航空器失事調查報告

ASC-AAR-02-04-002

中華民國89年10月31日
新加坡航空公司 006班機
BOEING 747-400 型機
國籍登記號碼 9V-SPK
於中正國際機場
起飛時撞毀在部分關閉跑道上

飛安

行政院飛航安全委員會
AVIATION SAFETY COUNCIL

中華民國民用航空法第八十四條第三項規定：

行政院飛航安全會對航空器失事及重大意外事件從事之認定、調查及鑑定原因，旨在避免失事之再發生，不以處分或追究責任為目的。

國際民航公約第十三號附約第三章第 3.1 節規定：

The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability.

因此，依據中華民國民用航空法及國際民航公約第十三號附約，本調查報告專供改善飛航安全之用。

本報告一式兩份, 分別以中文及英文繕寫, 以英文版為準。

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摘要報告

民國八十九年十月卅一日，台北時間 2317 時（世界標準時間 1517 時），新加坡航空公司 SQ006 班機（簡稱 SQ006）於桃園中正國際機場（簡稱中正機場）起飛時，撞毀於部份關閉之 05 右跑道上。該機機型波音 747-400、新加坡登記號碼 9V-SPK，目的地為美國洛杉磯國際機場。事故當時，中正機場處於象神颱風外圍之強風豪雨中。該機載有駕駛員三人、客艙組員十七人與乘客一百五十九人。

強大撞擊力及隨後引發之大火導致該機全毀。此次事故共造成八十三人死亡（四名客艙組員及七十九名乘客）；三十九人重傷（四名客艙組員及三十五名乘客）及三十二人輕傷（一名駕駛員、九名客艙組員及二十二名乘客），另兩名駕駛員及二十三名乘客則未受傷。

依據中華民國民用航空法第八十四條，行政院飛航安全委員會（簡稱本會）為負責調查發生於中華民國境內之民用航空器失事及重大意外事件之獨立政府機關，於事故發生後立即展開調查工作。受邀參與本次調查之機關包括：新加坡交通與資訊科技部（MCIT[1]）、美國國家運輸安全委員會（NTSB）、中華民國交通部民用航空局（簡稱民航局）以及稍後根據國際民航公約第十三號附約第 5.23 節受邀加入之澳洲運輸安全局（ATSB）等，其中新、美及澳方皆為國際民航公約第十三號附約所稱之授權代表。

失事現場調查作業於八十九年十一月十三日完成，擔任各分組召集人之本會調查官，於同日完成現場事實報告。隨即進行事實資料蒐集工作，本會人員曾赴新加坡實地瞭解新航運作情形，並訪談新航及新加坡民航局人員。各分組召集人並整合所有事實資料撰成事實資料報告。

本會於九十年二月二十日召開「事實資料確認會議」，確認當時所搜集到之事實資料，全體調查小組成員均出席此會。本會於同年二月二十三日發布「新航 SQ006 班機失事事實資料報告」，並將此報告公布於本會網站。

本會自九十年三月一日起著手進行調查分析工作。依國際民航公約第十三號附約第 5.25 節，各國授權代表參與失事調查之權限規定如下[2]：

“Participation in the investigation shall confer entitlement to participate in

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[1] 事故發生時，新方負責調查機關為交通及資訊科技部（Ministry of Communications and Information Technology, MCIT），因新加坡政府改組，自 2001 年 11 月 23 日起更名為「運輸部」（Ministry of of Transportation, MOT）。

[2] 本報告引用法規及談話內容處，除必要闡明者，皆以原文示之。

all aspects of the investigation, under the control of the Investigator-in-Charge, in particular to:

a) Visit the scene of the accident;

b) examine the wreckage;

c) obtain witness information and suggest areas of questioning;

d) have full access to all relevant evidence as soon as possible;

e) receive copies of all pertinent documents;

f) participate in read-outs of recorded media;

g) participate in off-scene investigative activities such as component examinations, technical briefings, tests, and simulations;

h) participate in investigation process meetings including deliberations related to analysis, findings, causes and safety recommendations; and

i) make submissions in respect of the various elements of the investigation.

Note 1 - It is recognized that the form of participation would be subject to the procedures of the State in which the investigation, or part thereof, is being conducted."

因此，國際民航公約第十三號附約明確表示，主辦調查國家有權決定授權代表之參與調查程度。依本會調查程序及本會第二十七次委員會議決議，本會允許授權代表參與上述所有方面之調查，但不包括國際民航公約第十三號附約第 5.25 **節之第**(*h*)**項。本會第二十七次委員會議亦達成決議：為維持獨立調查權力，本會應不受任何干預，依據蒐集到之事實資料，獨立從事分析、肇因鑑定及提出飛安改善建議。惟參與調查各方得有適當機會表示意見。**

根據上述基本指導原則，專案調查小組開始分析作業，並於同年七月四至五日召開「技術審查會議」，邀請各參與機關審閱本會調查分析資料，參與調查之相關國家與機關均受邀派員參加。

該次會議首日，本會向全體出席人員簡報分析資料。次日則由各方對本會首日提出之分析資料表達意見，另外補充並確認自九十年二月二十三日以後新蒐集之事實資料。

本會綜整九十年七月四至五日「技術審查會議」各方所撰意見，於同年九月卅日將「SQ006 **調查報告草案初稿」分送各參與調查機關審閱，並請其於卅天內提供意見。**

本會自九十年十一月一日起，綜整各方意見並修訂初稿，於九十一年一月三十一日發布「SQ006 **調查報告草案」，並依中華民國航空器失事及重大意外事件調查處理規則第二條規定（按，該條款符合第十三號附約第** 6.3 **節），分送各參與機關審閱，並請其於六十天內提供意見。**

本會於九十一年三月二十六日，另邀各參與機關代表列席本會第四十二次委員會議，民航局及新加坡交通與資訊科技部分別陳述其對「SQ006 **調查報告草案」之意見。**

本會於同年三月三十日收到各方對該草案之書面意見，經討論後，綜整完成調查報告，並於同年四月二十三日第四十三次委員會議審查通過。

依國際民航公約第十三號附約第 6.3 **節規定：**

"The State conducting the investigation shall send a copy of the draft Final Report to…all States that participated in the investigation, inviting their significant and substantial comments on the report as soon as possible….

If the State conducting the investigation receives comments within sixty days of the date of the transmittal letter, it shall either amend the draft Final Report to include the substance of the comments received or, if desired by the State that provided the comments, append the comments to the final report…."

綜上所述，本會已在調查作業過程中，提供各參與機關多次表達意見機會，已超過國際民航公約第十三號附約第 6.3 **節之規範。**

本調查報告係經周密之審查，並考量所有調查事實記錄以及全體參與調查單位提供之意見撰寫而成。雖然許多意見已為本會採納，依第十三號附約第 6.3 **節規定，本會將新加坡交通與資訊科技部、澳洲運輸安全局、美國運輸安全委員會及民航局之意見附於調查報告（詳如附錄** 7**），各方意見之採納情形對照表亦附於其中。**

本件調查報告格式係依照中華民國航空器失事及重大意外事件調查處理規則附表四，該附表符合第十三號附約之相關規定，唯有以下不同之處：

一、 第三章「結論」部分：為彰顯改善飛安之宗旨，不以處分或追究責任為目的。本會第三十九次委員會議決議，不再直接陳述「事故可能肇因及間接因素」，而以「調查結果」代之，並將其分為三類：與可能肇因相關之調查結果，與風險相關之調查結果，及其他調查結果。

二、 第四章「飛安改善建議」部分：除對有關機關提出改善建議外，本會並將各參與

機關提出之已實施或實施中之安全作為納入調查報告。本會認為此舉更能達成改善飛航安全目的。

因此，本會依據分析資料提出以下之調查結果及改善建議。

調查結果

在本報告中將調查結果分為以下三類：

與可能肇因有關之調查結果

此類調查結果係屬已經顯示或幾乎可以確定為與本次事故發生有關之重要因素。其中包括：不安全作為、不安全狀況或造成本次事故之安全缺失等。

與風險有關之調查結果

此類調查結果係涉及飛航安全之風險因素，包括未直接導致本次事故發生之不安全作為、不安全條件及組織和整體性之安全缺失等，以及雖與本次事故無直接關連但對促進飛安有益之事項。

其它調查結果

此類調查結果係屬具有促進飛航安全、解決爭議或澄清疑慮之作用者。其中部份調查結果為大眾所關切，且見於國際調查報告之標準格式中，以作為資料分享、安全警示、教育及改善飛航安全之用。

與可能肇因有關之調查結果

1. **事故當時正值象神颱風來襲，帶來豪雨及強風。台北時間** 2312:02 **時，飛航組員由終端資料廣播服務（**ATIS**）抄收編碼**“Uniform”**之** 05 **左跑道視程為** 450 **公尺。台北時間** 2315:22 **時，飛航組員收到機場管制席頒發之起飛許可及風向** 020 **度，風速** 28 **浬/時，陣風** 50 **浬/時。（**1.1; 1.7**）**

2. **民航局八十九年八月卅一日發布編號** A0606 **之飛航公告（**NOTAM**）稱自八十九年九月十三日至同年十一月廿二日，**05 **右跑道於** N4 **及** N5 **滑行道間，因道面施工部份關閉。**SQ006 **飛航組員瞭解** 05 **右跑道部份關閉，並且** 05 **右跑道當時僅供滑行之用。（**1.18.2.6; 2.5.2.1; 2.5.3**）**

3. SQ006 **未完全通過** 05 **右跑道頭標線區，繼續滑行至按預定起飛之** 05 **左跑道。航機進入** 05 **右跑道後，正駕駛員（**CM-1**）即滾行起飛，副駕駛員（**CM-2**）及加強飛航組員（**CM-3**）並未質疑** CM-1 **之決定。（**1.1; 1.18.1.1**）**

4. **飛航組員未能複查並確實瞭解其在滑至** 05 **左跑道之正確路線上，包括在滑入** 05 **左跑道前需先通過** 05 **右跑道。**（1.18.1.1; 2.5.3）

5. SQ006 **由停機坪滑向離場跑道時，飛航組員曾參考中正機場航圖。然而，該機由** NP **滑行道轉進** N1 **滑行道，並繼續轉向** 05 **右跑道時，三位組員均未確認滑行路徑。依吉普生**（Jeppesen）**航圖第** 20-9 **頁之中正機場航圖，滑行至** 05 **左跑道之路線須先由** NP **滑行道作** 90 **度右轉彎，再繼續沿** N1 **滑行道直行。而非直接由** NP **滑行道以連續之** 180 **度轉彎進入** 05 **右跑道。且當時亦無任何組員口頭確認進入那條跑道。**（1.18.1.1; 2.5.2.2; 2.5.4.3）

6. CM-1 **接近離場跑道之期望，伴隨著明顯之滑行道燈光引領其滑至** 05 **右跑道，導致** CM-1 **將其注意力著重在滑行道中心線燈上。他跟隨綠色之滑行道中心線燈滑入** 05 **右跑道。**（1.18.1.1; 2.5.7）

7. **趕在颱風進襲前起飛之時間壓力，及強風、低能見度及溼滑跑道等情況，均潛在地影響飛航組員下達決策和維持狀況警覺之能力。**（1.18.1.1; 2.5.6; 2.5.7）

8. **事故當晚，飛航組員可藉由以下資訊瞭解其所處之機場環境：**

   - **中正機場航圖**
   - **飛機航向參考資訊**
   - **跑道及滑行道指示牌**
   - N1 **滑行道連至** 05 **左跑道之滑行道中心線燈**
   - 05 **右跑道中心線燈顏色（綠色）**
   - 05 **右跑道邊燈可能未開啟**
   - 05 **左及** 05 **右跑道之寬度差異**
   - 05 **右和** 05 **左跑道燈光結構差異**
   - **目視輔助系統**（Para-Visual Display，PVD）**顯示飛機未對正** 05 **左跑道左右定位台**
   - **主要飛航顯示器**（Primary Flight Display，PFD）**資訊**

飛航組員失去狀況警覺而由錯誤跑道起飛。（1.1; 1.18.1; 2.5）

<u>**與風險有關之調查結果**</u>

1. **參照現行國際民航公約第十四號附約之標準及建議措施，中正機場得在** 05 **右跑道施工區外圍放置跑道關閉標線，但並無強制規定須在** 05 **右跑道頭放置跑道關閉標**

線。（1.10.4.2; 2.3.3）

2. **國際民航公約第十四號附約之標準及建議措施中部分語意不明，未對暫時關閉跑道之「短期」予以明確定義。**（1.10.4.2; 2.3.3）

3. **國際民航公約第十四號附約之標準及建議措施中有關仍作滑行用之暫時關閉跑道章節，未對「除供滑行作業外跑道關閉」提供適當資訊以警示飛航組員。**（1.10.4.2; 2.3.3）

4. **國際民航公約之相關規範中雖無明確規定須在仍作滑行用之暫時關閉跑道上設置警示，但就場站設施而言，由於中正國際航空站未考量於** 05 **右跑道入口處設置警示，以致無法提供最後一道防線，防止飛航組員誤入** 05 **右跑道。**（1.10.4.2; 2.3.3）

5. **根據國際民航公約第十四號附約之標準及建議措施，放置於** 05 **右跑道施工區外之護欄須為易脆材料所製，事故當時** 05 **右跑道施工區外所使用之護欄為非易碎之水泥護欄。**（1.10.4.2; 2.3.3）

6. **事故當時，中正機場有數項設施不符國際接受之標準及建議措施，若予適當重視，或許能加強飛航組員在滑行至** 05 **左跑道期間之狀況警覺，但缺少此項強化措施，並不足以證明** SQ006 **飛航組員因而失去狀況警覺，相關設施如下：**

   - **事故發生四日之後，調查小組發現緊接著** 05 **右跑道入口處，沿** N1 **滑行道往** 05 **左跑道方向之第一盞綠色滑行道中心線燈不亮，下一盞燈則不夠亮。但在事故當晚，前述燈光狀態無法確定。**（1.10.3.2.4; 2.3.1.2.3）

   - NP **滑行道轉向** 05 **右跑道之滑行道中心線燈間距，較** N1 **滑行道連至** 05 **左跑道之滑行道中心線燈間距為密，因此明顯可見。由** NP **與** N1 **滑行道中心線交會點延伸至** 05 **左跑道頭之直線部份應有** 16 **盞間距** 7.5 **公尺之中心線燈，而非** 4 **盞分別距交會點** 30 **公尺、**55 **公尺、**116 **公尺和** 138 **公尺之中心線燈。**（1.10.3.2.4; 2.3.1.2.2）

   - N1 **滑行道中心線直線部分之標線未延伸至** 05 **右跑道頭標線前後各** 12 **公尺處。**（1.10.3.1.2; 2.3.1.1）

   - **中正機場未架設跑道警戒燈及停止線燈。**（1.10.3.2.2; 1.10.3.2.3; 2.3.2）

   - **未架設綠黃交錯之滑行道中心線燈，以區隔儀降系統敏感區。**（1.10.3.2.4）

   - N1 **滑行道兩側之強制性指示牌架設於** 05 **左跑道等待位置前，而非與跑道等待位置標線並列。**（1.10.3.1）

   - **中正機場未架設迴路互鎖系統，以防止** 05 **右跑道之跑道燈及滑行道中心線燈同時開啟。**（1.10.5.1.1; 2.3.1.2.1）

- **中正機場之場面燈光系統監視機制係電子式，由人工控制。缺乏對個別燈具，或對場面燈光迴路故障燈具百分比監控功能。**（1.10.5.1.2）

7. **機場場面偵測裝備**（ASDE）**在低能見度時能減低機場地面作業風險，但國際民航公約第十四號附約之標準及建議措施未規定機場必須架設此項裝備。本會無法確定是否機場架設** ASDE **即能提供管制員有效資訊，以防止** SQ006 **滑入錯誤跑道。豪雨會造成** ASDE **訊號衰減，顯示效果降低。**（1.18.2.4; 2.4.2）

8. **民航局缺乏安全監督機制以獨立督察及評估中正機場，確保其場站設施符合國際標準及建議措施。**（1.17.9; 2.3.5.2.1; 2.3.5.3.2; 2.3.6）

9. **民航局缺乏特定之安全法規監督組織與機制，致使中正機場之跑道及滑行道燈光、標線及指示牌等不符合國際安全標準及建議措施狀況未受重視。**（1.17.9; 2.3.6）

10. **民航局未組成工作小組，根據國際民航公約第十四號附約，推動全面之「地面活動導引及管制系統」**（SMGCS）**計畫。**（1.10.5.2）

11. **由於中華民國非國際民航組織**（ICAO）**之會員國，因此無法參與該組織推展有關促進機場安全之各項計畫，以期符合國際標準及建議措施。**（1.17.10; 2.3.5.2.2）

12. **機場管制員未頒發進一步滑行及地面活動指示，亦未使用低能見度滑行術語通知飛航組員減速慢行。**（1.18.2.3; 2.4.1）

13. **飛航組員未請求管制員頒發進一步滑行指示。**（1.1; **附錄** 3）

14. **暗夜及大雨造成能見度減低，但未妨礙駕駛員目視跑道及滑行道燈光、標線和指示牌。**（1.18.1.1; 2.5.7.1）

15. **新航之溼跑道側風限制為** 30 **浬/時，而污染跑道側風限制為** 15 **浬。**CM-1 **準備起飛時評估當時狀況為溼跑道，確定側風未超過公司規定。新航及航管程序均未訂定量化方法以判斷溼跑道與污染跑道，造成飛航組員無法明確估算側風限制。**（1.18.4; 2.5.8）

16. **新航波音** 747-400 **操作手冊中未明載低能見度滑行操作程序。**（1.17.4.5; 2.5.4）

17. **新航未給予波音** 747-400 **駕駛員正式之低能見度滑行技巧訓練。**（1.18.1.1.1）

18. **新航未訂定**PVD**使用程序，以供駕駛員在類似本次失事當晚低能見度情況，以** PVD **確認航機由正確位置起飛。**（1.18.5.1; 2.5.6.3.3）

19. **新航之程序與訓練文件，未反映新加坡民航局核准之波音** 747-400 **飛航手冊附錄中有關使用** PVD **確認正確跑道規定。**（1.18.5.3; 2.5.6.3.3）

20. **新加坡民航局對航務之監督與訓練，未能確保新航已按核准之波音** 747-400 **飛航手冊附錄中有關使用** PVD **確認正確跑道規定，修正其相關文件及航務作業。**

（1.18.5.3; 2.5.10）

21. **事故當時，新航操作手冊之起飛前檢查程序未含「確認使用跑道」項目。**（1.18.1.1; 2.5.5）
22. **新航之訓練與程序未能確保其飛航組員獲得適當之知識與技術，在低能見度時，在地面精確操控航機。**（1.17.4.5; 2.5.4.5）
23. **新加坡民航局未充份執行對新航之程序與訓練督導，例行之飛安查核未能發現其在程序與訓練之缺失。**（1.17.1; 2.5.10）
24. **新航未明確定義其颱風程序，而執行程序之人員亦未充份瞭解程序及職責。**（1.17.7; 2.7.4）
25. **嚴重撞擊及快速竄燒之大火與濃煙導致現行緊急疏散訓練、設備及程序失效。**（1.15.1.2; 1.15.1.3; 1.15.1.4; 2.6.1）
26. **廣播系統失效後，**CM-1 **未指示客艙組員及乘客進行緊急疏散。**（1.15.1.2; 2.6.1）
27. **飛航組員與客艙組員一併實施年度緊急疏散複訓，但飛航組員係扮演乘客角色。新航之程序未規定飛航組員下達緊急疏散指令。**（1.15.1.1）
28. **部份組員之緊急疏散作業受到失事後不可預期之狀況影響。**（1.15.1; 2.6.1）
29. **生還者在疏散過程中因濃煙造成呼吸困難，且不易發現緊急燈光。**（1.15.1; 2.6.3.1; 2.6.3.2）
30. **在暗夜疏散情形下，僅** CM-2、CM-3 **及左側** 5 **號門客艙組員攜帶手電筒，其中左側** 5 **號門客艙組員曾利用手電筒協助乘客疏散。**（1.15.1.6）
31. **中正機場未參照國際民航公約建議，明訂機場緊急醫療救護程序及醫療協調官或臨時醫療協調官之職責。**（1.15.3.6; 2.6.4.1）
32. **中正機場未參照國際民航組織之標準及建議措施，提供惡劣天候之醫療與救援應變程序。**（1.15.3.6; 2.6.4.1）
33. **「中正國際航空站民用航空器失事處理作業實施要點」未參照國際民航公約建議建立周邊醫院資訊，如神經外科等。**（1.15.3.5; 2.6.4.2）
34. **疏散滑梯製造廠未在相關手冊中，提供航空器使用人於強風情況下之操作性能資訊。**（1.15.1.5; 2.6.2.2）
35. **失事時，該機因橫向撞擊力過大，造成右側** 4 **號和** 5 **號門疏散滑梯非預期之自動向艙內充氣。**（1.15.1.5; 2.6.2.2）

36. **中正機場消防隊處理重大失事之人力不足。**（1.14.1.2; 1.15.3.2; 2.6.4.3）

其它調查結果

1. **飛航組員均持有適當證照，符合新加坡民航局法規、新航規定及國際民航組織之標準及建議措施。**（1.5; 2.1）

2. **飛航組員依既有程序獲得完整簽派文件包括：天氣、載重與平衡、飛航公告及公司內部飛航通告等。**（1.18.1.1; 2.1）

3. **客艙組員均依該公司訓練計畫訓練合格。**（1.5; 2.1）

4. **組員之執勤時間、飛航時間、休息時間及非執勤活動等，未顯示曾受醫藥、行為或生理之因素，影響其失事當天之工作表現。**（1.5; 2.1）

5. **失事相關之管制員均持有適當證照，符合執勤資格。其執勤時間、休息時間及非執勤活動等，未顯示曾受影響其失事當天之工作表現。**（1.5.5; 1.5.6; 1.5.7; 1.5.8; 2.1）

6. **失事航空器之給證、裝備及維修均符合新加坡民航局法規及審核程序，及國際民航組織之標準及建議措施。無證據顯示該機存有機械、結構、飛操系統或發動機之失效而導致失事。**（1.6; 2.1）

7. **失事發生當晚，無證據顯示飛航組員曾受公司不當壓力，迫使其在惡劣天候中起飛。**（1.17.8; 1.18.1.1; 2.1）

8. **事故當時，飛航組員使用之吉普生航圖為有效版本。**（1.18.3; 2.5.2.2）

9. **飛航組員使用之滑行檢查及程序符合新航波音** 747-400 **操作手冊。**（1.18.1.1; 2.5.4.4）

10. **失事發生當晚，飛航組員選擇由** 05 **左跑道起飛係為適當。**（1.18.1.1; 2.5.3）

11. **雖然** CM-1 **曾要求加強飛航組員在滑行時確認側風限制，但在新航標準操作程序未明確指派加強飛航組員之任務。**（1.17.4.2; 1.18.1.1; 2.5.9.3）

12. **航管之滑行指示與起飛許可，未誤導飛航組員由部份關閉之** 05 **右跑道起飛。**（1.1; 2.1; **附錄** 2; 3）

13. **多項證據顯示在** SQ006 **起飛當時，**05 **右跑道邊燈未開啟之可能性較高。**（1.12.5; 1.16.5; 2.3.4）

14. **本次失事之死亡率為** 46%**；重傷率為** 22%**；輕傷率為** 18%**；未受傷率為** 14%。（1.2）

15. **失事後油箱起火，客艙中段之第** 31 **至** 48 **排座位屬非生還區，區內** 76 **名乘客中** 64 **人死亡，客艙尾段所有乘客皆生還。**（1.2）

16. **在失事緊急疏散過程中，由於撞擊力量、大火與強風之影響，無疏散滑梯能完全發揮作用。**（1.12.2.2; 1.16.3; 2.6.2）

17. **法務部法醫研究所執行七件驗屍工作，其中六件為嚴重燒傷致死，一件為撞擊致死。**（1.13.2; 2.6.5）

18. **機場救援及消防人員在失事後約三分鐘即抵現場進行消救作業。機尾部份小火迅速撲滅。惡劣天候下，機身前段及中段之火勢於十五分鐘後壓制住，四十分鐘後火勢完全控制。**（1.14.1.1; 1.14.1.2）

19. **失事期間，所有消防與及醫療人員均使用同一無線電頻率通話。**（1.15.3.1）

20. **因象神颱風帶來之豪雨及強風，導致中正機場大部份之醫療及救援行動未能依該站相關程序作業。**（1.15.3.2; 2.6.4）

21. **前十名逃出客艙之生還者，未經適當檢傷分類程序，即由機場救護車送往鄰近醫院。**（1.15.3.2; 2.6.4）

22. **失事後，未對三位飛航組員及四位管制員進行酒精及藥物測試，但無證據顯示酒精或藥物與失事有關。**（1.13.3）

23. **中華民國交通部未積極支持民航局在中正機場架設** ASDE **之建議。**（1.18.2.4; 2.4.2）

24. **中華民國民航局增訂定之法規皆須經過交通部冗長之行政程序。**（1.17.10; 2.4.2）

25. SQ006 **座艙語音記錄器電源開關時機雖符合國際民航組織之標準及建議措施及新加坡民航法，但美國聯邦航空法及歐盟聯合航空法，規定較早之電源啟動時機及較晚之電源切斷時機，較有利於事故後之飛航操作及人為因素調查作業。**（1.11.1.1; 2.7.1）

26. **本會於調查期間蒐集到六件與飛航服務有關之意外事件報告，中正機場開始運作迄今已逾廿二年，與中正機場場站設施相關之報告當不止此數。**（1.18.2.5; 2.4.3）

