was asked to relay transfer messages between Taipei ACC and Manila ACC. The callsign and reporting point were both unfamiliar to the AC.	i) Under this unusual situation, the AC was very cautious in taking the message and read back slowly to ensure correctness.

Threat Code	Threat Description	Threat Management	Analysis And Comment
TC117	ii) The AC was instructed to relay a complicated message and effect immediate coordination with an ACC.	ii) The AC did not have full picture of the traffic scenario, therefore, the message was relayed with difficult and finally the AC was told by the controller to revise the level in accordance with an ACC request.	ii) The AC did not understand the full context of the messages from both the ACC and the controller. The message relayed was a bit clumsy and inaccurate.
TC201	i) True airspeed of a flight plan was wrong.	i) The FDO, AC and controller were not aware of the wrong true airspeed (392kts A319) on a DOTMI outbound warning strip. No one noticed the wrong true airspeed.	i) Relied too much on machine which was unable to check illogical data on the FPL. The database of the FDPS would probably need to be updated.
	ii) No FPL for an inbound transfer.	ii) The AC requested FPL details from the transferring ACC.	ii) The handling was simple and smooth.
	iii) FPL error.	iii) FPL aircraft type A319; its wake turbulence category was mistyped as "H". The AC did not check the correctness of information on the strips.	iii) The wrong wake turbulence category was spotted by FDO.

Threat Code	Threat Description	Threat Management	Analysis And Comment
TC201	iv) No indication of status of flight in a flight plan remark column (non-schedule flight).	iv) The FDO and the AC did not check with the company or tower whether this flight was a cargo flight or not. The TFP informed the FDO that the flight was a cargo flight.	iv) Did not pay enough attention to unusual callsign(s) which quite often belonged to private jet and/or freighter.
	v) FPL with neither ATD nor delayed message.	v) The AC sent a message to other ACC to ask for latest progress of flight; the AC used a wrong FPL DTG in the message.	v) Correct action but slip in message content.
	vi) FPL without ATD.	vi) The AC sent message to departure aerodromes asking for ATD and the AC asked the FDO to call up company for latest information of those flights without ATD.	vi) The action was correct.
	vii) An inbound transfer having SSR code different with the code in its departure message.	vii) The AC clarified the SSR code with the transferring ACC.	vii) The action was correct.

Appendix H – Error Management

Error Code	Error Description	Error Management	Analysis And Comment
EA01	No readback on level.	The AC did not read back an initial level assigned by an ACC in a transfer.	Although it was not a mandatory requirement for one to read back a transfer, it was highly recommended to read back some pertinent information such as flight level and estimate.
EA02	i) The AC read back a callsign wrongly.	i) The AC read back a wrong flight number to the CDC who did not notice the wrong readback.	i) Simply a "hear back" and "read back" error. Both parties were not careful enough in verbal message handling.
	ii) Incorrect readback given.	ii) The AC read back a level wrongly. This was spotted and corrected by Manila ACC.	ii) This was the purpose of readback.
EA04	Incorrect information on flow control from other ACC not detected.	The AC carried out notification to other parties and did not notice the inaccurate information.	The AC did not comprehend the message completely but just acted in a mechanical way.
EA05	Wrong R/T callsign.	The AC used "HK XX" instead of "HK Government XX" in a transfer but the receiving ACC read back the transfer callsign correctly.	Unfamiliar with local operator R/T callsigns, it was a rule-based error.

Error Code	Error Description	Error Management	Analysis And Comment
EA06	The AC did not use the full callsign in coordination.	The AC assisted another AC by taking transfer of a flight; after copying the transfer, the AC informed the helper that only the airline designator was copied for the transfer; the flight number was not mentioned.	There was a risk of having two or more flights from the same airline.
EA09	i) Incorrect transfer information passed to an ACC.	i) The AC mistook another departure time as the BEKOL transfer although the error was within four minutes' buffer.	i) A slip in picking a wrong figure for calculation; however, it had to be noted that the display of those figures was not arranged in an ergonomic way for sighting.
	ii) Incomplete revised transfer.	ii) The AC only revised the level to an ACC but overlooked the need for estimate revision. That was discovered by the controller.	ii) The controller checked Box 12 of the strip and noticed one item was not acted upon.
EA10	The AC did not understand an enquiry from other ACC.	The enquiry was not complicated to be comprehended but the AC needed other ACC to say again a few times to capture the meaning.	The quality of the link was acceptable. It was purely the AC who was not accustomed to being asked something other than a routine task, for example, transfer.
EA11	i) The AC relayed wrong information to other AC sector.	i) The AC informed another AC sector of wrong callsign but that sector did not query.	i) Another example of "hear back" and "read back" error. Both parties were not careful enough in verbal message handling.

