

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

Threat and Error Management: An Analysis of Reported Safety Occurrences to the Civil
Aviation Authority of New Zealand 1998–2007

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

Master of Aviation

at Massey University, Palmerston North,
New Zealand

Timothy Graham

2010

Abstract

Current safety reports indicate a rise in the number of reported incidents involving both medium and small aeroplanes and helicopters. The purpose of this study is to identify specific threats, errors and Undesirable Aircraft States (UAS), present in safety-related occurrences reported to the Civil Aviation Authority of New Zealand (CAANZ).

Threat and Error Management (TEM) is used to improve safety margins in aviation operations through the practical integration of human factors knowledge. The TEM framework is used to guide the investigation of reported safety-related occurrences in a way that systematically identifies specific threats, errors and UAS.

This research employs the predictive safety method by investigating reported historical events, followed by analysing each event to list threats, errors and UAS. If a threat, error or UAS is identified in an occurrence, it is then marked 'present' under the corresponding column of the TEM taxonomic. After the completion of the classifications, solutions can be developed to prevent similar occurrences in the future.

To test for accuracy and consistency of threat, error and UAS classifications, ten randomly chosen occurrences were provided to ten aviation professionals. These tests included Cohen's Kappa test and a percentage of agreement test. Cohen's Kappa results reached significant agreement with half of the respondents and an overall percentage of agreement of 68 per cent compared with the researcher's classifications.

Results from the TEM classifications show the majority of threats had environmental influences and procedural errors. The most common UAS resulted mainly from Ground Navigation and Aircraft Handling operational conditions.

The TEM technique enabled a focus on the events that contributed to an incident rather than an accident. By applying the results from this TEM taxonomic, it is hoped

that pilots will benefit from a better understanding of the importance of TEM and how frequently threat and errors contribute to incidents. This research would then help flight operators and pilots better prepare themselves to react to the likelihood of specific threats or errors, if and when they occur.

Acknowledgements

This research has been made possible by:

- the love and support of Shelley Powell;
- the vast knowledge, wisdom and patience of Dr Ross St George;
- the Civil Aviation Authority of New Zealand (CAANZ); and
- the early input of Dr Jose Perezgonzalez, Paul Lee and Robert Yaansah.

Table of Contents

Abstract.....	ii
Acknowledgements.....	iv
Table of Contents.....	v
List of Tables	ix
Glossary.....	x
1.0 Introduction	1
2.0 Literature Review.....	3
2.1 Aviation Safety	3
2.2 Accidents and Incidents	5
2.3 Human Error Models.....	6
2.4 Human Factors Analysis and Classification System	9
2.5 Crew Resource Management.....	17
2.6 Flight Performance Assessment.....	18
2.7 Personal Pilot Mail-out Studies.....	21
2.8 Pilot Involvement in Hazardous Events	25
2.9 Threat and Error Management	26
2.10 Incident Reporting Systems	28
2.11 The CAANZ Safety Reporting System	30
3.0 Research Methodology and Data	32
3.1 Research Focus.....	33
3.2 The CAANZ Database	34
3.3 Data Processing.....	36
3.3.1 Data Analysis.....	37
3.3.2 Data Classification Examples.....	40
4.0 Results and Discussion	42
4.1 Classification Consistency Results.....	43
4.1.1 Classification Reliability.....	45
4.1.2 Classification Consistency Checks	46
4.2 Threats	47
4.2.1 Environmental Threats.....	49
4.2.2 Airline Threats.....	49
4.3 Errors.....	51