27. **駕駛艙加裝機場場面導引及導航系統能降低滑行、起飛及落地等飛航失事及意外事件。**（1.18.8; 2.7.6）

28. **新加坡未設獨立之航空器失事調查機關，從事客觀調查、獲致結論並提出改善建議。國際經驗顯示，設置獨立之航空器失事調查機關有利飛航安全。許多國家已採取行動確保航空器之失事調查，由獨立於民航法制與監督機關外之政府機關擔任。**（1.17.2; 2.7.7）

改善建議

致新加坡航空公司

本會建議新航：

1. **參考美國聯邦航空總署跑道安全國家藍圖（**National Blueprint for Runway Safety**）及民航通告** AC120-74**，擬訂並執行場面活動訓練計畫。（**3.1-[3~8];3.2-[16, 17, 22]**）**

2. **確認於低能見度滑行操作程序中，增訂請求管制員提供進一步滑行指示之需要，以協助正確之機場場面活動。（**3.2-[13]**）**

3. **複查現行** PVD **訓練及程序之適當性，確保文件與航務作業中皆能配合新加坡民航局核准之波音** 747-400 **飛航手冊附錄，使用** PVD **確認正確之離場跑道。（**3.2-[18, 19]**）**

4. **擬訂並落實明確之政策，確保飛航組員應用** PFD **及** PVD **等儀器所顯示之資訊，尤其是用在低能見度情況起飛之前。（**3.1-[8]**）**

5. **於所有起飛前檢查表中，加入目視識別及確認正確起飛跑道之檢查項目。（** 3.1-[8], 3.2-[21]**）**

6. **實施進階組員資源管理計畫以符現行作業需要，並依組員資源管理最新發展定期修正計畫。（**3.1-[3, 4]**）**

7. **審視現行跑道狀況判斷程序與作業之適當性，在大雨情況下，提供客觀判斷標準，以判斷溼跑道或污染跑道。（**3.2-[15]**）**

8. **進行程序督察，以消除現行指導原則及程序與公司手冊、管理者期望及實際作業間之衝突，如颱風程序或簽派簡報政策。（**3.2-[24]**）**

9. **修正緊急程序，增訂客艙廣播系統失效時，下達緊急疏散指令之替代方法。（**3.2-[26]**）**

10. **檢討飛航及客艙組員之相關程序與訓練，使其有效處理各類緊急狀況。（**3.2-[25, 26, 27, 28]**）**

致新加坡民用航空局

本會建議新加坡民用航空局：

1. **要求新航擬訂並落實地面活動訓練計畫，包括在低能見度地面操作時，請求管制員提供進一步滑行指示之程序。**（3.1-[3~8]; 3.2-[13, 16, 17, 22]）
2. **檢討新航** PVD **訓練及操作，確認其程序、訓練文件及實際作業符合新加坡民航局核准之波音** 747-400 **飛航手冊有關** PVD **之附錄。**（3.2-[18, 19, 20]）
3. **檢討飛航手冊附錄相關之文件審核、控管、分發以及為航空器使用人制定政策及程序等管理機制，適當管理飛航手冊之修正作業。**（3.2-[20]）
4. **確保新加坡之航空公司在其監管下執行空勤組員資源管理計畫，以符現行作法，並隨時注意組員資源管理之發展，以定期監控及修訂該計畫。**（3.1-[3, 4]）
5. **評估並支持適當之技術及方法研發專案，以協助飛航組員在大雨情況下，客觀判斷雨水影響跑道狀況。**（3.2-[15]）
6. **修訂新加坡民航局「空中航行法規」第卅七條第三項有關座艙語音記錄器電源提早啟動及延後切斷規定。**（3.3-[25]）

致新加坡政府

本會建議新加坡政府：

參考其它國家先例，設一獨立之飛航事故調查機關。（3.3-[28]）

致中華民國交通部民用航空局

本會建議中華民國交通部民用航空局：

1. **要求各塔台主管重新強調低能見度地面作業，進一步滑行及地面活動指示之觀念、訓練及使用時機。**（3.2-[12]）
2. **優先編列預算，加速執行在高航行量機場架設** ASDE **計畫。**（3.2-[7]）
3. **重新定義局內各組室之職掌，明確劃分各單位及人員之職責。**（3.2-[8, 9]）
4. **明確指定負責擬訂、修訂及發布民航法規之專責單位。**（3.2-[8]）
5. **擬定計畫，持續追縱國際民航組織之標準及建議措施及業界安全改善最佳實例，將所獲訊息傳送有關單位，作為檢討與必要行動以及進度監督之用。**（3.2-[6]）
6. **建立整體性風險評估與管理計畫，及監督所有計畫與執行之機制。**（3.2-[6, 7, 8, 9, 10]）

7. **評估並支持適當之技術及方法研發專案，以協助飛航組員在大雨情況下，客觀判斷雨水影響跑道狀況。**（3.2-[15]）

8. **立即改善中正機場及其它機場所有不符國際民航組織之標準及建議措施或相關規定之場站設施，如地面活動導引及管制系統計畫或緊急醫療程序等。**（3.2-[6, 10, 31, 32, 33]）

9. **比照第九級國際機場，確保機場救援及消防單位具有必要人力，以執行指派工作。**（3.2-[36]）

10. **檢討國內機場之通訊系統，研發機場各單位間緊急消救作業通訊改善計畫。**（3.3-[19]）

11. **建立可靠之意外事件通報系統，推廣此系統至所有使用者，並將系統之有效利用列為優先事項。**（3.3-[26]）

12. **檢視美國聯邦航空總署跑道安全國家藍圖及相關民航通告，作為執行改善之參考。**（3.2-[4, 5, 6, 7, 8, 9, 10]）

13. **確實研發適當場面活動相關科技，及中華民國機場及地形資料庫。**（3.3-[27]）

14. **頒布法規鼓勵運輸類國籍航空器，於駕駛艙裝置機場場面導引及導航系統，如電子活動地圖顯示器供機場場面活動使用。**（3.3-[27]）

<u>致中華民國交通部</u>

本會建議中華民國交通部：

1. **建立對民航局安全改善方案之專業監督能量，積極推動飛航安全。**（3.3-[23, 24]）

2. **主動積極支持民航局飛安改善計畫，如** ASDE **之採購作業。**（3.2-[10]; 3.3-[23]）

3. **完全授權民航局進行技術性安全法規之改善及實施，免除冗長繁瑣之行政程序。**（3.3-[24]）

<u>致波音公司</u>

本會建議波音公司：

1. **提供航空器使用人適當之技術指導資訊，包括緊急疏散滑梯在強風超過驗證限制時之警告事項。**（3.2-[34]）

2. **檢討客艙緊急燈光之有效性，確保失事生還者在濃煙情況中能獲得最大逃生機會。**（3.2-[29]）

3. **考慮於即將驗證及新獲驗證之航空器駕駛艙裝置機場場面導引及導航系統，如電子活動地圖顯示器。**（3.3-[27]）

4. **發展並提出必要之技術支援，提供客戶（航空公司）於駕駛艙裝置機場場面導引及導航系統，如電子活動地圖顯示器供機場場面活動使用。**（3.3-[27]）

5. **研發降低可生還失事中客艙廣播系統失效之方法，並提供航空器使用人改良之客艙廣播系統。**（3.2-[26]）

<u>致國際民航組織</u>

本會建議國際民航組織：

1. **研訂將** ASDE **或類似裝備，列為高航行量民航機場之標準裝備。**（3.2-[7]）

2. **修訂第十四號附約，明確定義及預防仍可滑行之部份關閉跑道標準。**（3.2-[3]）

3. **基於改善飛安目的，考慮接受中華民國以觀察員身份，參與國際民航組織各種活動。**（3.2-[11]）

4. **支持包括飛安基金會、航空公司駕駛員協會國際聯盟、機場作業協會及國際航空運輸協會等組織之政府或航空業界計畫，擬訂一套客觀方法，協助駕駛員在雨天情況下判斷溼跑道或污染跑道。**（3.2-[15]）

5. **鼓勵並支持政府或航空業界之研究計畫，改善乘客濃煙防護設備、強風與大火情況之緊急疏散滑梯功能。**（3.2-[29, 35]）

6. **擬訂必要之標準及建議措施，知會各會員國之民航主管機關，供其配合修訂相關法規，支持於駕駛艙裝置機場場面導引及導航系統。**（3.3-[27]）

7. **鼓勵所有會員國於商業用航空器駕駛艙裝置機場場面導引及導航系統，如電子活動地圖顯示器供機場場面活動使用。**（3.3-[27]）

8. **鼓勵所有會員國之民航主管機關，確實研發適當場面活動科技，如機場及地形資料庫於場站設施。**（3.3-[27]）

<u>致國際航空運輸協會</u>

本會建議國際航空運輸協會：

1. **由本次失事獲得之教訓，於強風及豪雨環境下，飛機受到嚴重撞擊後產生之大火與濃煙，使得許多緊急疏散系統失效、疏散程序無法作用。建議支持一項由政府或航空業界組成之國際合作研究計畫，藉以擬訂並改進航空器緊急疏散裝備與程序，預防未來類似失事之傷亡。**（3.2-[25]）

2. **提供會員航空公司適當技術指導資訊，包括緊急疏散滑梯在強風超過驗證限制時之警告事項。**（3.2-[34]）

3. **為安全保障及風險管理，敦促會員航空公司與其民航主管機關合作，確定其營運之機場符合國際民航公約第十四號附約之標準及建議措施，另敦促會員航空公司與其民航主管機關合作，擬訂評估場站設施程序作為外站督察項目之一。**（3.2-[6]）

4. **鼓勵會員航空公司於所屬航空器駕駛艙裝置機場場面導引及導航系統，如電子活動地圖顯示器供機場場面活動使用。**（3.3-[27]）

致美國聯邦航空總署

本會建議美國聯邦航空總署：

1. **由本次失事獲得之教訓，於強風及豪雨環境下，飛機受到嚴重撞擊後產生之大火與濃煙，使得許多緊急疏散系統失效、疏散程序無法作用。建議支持一項由政府或航空業界組成之國際合作研究計畫，藉以擬訂並改進航空器緊急疏散裝備與程序，預防未來類似失事之傷亡。**（3.2-[25]）

2. **檢討緊急疏散滑梯之設計，減少因橫向撞擊力造成緊急疏散滑梯非預期之自動充氣可能性。**（3.2-[35]）

3. **檢討客艙緊急燈光之有效性，確保失事生還者在濃煙情況中能獲得最大疏散機會。**（3.2-[29]）

4. **增訂規則，要求改良波音公司航空器之客艙廣播系統，使之在可生還之失事情況下仍可有效使用**[3]。（32-[26]）

致歐盟聯合航空局

本會建議歐盟聯合航空局：

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[3] 2001 **年** 4 **月，澳洲運輸安全局發出第** 20000231 **號改善建議：請美國聯邦航空總署及歐盟聯合航空局檢討高容量航空器之設計需求，確保客艙通話及廣播系統之整體性，特別是在航空器衝出跑道及其他造成起落架與機腹損壞情況之駕駛艙與客艙間通訊。，**

1. **由本次失事獲得之教訓，於強風及豪雨環境下，飛機受到嚴重撞擊後產生之大火與濃煙，使得許多緊急疏散系統失效、疏散程序無法作用。建議支持一項由政府或航空業界組成之國際合作研究計畫，藉以擬訂並改進航空器緊急疏散裝備與程序，預防未來類似失事之傷亡。**（3.2-[25]）

2. **檢討緊急疏散滑梯之設計，減少因橫向撞擊力造成緊急疏散滑梯非預期之自動充氣可能性。**（3.2-[35]）

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ADRAS	Aircraft Data Recovery and Analysis System	航空器資料讀取及分析系統
AEP	Airport Emergency Planning	機場緊急應變計畫
AFFF	Aqueous Film-Forming Foam	水液膜成形泡沫
AFM	Airplane Flight Manual	飛航手冊
AIP	Aeronautical Information Publication	台北飛航情報區飛航指南
ANWS	Air Navigation and Weather Services	飛航服務總台
AOC	Air Operator Certificate	航空運輸業營業許可證
AOCR	Air Operator Certificate Requirements	航空運輸業營業許可條件
APU	Auxiliary Power Unit	輔助動力系統
ARFF	Airport Rescue and Fire Fighting	機場救援及消防
ARM	Aircrew Resource Management	空勤組員資源管理
ASDE	Airport Surface Detection Equipment	機場場面偵測裝備
ASEP	Aircrew Safety Equipment and Procedures	空勤組員安全裝備及程序
ATC	Air Traffic Control	飛航管制
ATIS	Automatic Terminal Information Service	終端資料廣播服務
ATPL	Air Transport Pilot License	民航運輸業駕駛員執照
ATSB	Australian Transport Safety Bureau	澳洲運輸安全局
AWA	Airport Weather Advisor	機場氣象諮詢系統
CAA	Civil Aeronautics Administration	中華民國交通部民用航空局
CAAS	Civil Aviation Authority of Singapore	新加坡民用航空局
CB	Cumulonimbus	積雨雲
CCS	Casualty Clearance Station	急救檢傷中心
CFP	Computer Flight Plan	電腦飛航計畫
CIC	Crew-In-Charge	座艙長

CIQ	Custom, Immigration and Quarantine	海關、移民及檢疫
CRM	Crew Resource Management	組員資源管理
CVR	Cockpit Voice Recorder	座艙語音記錄器
EGT	Exhaust Gas Temperature	發動機尾管排氣溫度
EICAS	Engine Indication and Crew Alerting System	發動機指示及組員警示系統
EMM	Electronic Moving Map	電子動態地圖
ETOPS	Extended-Range Two-Engine Operations	雙引擎延程作業
FAA	Federal Aviation Administration	美國聯邦航空總署
FAM	Flight Administration Manual	新航飛航管理手冊
FCC	Flight Control Center	飛航管制中心
FCTM	Flight Crew Training Manual	飛航組員訓練手冊
FDAP	Flight Data Analysis Program	飛航數據分析程式
FDR	Flight Data Recorder	飛航資料記錄器
FMC	Flight Management Computer	飛航管理電腦
FOD	Foreign Object Damage	外物損害
HHDLU	Hand-Held Download Unit	手持式下載單元
ICAO	International Civil Aviation Organization	國際民航組織
ILS	Instrument Landing System	儀器降落系統
INTAM	Internal Notice to Airmen	內部飛航通告
LLZ	Localizer	左右定位台
MAC	Mean Aerodynamic Chord	平均氣動力弦
MCIT	Ministry of Communications and Information Technology	新加坡交通與資訊科技部
MEC	Main Equipment Center	電子艙
ND	Navigation Display	導航顯示器
NOTAM	Notice to Airmen	飛航公告
NTSB	National Transportation Safety Board	美國國家運輸安全委員會
NVM	Non Volatile Memory	非揮發性記憶體
OQAR	Optical Quick Access Recorder	光學式快速擷取記錄器

PAPI	Precision Approach Path Indicator	精確進場下滑指示燈
PFD	Primary Flight Displays	主要飛航顯示器
PIC	Pilot-In-Command	機長
PVD	Para-Visual Display	目視輔助系統
QAR	Quick Access Recorder	快速擷取記錄器
RAPS	Recovery, Analysis and Presentation System	飛航記錄資料分析及展示系統
RGL	Runway Guard Lights	跑道警戒燈
RVR	Runway Visual Range	跑道視程（儀）
SARPs	Standards and Recommended Practices	標準及建議措施
SEM	Scanning Electron Microscope	掃描式電子顯微鏡
SEP	Safety Equipment and Procedures	安全裝備及程序
SIA	Singapore Airlines	新加坡航空公司
SIGMET	Significant Meteorological Information	顯著危害天氣預報
SIP	Senior Instructor Pilot	資深教師機師
SMFCC	Senior Manager of FCC	飛航管制中心資深經理
SMGCS	Surface Movement Guidance and Control System	地面活動導引及管制系統
SSE	Safety, Section urity and Environment Department	安全、保安與環境部
SSFDR	Solid State Flight Data Recorder	固態式飛航資料記錄器
SVP	Senior Vice President	資深副總經理
TOGA	Takeoff / Go-Around	起飛/重飛
UDL	Left Upper Deck Door	上艙左側門
UDR	Right Upper Deck Door	上艙右側門
UTC	Co-ordinated Universal Time	世界標準時間
VMC	Visual Meteorological Conditions	目視天氣情況
VPSSE	Vice President of Safety, Security, and Environment	安全、保安及環境副處長

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1 事實資料

1.1 飛航經過

民國八十九年十月卅一日，台北時間 2317 時[4]（世界標準時間 1517 時），新加坡航空公司（簡稱新航）SQ006 班機，機型波音 747-400，新加坡登記號碼 9V-SPK，在象神颱風外圍環流強風豪雨下，於中正機場因施工部份關閉之 05 右跑道起飛時，撞擊護欄及施工機具。該定期客運班機原定由台北飛往美國洛杉磯，機上載有駕駛員三人(正駕駛員 CM-1、副駕駛員 CM-2 及加強飛航組員 CM-3）、客艙組員十七人及乘客一百五十九人。

本次事故共造成 83 人死亡（4 名客艙組員及 79 名乘客）、39 人重傷（4 名客艙組員及 35 名乘客）及 32 人輕傷（CM-2、9 名客艙組員及 22 名乘客），另 2 名駕駛員及 23 名乘客則未受傷。該機起飛時，油箱中裝載約 124,800 公斤燃油，該機因撞擊及隨後引發之火災導致損毀。

10 月 30 日 SQ006 三名駕駛員由新加坡開始執行「新加坡-台北-洛杉磯-台北-新加坡」航程任務，於完成當日新加坡至台北航程後，三名駕駛員於當日午夜抵達台北旅館，至 31 日 2035 時離開旅館前往機場。

2155 時，三名飛航組員報到執勤，隨後並完成起飛前準備工作，包括取得所需簽派文件[5]（如記載 05 右跑道部份道面關閉資訊之飛航公告[6]等）以及登機前檢查（此時飛機位於 B5 停機位），當晚是由 CM-1 擔任主飛駕駛員，負責滑行與起飛的操作。

依據當時機場值班管制員（許可頒發席）之錄音抄件[7]顯示，2257:16 時飛航組員接獲航管許可。

摘錄 2301:25 時，編碼為“Tango”之「終端資料廣播服務（ATIS）」：「…使用 05 左跑道，06 跑道僅供離場，預計 05 左跑道儀器降落系統第二類進場，風向 020 度，風速 36 浬/時，陣風 52 浬/時，能見度 500 公尺，05 左跑道跑道視程 450 公尺，06 跑道能見度 500 公尺，大雨，裂雲 200 呎，密雲 500 呎…注意 NS 滑行道已重新標示，建議使用 NS 滑行道時之航空器小心慢滑。NP 滑行道於 A1 與 A3 停機坪之間關閉。由

[4] 本報告所用之時間以 24 小時制台北當地時間為主，引用其它地方時間時將另加註地名。
[5] 新航委託長榮代理其台北中正機場簽派服務，詳細內容請見報告 1.17.4.3 節。
[6] 請參考附錄 1，編號 A0606 之飛航公告。
[7] 請參考附錄 2，台北許可頒發席之陸空通信抄件。

於施工，05 右跑道在 N4 與 N5 滑行道之間道面關閉。N4 與 N5 滑行道仍可使用...」

2305：57 時，SQ006 於 B5 停機位完成後推請求滑行，隨後獲得地面管制席許可：「新加坡 6 滑行至 06 跑道，沿滑行道…，更正，滑行至 05 左跑道，沿 SS 滑行道，West Cross 滑行道與 NP 滑行道」開始滑行。依據座艙語音記錄器錄音抄件[8]記載，地面管制席於 2306:08 時頒發滑行許可後，CM-2 表示：「我沒聽懂，那是什麼」，CM-1 重覆滑行許可；飛航組員之後討論至 05 左跑道之路徑；CM-2 於 2306:15 時覆誦許可：「沿 NP 滑行道滑行至 05 左跑道」。2307：05 時 CM-1 道：「慢慢滑行」，接著道：「OK，左轉，滑向右，現在經過方向零二四零」。此時因為高雄及香港機場皆已關閉，飛航組員開始討論備降場計劃。

2309：58 時，CM-1 道：「…要用很多的方向舵…」，CM-3 回答：「側風」。2310：21 時，CM-3 道：「…它接近了，他們拖愈久情形就會愈糟」，CM-1 回答：「是啊，如果我們還不起飛就會愈糟…這裡我要滑得很慢，因為要側滑了」。

2311：49 時， CM-1 道：「05 左的情形轉好了，能見度 550 公尺」。2312：58 時，該機在轉入 NP 滑行道後不久，飛航組員被要求轉換至塔台頻率。CM-2 呼叫塔台，塔台回覆：「新加坡 6 晚安，台北塔台，在 05 左跑道外等待」，CM-2 回覆收到。

2314：41 時，SQ006 沿著 NP 滑行道滑行，CM-2 道：「接下來是 N1 滑行道」，CM-1 接道：「好的，第二個右轉」，CM-2 回答：「對，第二個右轉」。2314：58 時，CM-1 指示 CM-2：「告訴他們我們準備好了…」；CM-2 呼叫後塔台隨後回覆：「新加坡 6 知道了，05 左跑道，滑行進入位置並等待」；之後又道：「新加坡 6，05 左跑道，風向 020 度，風速 28 浬／時，陣風 50 浬／時，許可起飛」，CM-2 回覆收到。依據飛航資料記錄器顯示，該機於管制員頒發許可時，正接近 NP 滑行道之西南端。

2315：48 時，飛航組員完成「起飛前檢查」。兩秒後 CM-2 道：「OK，綠燈在這裡」。CM-1 回答：「這裡很滑，我要稍微減速，這裡要慢慢轉」。依據飛航資料記錄器顯示，該機由 NP 滑行道右轉進入 N1 滑行道後，繼續右轉進入 05 右跑道。

2316：07 時，依據座艙語音記錄器錄音抄件記載，CM-2 道：「PVD[9]還沒對正哦」，CM-1 回答：「對，我們要先對正」，CM-3 接道：「我們需要 45 度」。2316：23 時，CM-1 道：「PVD 還沒作用呀，沒關係我們可以看見跑道，不是很差，OK，我先置於“High”的位置，準備好囉，所以 010 是從左邊，OK」， CM-2 回答：「OK」，接著是雨刷轉至高速聲音。

2316：44 時，座艙語音記錄器錄音顯示發動機聲音開始增大，11 秒後 CM-2 和 CM-3 同時呼叫：「80 浬/時」；2317：16 時 CM-1 道：「…有東西在那裏」；1 秒鐘

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[8] 請參考附錄 3 完整之座艙語音記錄器錄音抄件，為免翻譯造成失真，完整抄件仍以原文呈現。
[9] 目視輔助系統（Para-Visual Display，PVD），請參考報告第 1.18.5 節之敘述。

後聽到第一次撞擊聲。

該機開始起飛滾行約 33 秒後，撞擊 N4 與 N5 滑行道間之水泥澤西護欄、兩輛挖土機、兩輛蒸氣式壓路機、一輛推土機、一輛空氣壓縮機推車及一堆鋼筋。飛航資料記錄器最後記錄之最大空速為 158 浬/時，地速為 131 浬/時。

2317：36 時，中正塔台管制員見到爆炸及沿著該機起飛路徑上的大火，隨即按下警鈴通知消防隊。

1.2 人員傷害

波音 747-400 型機主艙配置 12 個頭等艙座位，28 個商務艙座位，316 個經濟艙座位，上艙另有 30 個商務艙座位；駕駛艙內配置 2 個駕駛員座位及 2 個觀察員座位；主艙前、中、後段共配置 16 個客艙組員座位，上艙則有 3 個客艙組員座位。

人員傷亡情形如表 1.2-1 所示。

表 1.2-1 傷亡統計表

傷亡	飛航組員	客艙組員	乘客	其他	總計
致命傷	0	4	79	0	83
重傷	0	4	35	0	39
輕傷	1	9	22	0	32
無礙	2	0	23	0	25
總計	3	17	159	0	179

本事件所有乘員死亡率為百分之四十六（83/179）；重傷率為百分之二十二（39/179）；輕傷率為百分之十八（32/179）；未受傷率為百分之十四（25/179）；乘客死亡率約為百分之五十（79/159）。

上艙 19 名乘客中計有 12 人罹難，死亡率為百分之六十三（12/19）；主艙中大部份罹難乘客分布於 31 排至 48 排的經濟艙區域中，此區域 76 名乘客中有 64 人罹難，罹難率為百分之八十四（64/76），另 12 名乘客均受重傷。

圖 1.2-1 顯示乘客座位分布及其受傷程度，資料來源為航空公司之乘客座位表及部份乘客訪談，由於失事前部份乘客也許自行換過座位，因此此圖並不能完全反應失事當時乘客真實座位。