Error Code	Error Description	Error Management	Analysis And Comment
EA11	ii) The AC passed wrong callsign (wrong flight number) and wrong squawk code to an ACC on a training flight.	ii) The AC read out the flight details from the flight plan and was not aware of wrong information being passed to the ACC which did not query.	ii) Same as above.
	iii) The AC passed incorrect information to the ACC which asked for ATA of a problem aircraft.	iii) The AC gave an estimated arrival time instead of an actual landing time.	iii) The AC was not attentive enough. That might be the case the AC mistook ATA for ETA.
	iv) The AC relayed wrong information to the COD.	iv) The AC relayed to the COD a wrong initial level assigned by another ACC. The observer pointed out the error.	iv) It was a fatal error and the result could be a serious undesired state. The observer noticed that the AC would not be aware of the slip of tongue; therefore, such a pointing out by the observer had to be made.
EA11	v) Incomplete information passed to the controller.	v) An ACC advised a local flight requesting "touch and go" and such a request was not relayed to the controller.	v) Pertinent information was filtered by the AC. There were two possibilities, namely, either the AC did not copy the message or the AC did not understand the message and no query was made; the AC might think that was not important.

Error Code	Error Description	Error Management	Analysis And Comment
EA12	The AC assumed the ACM had the pertinent information and did not verify with ACM.	The AC did not inform the ACM about a Macao departure.	Assumption gave rise to error in many situations. In this case, the ACM was not notified that the flight SSR code was not entered into the FDPS; as a result, aircraft airborne without flight plan correlation i.e. an undesired state.
EA13	i) Incomplete information on transfer passed to the controller.	i) After transfer, the AC advised the controller "standard" and the controller had to clarify the meaning of "standard".	i) Although it was a standard procedure, the majority of AC would voice out the exact figures and the controller would become "confused" by anything unusual but "standard".
	ii) Incomplete information to another ACC.	ii) The AC did not specify the callsign although that callsign was in the Entry List of the PLC. The AC requested "Any SIERA transfer?"	ii) The message was concise but not precise. The callsign on request should be specified so that other party could really look for the requested information.
EA14	The AC transferred a wrong level to an ACC.	The ACC acknowledged the wrong revised transfer level from HK ACC.	The observer prompted the AC that it was a wrong transfer level.
EB01	i) Wrong information was input into the PLC.	i) The AC typed a wrong SID into the PLC; this was discovered by the FDO who reminded the AC to do the correction.	i) A slip in data entry.

Error Code	Error Description	Error Management	Analysis And Comment
EB01	ii) Entered a wrong SSR code into the FDP.	ii) The AC was occupied with changing SID of all Macao departure strips/PLC and revised transfers and a mistake was made in the computer input.	ii) A slip in data entry. Aircraft airborne without correct correlation.
EB02	i) The SPE line was still engaged after communication.	i) The AC did not switch off the SPE line after exchange of messages with an ACC.	i) It was strange that some AC did not switch off the link after communication. They relied on the link to be terminated automatically.
	ii) The AC turned off the BUZZ of the SPE as when he/she left the position for the bathroom.	ii) The AC informed the controller that the position was not manned temporarily. However, it was not mentioned that the SPE was muted.	ii) A wilful violation. This move could block important message(s) from other ACC to reach the intended recipient in time.
EB02	iii) Message from an ACC was not copied by the AC completely.	iii) The AC copied the first part of a query message then removed the earpiece to relay the information to the controller without noticing that the ACC hadn't finished the message.	iii) R/T discipline was not observed. The AC was eager to pass the message to the controller and it was inappropriate simply to remove the earpiece without telling the ACC to "standby".