4.3.1	Aircraft Handling Errors	52
4.3.2	Procedural Errors	54
4.3.3	Communication Error.....	56
4.4	Undesirable Aircraft States	57
4.5	Phase of Flight.....	59
4.6	Frequency of Reported Occurrence by Type	60
4.7	Reported Occurrence Type by Year	61
4.8	Frequency of Threats and Errors.....	62
4.9	Time of Reported Occurrences	63
4.10	Geographic Location of Reported Occurrences.....	64
4.11	Occurrences by Aircraft Class	66
4.12	Pilot Hours.....	68
4.12.1	Last 90 Days	68
4.12.2	Total Flying Hours	69
4.12.3	Hours on Type	70
4.13	Incidents by Flight Rules	71
4.14	Airspace Incidents by Flight Rules.....	72
4.15	Accidents by Flight Rules.....	73
4.16	Seasonal Reporting	74
5.0	General Discussion.....	76
5.1	Why Incidents?.....	77
5.2	Applying Threat and Error Management	77
5.3	Motivation to Report	79
5.4	Line Operation Safety Audit and TEM.....	80
5.5	Crew Resource Management and Threat and Error Management	81
5.6	Threats	82
5.6.1	Environmental Threats.....	83
5.6.2	Airline Threats.....	86
5.7	Error	87
5.7.1	Aircraft Handling Errors	88
5.7.2	Procedural Errors	90
5.7.3	Communication Errors	91
5.8	Undesirable Aircraft States	94
5.9	Phase of Flight.....	96
5.10	Time of Reported Occurrence.....	98
5.11	Geographic Locations.....	98

5.12	Class of Aircraft	99
5.13	Pilot Hours—Expertise and Judgement	100
5.13.1	Last 90 Days	101
5.13.2	Total Hours.....	102
5.13.3	Hours on Type	104
5.14	Visual Flight Rule and Instrument Flight Rule Occurrences	104
5.15	Seasonal Trends in Occurrences	106
5.16	Safety Culture and Occurrence Reporting	107
5.16.1	Incident Reporting Systems	109
5.17	Preventing Incidents Turning into Accidents	110
6.0	Research Limitations.....	113
7.0	Further Research.....	114
8.0	Conclusion.....	115
9.0	References	117
10.0	Appendix 1: Threat and Error Management Taxonomic Categories.	126
11.0	Appendix 2: Threat, Error and UAS Frequency	130
12.0	Appendix 3: New Zealand Mountainous Zones	139
13.0	Appendix 4: Threat and Error Management Taxonomic Occurrence Examples.....	141
14.0	Appendix 5: Occurrence Database Fields	147
15.0	Appendix 6; Reliability Survey Handout	148
16.0	Appendix 7: Abbreviations.....	160
17.0	Appendix 8: Location Abbreviations	163

List of Figures

<i>Figure 1.</i> The ‘Iceberg Model’ of Accidents	5
<i>Figure 2.</i> SHELL Model	6
<i>Figure 3.</i> Human Elements of Accident Causation.....	8
<i>Figure 4.</i> Human Factors and Classification System	10
<i>Figure 5.</i> Model of Flight crew Error Management	11
<i>Figure 6.</i> Model of Flight Crew Error.....	12
<i>Figure 7.</i> Total Percentage Classification —Threat.....	48
<i>Figure 8.</i> Frequency of Environmental Threats.....	49
<i>Figure 9.</i> Frequency of Airline Threats.....	50
<i>Figure 10.</i> Total Percentage Classification —Error	52
<i>Figure 11.</i> Frequency of Aircraft Handling Errors	53
<i>Figure 12.</i> Frequency of Procedural Errors	54
<i>Figure 13.</i> Frequency of Communication Errors	56
<i>Figure 14.</i> Frequency of UASs	57
<i>Figure 15.</i> Total Percentage of Subcategory UAS	58
<i>Figure 16.</i> Phase of Flight by Occurrence Type.....	59
<i>Figure 17.</i> Frequency of Reported Occurrences by Type.....	60
<i>Figure 18.</i> Reported Occurrence Type by Year	61
<i>Figure 19.</i> Total Percentage of Threats and Errors	62
<i>Figure 20.</i> Time of Reported Occurrences: Accidents, Airspace Incidents & Incidents.....	63
<i>Figure 21.</i> Geographic Location of Reported Occurrences.....	64
<i>Figure 22.</i> Classification Consistency Results.....	66
<i>Figure 23.</i> Pilot Hours—Last 90 Days	68
<i>Figure 24.</i> Pilot Hours—Total Flying Time.....	69
<i>Figure 25.</i> Pilot Hours—On Aircraft Type.....	70
<i>Figure 26.</i> Incidents by Flight Rules	71
<i>Figure 27.</i> Airspace Incidents by Flight Rules.....	72
<i>Figure 28.</i> Accidents by Flight Rules.....	73
<i>Figure 29.</i> Seasonal Reporting	74
<i>Figure 30.</i> Killing Zone—Fatal Accidents.....	103
<i>Figure 31.</i> Subcategory Geographic Location of Safety Occurrences.....	137
<i>Figure 32.</i> Mountainous Zones—North Island	139
<i>Figure 33.</i> Mountainous Zones—South Island	140