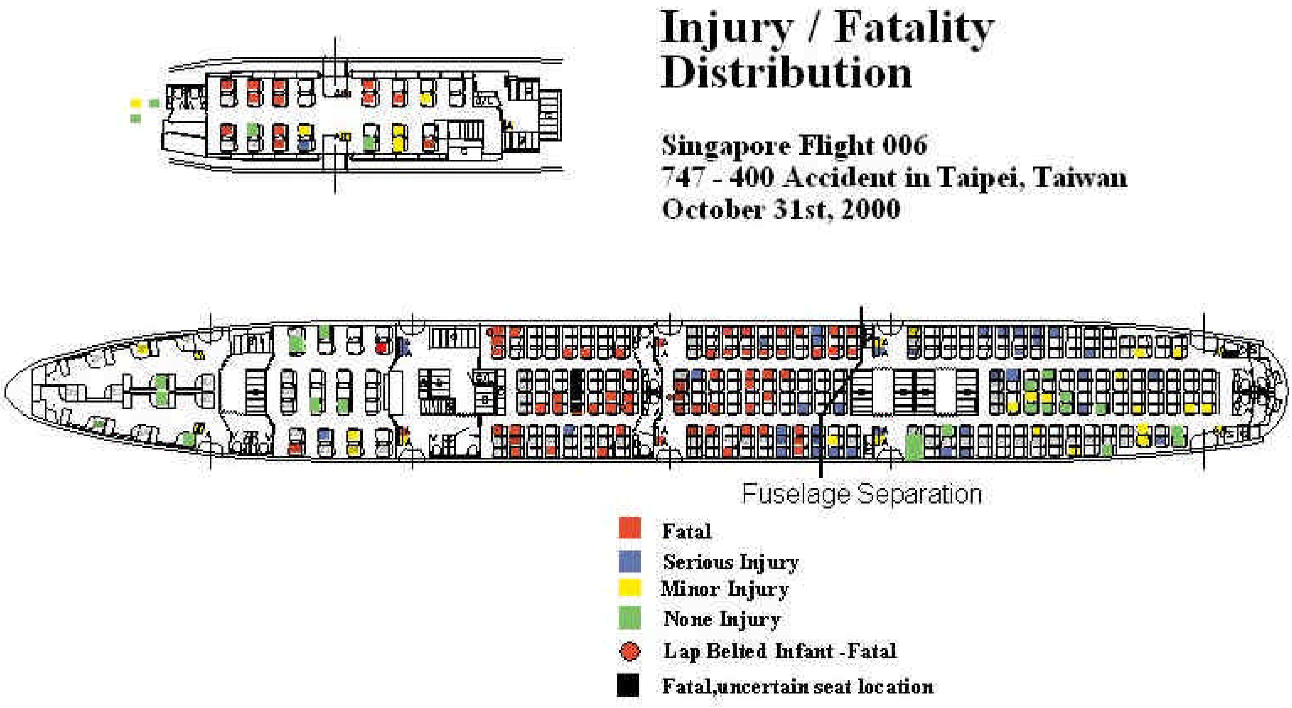

圖 1.2-1　　**人員傷亡分佈圖**

1.3　　航空器損害情況

航空器遭受嚴重撞擊及隨後引發之大火以致全毀，殘骸沿跑道散佈於整個失事現場。

後段機身（座位 49 **排之後）與前段分離，外型大致完整；前段與中段機身（座位** 48 **排以前）則遭嚴重火燒。駕駛艙內除油門推桿外所有儀表及面板全? ；左、右翼及前段機身雖遭大火燒? 但外型完整，前段機身呈現蒙皮熔融現象。**

1.4　　其它損害情況

施工人員在 05 **右跑道現場留有** 11 **個施工坑洞及** 6 **部機具，包括兩輛挖土機（圖** 1.4-1**）、兩輛蒸氣式壓路機（圖** 1.4-2**）、一輛推土機（圖** 1.4-3**）以及一輛空氣壓縮機。六輛機具皆因嚴重撞擊而損毀，除一輛挖土機與一輛推土機外，其餘機具都由原先位置撞落至各個施工坑洞。**

圖 1.4-1　　挖土機（在 5 號坑洞內）

圖 1.4-2　　振動滾筒（在 11 號坑洞內）

圖 1.4-3　　推土機（在 11 號坑洞內）

1.5 人員資料

1.5.1 正駕駛員（CM-1）

CM-1 為馬來西亞籍，生於 1959 年。設籍於馬來西亞 Johore Bahru，但住在新加坡。

1979 年 3 月 12 日 CM-1 以新訓駕駛員身份進入新航，但自 1980 年 8 月至 1981 年 4 月及 1983 年 2 月至 1984 年 5 月期間，因公司職務調動致其飛航訓練兩度中斷。恢復駕駛員工作後，於 1986 年 4 月 11 日起擔任波音 747-300 型機副駕駛員，1991 年 7 月轉任波音 747-400 型機副駕駛員，1995 年 11 月 16 日晉升為空中巴士 310-200/300 型機正駕駛員，1997 年 4 月被任命為督導正駕駛員，1998 年 4 月 13 日轉任波音 747-400 型機正駕駛員。

1993 年 1 月 2 日 CM-1 取得民航運輸業駕駛員執照（ATP），並持有波音 747-200/300、波音 747-400 及空中巴士 310-200/300 等型機之檢定。2000 年 8 月 19 日完成最近一次適職考驗，其中包括第三類儀降進場；2000 年 4 月 21 日完成最近一次航路考驗；2000 年 6 月 20 日完成最近一次安全裝備及程序考驗，2000 年 6 月 14 日完成最近一次 PVD 複訓。

CM-1 於 1985 年 7 月 7 日完成第一階段之空勤組員資源管理訓練，1988 年 7 月 14 日完成第二階段之空勤組員資源管理訓練，1999 年 2 月 28 日完成第三階段之空勤組員資源管理訓練。

至失事當日，CM-1 總飛行時間為 11,235 小時，其中波音 747-400 型機飛行時間為 2,017 小時。最近 12 個月飛行時間為 806 小時 53 分，最近 90 日飛行時間為 164 小時 11 分，最近 60 日飛行時間為 148 小時 35 分，最近 30 日飛行時間為 78 小時 56 分，本班機任務前 CM-1 休息時間為 23 小時 39 分。

1.5.1.1 個人因素

CM-1 無任何事件處分或警告記錄，其個人記錄顯示，十三年前曾接獲公司警告，告知該員於蘇黎士離場時應注意實施減低噪音操作。

依據公司記錄，CM-1 在波音 747-400 之初訓考驗、複訓（模擬機）考驗、航路考驗及基本考驗中，表現皆高於最低要求，其技術能力被評為高於駕駛員之平均水準。

執行 CM-1 最近一次基本考驗之資深教師機師（Senior Instructor Pilot，SIP）在訪談中表示，CM-1 在該次考驗中成績中等。執行 CM-1 最近一次航路考驗之教師機師以及在本次事故發生前與 CM-1 同組飛行之駕駛員表示，CM-1 最近並無不尋常或特殊

表現。

CM-1 於訪談中表示無財務或個人問題。

1.5.1.2 醫學因素

CM-1 持有之新加坡民航運輸業駕駛員體檢證核發日期為 2000 年 9 月 5 日，無任何限制，該員身高 170 公分，體重 65.7 公斤，兩眼裸視遠距視力為 6/6（相當於 20/20），近距視力為 N5（正常），經 Ishihara plates 檢查無色盲。

1.5.1.3 72 小時歷史記錄

CM-1 於 2000 年 10 月 27 日新加坡時間 2100 時（世界標準時間+8），執行由新加坡飛往澳洲墨爾本之班機。10 月 28 日墨爾本時間 0600 時（世界標準時間+10）抵達墨爾本，約 1 小時後抵達旅館，休息至墨爾本時間 1700 時，與副駕駛員共進晚餐，約兩小時後返回旅館房間，直至隔日墨爾本時間 0300 時才入睡，睡至中午，約墨爾本時間 1400 時與副駕駛員共進午餐，之後回房間繼續休息。CM-1 於墨爾本時間 1730 時離開墨爾本，於新加坡時間約 2230 時抵達新加坡。

10 月 30 日 CM-1 自新加坡時間 0100 時睡至 1100 時，在家午餐後，約新加坡時間 1730 時離家前往機場準備飛往台北，於台北時間 2145 時飛抵台北，於午夜左右抵達旅館。

10 月 31 日夜 CM-1 自 0100 時休息至 1100 時；在訪談中，該員稱：「當晚睡得很好沒被打擾」，1130 時 CM-1 與同組飛航組員共進午餐，午餐時間約 2 小時，之後休息一會兒並於 1600 時至 1900 時再度入睡。於 2035 時離開旅館，2155 時抵機場報到。

依 CM-1 所述，事故發生前三天之飲食、睡眠及工作都如往常。

1.5.2 副駕駛員（CM-2）

CM-2 為新加坡籍，生於 1959 年，設籍並住在新加坡。

1994 年 6 月 6 日 CM-2 以新訓駕駛員身份進入新航，進公司前為新加坡陸軍軍官，完成新訓駕駛員訓練後，於 1997 年 1 月起擔任空中巴士 310-200/300 型機副駕駛員，1998 年 6 月轉至波音 777-200/300 機隊，2000 年 2 月轉至波音 747-400 機隊。

1999 年 8 月 6 日 CM-2 取得民航運輸業駕駛員執照，並持有空中巴士 310-200/300、波音 777-200/300 及波音 747-400 等型機之檢定。2000 年 10 月 19 日完成最近一次適職考驗，其中包括第三類儀降進場；2000 年 2 月 16 日完成最近一次

航路考驗；2000 年 6 月 20 日完成最近一次安全裝備及程序考驗；1999 年 12 月 12 日完成最近一次 PVD 複訓。

CM-2 於 1997 年 6 月 12 日完成第一階段之空勤組員資源管理訓練，1999 年 10 月 18 日完成第二階段之空勤組員資源管理訓練。

至失事當日，CM-2 總飛行時間為 2,442 小時，其中波音 747-400 型機飛行時間為 552 小時。最近 12 個月飛行時間為 682 小時 02 分；最近 90 日飛行時間為 201 小時 11 分；最近 60 日飛行時間為 133 小時 46 分；最近 30 日飛行時間為 42 小時 14 分。本班機任務前 CM-2 之休息時間為 23 小時 39 分。

1.5.2.1 個人因素

CM-2 之個人記錄中，無任何事件處分記錄。

CM-2 在波音 747-400 型機之初訓考驗、複訓（模擬機）考驗、航路考驗及基本考驗中，其表現皆高於最低要求；依據其訓練記錄，其技術能力被評為平均水準以上。

執行 CM-2 最近一次基本考驗之資深教師機師在訪談中表示，CM-2 在該次考驗中成績中等；執行 CM-2 最近一次航路考驗之教師機師表示，CM-2 在該次考驗中表現中等；本次事故前，曾與 CM-2 同組飛行之駕駛員亦表示，CM-2 是一位表現在平均水準以上之駕駛員。

CM-2 表示無財務及個人問題。

1.5.2.2 醫學因素

CM-2 持有之新加坡民航運輸業駕駛員體檢證核發日期為 2000 年 7 月 26 日, 無任何限制，該員身高 174 公分，體重 76.3 公斤，兩眼裸視遠距視力為 6/6（相當於 20/20），近距視力為 N4.5（正常），Ishihara plates 檢查無色盲。

1.5.2.3 72 小時歷史記錄

CM-2 於 10 月 26 日執行由美國舊金山至新加坡之任務，10 月 27 日至 29 日間無任務，此期間大都在家中與家人同處。

10 月 30 日 CM-2 於新加坡時間 0615 時起床，稍後至新航處理財務事宜，在新加坡時間 1600 時前小睡片刻，新加坡時間 1630-1645 時駕車抵達機場，準備執行 SQ006 任務（新加坡至台北段，新加坡時間 1730 時由新加坡出發，台北時間 2125 時抵達台北），約於午夜抵達台北旅館，但未能立即入睡。

10 月 31 日約 0800 時起床後到健身房運動，使用跑步機約 30 分鐘，並做了些伸展和重量訓練約一個小時，於 1130 時和其他組員會合共進午餐，午餐持續約兩個小時，之後回旅館繼續睡覺，約於 2035 時離開旅館前往機場，於 2155 時報到。

依 CM-2 所述，事故發生前三天之飲食、睡眠或工作都如往常。

1.5.3 加強飛航組員（CM-3）

CM-3 為新加坡籍，生於 1962 年，設籍並住在新加坡。

1992 年 3 月 9 日 CM-3 進入新航，完成新訓駕駛員訓練後，於 1993 年 11 月 9 日起擔任空中巴士 310-200/300 型機副駕駛員，於 1995 年 6 月轉至波音 747-400 機隊。

1997 年 1 月 7 日 CM-3 取得民航運輸業駕駛員執照，並持有空中巴士 310-200/300 及波音 747-400 型機之檢定。2000 年 8 月 31 日完成最近一次適職考驗，其中包括第三類儀降進場；2000 年 2 月 20 日完成最近一次航路考驗；2000 年 2 月 22 日完成最近一次安全裝備及程序考驗；2000 年 6 月 14 日完成最近一次 PVD 複訓。在 28 天休假後，2000 年 10 月 29 日完成模擬機飛行複訓。

CM-3 於 1993 年 7 月 30 日完成第一階段之空勤組員資源管理訓練，1994 年 8 月 10 日完成第二階段之空勤組員資源管理訓練。至失事當日，CM-3 總飛行時間為 5,508 小時，其中波音波音 747-400 型機飛行時間為 4,518 小時，最近 12 個月飛行時間為 823 小時 57 分，最近 90 日飛行時間為 139 小時 30 分，最近 60 日飛行時間為 92 小時 19 分，最近 30 日接受模擬機複訓時間 4 小時。本班機任務前 CM-3 之休息時間為 23 小時 39 分。

1.5.3.1 個人因素

CM-3 無任何事件處分記錄。

CM-3 在波音 747-400 之初訓考驗、複訓（模擬機）考驗、航路考驗及基本考驗中，表現皆高於最低要求；依據訓練記錄，其技術能力被評為高於平均水準。

CM-3 表示無財務或個人問題。

1.5.3.2 醫學因素

CM-3 持有之新加坡民航運輸業駕駛員體檢證核發日期為 2000 年 9 月 7 日，該員身高 177 公分，體重 72 公斤，兩眼裸視遠距視力為 6/18（相當於 20/60），矯正後為 6/6（相當於 20/20），兩眼裸視近距視力為 N5（正常），該證註記飛行時需配戴眼鏡校正視力，同時應攜帶另一副備用，此外無其它限制，Ishihara plates 檢查無色盲。

1.5.3.3 72 小時歷史記錄

CM-3 於 2000 年 10 月 28 日前有 28 天休假，其中幾天在香港，據 CM-3 表示，在假期結束前 3 天返回新加坡。CM-3 於訪談中表示，期間有適當休息，每日睡眠約 10 小時。CM-3 於 10 月 29 日假期結束後，實施波音 747-400 模擬機熟悉訓練以恢復原有資格。

由於 CM-3 須執行 SQ006 第二天台北至洛杉磯任務，因此 10 月 30 日以乘客身份搭乘該機前往台北，抵台北後約於午夜住進旅館，不久後便入睡。

10 月 31 日 CM-3 約於台北時間 1030 時起床，1130 時與其他飛航組員共進午餐，午餐時間約 2 小時，回到旅館房間後，複習航圖並休息兩、三個小時。約於 2155 時和其他組員一起抵機場報到。

依 CM-3 所述，事故發生前三天之飲食、睡眠或工作皆如往常。

1.5.4 客艙組員

SQ006 之客艙組員初、複訓完成日期如表 1.5-1 所示。

表 1.5-1　　客艙組員訓練記錄

客艙組員座位位置	初訓日期	複訓日期	座艙長複訓日期
上艙左側門	1997.10.29	2000.10.10	不適用
上艙右側門	1978.6.30	2000.9.19	2000.4.28
上艙廚房	1997.11.11	2000.10.10	不適用
主艙左側 1 號門	1990.9.25	2000.3.30	不適用
主艙右側 1 號門	1989.5.3	2000.8.23	不適用
主艙左側 2 號門,內側	1973.8.3	1999.11.25	2000.5.23
主艙左側 2 號門,外側	1998.10.21	2000.10.11	不適用
主艙右側 2 號門,內側	1987.12.23	2000.9.13	不適用
主艙右側 2 號門,外側	1979.11.7	2000.7.20	2000.1.13
主艙左側 3 號門,內側	無人	不適用	不適用
主艙左側 3 號門,外側	1992.7.13	2000.8.31	不適用
主艙右側 3 號門,內側	無人	不適用	不適用
主艙右側 3 號門,外側	1996.4.30	2000.4.27	不適用
主艙左側 4 號門,內側	1995.10.16	2000.8.22	不適用
主艙左側 4 號門,外側	1992.5.11	2000.4.6	不適用
主艙右側 4 號門,內側	2000.8.10	未逾期	不適用
主艙右側 4 號門,外側	1995.1.13	1999.12.23	不適用
主艙左側 5 號門	2000.2.24	未逾期	不適用
主艙右側 5 號門	2000.2.23	未逾期	不適用

1.5.5　管制員甲-機場管制席（LC）

管制員甲已在中正塔台工作三年，符合民航局管制員資格及訓練要求。

1.5.5.1　72 小時歷史記錄

管制員甲 2000 年 10 月 29 日未值班。

該員於訪談時表示，其於 2000 年 10 月 30 日 0700 時起床，之後看書，中午用過午餐，午睡至 1600 時，之後於 1840 時到達塔台，1845 時開始值班。塔台值班記錄顯示管制員甲於 1845 時開始值班。

10 月 31 日 0900 時工作結束後，該員約於 1030 時回到家中，休息至 1200 時起床用午餐，之後又睡到 1500-1600 時，後於 1840 時到達塔台工作。

該員在事故前 72 小時共值班 18.5 小時，包含交班休息時間在內，並表示 72 小時內飲食、工作及睡眠一切如常。

1.5.6 管制員乙-地面管制席（GC）

管制員乙已在中正近場台及塔台工作四年，符合民航局管制員資格及訓練要求。

1.5.6.1 72 小時歷史記錄

管制員乙於 2000 年 10 月 29 日值班，約 0720 時由家中前往機場，約 0845 時抵達並於 0900 時接班，1900 時工作結束後約 2020 回到家中休息。

10 月 30 日該員於 0720 時由家中前往機場，約 0845 時到達並於 0900 時接班，同樣 1900 時工作結束後約 2020 回到家中休息。

該員表示 10 月 31 日白天時皆在家中休息，1720 時由家中前往機場，約 1840 時到達，0900 時交班，11 月 1 日 0900 時工作結束。

該員在事故前 72 小時共值班 24.5 小時，包含交班休息時間在內，並表示 72 小時內飲食、工作及睡眠一切如常。

1.5.7 管制員丙-許可頒發席（CD）

管制員丙已在中正塔台工作三年，符合民航局管制員資格及訓練要求。

1.5.7.1 72 小時歷史記錄

該員 10 月 29 日白天未當班，約 1720 時由家中前往機場，1840 時到達，1900 時交班，直至隔日 0900 時工作結束，1020 時回到家，當日便整日在家休息。

10 月 30 日白天該員未當班，約 1720 時由家中前往機場，1840 時到達，1900 時交班，直至隔日 0900 時工作結束，1020 時回到家，當日便整日在家休息。

10 月 31 日白天該員未當班，約 1720 時由家中前往機場，1840 時到達，1900 時交班，直至隔日 0900 時工作結束，1020 時回到家，當日便整日在家休息。

該員在事故前 72 小時共值班 31.5 小時，包含交班休息時間在內，並表示 72 小時內飲食、工作及睡眠一切如常。

1.5.8 管制員丁-飛航資料席（FD）

管制員丁已在民航局工作五年，符合民航局近場台及塔台管制員資格，同時亦為塔台管制員教官。

1.5.8.1 72 小時歷史記錄

該員約於 10 月 29 日 0640 時開車前往中正塔台，約 0800 時到達，並於 0840 時接班，1700 時工作結束後約 2010 回到家中。

該員約於 10 月 30 日 0640 時開車前往中正塔台，約 0800 時到達，並於 0840 時接班，1700 時工作結束後約 2010 回到家中。

該員 10 月 31 日白天未當班，下午因颱風接近關係，提早於 1600 時開車前往機場，約 1700 時到達，並於 1840 時接班，隔日 0900 時工作結束約 1010 回到家中休息。

該員在事故前 72 小時共值班 31.5 小時，包含交班休息時間在內，並表示 72 小時內飲食、工作及睡眠一切如常。

1.6 航空器資料

1.6.1 基本資料

表 1.6-1 失事航空器基本資料

1	國藉登記標誌及登記號碼	新加坡登記 9V-SPK
2	機型	波音 747-412B
3	製造商	波音商業飛機公司（簡稱波音公司）
4	序號	28023
5	出廠日期	1997 年 1 月 21 日
6	使用人	新加坡航空公司 Airline House, 25 Airline Road, Singapore 819829
7	所有權人	新加坡航空公司 Airline House, 25 Airline Road, Singapore 819829
8	登記證書號碼	S151
9	適航證號碼 有效期限	AWC431 2000 年 1 月 21 日至 2001 年 1 月 20 日
10	總計飛行時數	18,459 小時（至 2000 年 10 月 29 日）
11	總計落地次數	2,274 次（至 2000 年 10 月 29 日）
12	上次維修類別	A Check
13	上次維修日期	2000 年 9 月 16 日，飛行時數 17,838 小時/187 次落地
14	自上次維修檢查起，總計飛行時數/落地次數	飛行時數 621 小時/87 次（至 2000 年 10 月 29 日）

1.6.2 載重與平衡

中華航空公司地勤人員為 SQ006 製作裝載表。本會審查該表後發現，該機載重與平衡均在操作限制內。

1.6.3 維修記錄

經本會人員檢視其 2000 年 8 月 1 日至 10 月 31 日三個月間之飛行記錄簿及相關維修記錄，未發現該機於飛行前有延遲改正項目及未完成修護之缺點，亦未發現最近 30 天內有相關之維修記錄，未發現該機有不符適航標準之情形。

1.7 天氣資料

1.7.1 天氣概述

國內北部地區受東北季風及象神颱風影響，各地均有陣雨。當時象神颱風中心位於中正機場南方 360 公里處，最大風速 75 浬/時、陣風 90 浬/時，中心氣壓 965 百帕。

事故發生時，台北航空氣象中心曾發布中正機場積雨雲（CB）之顯著危害天氣預報（SIGMET），以及數個大風警報及颱風警報。

1.7.2 地面天氣觀測

以下為事故發生前後，中正機場氣象台之地面天氣觀測記錄[10]：

時間 2240；類型—選特天氣觀測；風向 020°，風速 38 浬/時，陣風 58 浬/時；能見度 800 公尺；跑道視程—R05/800 公尺、R06/800 公尺；天氣現象—大雨；裂雲 200 呎、密雲 500 呎；溫度 21℃，露點 20℃；高度表撥定值 1002 百帕；RWY 05 風切[11]；趨勢預報—無顯著變化。

時間 2254；類型—選特天氣觀測；風向 020°，風速 36 浬/時，陣風 52 浬/時；能見度 500 公尺；跑道視程—R05/450 公尺、R06/500 公尺；天氣現象—大雨；裂雲 200 呎、密雲 500 呎；溫度 21℃，露點 20℃；高度表撥定值 1001 百帕；RWY 05 風切；趨勢預報—無顯著變化。

時間 2300；類型—整點天氣觀測；風向 020°，風速 36 浬/時，陣風 56 浬/時；能見度 600 公尺；跑道視程—R05/450 公尺、R06/550 公尺；天氣現象—大雨；裂雲 200 呎、密雲 500 呎；溫度 21℃，露點 20℃；高度表撥定值 1001 百帕；RWY 05 風切；趨勢預報—無顯著變化；雨量 22.5 公厘。

時間 2320；類型—另加天氣觀測；風向 020°，風速 30 浬/時，陣風 61

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[10] 此風向風速及跑道視程為 10 分鐘平均值

[11] 此風切紀要由 2127 之駕駛員報告獲得，該機於最後進場，高度 500 呎時遭遇風切。

浬/時；能見度 600 公尺；跑道視程—R05/550 公尺、R06/800 公尺；天氣現象—大雨；裂雲 200 呎、密雲 500 呎；溫度 21℃，露點 21℃；高度表撥定值 1002 百帕；RWY 05 風切。

1.7.3 駕駛員由航管獲得之天氣資訊

根據座艙通話記錄器抄件，駕駛員於起飛前由航管通信獲得關於 05 左跑道之天氣資訊如下所示[12]：

2307:16 時：風向 020°，風速 25 浬/時，陣風 41 浬/時；跑道視程—450 公尺。

2313:38 時：風向 020°，風速 24 浬/時，陣風 43 浬/時。

2315:22 時：風向 020°，風速 28 浬/時，陣風 50 浬/時。

1.8 助、導航設施

中正機場助航設施當時無故障記錄。

1.9 通信

SQ006 與中正機場塔台間之無線電通信正常。

1.10 場站資料

1.10.1 概述

美國派森斯公司（Ralph M. Parsons Company）於民國五十九年依國際民航組織之標準及建議措施（SARPs）設計中正機場。當時，中華民國尚為國際民航組織會員國。民國六十三年開工至民國六十八年完工啟用，此期間中華民國已非國際民航組織會員國。中正機場圖如圖 1.10-1 所示。