Error Code	Error Description	Error Management	Analysis And Comment
EB04	The AC did not make fault-reporting.	Although an ACC advised the readability was 3 only, the AC did not take action i.e. fault reporting.	The AC would rather live with marginal quality of the intercom.
EB05	Incomplete equipment setup.	The FDO reminded the AC to turn on the ISS display.	A checklist, if so available, might help the AC to follow the setup procedure.
EC01	The AC wrote a wrong estimate in Box 12 of a strip.	However, the correct information was passed to other ACC.	A slip in handwriting.
EC02	i) No strip marking.	i) The AC did not mark the strip after transfer for example, revised transfer level in Box 12 or tick Box 12.	i) It was a night shift; it might be a night effect that the AC could not concentrate fully.
	ii) Missing strip marking.	ii) The AC did not annotate a red circle on the equipment (without "R") on a warning strip.	ii) A slip in checking on strip.
EC04	Wrong strip delivered to the controller.	The AC passed one strip to the ER for a NOMAN departure. The controller noticed that it was a departure and asked the AC for another strip.	Inattentive to work.
EC05	Wrong information on strips not detected.	Nobody was aware of the wrong true air speed on the strips.	Relied too much on the database of the FDPS. It also highlighted the deficiency of the system.

Error Code	Error Description	Error Management	Analysis And Comment
EC07	The AC did not scan the flight progress strip board to detect error.	Both the AC and ER were not aware of a flight not yet transferred to Sanya ACC. The observer advised the ER of such an oversignt in transfer.	The observer had to prompt both the ER and AC in this incident as this would be a serious mistake if not corrected.
EC08	i) The AC did not check the correctness of information on the strips.	i) The AC just passed on the strips from FDO to the ER without checking the strips at all.	i) It is a rule-based error. The AC recklessly passed the strips to the controller.
	ii) The AC wrote wrong information on the transfer slip.	ii) The AC wrote "RW" on transfer slip but the flight was non-RNP10, the FDO pointed out the error to the AC.	ii) Teamwork prevented such an error.
EC13	Heavy traffic but still in combined mode.	The workload was so high that the AC barely handled the work.	The AC should ask for assistance. There was just too much traffic to handle. Supervisor around should render assistance or order sectorisation.
EC14	i) Confusing handwriting.	i) The handwriting was barely legible.	i) An error-prone handwriting.
	ii) Illegible handwriting.	ii) The FDO misread the estimate on the transfer slip. The AC discovered that the printed estimate was incorrect.	ii) The AC should learn his/her own lesson that the poor handwriting he/she created would be reflected in the output.

Error Code	**Error Description**	**Error Management**	**Analysis And Comment**
EC15	There was no self-briefing prior to TOW.	The AC should have updated himself/ herself with the latest instructions through self-briefing.	It was a violation.
EC17	i) The AC briefed the relief AC wrong number of pending BEKOL through area traffic in the BEKOL departure log sheet.	i) The AC was not aware of this error.	i) The wrong information did not cause any problem at all; it was just a matter of accuracy in HOW.
	ii) By saying "noting special", the AC did not provide a complete HOW to the relief AC.	ii) The AC only gave a HOW on the runway-in-use.	ii) The relief AC should not accept the HOW. He/she should ask for information on traffic and pending item to show that a systematic HOW was desirable.
EC18	i) Did not sign the occupancy record.	i) No one noticed the missing entry in the occupancy record.	i) A rule-based error.
EC18	ii) Did not sign the occupancy record.	ii) The FD reminded the AC to sign the occupancy record.	ii) Teamwork recovered such an error.
EC19	The AC did not sign the Daily Manning Record prior to TOW.	The AC should have signed the Daily Manning Record to acknowledge he was conversant with the latest instructions.	A rule-based error.

Error Code	Error Description	Error Management	Analysis And Comment
EC20	PLC was not signed on with the AC personal R/T initials.	The AC did not sign on with personal R/T initials during opening position and all TOW sessions.	There was only one out of 24 observations the AC signed on the PLC. It had to be noted that the "sign on" requirement was a bit tedious as the AC needed to sign the Daily Manning Sheet, occupancy log book and EFS during a shift. Such repeated processes should be kept to a minimum.
EC21	COD voiced out BEKOL departure airborne but the AC did not copy the message.	The AC did not copy COD's message. The FDO reminded the AC of the BEKOL departure.	Teamwork recovered the error.
EC22	i) The AC was not familiar with the published procedure.	i) The AC requested an ACC to *transfer a flight departing from* Shenzhen to Macao while Macao runway 16 was in use.	i) The AC was not able to change to another set of operating mode after runway change. A checklist or quick reference material around might help the AC to recall what the changes were.
	ii) The AC was not conversant with airspace dimensions.	ii) The AC did not know the vertical limits of ACCs which were overlapping each other.	ii) A new procedure that was still new to the AC.
	iii) Unfamiliar with airline telephony.	iii) The AC used an old telephony on airline ALK "Air Lanka" in transfer.	iii) A slip in memory but the AC could still pronounce the telephony in alphabets that did not cause any problem at all.