List of Tables

<i>Table 1. Aircraft Statistics Category</i>	4
<i>Table 2. Classification Consistency Results</i>	44
<i>Table 3. Environmental Threat Categories</i>	126
<i>Table 4. Aircraft Threat Categories</i>	126
<i>Table 5. Aircraft Handling Error Categories</i>	126
<i>Table 6. Procedural Error Categories</i>	128
<i>Table 7. Communication Error Categories</i>	128
<i>Table 8. Undesirable Aircraft State Categories</i>	129
<i>Table 9. Subcategory Event Table of Environmental Threats</i>	130
<i>Table 10. Subcategory Event Table of Airline Threats</i>	131
<i>Table 11. Subcategory Event Table of Aircraft Handling Errors</i>	132
<i>Table 12. Subcategory Event Table of Procedural Error</i>	133
<i>Table 13. Subcategory Event Table of Communication Errors</i>	134
<i>Table 14. Subcategory Event Table of UASs</i>	135
<i>Table 15. Totals for Phase of Flight</i>	136
<i>Table 16. Totals for Geographic Location</i>	138
<i>Table 17. Environmental Threat Occurrence Examples</i>	141
<i>Table 18. Airline Threat Occurrence Examples</i>	142
<i>Table 19. Aircraft Handling Error Occurrence Examples</i>	143
<i>Table 20. Procedural Error Occurrence Examples</i>	144
<i>Table 21. Communication Error Occurrence Examples</i>	145
<i>Table 22. UAS Occurrence Examples</i>	146

Glossary

Accident: an occurrence that is associated with the operation of an aircraft and takes place between the time any person boards the aircraft with the intention of flight and such time as all such persons have disembarked and the engine or any propellers or rotors come to rest.

(1) A person is fatally or seriously injured as a result of

- a. being in the aircraft;
- b. direct contact with any part of the aircraft, including any part that has become detached from the aircraft; or
- c. direct exposure to jet blast

except when the injuries are self-inflicted or inflicted by other persons, or when the injuries are to stowaways hiding outside the areas normally available to passengers and crew; or

(2) the aircraft sustains damage or structural failure that

- a. adversely affects the structural strength, performance or flight characteristics of the aircraft; and
- b. would normally require major repair or replacement of the affected component,

except engine failure or damage that is limited to the engine, its cowlings, or accessories, or damage limited to propellers, wing tips, rotors, antennas, tyres, brakes, fairings, small dents, or puncture holes in the aircraft skin; or

(3) aircraft is missing or is completely inaccessible (CAANZ, 2009c).

Classifications: judgements or decisions made to determine whether a threat, error or UAS was present in each occurrence.

Errors: errors are defined as flight crew actions or inactions that:

- (1) lead to a deviation from crew or organisational intentions or expectations,
- (2) reduce safety margins, and

- (3) increase the probability of adverse operational events on the ground or during flight (Merritt & Klinect, 2006).

Incident: any occurrence, other than an accident, that is associated with the operation of an aircraft and affects, or could affect, the safety of operation (CAANZ, 2009c).

Occurrence: an accident or incident (CAANZ, 2009c).

Threats: defined as events or errors that:

- (1) occur outside the influence of the flight crew (i.e. not caused by the crew);
- (2) increase the operational complexity of a flight; and
- (3) require crew attention and management if safety margins are to be maintained (Merritt & Klinect, 2006).

Undesirable Aircraft States (UAS) is defined as a position, speed, attitude, or configuration of an aircraft that:

- (1) results from flight crew error, actions, or inaction,
- (2) clearly reduces safety margins (Merritt & Klinect, 2006).