[12] 中正機場塔台所顯示之風向風速及跑道視程為 2 分鐘平均值。

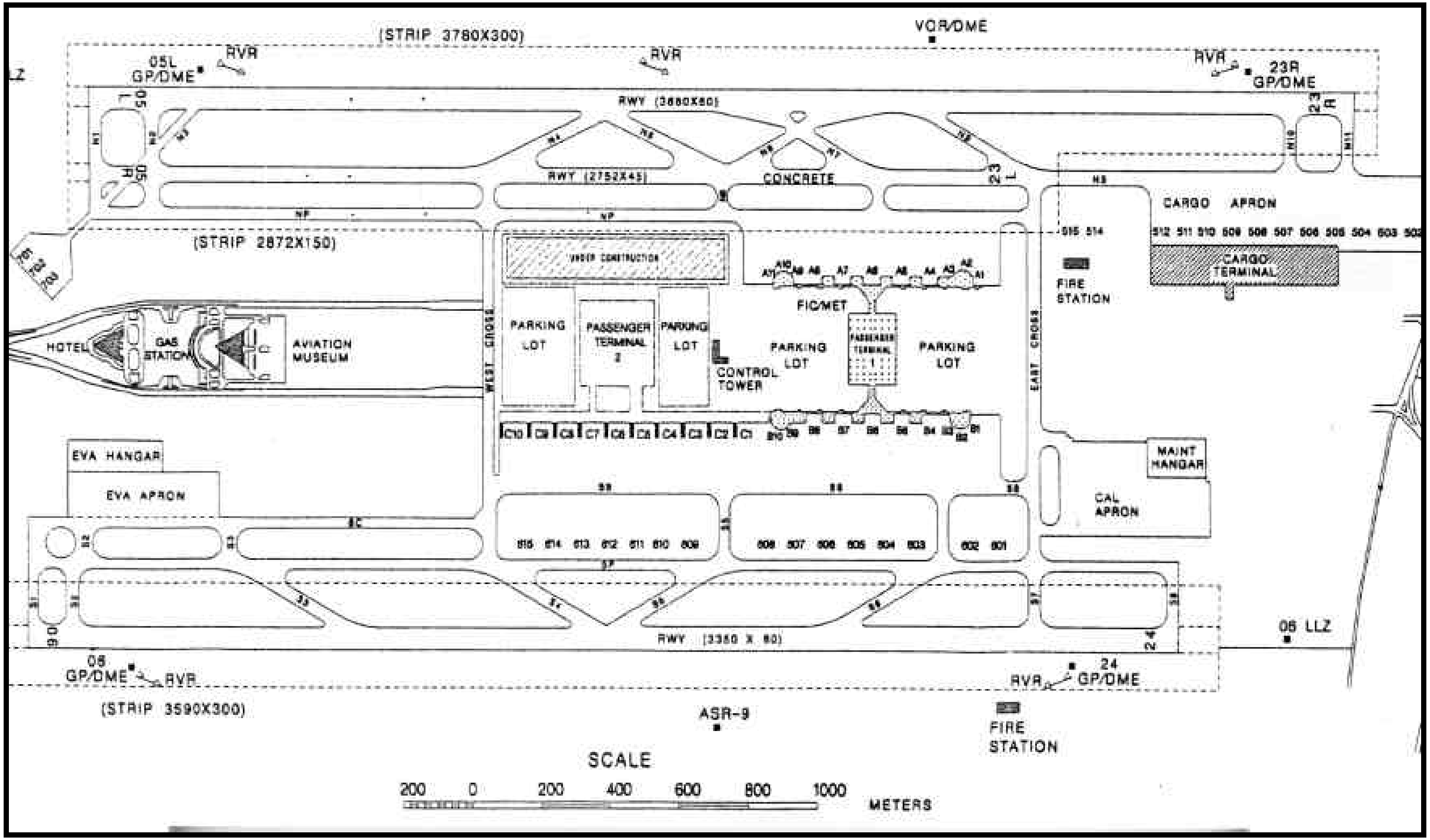
(STRIP 3780X300)
VOR/DME
05L
GP/DME
RVR
RVR
RVR
23R
GP/DME
RWY (3660X60)
RWY (2752X45)
CONCRETE
(STRIP 2872X150)
CARGO APRON
CARGO TERMINAL
FIRE STATION
UNDER CONSTRUCTION
FIC/MET
PARKING LOT
PASSENGER TERMINAL 2
PARKING LOT
CONTROL TOWER
PARKING LOT
PASSENGER TERMINAL 1
PARKING LOT
WEST CROSS
EAST CROSS
HOTEL
GAS STATION
AVIATION MUSEUM
EVA HANGAR
EVA APRON
MAINT HANGAR
CAL APRON
RWY (3350 X 60)
06
GP/DME
RVR
(STRIP 3590X300)
ASR-9
RVR
24
GP/DME
FIRE STATION
06 LLZ
SCALE
200 0 200 400 600 800 1000
METERS

圖 1.10-1　**中正機場圖**

該機場原設計並未有 05 右/23 左跑道，而是一條平行於 05 左/23 右跑道之滑行道，當時稱為 A 滑行道，並依據當時之國際民航組織標準及建議措施裝設綠色滑行道中心線燈。唯於機場施工中，考量 05 左/23 右跑道關閉時須有緊急備用跑道，於是對 A 滑行道加以改建，並於機場啟用時，改稱為 05 右/23 左跑道。

民國六十年之後，中華民國已非國際民航組織會員國，雖然機場在建造時依據當時國際民航組織標準及建議措施以及美國聯邦航空總署之規範，但民航局已無法再由國際民航組織直接獲得後續修訂之標準及建議措施。

根據民航局官員表示，中正機場 05 右跑道已計劃變更為 NC 滑行道，但變更計劃因材料採購無法配合而延後。同時，05 右跑道在 N4、N5 滑行道間亦因道面維修而關閉。事故發生時，05 右跑道除施工區外，仍為供航機滑行使用之跑道。

1.10.2 事故時跑滑道之具體特徵

1.10.2.1 跑道配置

中正機場有三條跑道，兩條在航站大廈北邊之平行跑道及一條在航站大廈南邊之跑道。北邊主跑道為 05 左/23 右，平行跑道則為 05 右/23 左。二條跑道中心線相距 214 公尺。航站大廈南邊則為 06/24 跑道。

05 左/23 右跑道長 3,660 公尺，寬 60 公尺，道面由無溝紋水泥混凝土板塊組成，為第二類儀降跑道（CAT II）。

05 右/23 左跑道長 2,752 公尺，寬 45 公尺，為非儀器跑道。此跑道裝置綠色滑行道中心線燈供滑行用，白色跑道邊燈供起飛用。此跑道不供落地使用，但駕駛員可提出請求，經中正機場及航管單位同意後用以起飛。一般而言，在 501-515 號停機坪內停有大型航空器時，因安全隔離不足而不會同意此項請求。另外，正側風超過 22 節（乾跑道）或 17 節（溼跑道）時，05 右/23 左跑道及與其平行之 NP 滑行道禁止同時間使用。

06/24 跑道長 3,350 公尺，寬 60 公尺，以無溝紋水泥混凝土版塊組成道面，為第一類儀降跑道（CAT I）。

1.10.2.2 北面滑行道配置

中正機場北面之滑行道包括：NP, NS, N1, N2, N3, N4, N5, N6, N7, N8, N9, N10, N11 及 East Cross、West Cross。

NP 滑行道寬 30 公尺，道肩寬 11 公尺。其他滑行道（即 N1、N2….及快速脫離滑

行道 N4、N5、N7、N8…）則寬 35 公尺，道肩寬 11 公尺。

NP 滑行道由航站北面客機停機坪起向西延伸，靠近且與 05 右/23 左跑道平行。兩者中心線距離為 110 公尺。NP 滑行道面架設架有綠色滑行道中心線燈及藍色滑行道邊燈。

N1 滑行道與 NP 滑行道垂直，由 NP 滑行道起經 05 右跑道頭延伸至 05 左跑道。此滑行道長 324 公尺，由 NP 滑行道中心線至 05 右跑道中心線距離為 110 公尺，由 05 右跑道中心線至 05 左跑道中心線間距離為 214 公尺。道面架設架有綠色中心線燈及藍色滑行道邊燈。

1.10.3 事故時之目視助航設施

1.10.3.1 標線

1.10.3.1.1 跑道等待位置及標線

中正機場 05 左跑道有兩個跑道等待位置，分別位於 N1 及 N2 滑行道。二者皆位於 05 左跑道中心線南方 120 公尺處。

第三個跑道等待位置位於 NP 滑行道上，距 N1 滑行道中心線東 76 公尺處。各跑道等待位置如圖 1.10-2 所示。

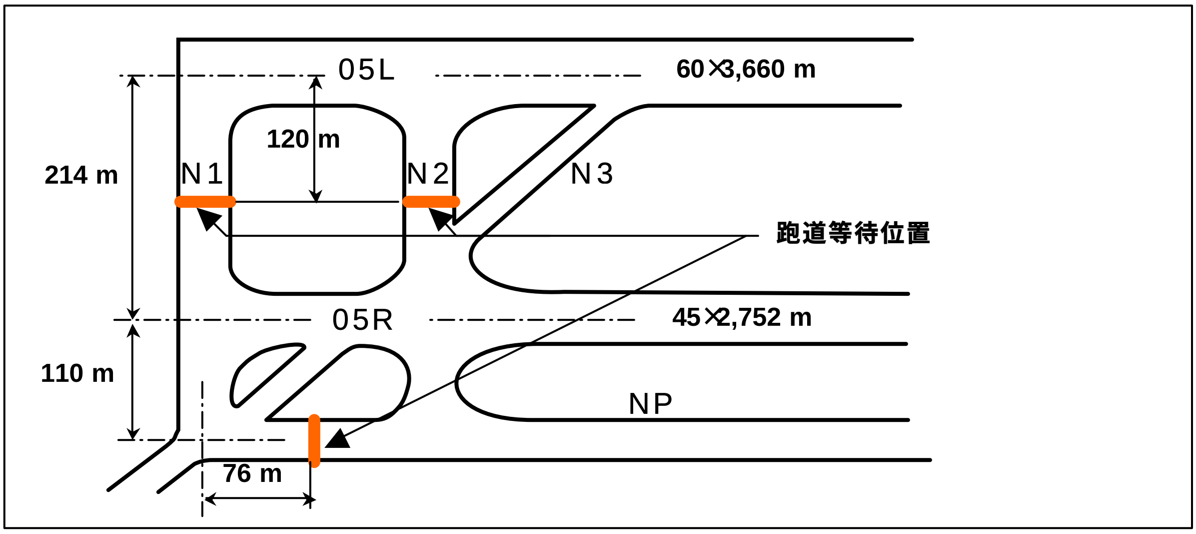

圖 1.10-2　各跑道等待位置之相對距離

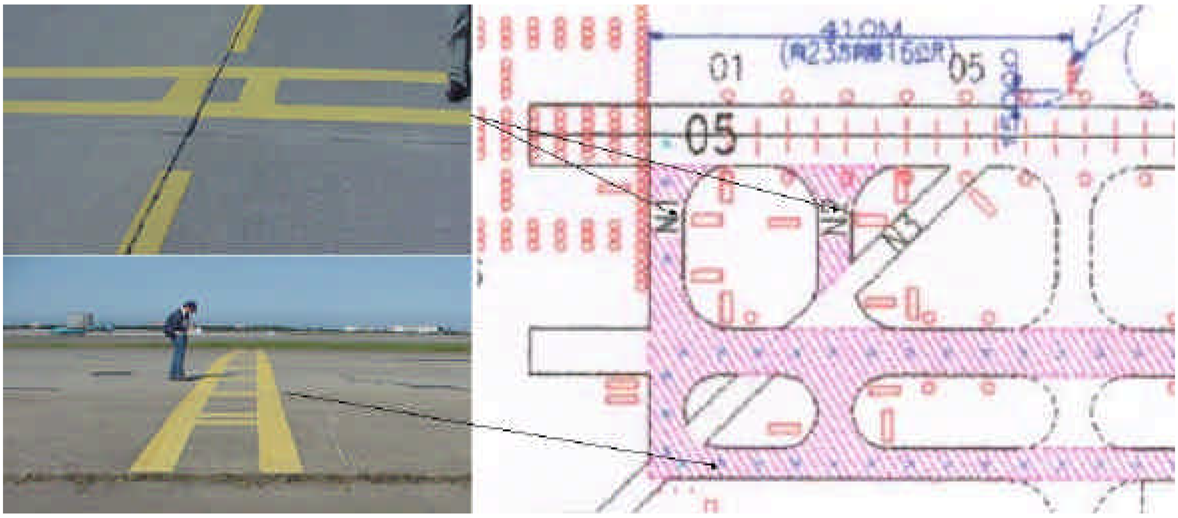

圖 1.10-3　N1 及 NP 滑行道上之跑道等待位置標線

根據國際民航公約第十四號附約第 1 冊第 3.11.6 節之表 3-2，跑道等待位置與非儀器起飛跑道中心線之最短距離為 75 公尺。若為精確進場跑道，則最短距離為 90 公尺，若保護儀降/微波降落系統臨界區所需之距離較長時，則以此距離為主。

摘錄國際民航公約第十四號附約第 1 冊 5.2.9.2 節、5.2.9.3 節、5.2.9.5 節有關跑道等待位置之標準與建議措施如下：

5.2.9.2 **節（標準）：**

> *"At an intersection of a taxiway and a non-instrument, non-precision or takeoff runway, the runway holding position marking shall be as shown in Figure 5-6[13], pattern A."*

[13] 請參考圖 1.10-4。

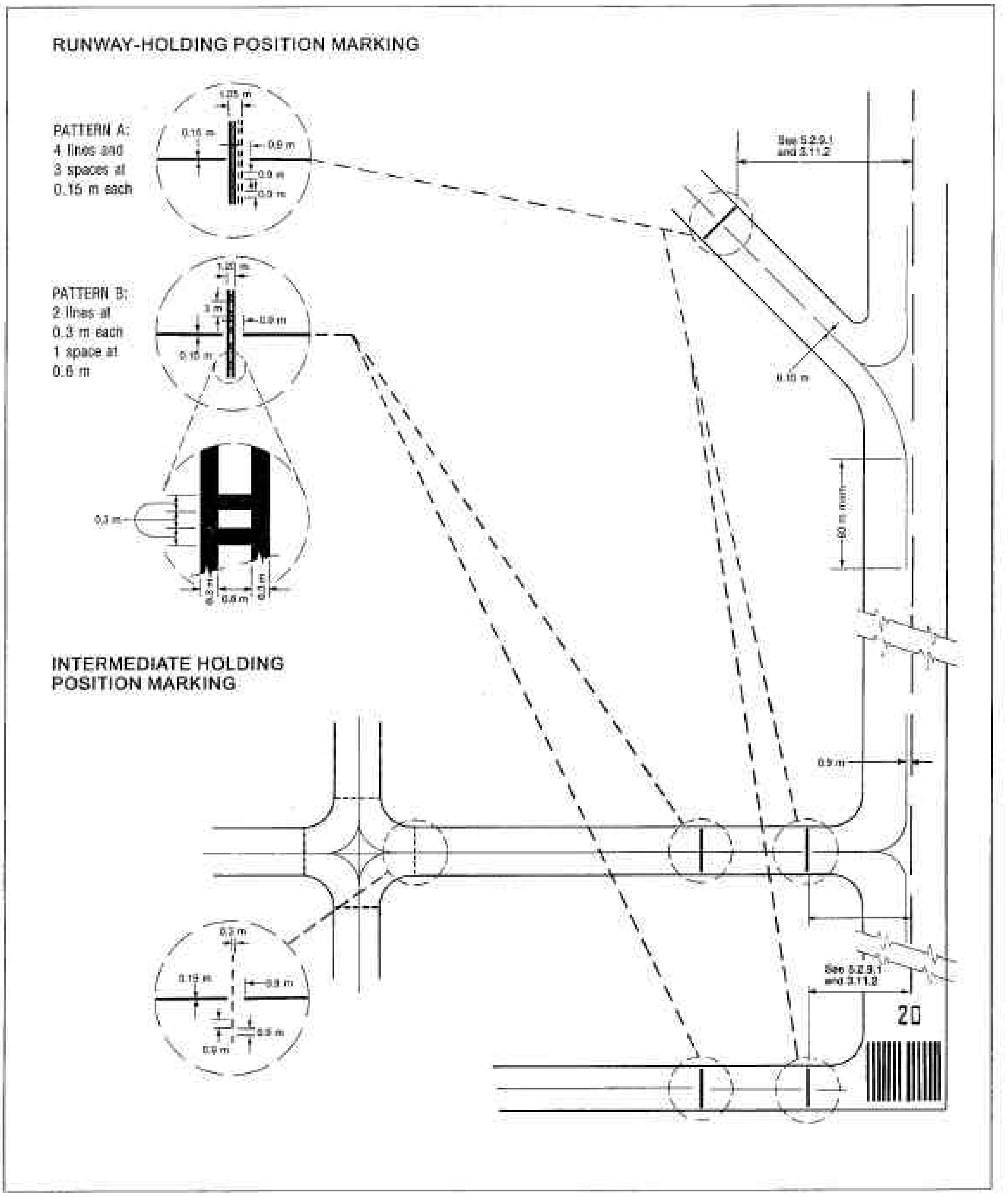

圖 1.10-4　　**摘自國際民航公約第十四號附約第** 1 **冊圖** 5-6

5.2.9.3 **節（標準）：**

"Where a single runway holding position is provided at an intersection of a taxiway and a precision approach category I, II, III runway, the runway holding position marking shall be as shown in Figure 5-6, pattern A. Where two or three runway holding positions are provided at such an intersection, the runway holding position are provided at such an intersection, the runway

holding position marking closer to the runway shall be shown in Figure 5-6, pattern A and the markings farther from the runway shall be as shown in Figure 5-6, pattern B."

5.2.9.5 **節：**

"*Recommendation - Where increased conspicuity of the runway holding position is required, the runway holding position marking should be as shown in Figure 5-7*[14]*, pattern A or pattern B, as appropriate."*

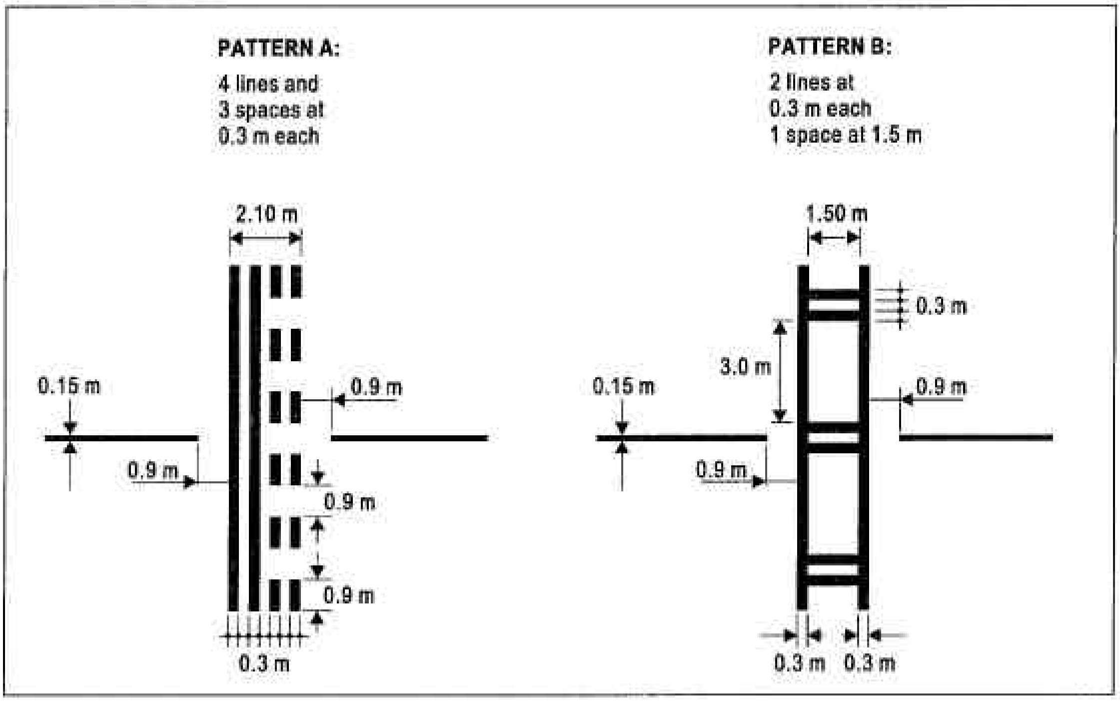

圖 1.10-5　　**摘自國際民航公約第十四號附約第** 1 **冊，圖** 5-7

美國聯邦航空總署民航通告 AC150/5340-1H **建議『一組跑道等待位置標線應包含四條黃線及三個間隔，寬度皆為** 15 **公分』。**2000 **年** 12 **月** 1 **日起，美國聯邦航空總署標準將標線及間隔寬度加倍至** 30 **公分。**

設置儀器/微波降落系統臨界區等待位置標線（類似圖 1.10-5 **之** B **型標線）之目的，『讓航機識別在未獲許可進入儀降臨界區時應停止之位置，而臨界區是為導航信號不受干擾而設置。』**

『當跑滑道等待位置與儀降臨界區之等待位置距離不大於 15 **公尺時，設置一等待位置即可，此時不會影響其效用。此情形下，跑道前等待位置可後移至儀降臨界區等待**

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14 **請參考圖** 1.10-5。

位置，且僅需設置跑道等待位置標線。』

『在水泥混凝土及淺色道面上，所有跑道等待位置標線須為黃色並加黑色框線。』

1.10.3.1.2 滑行道中心線標線

中正機場之滑行道中心線標線均為 20 公分寬之黃顏色標線，標示於所有滑行道面。

N1 滑行道之單線中心線標線以一連續之弧形由 NP 滑行道連至 05 右跑道之中心線，而另一反向弧形則由 05 右跑道中心線位置切至 N1 滑行道中心線，切線繼續延伸至 05 左跑道邊線止，然 N1 滑行道經 05 右跑道頭標線區兩側之部份中心線標線則未標示，如圖 1.10-6 所示。

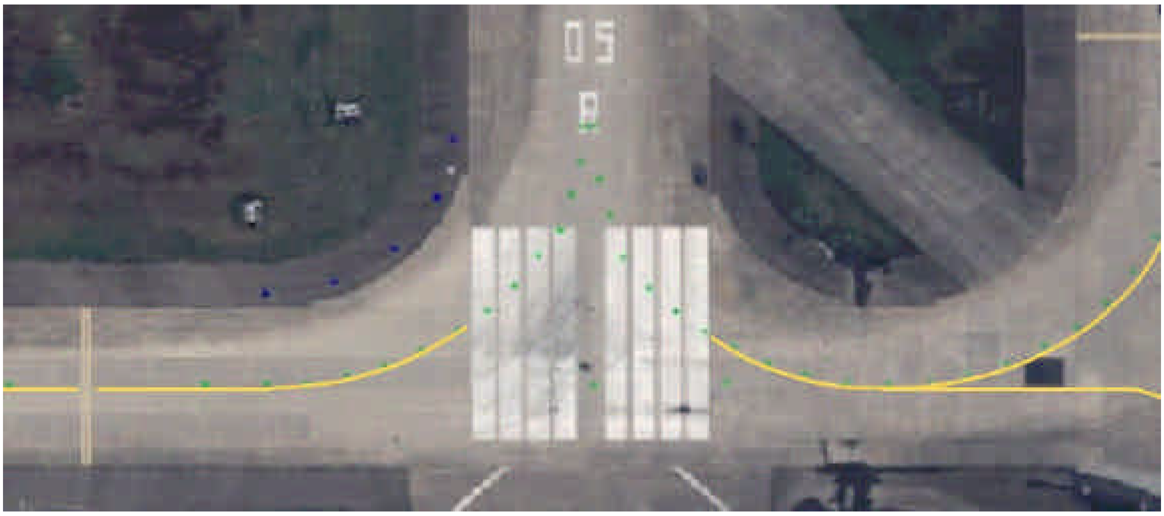

圖 1.10-6　　05 右跑道頭標線區之滑行道中心線標線

根據民航局「民航機場土木設施設計標準規範」3.8.5.1 節：

『…滑行道中心線標線與跑道端標誌、指示標誌、著陸區標誌及著陸點標誌衝突時，滑行道中心線標線應中斷，中斷處與跑道端標誌及指示標誌保持 12m 間隔，…』

上述民航局所使用之標誌即本報告之標線；跑道端標誌即本報告之跑道頭標線；指示標誌即跑道方位標線。

如圖 1.10-7 所示。

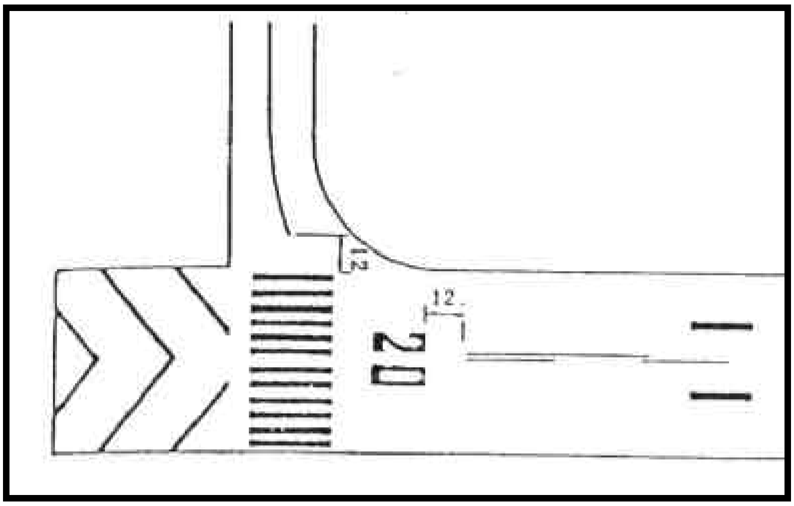

圖 1.10-7　　滑行道中心線標線中斷說明

根據國際民航公約第十四號附約第 1 **冊第** 5.2.8.1 **節（標準）：**

"At an intersection of a runway and taxiway, the markings of the runway shall be displayed and the taxiway marking shall be interrupted, except runway side stripe markings may be interrupted."

根據國際民航公約第十四號附約第 1 **冊第** 5.2.1.3 **節（標準）：**

"At an intersection of a runway and taxiway, the markings of the runway shall be displayed and the taxiway marking shall be interrupted, except runway side stripe markings may be interrupted."