Error Code	Error Description	Error Management	Analysis And Comment
EC23	i) Inattentive to duty.	i) The AC read non-ATC material for three minutes.	i) It was common during a slack period.
	ii) Lunch at workplace.	ii) The AC continued with lunch without any complaint.	ii) The break pattern did not match with the meal time; the next break will be hours later, therefore, that promoted the meal at the workstation.
EC24	No briefing provided to AC helper.	The AC did not brief the AC helper about the runway-in-use, traffic on the flight progress strip board, etc.	A poor helper relationship. Without a picture of the traffic situation, the function of helper would be depleted.
EC25	Did not request transfer.	The AC neither requested transfer from an ACC nor sent an AFTN message to request the latest progress of the flight.	It was a requirement to chase up possible late transfer from another ACC. However, there were a number of flights that were within 20 minutes of the estimated time over the boundary and this situation often existed; besides, no departure message received for any one of these flights; therefore, it could discourage the AC to keenly chase up the transfer. Insufficient alert for pending inbounds on the system itself could be another possible reason.

Error Code	Error Description	Error Management	Analysis And Comment
EC26	Mishandling of transfer slip.	The AC passed a revised transfer slip to ER but the relevant strips were still with FDO and the AC should have noted that.	Such a deficiency in executing procedure had to be reiterated in the HOW note and also there should be alerting functions in the system for example, the callsign concerned was blinking.
EC27	Incorrect routeing input in the FDPS.	An AC of another sector noticed the error and informed the AC to verify the flight plan routeing.	The error was spotted by another AC section because that flight would transit that AC sector: team work recovered the error.
EC28	Did not check EFS message.	The AC as a matter of course pressed the acknowledge key to get rid of all the messages in the EFS.	Workload was not the explanation for such a behaviour. It was a wilful violation of procedure.
EC29	Misread EFS message.	The AC misread SIA802 as TGW802 for the prepared transfer slip.	A slip on callsign confusion.
EC99	i) Emergency frequency 121.5 or 121.5 Xisha not guarded.	i) Such an error was not detected for the whole session of the observation and the AC did not do anything about it.	i) Though it was an old Kai Tak practice and there is a written instruction written in the manual for Chek Lap Kok Airport, the emergency frequency was not monitored for each of the 24 observations in NOSO.
	ii) Absence without informing the controller.	ii) The AC left his/her position for the bathroom without telling the ER.	ii) Position not manned without informing anyone; it was simply a wilful violation.

Error Code	Error Description	Error Management	Analysis And Comment
EC99	iii) Did not process transfer.	iii) The AC passed the transfer slip to the FDO when the flight was about 23 minutes from KAPLI.	iii) Trying to avoid the work induced by possible revised transfer, the AC delayed actioning the transfer until it was apparent there would be no revision. This strategy of avoiding extra workload should not be encouraged as the controller would not have the true picture of traffic in time.

Appendix I – Undesired State Management

Undesired State Code	Undesired State Description	Undesired State Management	Analysis and Comment
UA01	Without the information of SID and SSR code, there were no departure strips nor correlation of aircraft SSR code and callsign.	No action taken but the ACM entered the information into the FDP system after the outbreak of event.	Macao tower did not pass departure information of a DOTMI flight to HK in the first place (a threat); the ACN answered a call from Macao tower on that flight and assumed the ACM had the required information. The ACN should not bypass the information for ACM.
UA01	A Macao departure airborne without FDP correlation.	The AC quickly entered the correct SSR code in the PLC.	The undesired state was originated from Macao runway change (a threat) during peak hours. The AC entered a wrong SSR code into the FDP; this error could be avoided if the AC just changed the SID in FPL active mode. The AC chose a method which was prone to error.
UB06	BEKOL departure was four minutes from BEKOL when transfer was effected.	5 minutes after the BEKOL departure, the ACN checked the departure list and noted that the BEKOL departure was not yet transferred.	The COD did not notify the ACN a BEKOL departure (a threat). The AC was also distracted by an APS who was conducting an investigation which was relevant to the AC. Lack of team role and effective prompt (e.g., alarm, flight data operator) for all the BEKOL departures.