此外，美國聯邦航空總署民航通告 AC150/5340-1H **建議當滑行道與跑道末端交叉時，滑行道中心線標線須在跑道邊中斷，但當航管單位指定之滑行路徑須穿越跑道時，則該滑行道中心線標線可同時橫越跑道（不論是直線橫越或有所偏移）。唯當此中心線標線碰到任何跑道標線時，則應中斷。**

該署民航通告 AC150/5340-1H **亦建議，用作低能見度作業（跑道視程低於** 360 **公尺），之滑行道，其中心線標線可橫越除跑道方位標線外之所有跑道標線。**

1.10.3.2　燈光

中正機場之 05/23 **跑道燈光系統如表** 1.10-1 **所示。**

表 1.10-1　　05/23 跑道燈光系統

設施	使用的跑道燈光線路
05 左/23 右跑道	進場燈（白色，第二類儀降紅色邊帶） 跑道中心線燈（白/紅） 高亮度跑道邊燈（白/黃）、跑道端燈（紅）及跑道頭燈（綠色） 落地區燈（白） 精確進場下滑指示燈（PAPI）（白/紅） 跑、滑道交界處之滑行道邊燈（藍）
05 右/23 左跑道	跑道邊燈（白/黃）及跑道端燈（紅）及跑道頭燈（綠） 滑行道中心線燈（綠） 跑、滑道交界處之滑行道邊燈（藍）

1.10.3.2.1 跑道邊燈及跑道端燈

中正機場 05 左/23 右及 05 右/23 左跑道均架設有雙向聚光之跑道邊燈。燈距約 55 至 60 公尺，兩者之製造廠商及規格皆相同（符合美國聯邦航空總署規格，Crouse Hinds L-862 直立燈及 L-852 平地燈）。直立之跑道邊燈使用的燈泡型別為 6.6A/T4Q/CL/2PPF 及 Philips 6372/200W/6.6A/8L，圖 1.10-8 為一裝置於 05 右/23 左跑道之跑道邊燈。

圖 1.10-8　　05 右/23 左跑道高起邊燈

而中正機場 05 左/23 右及 05 右/23 左跑道亦同樣裝置有跑道端燈，05 右/23 左跑道兩端分別有 8 盞跑道末端燈，對稱分佈於跑道中心線兩側，跑道末端燈及跑道邊燈屬同一迴路，因此由塔台之同旋鈕控制。

1.10.3.2.2 跑道警戒燈

跑道警戒燈（RGL**）為「地面活動導引及管制系統」（**SMGCS**）組件之一。架設架設方式為在滑行道上之跑道等待位置兩側設置一對直立之黃色閃光燈，或是直接橫越滑行道，於跑道等待位置標線上架設一列黃色閃光燈，其功用在確認跑道是在使用中，協助避免跑道入侵。**

依據國際民航公約第十四號附約第 1 **冊第** 5.3.20.1 **節（標準）：**

"*Runway guard lights, Configuration A, shall be provided at each taxiway/runway intersection associated with a runway intended for use in: a) runway visual range conditions less than a value of 550 meters where a Stop bar is not installed; or b) runway visual range conditions values between 550 meters and 1200 meters, and where the traffic density is heavy.*"

根據美國聯邦航空總署民航通告 AC120-57A **第** 8b **段中第一條，有關跑道視程低於** 1,200 **呎時之規定：**

"All taxiways that provide access to an active runway (regardless of whether they are part of the low visibility taxi route) should have runway guard lights installed at the runway holding position on the taxiway."

失事當時，中正機場未架設跑道警戒燈。

1.10.3.2.3 停止線燈

停止線燈由直立型及平地型之紅色燈組成，裝置於跑道等待位置或儀降臨界區等待位置標線。該燈之啟閉由航管人員控制，配合航機可能進入及穿越跑道之滑行道中心線/引導燈光系統（平地式綠色）。該燈裝置目的在於攔住車輛或航機，除非獲得航管人員許可進入始能進入跑道。

停止線燈亦為「地面活動導引及管制系統」組件之一，用於加強低能見度時之滑行作業，以減少跑道入侵及其它意外可能性。

根據國際民航公約第十四號附約第 1 **冊第** 5.3.17.1 **節（標準）：**

"A *stop bar shall be provided at every runway holding position serving a runway when it is intended that the runway will be used in runway visual range conditions less than a value of 350m, except where, a) appropriate aids and procedures are available to assist in preventing inadvertent* *incursions of aircraft and vehicles onto the runway; or b) operational procedures exist to limit, in runway visual range conditions less than a value of 550m, the number of: 1) aircraft on the maneuvering area to one at a time; and 2) vehicles on the maneuvering area to the essential minimum.*"

根據國際民航公約第十四號附約第 1 **冊第** 5.3.17.2 **節（**1999 **年** 7 **月）：**

"*Recommendation - A stop bar should be provided at every runway-holding position serving a runway when it is intended that the runway will be used in runway visual range conditions of values between 350m and 550m, except where:*

a) appropriate aids and procedures are available to assist in preventing the inadvertent incursions of aircraft and vehicles onto the runway; or

b) operational procedures exist to limit, in runway visual range conditions less than a value of 550m, the number of:

1) aircraft on the maneuvering area to one at a time; and

2) vehicles on the maneuvering area to the minimum."

國際民航公約第十四號附約第 1 **冊第** 5.3.17.3 **節指出「**5.3.17.2 **節之規定，於** 2001 **年** 1 **月** 1 **日起將適用為標準」。**

美國聯邦航空總署民航通告 AC150/5340-28**，在「低能見度滑行道燈光系統」記載美國聯邦航空總署有關停止線燈架設標準：**

"*Stop bars are required for operations below 183m RVR at illuminated taxiways that provide access to the active runway.*"

事故發生時，中正機場未建立「地面活動導引及管制系統」，故未架設架設停止線燈。

1.10.3.2.4 滑行道中心線燈

中正機場北面所有滑行道均架設架設滑行道中心線燈（美國聯邦航空總署規格，L-852 **型）,機場南面滑行道則無。滑行道出口及入口之中心線燈延伸至跑道中心線處。**05 **右**/23 **左跑道亦架設架設滑行道中心線燈（未架設跑道中心線燈）。在滑行道直線部分，中心線燈間距** 30 **公尺。滑行道彎道部分，燈距則為** 7.5 **公尺，兩者架設之中心線燈規格相同，功率皆為** 65 **瓦，雙向綠色燈光。**

在滑行道出口處未架架設綠、黃交錯之滑行道中心線燈，以區隔儀降臨界區。當航

機沿 NP 滑行道滑行時，滑行道直線部份之中心線燈間距為 30 公尺。當其沿彎道右轉進入 N1 滑行道時，其中心線燈間距變為 7.5 公尺，直到與 N1 滑行道中心線直線之切點。此時航機繼續沿彎道進入 05 右跑道，而中心線燈間距仍為 7.5 公尺直至與 05 右跑道中心線相切處。之後，沿著 05 右跑道之滑行道中心線線燈間距又恢復為 30 公尺，此時航機可沿 N1 滑行道朝 05 左跑道前進，然至 05 左跑道等待位置前之直線部份，共有四盞滑行道中心線燈，此滑行道中心線燈位置分別距切點（彎曲之 NP 滑行道中心線標線與 N1 滑行道中心線標線直線部份交會點）30 公尺、55 公尺、116 公尺及 138 公尺（如圖 1.10-9）。

本會人員於現場蒐證時（民國八十九年十一月四日），發現在切點後第一盞滑行道中心線燈故障，第二盞燈則不夠亮，如圖 1.10-10。

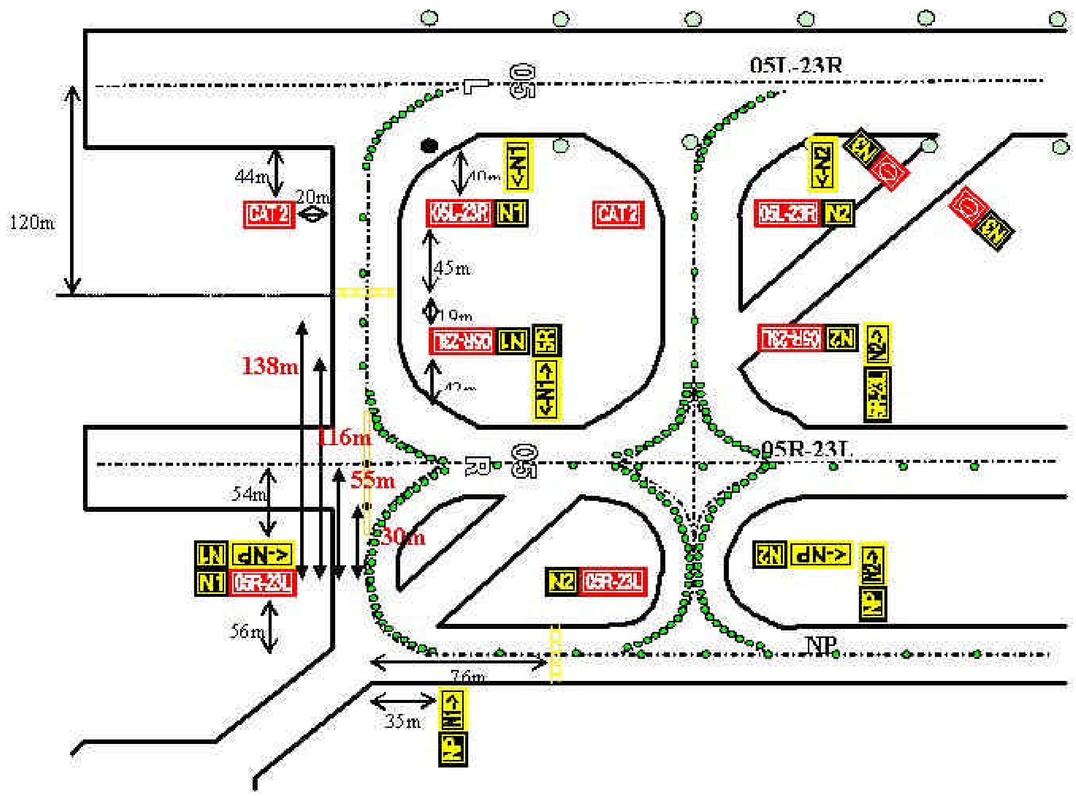

圖 1.10-9　　N1 滑行道中心線燈間距

圖 1.10-10　05 右跑道頭處之 N1 滑行道中心線燈情況（攝於八十九年十一月四日）

根據國際民航公約第十四號附約第 1 冊第 5.3.15.1 節（標準）：

"Taxiway centerline lights shall be provided on an exit taxiway, taxiway, de/anti-icing facility and apron intended for use in runway visual range conditions less than a value of 350 m in such a manner as to provide continuous guidance between the runway center line and aircraft stands, except that these lights need not be provided where the traffic density is light and taxiway edge lights and center line marking provide adequate guidance."

根據國際民航公約第十四號附約第 1 冊第 5.3.15.2 節：

"Recommendation - Taxiway centerline lights should be provided on a taxiway intended for use at night in runway visual range conditions of 350 m or greater, and particularly on complex taxiway intersections and exit taxiways, except that these lights need not be provided where the traffic density is light and taxiway edge lights and centre line marking provide adequate guidance."

根據國際民航公約第十四號附約第 1 冊第 5.3.15.4 節（標準）：

“Taxiway centerline lights shall be provided on a runway forming part of a standard taxi-route and intended for taxiing in runway visual range conditions less than a value of 350 m, except that these lights need not be provided where the traffic density is light and taxiway edge lights and centre line marking provide adequate guidance.”

根據國際民航公約第十四號附約第 1 **冊第** 5.3.15.7 **節（標準）：**

“Taxiway centerline lights on an exit taxiway shall be fixed lights. Alternate taxiway centerline lights shall show green and yellow from their beginning near the runway centerline to the perimeter of the ILS/MLS critical/sensitive area or the lower edge of the inner transitional surface, whichever is farther from the runway; and thereafter all lights shall show green (Figure 5-20). The light nearest to the perimeter shall always show yellow. Where aircraft may follow the same centerline in both directions, all the centerline lights shall show green to aircraft approaching the runway.”

根據國際民航公約第十四號附約第 1 **冊第** 5.3.15.10 **節：**

“Recommendation – Taxiway centerline lights should normally be located on the taxiway center line marking, except that they may be offset by not more than 30 cm where it is not practicable to locate them on the marking.”

根據國際民航公約第十四號附約第 1 **冊第** 5.3.15.11 **節：**

“Recommendation - Taxiway centerline lights on a straight section of a taxiway should be spaced at longitudinal intervals of not more than 30m, except that:

a) larger intervals not exceeding 60m may be used where, because of the prevailing meteorological conditions, adequate guidance is provided by such spacing;

b) intervals less than 30m should be provided on short straight sections; and

c) on a taxiway intended for use in RVR conditions of less than a value of 350m, the longitudinal spacing should not exceed 15m.”

根據國際民航公約第十四號附約第 1 **冊第** 5.3.15.12 **節：**

“*Recommendation - Taxiway centerline lights on a taxiway curve should continue from the straight portion of the taxiway at a constant distance* *from the outside edge of the taxiway curve. The lights should be spaced at intervals such that a clear indication of the curve is provided.”*

根據國際民航公約第十四號附約第 1 **冊第** 5.3.15.13 **節：**

“Recommendation - On a taxiway intended for use in RVR conditions of less than a value of 350 meters, the lights on a curve should not exceed a spacing of 15 meters and on a curve of less than 400 meters radius the lights should be spaced at intervals of not greater than 7.5 meters. This spacing should extend for 60 meters before and after the curve.

Note 1. - Spacings on curves that have been found suitable for a taxiwa y intended for use in RVR conditions of 350 meters or greater are:

Curve radius	*Light spacing*
up to 400m	*7.5m*
401m to 899m	*15m*
900m or greater	*30m”*

根據國際民航公約第十四號附約第 1 **冊第** 9.4.20 **節（標準）：**

“A light shall be deemed to be unserviceable when the main beam average intensity is less than 50 percent of the value specified in the appropriate figure in Appendix 84. For light units where the designed main beam average intensity is above the value shown in Appendix 84, the 50 percent value shall be related to that design value”

有關滑行道中心線燈之標準，可參考美國聯邦航空總署民航通告 AC150/5340-28 **「低能見度滑行道燈光系統」。該通告建議若滑行道屬常用路線，在跑道視程低於** 365 **公尺時，滑行道中心線燈應橫越跑道。當滑行道中心線燈橫越跑道時，自跑道中心開始，燈的顏色應為綠黃交錯（**AC150/5340-28, 3b**）。跑道視程** 365 **公尺以上時，滑行道直線部份之中心線燈間距為** 30 **公尺，低於** 365 **公尺則為** 15 **公尺。美國聯邦航空總署規定滑行道中心線燈與中心線橫向距離為** 0.6 **公尺。航空器脫離跑道時所見之滑行道中心線燈（引導脫離燈），應為不同顏色燈光，以警告航空器及車輛駕駛員仍在跑道安全區或儀降臨界區內（取兩者中較嚴格者）。綠、黃交錯燈（第一盞為綠燈）之架設架設須自跑道中心線開始，至跑道等待位置或儀降臨界區等待位置（取兩者中較嚴格者）後一盞中心線燈位置止。**

事故發生時，05 **左**/23 **右跑道起飛跑道視程標準為** 200 **公尺。**

1.10.3.3 滑行道及相關資訊指示牌

中正機場裝置多種指示牌，其中架設架設於滑行道與跑道入口間之指示牌為紅底白字。指示牌高約 1.1 **公尺，內有照明燈具。指示牌位置與最近之滑行道邊緣相距約** 20 **公尺。**

架設於 N1 **滑行道左側，距** 05 **右跑道中心線南面** 54 **公尺處之指示牌，其上標示跑道名稱「**5R-23L**」。**

架設於 N1 **滑行道左側，距** 05 **左跑道中心線南面** 75 **公尺處之指示牌，其上標示「**CAT2**」，而架設於** N1 **滑行道右側，與「**CAT2**」同一位置之指示牌則標示「**5L-23R|N1**」。**

以下係摘錄自國際民航公約第十四號附約第 1 **冊第** 5.4.2 **節有關滑行道及資訊指示牌之設計與架設位置部份內容，提供跑滑道交叉口、等待位置、跑道名稱及臨界區等指示牌之相關規定：**

第 5.4.2.8 **節：**

"A runway designation sign at a taxiway/runway intersection or a runway/runway intersection shall be located on each side of the runway holding position marking facing the direction of approach to the runway."

第 5.4.2.9 **節：**

"A category I, II, III holding position sign shall be located on each side of the runway holding position marking facing the direction of the approach to the critical area."

第 5.4.2.12 **節：**

"Existing installations need not meet the requirement of 5.4.2.8, 5.4.2.10, and 5.4.2.11 to provide a sign on each side of the taxiway until 1 January 2001."

第 5.4.2.14 **節：**

"The inscription on a runway designation sign shall consist of the runway designations of the intersecting runway properly oriented with respect to the viewing position of the sign, except that a runway designation sign installed in the vicinity of a runway extremity may show the runway designation of the concerned runway extremity only."

第 5.4.2.15 **節：**

“The inscription on a category I, II and III or joint II/III holding position sign shall consist of the runway designator followed by CAT I, CAT II, CAT III or CAT II/III, as appropriate.”

1.10.4 場站施工

1.10.4.1 場站施工過程

國內所有機場之設施改善計畫皆由民航局提出。該類計劃有不同來源，包括局內相關單位建議，或經諮詢航站使用者及業者後提出。

此外，中正機場管理部門每兩個月與機場使用者委員會（指機場安全小組）舉行會議時，也可提出改善計畫。此類會議邀請局內相關單位、航空公司代表、航廈內之販賣業者及政府機關如海關等出席。航空站航務組、維護組及貨運站人員亦有代表出席。此會議提供與會者討論影響航站作業及設施之管道。

一旦決定某項場站改善計畫，中正機場或民航局場站組即配合提出預算需求。核准後發包予廠商，並由航站維護組督導。承包商須承擔相關安全規範責任。承包商施工期間之安全措施，須經航站航務組審核。

機場使用者藉由飛航公告瞭解機場施工狀況及可能造成之影響。飛航公告係由機場內之諮詢台（隸屬民航局飛航服務總台）協調航站航務組、維護組及塔台後發布。決定各階段跑道關閉施工時程前，機場作業需求需先考量。

05 右/23 左跑道施工之飛航公告 A0606（見附錄 1）於 2000 年 9 月 13 日發布。該公告說明 N4 及 N5 滑行道間之 05 右/23 左跑道因施工關閉，停止起飛操作，但該跑道其他部份以及 N4、N5 滑行道仍可作為滑行之用。

1.10.4.2 暫時及部份道面關閉跑道施工區之目視導引設施

根據中正機場提供資訊，由於該區常有颱風帶來強風及大雨，輕質易碎之塑膠製品及紅色障礙燈很容易被吹離或沖走，形成外物損害（FOD）航空器之可能。為防止此類情況，中正機場於緊鄰施工區域，提供混凝土製高約 0.8 公尺、長 1 公尺澤西護欄以為阻攔。該護欄塗漆為黃色、橙色或黃黑混合線條。護欄上裝有夜間使用之電池式紅色警告閃光燈，燈距約 2 至 5 公尺。（見圖 1.10-11）

圖 1.10-11 **由** 05 **左跑道觀察** 05 **右跑道關閉施工區**

事故當時，澤西護欄為唯一在跑道上供辨識施工區域之目視助航設施。05 **右**/23 **左跑道兩端部份區段仍須供滑行使用，因此保持開放而未加阻隔。**

根據國際民航公約第十四號附約第 1 **冊第** 7.1.2 **節：**

"Recommendation - A closed marking should be displayed on a temporarily closed runway or taxiway or portion thereof, except that such marking may be omitted when the closing is of short duration and adequate warning by air traffic services is provided."

根據國際民航公約第十四號附約第 1 **冊第** 7.1.3 **節（標準）：**

"On a runway a closed marking shall be placed at each end of the runway, or portion thereof, declared closed, and additional markings shall be so placed that the maximum interval between markings does not exceed 300 m. On a taxiway a closed marking shall be placed at least at each end of the taxiway or portion thereof closed."

根據國際民航公約第十四號附約第 1 **冊第** 7.1.4 **節（標準）：**

"Note- *When an area is temporarily closed, frangible barriers or markings utilizing materials other than paint or other suitable means may be used to identify the closed area.*"

根據國際民航公約第十四號附約第 1 **冊第** 7.1.7 **節（標準）：**

"*In addition to closed markings, when the runway or taxiway or portion thereof closed is intercepted by a usable runway or taxiway, which is used at night, unserviceability lights shall be placed across the entrance to the closed area at intervals not exceeding 3 m (see 7.4.4)*."

根據美國聯邦航空總署民航通告 AC150/5340-1H **第** 1 **章第** 4 **節「暫時關閉跑道及滑行道」之建議：**

"*When it is necessary to provide a visual indication that a runway is temporarily closed, crosses are placed only at each end of the runway on top of the runway designation markings or just off the runway end when required by construction activity. The crosses are yellow in color and conform to the dimensions specified in the advisory circular. Since the crosses are temporary, they are usually made of some easily removable material, such as plywood or fabric rather than painted on the pavement surface. Any materials used for temporary crosses should provide a solid appearance. Since these crosses will usually be placed over white runway markings, their visibility can be enhanced by a 15 cm black border.*

A raised-lighted cross may be placed on each runway end in lieu of the markings described to indicate the runway is closed. Normally the raised-lighted cross would be located on the runway; however, it may be located in the safety area on the extended runway centerline.

Temporarily closed taxiways are usually treated as hazardous areas. However, as an alternative, a yellow cross that conforms to the dimensions in Figure 20[15] *may be installed at each entrance to the taxiway.*

If the runway or taxiway will be closed during nighttime, the runway lights will normally be disconnected so that they cannot be illuminated unless such illumination is needed to perform maintenance operations on or adjacent to the runway."

[15] **請參考圖** 1.10-12。

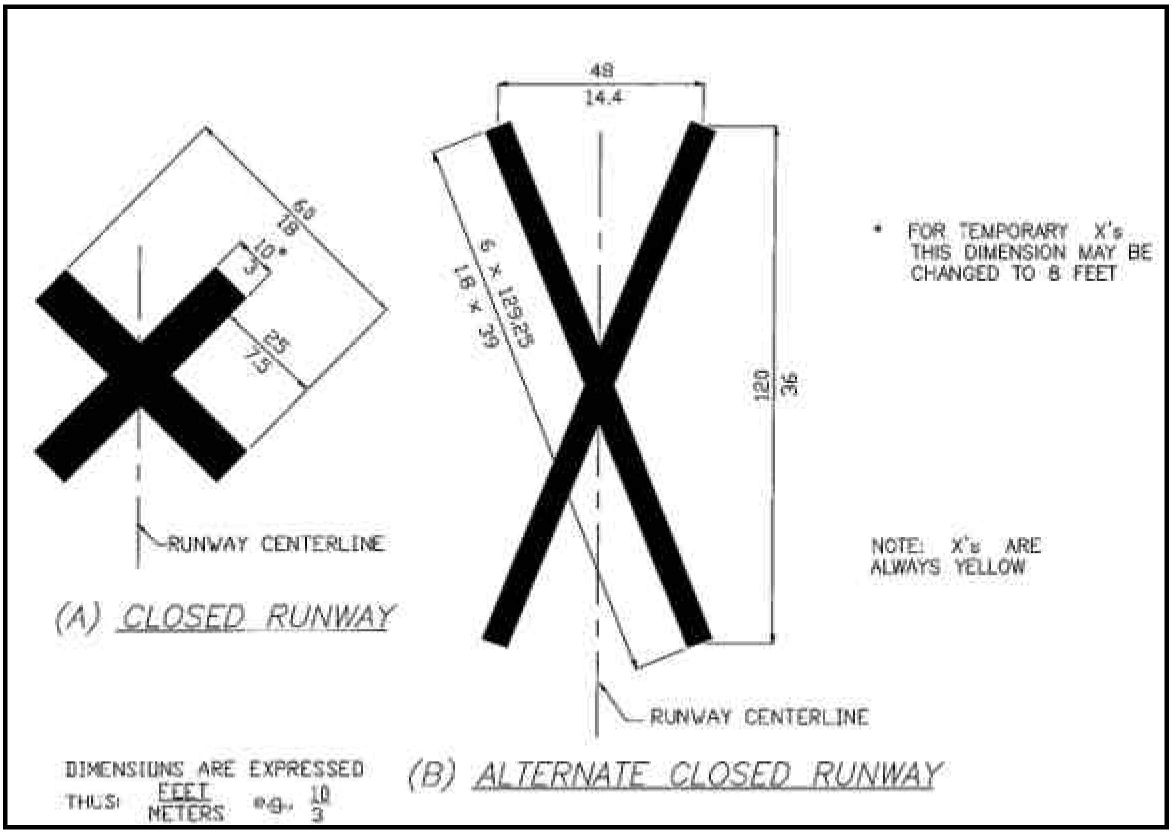

圖 1.10-12 **摘自美國聯邦航空總署民航通告** AC150-5340.1 **圖** 20

1.10.5 裝備與設施

1.10.5.1 機場燈光監控

1.10.5.1.1 迴路互鎖[16]

根據國際民航公約第十四號附約第 1 **冊第** 8.2.3 **節（標準）**:

"Where a runway forming part of a standard taxi-route is provided with runway lighting and taxiway lighting, the lighting systems shall be interlocked to preclude the possibility of simultaneous operation of both forms of lighting."

中正機場跑道及滑行道燈光由塔台內之個別按鈕操作。不同燈光迴路亦各有單獨旋鈕提供機場燈光亮度選擇。圖 1.10-13 **顯示塔台內之燈光控制面板。**

16 **「迴路互鎖」**（interlock）**係防止多個燈光系統同時使用之機制，如在中正機場有迴路系統裝置，**05 **右跑道邊燈及中心線燈開關即不能同時開啟。**

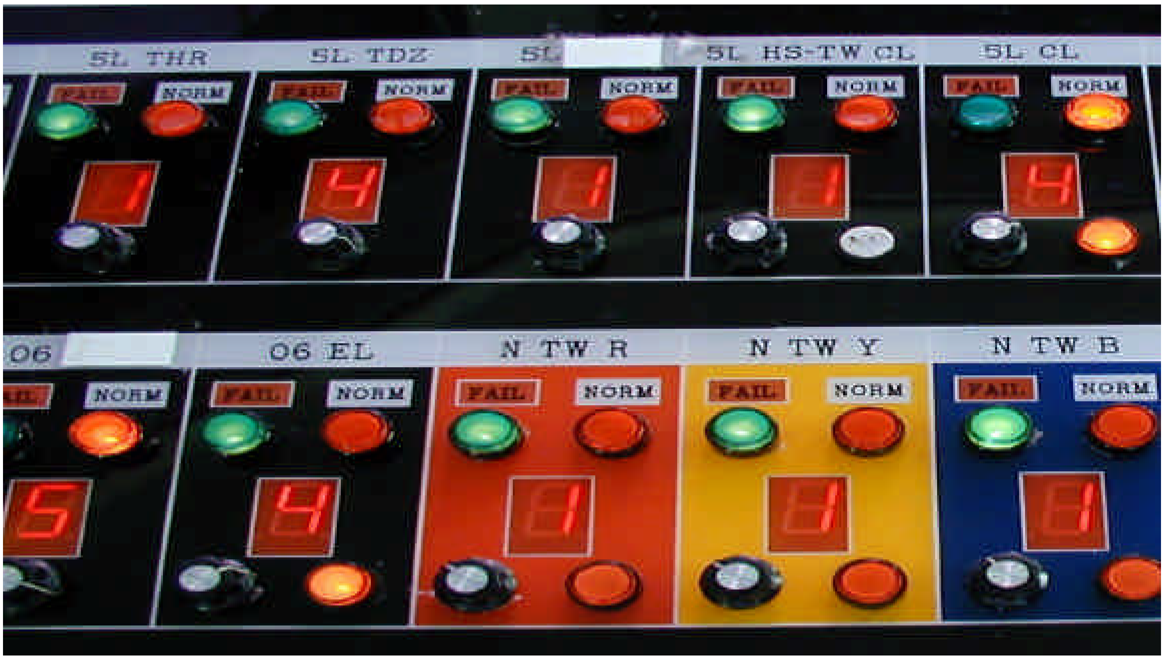

圖 1.10-13　**機場燈光控制面板**

此燈光系統於 1979 **年裝置，當時國際民航公約第十四號附約標準與建議措施未要求此類燈光須有互鎖機制。該附約修訂後，中正機場亦未加設燈光互鎖機制。**

中正機場航管程序規定，05 **右**/23 **左跑道有航空器起飛時，**NP **滑行道不能同時使用。因** 05 **右跑道與滑行道燈光無互鎖，因此塔台管制員間須相互協調，並以人工操作配合該跑道所需求之燈光。（如圖** 1.10-13 **及** 1.10-14 **燈光控制面板所示）**

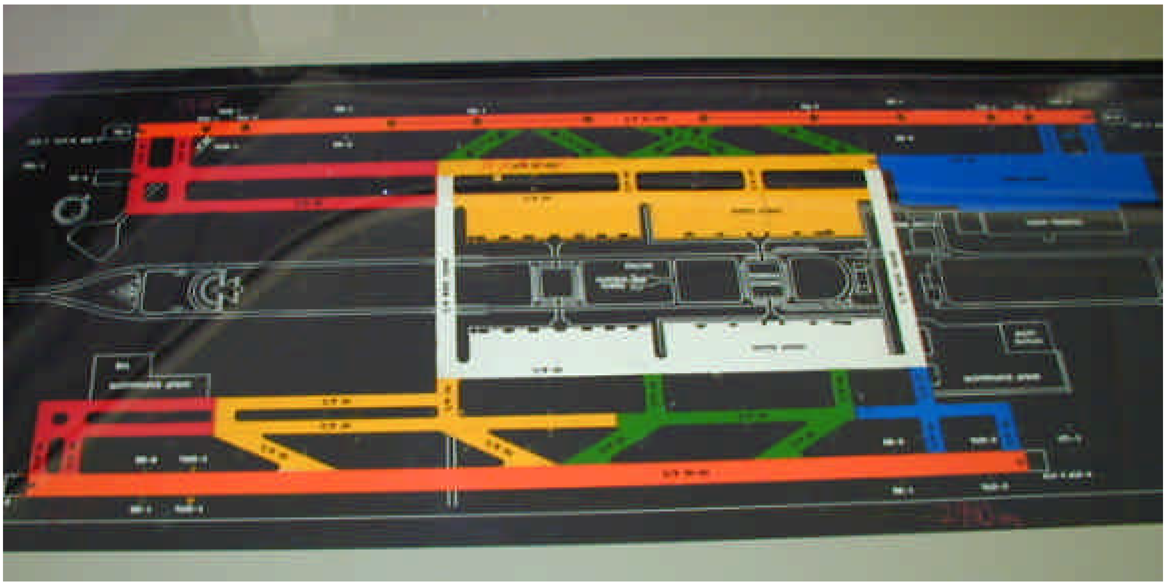

圖 1.10-14　**中正機場燈光控制配置圖**

失事當時為夜間，根據航管作業程序，當航機由 West Cross **滑行道進入** NP **滑行道時，塔台管制員須將** NP **及** N1 **滑行道中心線燈開啟，提供駕駛員滑行路徑之參考。**

1.10.5.1.2 迴路監控

根據國際民航公約第十四號附約第 1 **冊第** 8.3.3 **節：**

“Recommendation - For a runway meant for use in runway visual range conditions less than a value of 550 m, the lighting systems detailed in Table 8-1 should be monitored so as to provide an immediate indication when the serviceability level of any element falls below the minimum serviceability level specified in 9.4.26 to 9.4.30, as appropriate. This information should be immediately relayed to the maintenance crew.”

根據國際民航公約第十四號附約第 1 **冊第** 8.3.4 **節：**

“Recommendation - For a runway meant for use in runway visual range conditions less than a value of 550 m, the lighting systems detailed in Table 8-1 should be monitored automatically to provide an immediate indication when the serviceability level of any element falls below the minimum level specified by the appropriate authority below which operations should not continue. This information should be automatically relayed to the air traffic services unit and displayed in a prominent position.”

機場燈光系統妥善率由人工或電子監控。電子監控是由線路連接恆流調節器之繼電器指示迴路狀態。此方式提供整個迴路狀態之回綬。每一迴路之工作狀態顯示於塔台內燈光控制面板上之指示燈。機場未架設任何單一燈具或迴路故障燈泡比率之電子監控裝置。

人工監控是由駐中正機場之飛航服務總台機電台負責。該單位人員巡場時隨時與塔台保持聯絡，利用空檔進入跑、滑道檢視。

除 05 **左**/23 **右跑道視程儀外，中正機場無其它數據資料，記錄機場內燈光迴路狀態及各迴路選用情形。**05 **左跑道視程儀電腦記錄** 05 **左**/23 **右跑道邊燈狀態，提供參數以計算出當時之跑道視程，並顯示於塔台。記錄顯示** 05 **左**/23 **右跑道邊燈於事故當時，燈光強度選擇為第三級**[17]**。**

1.10.5.2 地面活動導引及管制系統（SMGCS）

根據國際民航公約第十四號附約第 1 **冊第** 8.9.1 **節（標準），**

“A surface movement guidance and control system shall be provided at an

aerodrome.”

地面活動導引及管制系統提供航空器由落地跑道至停機位置及由停機位置至起飛跑道及其他機場內活動之導引、控制及規範。該系統由目視助航設施、非目視助航設施、程序、控制、規則、管理及資訊設備適當組合而成。

中正機場無低能見度作業時之機場地面活動導引及管制系統計畫。

1.10.6 目視助航設施維護

類似機場燈光系統，民航局助航組依國際民航組織標準及建議措施提供機場指示牌技術規格，飛航服務總台負責架設。

飛航服務總台亦負責維護中正機場指示牌。每日巡場檢查機場燈光時亦檢查機場指示牌。發現燈管破裂當天即予更換。此外，每週及每月定期維護檢查時，將指示牌拆下維修。

中正機場維護組負責維護機場標線。跑道標線重新油漆與輪胎膠屑清同時進行。其他標線每二至三年重漆一次。

1.10.7 05 右/23 左跑道更改為 NC 滑行道

民國八十一年民航局委託交通部運輸研究所（交通部所屬研究機構）重新規劃中正機場民國八十九年至九十九年之擴展方案。運輸研究所將該案外包予荷蘭機場顧問公司（NACO**）。由於機場附近居民強烈反對及預算考量，**NACO **計劃後由亞聯顧問公司（**ATCI**）及加拿大航空計劃飛航技術服務公司重新評估。**

民國八十九年三月，亞聯公司在「中正機場主計畫第一期」建議：

『為長期考量，*05* ***右****/23* ***左跑道可卸下其跑道功能，降級為與*** *05* ***左****/23* ***右跑道平行之滑行道，以提供*** *05* ***左****/23* ***右跑道較佳滑行作業。』***

同年十月三日，民航局發布編號 A007 C015/00 **飛航指南補充通知書：**

『*2000* ***年*** *11* ***月*** *1* ***日世界標準時間*** *1700****，中正機場*** *05* ***右****/23* ***左跑道更改為*** *NC* ***滑行道，現有之跑道中心線燈（綠色）及邊燈（白色）仍將留置於*** *NC* ***滑行道上直到未來公告變更，但跑道標線將改變為滑行道標線。』***

同年十月廿三日民航局發布編號 A0740 **飛航公告：**

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[17] **跑道視程儀記錄之燈光強度為第三級，不同於塔台管制員所記錄之第四級。**

『05 右/23 左跑道更改時間延後，確切更改時間另行通知。』

民航局官員表示，於執行跑道轉換成滑行道時，發現指示牌須由國外進口，採購作業無法配合飛航指南補充通知書指定日期完成。原定 05 右跑道轉換時程必須延後。

事故發生後，在同年十二月廿八日，民航局發布編號 A010 C021/00 飛航指南補充通知書：

『自 2001 年 2 月 1 日世界標準時間 0000 起，中正機場之 05 右/23 左跑道及 NS 滑行道將更名為 NC 滑行道。原跑道標線轉換成滑行道標線。原跑道邊燈（白色）將移除，原跑道中心線燈（綠色，30 公尺間距）不變。05 右/23 左指示牌及相關指示牌將於正式更名前 36 小時更換為滑行道指示牌。』

1.11 飛航記錄器

本會人員抵達現場時，該機之座艙語音記錄器（Cockpit Voice Recorder，CVR）與飛航資料記錄器（Flight Data Recorder，FDR）皆完好固定於機身後段機架上。從兩具記錄器外觀看來，未發現有高溫或撞擊損壞跡象，或因救援而造成之污染或損?。

八十九年十一月一日，檢察官查看並記錄了型號、件號及序號後，將記錄器交本會進行後續解讀。

記錄器送達本會後，本會專家立刻進行外觀檢查，未發現有明顯損壞，隨後拆解記錄器並檢查內部機構與組件，亦未發現任何損壞痕跡。

兩具記錄器資料隨後皆順利下載解讀。

1.11.1 座艙語音記錄器

該機配備 Fairchild A200S 型固態式座艙語音記錄器，件號為 S200-0012-00，序號為 00744，所錄之聲音品質良好，四個聲音頻道包括加強飛航組員、副駕駛員、正駕駛員以及駕駛艙區域麥克風。

座艙語音記錄器電源在一號發動機啟動時同時開啟，所有飛航組員皆使用熱線麥克風系統。為提高下載資料之可讀性，解讀過程中採用先進之雜音濾除及功率放大技術。

座艙語音記錄器抄件主要根據座艙語音記錄器無線電通訊記錄、航管錄音抄件及飛航資料記錄器資料（VHF Keying）進行時間同步。

此座艙語音記錄器之錄音長度約 123 分鐘[18]，與事故班機有關之聲音資料共 16 分

[18] 該記錄器所規範之最小記錄長度為 120 分鐘。

鐘又 30 **秒。錄音開始於** 2300:53 **時，當時該機正由中正機場** B5 **停機位後推，記錄無間斷，持續記錄至** 2317:22 **時停止，即第一次撞擊後不久。記錄過程包含後推、發動機啟動與飛機經由** SS、West Cross、NP、N1 **滑行道至** 05 **右跑道之滑行過程，但此一記錄未包含一號發動機啟動前之飛航組員起飛前之準備活動。座艙語音記錄器抄件請參考附錄** 3。

1.11.1.1 座艙語音記錄器電源開關邏輯之規範

根據新加坡提供之波音 747-400 **維修手冊第** 23-71-01 **節，有關座艙語音記錄器電源開關之說明如下：**

"(2) The purpose of the VOICE REC ENG CUT relay is to reduce wear on the voice recorder system by automatically turning the system off 5 minutes after all engines are cut.…The voice recorder switch can be manually placed in the auto position, or will automatically switch to this position when at least one engine is running, for in-flight operation of the system."

根據美國聯邦航空法 FAR 14 CFR - CHAPTER 1 - PART 91.609**，座艙語音記錄器，**

"Is operated continuously from the use of the checklist before the flight to completion of the final checklist at the end of the flight."

根據歐盟聯合航空法 JAR-OPS 1.700（2000 **年** 7 **月** 1 **日公布），有關座艙語音記錄器電源開關之說明如下：**

"(c) The cockpit voice recorder must start automatically to record prior to the aeroplane moving under its own power and continue to record until the termination of the flight when the aeroplane is no longer capable of moving under its own power. In addition, depending on the availability electrical power, the cockpit voice recorder must start to record as early as possible during the cockpit checks prior to engine start at the beginning of the flight until the cockpit checks immediately following engine shutdown at the end of the flight."

根據新加坡民航法 37 **節第** 3 **條，有關座艙語音記錄器電源開關之說明如下：**

"On any flight on which a flight data recorder or a cockpit voice recorder is required by this Order to be carried - in an aeroplane, it shall always be in use from the beginning of the take-off run to the end of the landing run."

根據國際民航公約第六號附約第 6.3.10.1 **節之相關規定：**

“Flight recorders shall not be switched off during flight time.”

根據國際民航公約第一號附約有關「Flight Time**」之定義**:

“The total time from the moment an aircraft first moves under its own power for the purpose of taking off until the moment it comes to rest at the end of the flight.”

由系統設計角度而言，波音公司之設計允許各航空公司依其本身不同之需求，選擇不同之座艙語音記錄器電源開啟邏輯設定。

1.11.2 飛航資料記錄器

該機配備 AlliedSignal **固態式飛航資料記錄器，件號為** 980-4700-033**，序號為** 1634**。本會記錄器專家使用** AlliedSignal **手持式下載單元（**HHDLU**）、**Aircraft Data Recovery and Analysis System**（**ADRAS**）及** Recovery, Analysis and Presentation System**（**RAPS**）等裝備及系統解讀該具記錄器，記錄器總計記錄** 318 **個飛航參數。本會人員利用解讀資料，計算失事航機在機場地面滑行至起飛滾行階段之移動情形，以及飛機其它方面狀態。**

飛航資料記錄器開始記錄時間為 2300:00 **時，當時該機位於** B5 **停機位，飛航資料記錄器資料顯示，**2316:34 **時該機航向** 50.6 **度，開始加速準備起飛，飛航資料記錄器於** 2317:12.16 **時停止記錄。**

1.11.2.1 快速擷取記錄器

事故之後，本會於 11 **月** 5 **日現場堪驗時尋得該機之快速擷取記錄器（**Quick Access Recorder**，**QAR**），其外表嚴重受損。送回本會實驗室後，記錄器專家將其拆解並取出記錄光碟，光碟本身雖受污染，但經清潔及檢查後發現光碟並無損壞。原始光碟經本會人員製作備份後，送往新航及** Penny & Giles Aerospace **公司進行解讀。**

新航於 11 **月** 8 **日將解讀後之資料送交本會，解讀結果顯示** QAR **停止記錄時間為** 2316:23 **時（該機起飛前），**QAR **資料與飛航資料記錄器所解讀之資料結果一致。**

Penny & Giles Aerospace **公司於** 11 **月** 22 **日完成** QAR **非揮發性記憶體（**Non-Volatile Memory**，**NVM**）之解讀，並確認記錄器於** 2316:40 **時停止（該機起飛前），**NVM **及飛航資料記錄器所解讀之資料亦為一致。**

1.11.2.2 飛航資料記錄器之地面軌跡與衛星影像

圖 1.11-1 **顯示以飛航資料記錄器經緯度資料（經平滑處理後）所呈現之飛航軌跡**

（黃色線），並與該區之衛星影像套合，用以顯示滑行路徑與機場場面之關係。此圖亦包含 SQ006 地面軌跡及測量之殘骸分佈。

本會利用 RAPS 結合衛星影像、座艙語音記錄器聲音資料及飛航資料記錄器參數資料製作該機之三維模擬動畫，因飛航資料記錄器記錄之經緯度參數精確度有其限制，因此本會利用地速、磁航向及偏流角等參數計算航機運動之地面軌跡，並以套合後之空照圖校對軌跡與機場之相對位置（如圖 1.11-2）。

圖 1.11-1　　套合飛航資料記錄器飛航軌跡、地面測量資料及衛星影像俯視圖

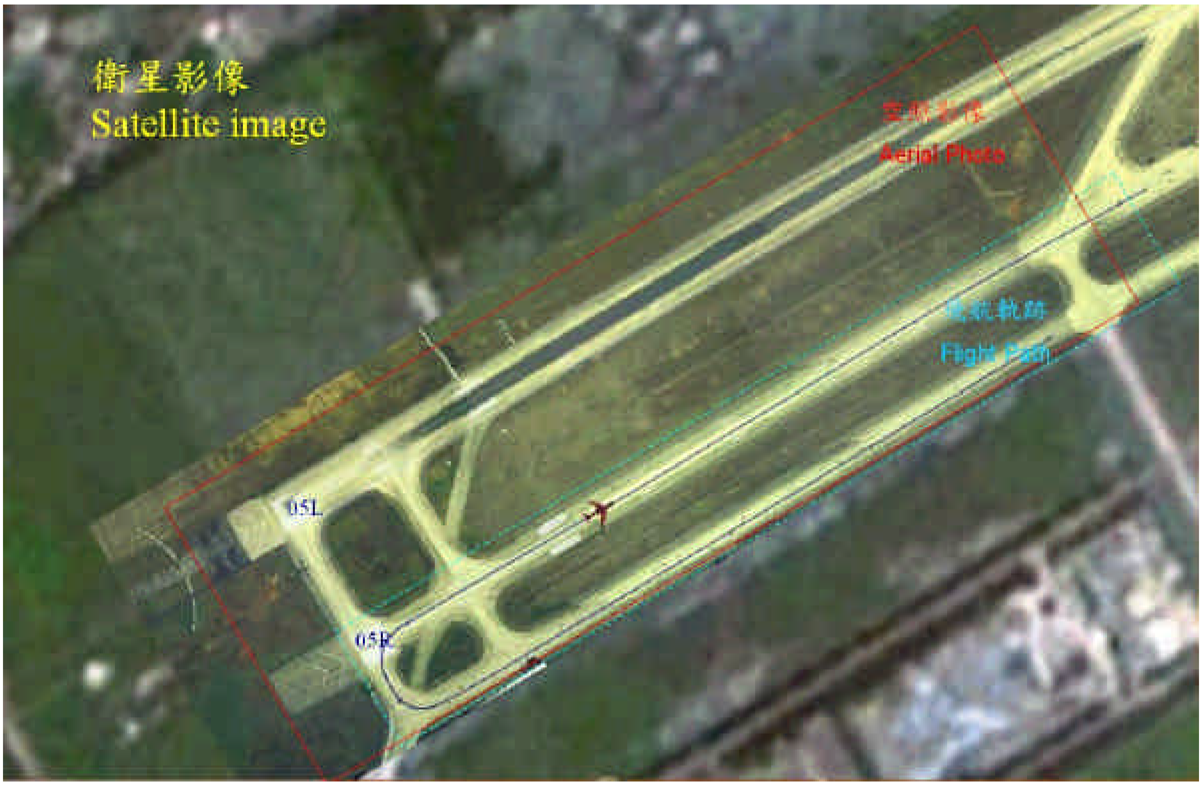

圖 1.11-2　　套合飛航資料記錄器飛航軌跡、衛星影像及空照影像之三維模擬動畫圖

1.12　　航空器殘骸與撞擊資料

本次失事調查地面作業包括機身殘骸及地面痕跡之勘驗與定位，範圍為 N1 至 N8 滑行道間之 05 右跑道。起落架胎痕記錄範圍為 N1 滑行道至初始撞擊點。測量中發現，跑道微濕時胎痕清晰可見，在跑道乾燥或過於濕濡時則無法清楚辨識。

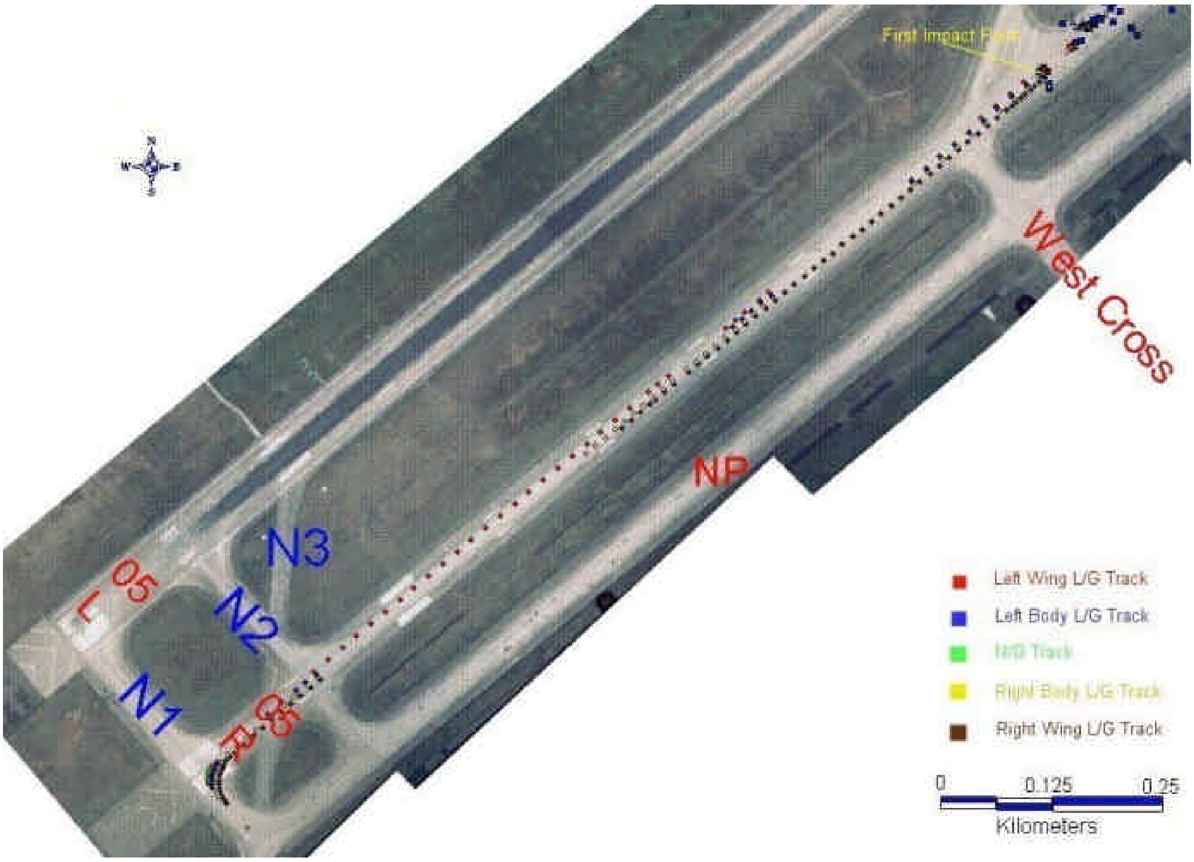

圖 1.12-1　　胎痕記錄

本次勘驗共辨識及記錄 396 件殘骸（較為重要或原先即有件號標示者）及其座標位置，並於標示識別標籤後攝影存證。除被火燒毀之元件外，所有主要元件都已完成辨識與統計。

1.12.1　　殘骸分佈及撞擊資料

初始撞擊點於距跑道頭 4,080 呎處（圖 1.12-3），殘骸自此沿 05 右跑道散佈（圖 1.12-2），機身於站位 1560[19]處斷成兩截，前機身停止於距跑道頭 6,840 呎處，朝向方位 085 度，左右兩翼附於其上；後機身平躺於跑道上，朝向方位 040 度，依訪談記錄，機身曾因救難而被移動，原位置約朝向方位 130 度且向左側傾倒（圖 1.12-4、5）。

[19] 波音 747-400 機身與機翼站位圖請參考附錄 4。

圖 1.12-2　　**殘骸與機場相關位置**

圖 1.12-3　　**初始撞擊點（如紅圈所示）**

圖 1.12-4　　與滾行方向相反之殘骸分布圖

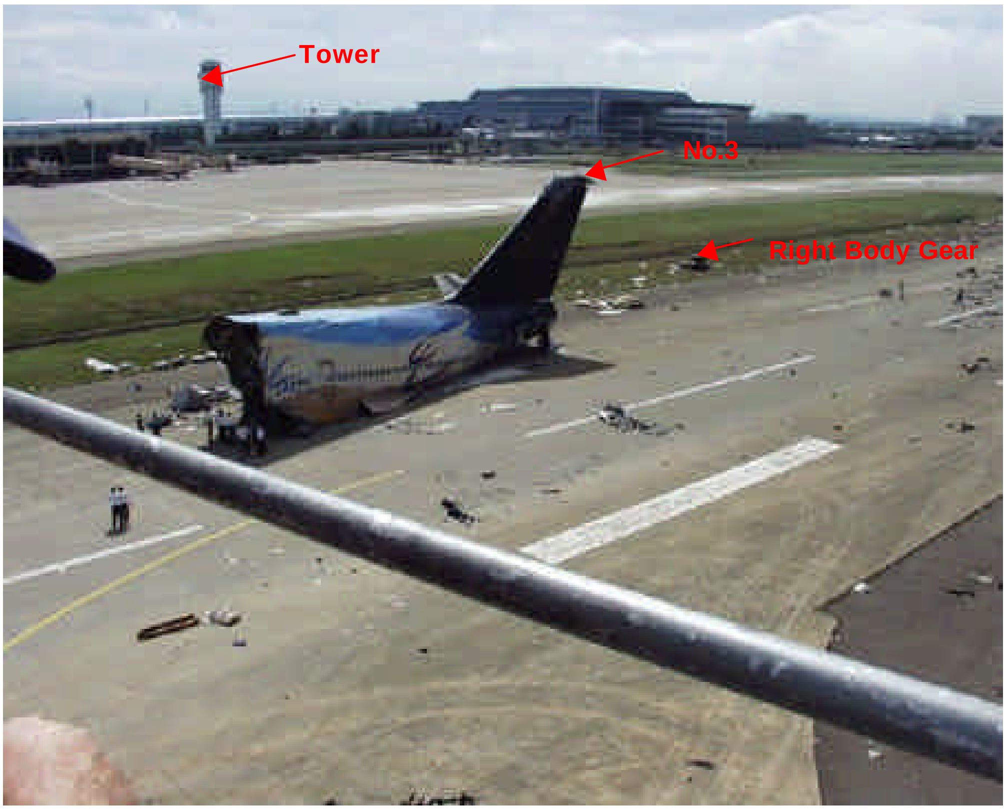

圖 1.12-5　　朝跑道頭之殘骸分布

1.12.2 殘骸勘驗

1.12.2.1 機身前段

機身前段包括編號 41、42、及 44 段及兩翼位於 05 右跑道左側（圖 1.12-6），可明顯看出曾遭嚴重火燒。

右側機身之壓力隔框至翼根、主電子艙及前貨艙均為大火燒?。左側機身之主艙地板自機身站位 130 至 1284 處受嚴重火燒外尚稱完整。機身站位 320 至 1000 處遭嚴重燒毀，但仍可辨識出 30%之主艙地板結構。

右翼遭大火完全燒?，但仍可辨識出部分前後翼樑（Spar）及翼尖（Winglet）（圖 1.12-7）

左翼翼尖部分遭大火完全燒?，但仍可識別出其輪廓，翼尖部分於機翼站位 1360 處斷裂。

圖 1.12-6 機身前段

圖 1.12-7　　**左右兩邊機翼**

1.12.2.2　　機身後段

機身後段包含編號 46 **及** 48 **段，位於** 05 **右跑道中心線右側。（圖** 1.12-8**）**

機身於 4 **號門前方斷裂，約於機身站位** 1560 **處形成一斷面。**

支撐架、縱樑、及左機腹蒙皮均脫離，4 **號艙門至** 5 **號艙門間之右機腹蒙皮有擠壓現象，機腹蒙皮自機身站位** 2410 **至** 2747 **間有嚴重擦痕與脫落，機身左側窗口上方有大區域之磨擦痕跡。**

編號 48 **段機身及機尾部分可見明顯火燒痕跡。**

右側水平尾翼雖遭火燒，但大致完整，左側水平尾翼約在水平尾翼站位 270 **處斷裂（圖** 1.12-9**）。**

垂直尾翼遭大火薰黑，但未脫離機身，上方有部分斷裂。

機身編號 48 **段下方蒙皮無縱向擦痕痕跡。**

圖 1.12-8　　**機身後段**

圖 1.12-9　　**左右水平尾翼**

1.12.2.3　客艙內損壞情形

該機共配置九個廚房，前段之 G1、G2、G3、G3A **及** G4 **五個廚房均燒毀，在後段機身外，尋獲已脫離地板之** G5、G6 **廚房，另在後段機身內尋獲向左傾斜之** G7、G8 **廚房。**

1.12.2.3.1 客艙組員座椅

該機共配置十九張客艙組員座椅，其損壞情形如表 1.12-1 **說明。**

表 1.12-1　　**客艙組員座椅**

客艙組員位置	座椅情況
上艙左側門	焚毀
上艙右側門	焚毀
上艙廚房	焚毀
主艙左側 1 號門	焚毀
主艙右側 1 號門	焚毀
主艙左側 2 號門（外側）	焚毀
主艙左側 2 號門（內側）	焚毀
主艙右側 2 號門（外側）	焚毀
主艙右側 2 號門靠內側	焚毀
主艙左側 3 號門（外側）	焚毀
主艙左側 3 號門（內側）	焚毀
主艙右側 3 號門（外側）	焚毀
主艙右側 3 號門（內側）	焚毀
主艙左側 4 號門（外側）	前方內側腳架脫開，座椅結構損壞，椅架內側結構與椅背脫離，椅面向下，上有破碎物，無火燒痕跡。
主艙右側 4 號門（外側）	燒毀，通訊話筒離位，手電筒之封帶斷開。
主艙左側 5 號門	無損壞
主艙右側 5 號門	無損壞

1.12.2.3.2 艙門及疏散疏散滑梯/艇

左側 1 號門（1L）

左側 1 號門完整並在全開位置，操作手柄在「自動模式」位置。1L 疏散滑梯部分展開並伸出機外。起動拉桿旁控制疏散滑梯展開之安全插銷仍在定位，疏散滑梯近門檻處有明顯火燒痕跡，疏散滑梯充氣機進口處無火燒現象。

右側 1 號門（1R）

右側 1 號門及機械裝置均遭火燬，但由控制手柄機構可看出手柄在「手動模式」（即非自動充氣模式）。1R 疏散滑梯包仍封裝於門內，並有輕微火燒痕跡。

左側 2 號門（2L）

左側 2 號門完整且在全開位置，操作手柄在「自動模式」位置。疏散滑梯部分展開並伸出機外。起動拉桿旁控制疏散滑梯展開之安全插銷仍在定位，2L 疏散滑梯有多處燒痕，並已與起動拉桿分開。疏散滑梯充氣機入口處無火燒痕跡。詳見圖 1.12-10。

圖 1.12-10　左側 2 號門疏散滑梯充氣機

右側 2 號及 3 號門（2R 及 3R）

右側 2 號及 3 號門均被燒毀，並於前段機身殘骸中尋獲。兩艙門均已嚴重燒毀，僅存些許可辨識之機構殘骸。

左側 3 號門（3L）

左側 3 號門仍完整，呈半開狀態，操作手柄在「自動模式」，3L 疏散滑梯掉落於該門下方，並未充氣伸展，但有中度燒毀情形。

上艙左側門（UDL）

上艙左側門完整已被開啟，該門下垂觸地，操作手柄在「自動模式」。UDL 疏散滑梯展開並伸出機外，有明顯受火燒跡象。

上艙右側門（UDR）

上艙右側門在前段機身殘骸西側，操作手柄及疏散滑梯均未尋獲。

右側 4 號門（4R）

右側 4 號門完整，未被開啟，操作手柄在「自動模式」。4R 疏散滑梯在艙內充氣伸展。充氣機入口處及滑梯內部有火燒破損痕跡。


圖 1.12-11　右側 4 號門疏散滑梯充氣機（左）及其內部火燒情形（右）

左側 4 號門（4L）

左側 4 號門完整，未被開啟，根據客艙組員訪談，疏散時無人接觸門把，操作手柄在「自動模式」，4L 疏散滑梯包完好封裝於門內，並未伸展。

右側 5 號門（5R）

右側 5 號門未被開啟，但本會為取出飛航記錄器，由外部打開此門。5R 疏散滑梯在機內自動充氣伸展。發現滑梯下緣有一道六吋長割口。

左側 5 號門（5L）

左側 5 號門未被開啟，5L 疏散滑梯亦未充氣伸展。

於失事現場尋獲左側 1 號、2 號及右側 4 號疏散滑梯，送往原製造廠進行檢測（詳見報告 1.16 節）。

各客艙門及其緊急疏散滑梯使用情形如表 1.12-2

表 1.12-2　客艙門及疏散滑梯情況

艙門	艙門啟閉狀況	開啟者	滑梯狀況
UDL	全開	UDR 客艙組員	完全展開但被燒穿
UDR	全開	UDR 客艙組員	未尋獲
1L	全開	1L 客艙組員	半伸展，被火燒穿
1R	關閉		半伸展，輕微燒毀
2L	全開	2R 外側客艙組員	半伸展，被火燒穿
2R	焚毀		未尋獲
3L	半開	無法確定	中度燒毀，未伸展
3R	焚毀		未尋獲
4L	關閉		滑梯封裝於門內
4R	關閉		滑梯在艙內充氣伸出，其充氣機口及滑梯內部有火燒之痕跡
5L	關閉		滑梯封裝於門內
5R	關閉		在艙內自動充氣，滑梯下方有一道 6 吋長割口

1.12.2.3.3 後段機身之置物箱

第 54 排 D、F、G、H 座位至第 60 排 D、F、G、H 座位上方置物箱與上方機身結構之連桿脫離，四支折斷之連桿及一支完好連桿取下後進行金相材料檢測。（檢測結果請見 1.16 節）

1.12.3　發動機

現場尋獲之四具發動機皆與機身脫離，檢視發現在撞擊前，發動機並無葉片脫離或遭火燒跡象。（圖 1.12-12）

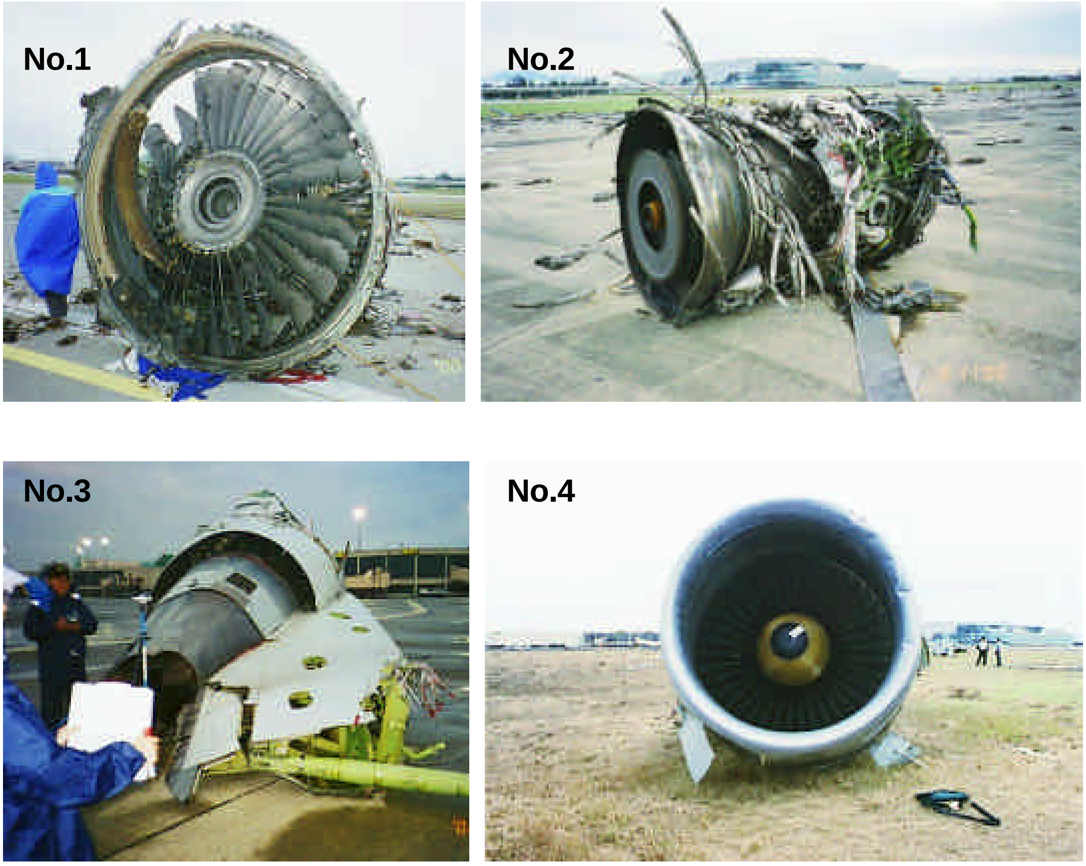

圖 1.12-12　**四具發動機**

1.12.4　飛操系統

1.12.4.1　左翼

左翼翼尖大部分被火燒?，翼根部分火燒現象較不嚴重。

1.12.4.2　右翼

右翼大部分均遭火燒毀，所有飛操面亦皆遭焚?。

1.12.4.3　水平尾翼

水平尾翼配平唧筒機構及螺桿頂軸（Jack Screw）**均無損傷，右水平尾翼則有輕微火燒現象。**

1.12.4.4 升降舵

升降舵感知唧筒（Elevator Feel Actuators）及扇形盤（Quadrant）經目視檢查無損傷，右升降舵有輕微火燒現象。

1.12.4.5 垂直尾翼及方向舵

垂直尾翼及方向舵火燒現象不嚴重。

1.12.4.6 主要元件

所有機上主要元件散落於 05 右跑道上，受撞擊力與火燒致嚴重損毀。

1.12.5 跑道邊燈電線

兩條帶著接頭的跑道邊燈電線，分別於 05 右跑道右邊及左邊編號 RE239 位置及 RE240 位置處尋獲。RE239 位於距 05 右跑道頭 6270 呎處，RE240 則位於距 05 右跑道頭 6,670 呎處。兩電線均發現於失事時殘骸通過之路徑上。其位置如圖 1.12-13 所示。在 RE240 位置附近之地面車輛胎痕及殘骸碎片分佈如圖 1.12-14 所示。

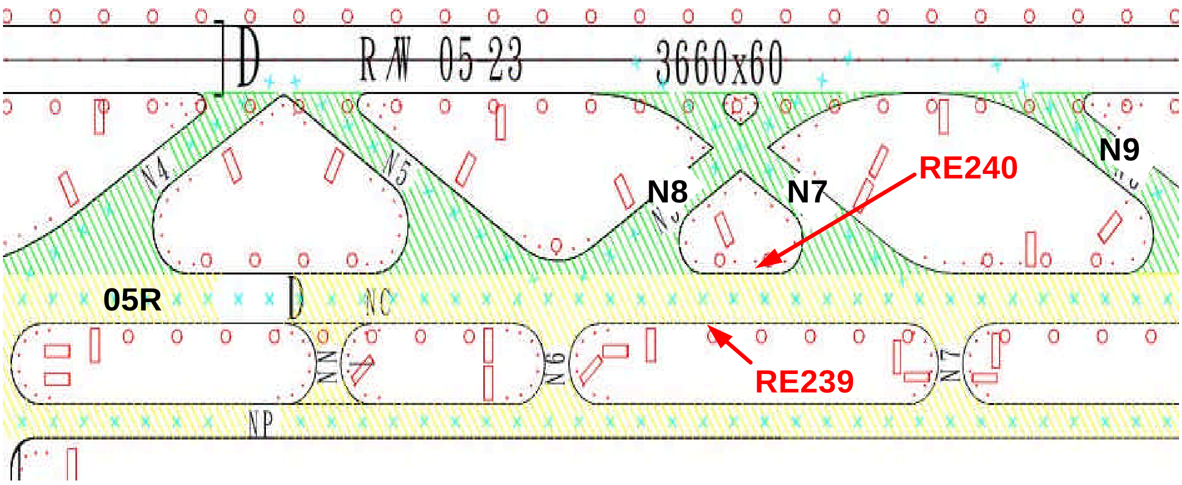

圖 1.12-13 跑道邊燈 RE239 與 RE240 之位置

圖 1.12-14　RE240 附近有地面車輪胎痕與殘骸碎片

RE239 電線發現時未連接於任何地面之插座。雖說發現時鄰近有些破碎燈具，然無法確定該電線屬那一盞跑道邊燈。

RE240 位置之燈具在離地約 3.8 至 5 公分處切斷。切斷處沿著燈具之同一高度。燈具底部仍有螺栓與其底座結合，但上部已脫離。附近未發現金屬或玻璃碎片。兩條線束即裸露在離該燈座 5 到 15 公分處。尋獲時，發現其插頭仍連接於地下之插座。即將插頭拔出插座並於電線上做標示（圖 1.12-15）。

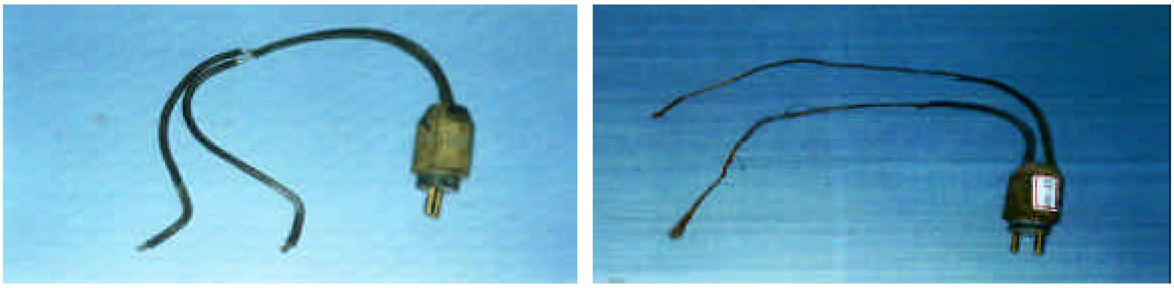

圖 1.12-15　跑道邊燈 RE239 電線（左）及 RE240 電線（右）

RE239 與 RE240 電線各有兩條線束（標示為 RE-239-1、RE239-2；RE240-1 及 RE240-2）。均送往中山科學研究院（簡稱中科院）及澳洲運輸安全局做後續檢驗。測試結果參閱本報告第 1.16.5 節。

1.13 醫學與病理

1.13.1 醫療作業

受傷乘客被送往以下醫院治療：中壢天成及勵新醫院、桃園敏盛及新陽明醫院、台北榮民總醫院及馬偕醫院、林口長庚醫院。組員則被送往台大醫院檢查。

1.13.2 驗屍

於調查初期，本會曾會同美國運輸安全委員會法醫專家，就醫學及病理學需要，與法務部及法醫進行溝通。

法務部法醫研究所共進行七件驗屍工作，結果顯示其中一位係頭部撞擊傷重致死，其餘六位係嚴重燒傷致死。

1.13.3 飛航組員及塔台管制員之酒精與藥物檢測

失事後，未對三位飛航組員及四位管制員進行酒精及藥物測試，但無證據顯示酒精或藥物與失事有關。

1.14 火災

1.14.1 消救人力及法規

中正機場之機場救援及消防（ARFF）分類屬第九級。

根據國際民航公約第十四號附約第 1 冊第 9.2.19 節：

"Recommendation - The operational objective of the rescue and fire fighting service should be to achieve response times of two minutes, and not exceeding three minutes, to the end of each runway, as well as to any other part of the movement area, in optimum conditions of visibility and surface conditions.

Note 1-Response time is considered to be the time between the initial call to the rescue and fire fighting service, and the time when the first responding vehicle(s) is (are) in position to apply foam at a rate of a least 50 percent of the discharge rate specified in Table 9-2"

根據國際民航公約第十四號附約第 1 冊 9.2 節建議，第九級機場配置救援與消防車輛最少數量為 3 輛，滅火劑量應不少於 36,400 公升，滅火劑噴射率應不小於每分鐘 13,500 公升。

中正機場內共 8 輛泡沫消防車，總滅火劑量為 86,000 公升，滅火劑噴射率為每分鐘 42,000 公升。

本會於民國九十年二月廿九日測試由消防站南站至 05 左跑道頭之消防車應變時間，測試車輛使用 2 分 48 秒抵達預定地點，並射出滅火劑。

根據消防隊長提供資料，失事當晚 68 名消防隊員有 32 名值班。同為第九級之國際機場，香港赤?角機場有 220 名消防隊員，新加坡樟宜機場有 160 名消防隊員。

1.14.2 火災情形

依據訪談資料，消防隊長趕到現場時發現機首、中段及機翼已陷入火海。由於強烈陣風助長火勢，隊長指示隊員於上風處噴灑泡沫滅火劑於前、中段機身及客艙內。消防隊員於左側 1 號門附近搶救出 3 名乘客，以及機身前段左側嚴重灼傷自行跳出之數名乘客。

消防隊長表示消防隊抵達現場後 10 至 15 分鐘內火勢獲得控制，但隨後有回火及復燃現象， 40 分鐘才將火完全撲滅。航機後段僅遭受輕微火燒。

1.14.2.1 啟動階段

根據訪談消防隊員資料及當時機場第一頻道無線電通話記錄抄件，中正機場消防隊南站於 23 17：36 秒聽到失事警鈴，隨後航管以電話通知消防隊，稱飛機墜毀於使用中之 05 左/23 右跑道。

1.14.2.2 反應階段

失事後，消防隊南站之 2 輛快速搶救泡沫消防車、4 輛泡沫消防車、1 輛乘客救傷車、4 輛救護車及 2 輛照明車先後抵達現場。

根據與第一位抵達現場之消防隊員訪談，該員聽到爆炸聲立即朝 05/23 跑道前進，該員稱在待命室先見到火光，隨後聽到警鈴響起。趕赴現場途中遭遇低能見度、強風及大雨。進入航站北面之事故現場，須通過使用中之 06 跑道及滑行道。跟隨滑行道中心線燈沿 East Cross 滑行道，隨即目視失事地點火光，抵達現場後，立於機鼻及左翼間之上風處。由駕駛座操作噴出泡沫滅火劑。

消防隊初期集中於撲滅左側機身及左翼根部嚴重燃燒部位，但隨後大火蔓延至前機

身其他部位。

2320:45 時第一頻道錄音抄件顯示「先噴化學泡沫，先噴化學泡沫」。當時無資料顯示第 2 輛以後之消防車抵達時間，第 1 輛快速搶救消防車（3 號泡沫消防車）通過使用中之 06/24 跑道時，未獲塔台許可。

事故當時消防隊北站因維修而關閉，消防隊南站屬 24 小時待命。由於北站關閉，每日 0900 至 2200 期間，消防隊派遣兩輛消防車於國內線機坪待命。

民國九十年二月廿一日，航空站航務組長提供本會現場消防車位置圖，指出所有抵達現場消防車均位於失事航機上風處，由東北至東南方呈弧形排列。

6 號消防車使用 40 至 60 秒撲滅機身尾段輔助動力系統附近之火勢，隨後消防隊員進入該段客艙，並回報無人員留置其內，飛航組員曾見消救人員自機身尾段帶出一名女性乘客）。

陸續有 34 輛消防車，54 輛救護車及 7 輛照明車由其他地區消防站、醫院、軍方等趕來支援。約 2340 時，場外支援單位抵達北機口，部分車輛被要求直赴失事地點。

消救過程未使用化學乾粉、鹵化碳氫化合物（海龍）及二氧化碳等輔助劑協助滅火。

1.14.3 機場緊急應變演習

根據機場緊急應變計畫，中正機場每年實施兩次演習，其中一次為所有相關單位參與之大規模演習。失事前最後一次演習於民國八十九年七月五日舉行。

消防隊員每三個月於開放場地舉行一次複訓，但該場地並無模擬客艙。複訓時，隊員穿戴空氣面罩及其他搶救裝備。

1.15 生還因素

1.15.1 疏散

該機載有 159 名乘客，包括 153 名成人、3 名兒童、3 名嬰兒。本會訪談 80 名生還乘客中之 19 位。另寄出問卷予其他生還乘客，但僅有 4 位回覆。

1.15.1.1 新航組員緊急疏散程序及訓練

新航飛航組員及客艙組員均按該公司所頒「空勤組員安全裝備及程序」（ASEP）實施緊急應變程序之訓練。

依據該手冊第 4 章第 4 節，陸上緊急疏散如下：

“The primary focus of any emergency evacuation is to rapidly evacuate the occupants. To achieve this, crew should take steps to avoid incapacitation as far as possible. Evacuation procedures are based on minimum Primary Crew complement and any incapacitation will increase the passenger evacuation time. Use positive commands in a strong and forceful voice when directing the evacuation.

NOTE: *The initiation of an evacuation is the Commander's responsibility. Should a Cabin Crew consider that an evacuation is necessary, he should advise the Commander of the situation and await his decision. In cases, where it is obvious that an evacuation is imperative and no contact with the cockpit has been possible, the Cabin Crew should initiate the evacuation as soon as possible.”*

根據新航之「空勤組員安全裝備及程序」，組員必須完全熟悉彼此之工作，組員失能時，其他組員可替代其工作。新航之客艙事務長（CIC）負責在飛航中督導所有規定責任與程序均被執行。

新航在年度緊急疏散複訓包括駕駛員及客艙組員地面學科訓練。每班約有 10 至 15 人，地面學科完成後，所有組員至客艙模擬機實施演習。

地面學科教師會設定不同之情境，如客艙起火或迫降等。飛航組員扮演乘客坐於客艙中，客艙組員坐客艙指定座位。客艙廣播系統（PA）以預錄廣播詞對客艙組員及乘客下達指示：「準備疏散，抱頭低臥準備撞擊…」，預錄之廣播詞由教師啟動。緊急迫降後客艙事務長宣佈緊急疏散。所有組員立即解開安全帶與肩帶，站立並對乘客喊叫「解開安全帶，過來這邊」，客艙組員並檢查艙門外狀況以確保艙門安全開啟。客艙組員依「空勤組員安全裝備及程序」打開艙門後，檢查疏散滑梯/艇之自動充氣情況，客艙組員此時握住門邊手把以免被疏散之乘客擠落。若疏散滑梯/艇無法自動充氣，客艙組員拉起充氣手柄進行充氣。確認疏散滑梯/艇已充氣後，客艙組員才指引乘客往外跳。

在新航組員聯合緊急疏散複訓中，所有飛航組員都坐在客艙當中扮演乘客。飛航組員並未在客艙模擬機，透過客艙廣播系統或其他替代方式下達緊急疏散疏散指令。此外飛航組員訓練亦未含座艙廣播系統失效時之訓練。

本會觀察新航緊急複訓時發現，新航組員在首次緊急疏散訓練係穿著制服，但疏散複訓時則穿著便服。

1.15.1.2 飛航組員之緊急疏散行動

根據訪談資料，失事後 CM-1 在上注意到上艙兩個出口皆已開啟。右側有大火，乘客由左側出口疏散，CM-1 敘述他在乘客之後，抓住燒毀滑梯跳到地上。

根據訪談資料，CM-2 留意到 CM-1 曾使用客艙廣播系統，但該系統失效。執行疏散檢查表後飛航組員離開駕駛艙。CM-2 聽到 CM-3 說「跟著燈光走，跟著燈光走」（即按地板疏散燈光指示前進）。在黑暗中看不見其他人。至上艙左側緊急出口時，見到外面火光，但見不到疏散滑梯，他仍決定用上艙左側出口疏散。CM-2 未見任何人有疏散舉動，因此決定先撤離，並對在上艙左側緊急出口呼喊「留在原地，留在原地，我先跳，我先跳」，跳落地面後再對上艙左側門的人呼喊，要他們往下跳，乘客一個接一個由客艙跳下。

根據訪談資料，CM-3 第一個離開駕駛艙，當其離開駕駛艙到上艙後，見到煙及飛塵充斥，約略看到兩三排地板上之疏散指示燈，並發現左側緊急出口開啟，外面烈火燃燒。有數人包括一位男性客艙組員正在開右側緊急出口。當時乘客仍在上艙，CM-3 起初想到主客艙查看，但發現樓梯間佈滿黑煙。轉回來看見左側大火較弱，並有乘客往下跳。CM-3 當時並未看見 CM-1，只見到一女性客艙組員在左側緊急出口旁哭泣，於是叫其往下跳，自己由同一出口順著燒毀之滑梯下去。CM-3 稱是最後一個逃離飛機。跳出去後，他見到 CM-2 在地面。

1.15.1.3 上艙組員之緊急疏散行動

根據上艙 17A 座，面對 UDL 客艙組員之乘客訪談，他看到一名男性客艙組員（上艙右側客艙組員）打開樓上兩艙門，並且注意到這名客艙組員引導乘客經樓梯下到主艙。這位乘客說，兩艙門打開後，火燒臭味及濃煙立即進來，該男性客艙組員於此次事故中罹難。

根據「空勤組員安全裝備及程序」，在緊急疏散時，組員有責任先檢查出口是否可安全開啟，並檢查疏散滑梯/艇是否已充氣，再指揮引導乘客疏散。根據上艙左側門客艙組員之訪談，該員記得起飛前與上艙右側組員交互檢查客艙門手柄是放在「自動模式」。當失事發生時，上艙很快就充滿濃煙與灰塵，上艙左側門客艙組員看到上艙右側客艙組員打開右側艙門，而 17A 座乘客見到上艙右側客艙組員立即被外面湧入之濃煙與大火逼退，上艙右側客艙組員隨即再打開上層左側艙門，當該門打開後，疏散滑梯立即充氣但不久即被火燒毀漏氣。上層左側客艙組員也注意到客艙事務長在上艙出現，也看到 CM-2 抓住燒毀成條狀之疏散滑梯跳下去，該客艙組員隨 CM-2 由同一出口跳下。

上艙空廚客艙組員座位朝向機尾。該員因燈光開關故障無法調暗，故在撞擊時可清楚看到空廚內物品往前彈出。飛機停止時，他未聽到緊急疏散指示，但立即解開安全帶，

向乘客大喊「解開安全帶」。同時，他感覺到熱氣及煙由主客艙湧上來。他遞一條毛巾給由主艙上來躲避濃煙大火之右側 2 號門客艙組員。也看到數位乘客由上艙奔下樓梯，並跳下飛機。上艙空廚客艙組員也跟隨下樓，由左方 2 號門逃出機外。

上艙左側門客艙組員稱其所穿涼鞋在緊急疏散時失落。

1.15.1.4 主艙 1 號、2 號及 3 號門客艙組員緊急疏散行動

根據生還之上艙組員與乘客表示，客艙事務長在第一次撞擊時即上樓。該事務長未聯絡機長，亦未下達緊急疏散指令，他在此次失事未能生還。

根據與主艙左側 1 號門客艙組員之訪談，在失事後未接獲任何緊急疏散指令。檢查機外情況後，即打開左側 1 號門，並推下疏散滑梯/艇，當時聽到 1 號梯/艇充氣聲音。考量門檻離地約只有 1.5 米高，並察覺煙由客艙後方向前漫延來，又無其他疏散出口，便引導前方 8 位乘客（其中 3 位為商務艙乘客）由 1 號左側門逃出。當時客艙能見度約為 1 米左右，火及濃煙間歇侵入客艙，在看不到其他乘客後，自己由 1 號左側門逃出。

根據與主艙右側 1 號門客艙組員之訪談，該員當時留意右側 1 號門外大火燃燒，決定不開右側 1 號門，並大聲對乘客喊叫解開安全帶。與 1 號左側客艙組員一起引導乘客由 1 號左側門疏散。

在此次事件中，5 位頭等艙乘客均由 1 號左側門疏散。其中一人輕傷，其餘四人無傷。

失事發生時，主艙左側 2 號門客艙組員聽到右方傳來兩聲巨響，因面向後方，可看到火由後方燒起。未獲緊急疏散指令，自己先解開安全帶往左前方走道移動並跑上樓去，這位女性客艙組員自上艙空廚客艙組員手中接獲濕毛巾蓋住鼻子後與右側 2 號門客艙組員，在飛機完全停止後再回到主艙。

右側 2 號門客艙組員在失事發生時，看到火焰經艙內兩側通風口進入客艙。該員隨即往樓上跑以避開火焰，留意到有人在開樓上左側客艙門，之後又回到主艙。觀察到航機右側有大火，因此未開右側 2 號門。該員打開左側 2 號門並將疏散滑梯推出去，聽見滑梯/艇充氣聲，很快又聽到漏氣聲。該員始終未聽到緊急疏散指令，自己也未下達緊急疏散指示，其後由左側 2 號門疏散。

在此事件中，坐於左、右側 3 號門之兩位客艙組員均未生還。

1.15.1.5 主艙 4 號及 5 號門客艙組員緊急疏散行動

根據右側 4 號門外側客艙組員所述，在發生事件時看見氧氣面罩及雜物落下，客艙

全黑，看不到緊急照明指示燈。立刻解開安全帶跳到空廚旁，見到一團火球湧入客艙但很快消失，這團火球燒及身旁邊另位客艙組員。他留意到航機在停止後斷裂，立即由機身斷口處跑出去並見到右側 4 號門內側之客艙組員。

根據右側 4 號門內側客艙組員所述，機身停止後，廚房設備有移位狀況，附近氧氣面罩落下。當時 4 號右側門窗戶破裂。數秒後，右側 4 號門上疏散滑梯自動充氣，將她困在座位上。當時她幾乎窒息。感覺到熱流，之後被燒傷。這時疏散滑梯被火燒毀，她看不見客艙緊急疏散燈，解開安全帶後，就由機身斷口處逃脫，見到另一位客艙組員和一位女性乘客在機外空地上，她協助數位乘客疏散後即跑向遠處一輛車，車上有 20 位生還者。她當時被火嚴重灼傷，由斷口處逃出來時，消防人員已在行動。

根據左側 4 號門內側之客艙組員所述，在失事發生當時，氧氣面罩掉落，客艙燈光全黑，有一團火球由左後方走道向她襲擊，燒傷左腿，當機身停止後，聞到新鮮空氣由斷口飄入，她應 4 號左側門外側客艙組員要求，在斷口外協助疏散乘客，並帶 6 至 8 位乘客走向航站大廈。

根據坐於左側 4 號門外側之客艙組員所述，他發現廚房已向左傾倒，4 號左側緊急疏散指示燈亮起。當他解開安全帶時，發現自己站在 4 號左側門上（該機之尾段已左頃約 90 度，致機身左側在下方位置），推開前方阻擋之衣物後，發現機身斷口並由此跳出。他要求 4 號左側門內側之客艙組員跟他出去，並留在斷口處外照顧乘客疏散。之後回到機尾客艙內向其餘乘客喊叫「朝這邊過來」，該員見左側 5 號門客艙組員用手電筒指引乘客走向飛機斷口，4 號左側門客艙組員為資深組員且為最後一位離開。

據右側 5 號門客艙組員所述，失事當時，見 4 號門外有火，她被自動充氣之疏散滑梯困住而幾乎窒息，也看不到其他乘客情況。解開安全帶後就掙脫充氣滑梯。告訴旁邊乘客往前移動找尋出口，坐在機尾之客艙組員與十多位乘客即從斷口逃出。

據左側 5 號門客艙組員所述，爆炸後見天花板、上方置物箱及物品墜落，到處是煙，乘客擠向 5 號左側門並要求開門，但門壓在地上無法打開。因客艙內很暗，自座位旁取出手電筒，朝前指示乘客疏散。隨後聽見左側 4 號門之外側客艙組員指揮乘客往前移動。該組員導引約 15 位乘客往前走，由斷口疏散並協助乘客跨過水溝走向航站大廈。

有片女性客艙組員裙子之下擺卡在右側 4 號疏散滑梯充氣機進口處。

坐於主艙及上艙之生還者均稱，須趴下才能呼吸到新鮮空氣。左側 2 號門及上艙廚房之客艙組員均表示失事時，須以濕巾掩住口鼻才能呼吸。

1.15.1.6 緊急裝備

由訪談飛航組員得知，CM-3 及左側五號門客艙組員在緊急疏散時，曾取用機上手電筒，而 CM-2 則使用自備手電筒，其他組員未取用座位旁之手電筒。

組員均未取用手提擴音器指揮乘客疏散。

據訪談資料，失事發生時，由於有濃煙及灰塵，地板之路徑指示燈及緊急出口指示燈都顯得昏暗不清。

1.15.2 疏散後情況

據機身尾段生還乘客及組員訪談，數位客艙組員及乘客均穿過水溝走向航站大廈之急救檢傷中心（CCS）。有輛巴士在水溝與大樓中間載運部分人員到航站。從另一班機乘客拍到失事當時之錄影帶，觀察到生還乘客步行至航站大廈情況。根據多名組員與乘客敘述，航站大廈內所獲協助不多。多數協助係來自組員與乘客。而當醫療人員抵達時，傷患之救護行動缺乏適當之協調。

1.15.3 機場緊急應變及醫療

1.15.3.1 現場指揮與管制

約於失事一小時後，於機身尾段東北方 50 公尺處，利用一輛大型客車成立行動指揮所，由機場航務組組長管理。機場內所有消防及救護人員使用同一頻率通聯。失事現場不同之救援單位使用各自獨立之無線電頻率。

當地憲兵隨後支援航警協助失事現場之安全管制。

1.15.3.2 救援作業

失事當時，象神颱風接近國內，強風豪雨使急救檢傷中心無法設在失事現場附近，因此改在第九號登機門下之航務大廳內設立。

根據與中正機場消防隊人員訪談，當消防車抵達現場時，由 4 名消防隊員組成救援小組，這些經一級急救訓練（EMT 1）之消防隊員由左側 1 號門附近救出 3 名乘客。這 3 名乘客遭受嚴重灼傷並由機場消防隊救護車送到附近醫院。消防隊員另於左側 1 號門外滑梯下搶救出一名乘客。失事初期並無消防隊軟管手或救援人員進入前段機身。強風促使大火猛烈燃燒機身前、中段，(如圖 1.15-1 所示)。機身後段受煙及火影響較小。消防隊員於救援初期，均未配帶呼吸器，消防隊長解釋當時不需使用呼吸器理由，包括火勢太大消防隊員無法接近及進入客艙內，消防隊員因可能爆炸及高溫需保持安全距離，所有消防隊員位於上風處滅火，不會造成呼吸困難故未配帶呼吸器。消防隊長提到呼吸器可能在高溫環境充滿霧氣，反而限制隊員視野。

圖 1.15-1　SQ006 撞擊停止後約 30 秒飛機前段大火燃燒情形（照片由失事時滑經 A4 停機坪之班機內乘客拍攝）

生還人員經機場地面服務車輛、機場公務車及救護車由失事現場運送至急救檢傷中心。根據乘客描述，有人被有閃光燈之車輛接送，有人步行往急救檢傷區。根據機場航務組組長，他載了 7 至 8 名受驚之輕傷或無傷乘客至急救檢傷區。

第一批約 10 名生還人員直接由失事現場送往 30 公里外之林口長庚醫院，受傷乘客均未經檢傷分類便直接送往醫院，送醫途中亦無醫療人員照料。消防隊人員無法清楚記得何時搭載第一批乘客或何時出發運送第一批乘客至醫院，稍後救出之生還人員則送至急救檢傷中心。

機場救護車及救援車輛載有急救醫療用品，當時這些車輛來回失事現場及醫院間，所載急救醫療用品並未於急救檢傷中心卸下。

失事期間急救檢傷中心人員曾提供生還人員水及毛毯，無人將消防隊北站庫存醫療急救器材取出使用。

機場消防隊救護車開往附近醫院後，敏盛醫院機場門診部醫護工及鄰近空軍基地醫護人員陸續抵達，開始提供醫療急救器材。敏盛醫院指定輪值人員為機場緊急醫療協調官，當日該輪值醫護工為退休軍醫，但未持有民用證照。

1.15.3.3　醫療協調官及臨時醫療協調官

民國八十四年中正國際航空站與林口長庚紀念醫院、桃園敏盛醫院及其他醫院簽訂醫療服務合約。之後敏盛醫院於民國八十五年於中正機場設立門診部。另外，民航局要

求所有國內機場與其鄰近醫院簽訂醫療支援協議，以因應機場內外之事故。

事故期間，敏盛醫院負責中正機場內之醫療。一般而言，機場門診部醫生上班時間為 0830 至 1730 時。非上班時間僅有醫護工在門診部值勤，根據中正機場與敏盛醫院合約，敏盛醫院負責處理緊急醫療。該院門診部職員為指揮醫療作業之醫療協調官，但並未獲得醫療協調官相關訓練，門診部醫生亦不悉醫療協調任務。中正機場無完整之緊急醫療處理作業程序。機場內消防隊於上班時間有 2 名護士待命，但未被指派醫療協調官之職責。國際民航組織機場服務手冊（ICAO Doc 9137）第 3.6.3 節：

"*A medical co-ordinator should be assigned to assume control of the emergency medical operations at the accident site. If airport services exits, the medical co-ordinator may be designated from the airport medical staff. In some cases, it may be necessary to appoint an interim medical co-ordinator, to be relieved when the designated medical co-ordinator arrives on site. The interim medical coordinator can be designated from the airport rescue and fire fighting personnel.*"

1.15.3.4 檢傷分類及醫療處理

受指定為現場指揮官之機場航務組組長，將急救檢傷中心設於第一航廈第 9 號登機門下航務大樓之駕駛員報到大廳內（面積約 900 平方公尺）。有限之醫療器材置於該中心內。兩名航務員被指派處理急救檢傷中心相關聯絡事宜，負責通知所有醫療支援單位及告知相關人員急救檢傷中心位置。急救檢傷中心負責人員隨後由敏盛醫院機場門診部醫護工、敏盛醫院醫師、長庚醫院醫師及桃園縣衛生局主管接管。

「中正國際航空站民用航空站失事處理作業實施要點」有簡短說明檢傷分類及醫療處理：

『受傷乘客經檢傷分類後，協助緊急醫療救護網各責任醫療院所安排傷患後送醫院救治事宜。檢傷傷票型式如附錄十八』

本會發現多位受傷或未受傷生還者未經檢傷分類即直接送往醫院。

1.15.3.5 醫院資訊

國際民航組織機場服務手冊（ICAO Doc 9137）第 3.7.1 節：

"…It is mandatory to establish in advance an accurate list of surrounding hospitals. They should be classified according to their effective receiving capacity and specialized features, such as neurosurgical ability or burn treatment. In most circumstances, it is unwise to deplete the most

proximate hospital to the accident site of essential medical and nursing personnel."

國際民航組織機場服務手冊（ICAO Doc 9137**）第** 4.1.7 **節有關醫療協調官責任如下：**

a）immediately provide and transport doctors and medical teams skilled in trauma care to the accident site upon notification of the emergency;

b）provide medical care to the casualties when they arrive at the treatment area; and

c）ensure that adequate doctors and nurses, operating rooms, intensive care units, surgical teams, blood and blood volume expanders are available for emergency situations, including aircraft accidents.

「中正國際航空站之民用航空站失事處理作業實施要點」並未提供如神經外科手術處理能力之具體說明。

1.15.3.6 緊急應變作業相關法規及程序

國際民航組織緊急應變作業相關法規及程序如下。

國際民航組織機場服務手冊（ICAO Doc 9137**）第** 1.1.9 **節：**

"Recommendation - The stabilization and emergency medical treatment of casualties is of equal importance. The speed and skill of such treatment is crucial in situations where life hazards exit. An effective rescue effort requires adequate preplanning for emergency as well as execution of periodic practice exercises."

國際民航組織機場服務手冊（ICAO Doc 9137**）第** 3.6.1 **節：**

"Recommendation - The purpose of the medical service during an accident is to provide triage, first aid and medical care in order to:

(a) save as many lives as possible by locating and stabilizing the most seriously injured, whose lives may be in danger without immediate treatment.

(b) provide comfort to the less seriously injured and to administer first aid; and

(c) transport casualties to the proper medical facility.”

國際民航組織機場服務手冊（ICAO Doc 9137**）第** 3.6.3 **節：**

“Recommendation - A medical co-ordinator should be assigned to assume control of the emergency medical operations at the accident site. …In some cases, it may be necessary to appoint an interim medical coordinator, to be relieved when the designated medical coordinator arrives on site. The interim medical co-coordinator can be designed from the airport rescue and fire fighting personnel.”

國際民航組織機場服務手冊（ICAO Doc 9137**）第** 4.1.6 **節：**

“Recommendation - It shall be the responsibility of the medical co-ordinate to supervise the medical services and to:

a） verify the notification of mutual aid medical and ambulance services and their subsequent arrival at the rendezvous point or staging area;

b） organize the necessary actions for triage, treatment of the casualties, and their eventual evacuation by appropriate means of transportation;

c） control the flow of casualties and ensure, together with the transportation officer, the dispatch of the casualties to the appropriate hospitals by all available means of transportation;

d） maintain an accurate list of the casualties including their names and their final disposition;

e） co-ordinate the transaction of the uninjured to the designated holding area with the aircraft operator concerned;

f） provide medical evaluation of ambulatory and uninjured survivors;

g） arrange for the replenishment of medical supplies, if necessary; and

organize, with the police, reception facilities for the dead.”

國際民航組織機場服務手冊（ICAO Doc 9137**）第** 9.2.3 **節：**

“Recommendation - The first qualified, medically trained person to arrive at the site must immediately begin initial triage. This person(s) will continue performing triage until relieved by a more qualified person or the designed airport triage officer. Victims should be moved from the triage area to the appropriate care holding areas before definitive treatment is rendered. Casualties should be stabilized at the care holding areas and then transported to an appropriate facility.”

國際民航組織機場服務手冊（ICAO Doc 9137**）第** 3.3.1 **節：**

"Recommendation - The Prime responsibility of airport rescue and fire fighting personnel is to save lives. Property endangered by aircraft incidents and accidents occurring on or near the airport should be preserved as far as practicable. To achieve this objective, fire should be suppressed and any re-ignition prevented. There are aircraft accidents, however, where fire may not occur, or where the fire may be rapidly extinguished. In every case, the procedures should provide for the most rapid evacuation possible of survivors of the accident."

根據「中正國際航空站民用航空站失事處理作業實施要點」區分為場內失事及場外失事兩種程序，場內失事又分為兩類：1. **航空器著陸後，部分損壞，無燃爆，人員無傷亡；**2. **航空器著陸後發生燃爆，人員有傷亡。第二類關於消防救護程序如下：**

『消防車與救護車同步出勤馳赴失事現場，展開消防救護作業。

火勢控制後，以搶救乘客為優先，實施受傷乘客初期檢傷包紮之作業，消防車繼續擔任現場警戒，避免二次燃爆。』

相關於救護及醫療處理程序部分說明如下：

『敏盛醫院機場門診部應

*（1）**接獲聯絡通報組航空器失事通報後，立即由大園敏盛醫院機場門診部成立醫護組派遣醫生護士及救護車馳赴失事現場成立急救檢傷中心實施初期救護作業，航空器失事醫療救護示意圖如附錄十六。***

*（2）**協調後續到達支援之桃園區緊急醫療救護往所屬各責任醫療院所實施醫療救護作業桃園區緊急醫療救護責任醫院聯絡名單如附錄十八。***

*（3）**受傷乘客經檢傷分類後，協助緊急醫療救護網各責任醫療院所安排傷患後送醫院救治事宜。檢傷傷票型式如附錄十八。』***

部分規定亦於「中正國際航空站航務組消防隊作業手冊」中敘述:

a. ***消防車部署完成後，車長立即開啟車頂炮塔噴嘴，以半流量或全流量直噴噴射泡沫降低機身溫度，減少火焰繼續燃燒機身，以掩護機上人員迅速脫離。***

b. ***軟管手立即將車前軟管拉出以霧狀泡沫噴灑於機身出口部分並配合車上砲塔，開闢安全避難通路，供救護人員安全登機救人。***

c. ***搶救人員攜帶搶救工具，隨軟管手之後接近航空器，循安全通路將機上被困人員救出後，交醫護人員急救。***

1.16 測試與研究

1.16.1 模擬滑行路徑

八十九年十一月六日約 0400 時，本會借用新航波音 747-400 型貨機[20]模擬失事當晚 SQ006 滑行情況，藉此研析由駕駛艙內目視跑道與滑行道標線及指示牌之顯著程度，並檢視駕駛艙內儀表指示情況。進行模擬時，中正機場能見度超過 10 公里，小雨。模擬滑行目的為使調查人員熟悉 SQ006 滑行路徑。

模擬滑行時，同時於駕駛艙內進行錄影與錄音，一具攝影機由右座駕駛員操作向前拍攝，另一具攝影機由一位觀察員操作，由正駕駛員右耳附近位置向前拍攝。

在鄰近 05 右跑道頭附近，由駕駛艙中觀察到下列標線與指示牌：

(a) N1 滑行道西南面，一標示「N1/ 5R-23L」之黑/紅色指示牌；

(b) 05 右跑道上，標示「05」及「R」之白色跑道方向標線；

(c) N1 滑行道在 05 左及 05 右跑道之間，標示「CAT 2」之紅色指示牌；

(d) N1 滑行道東北面，一標示「5L-23R|N1」之紅/黑色指示牌；

(e) 05 右跑道頭之白色跑道頭標線；

(f) 通向 05 左跑道之綠色 N1 滑行道中心線燈（圖 1.16-1）；及

(g) 距 05 右跑道頭約 100 公尺處之 N2 滑行道中心線燈由跑道左側彎進跑道而併入 05 右跑道中心線燈（圖 1.16-2）。

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[20] 該機未裝置 PVD。

圖 1.16-1　　通向 05 左跑道之滑行道中心線燈（由波音 747-400 正駕駛位置之視野）

圖 1.16-2　　由 N2 滑行道中心線燈融入 05 右跑道之中心線燈（由波音 747-400 正駕駛位置之視野）

其它發現事項：

(a) **在兩主要飛航顯示器（PFD）中，儀器降落系統左右定位台指針皆為完全偏左之指示；**

(b) **兩 PFD 中跑道方位標線皆偏離中心而移向顯示器左邊；**

(c) **左 PFD 下滑道指示為高一個點（dot）；右 PFD 則顯示低一個點；**

(d) **導航顯示器（Navigation Display，ND）在 10 浬範圍時，地圖顯示有微小誤差；**

(e) 按下起飛/重飛（TOGA）鈕時，飛航管理電腦之經度與緯度未改變（地圖未移動）；

(f) 當中正塔台將 05 左跑道之跑道燈亮度置於第 1 級和第 2 級時，較不易看見該跑道燈（05 左跑道之跑道邊燈、落地區燈與中心線燈亮度分為 5 級，事故當晚之亮度為第 3 級）；

(g) 無標示顯示 05 右跑道關閉；

(h) 由駕駛艙無法看到 05 右跑道上之障礙物或障礙燈；

(i) 航空器由 N1 滑行道轉入 05 右跑道時，由駕駛艙可看見「05」及「R」之跑道方向標線；及

(j) 航空器對正 05 右跑道後，由駕駛艙無法再目視「05」及「R」之跑道方向標線。

1.16.2 緊急照明燈光測試

在本測試中，本會將乘客緊急疏散指示燈及 4、5 號門間之地板疏散指示燈（圖 1.16-3）之四組電池組（第五組無法尋獲），於 4、5 號門後取下，送往中正機場之華航維修廠進行測試，各電瓶組皆通以 7 安培電流，過電後四者之瞬間電壓為 5.2 伏特，10 秒後則降至 0.1 伏特以下，結果顯示各電瓶組皆完全放電。

圖 1.16-3 緊急照明燈光測試結果

另取一充足電之正常電瓶以測試後機身緊急照明燈，所得結果如表 1.16-1 所示。

表 1.16-1　　**緊急照明燈光測試結果**

位置	燈光	情況
4L	出口指示燈（門之兩側及上方）	不亮
4L	地板疏散指示燈（門前）	不亮
4R	緊急照明燈（門上方）	亮
5L	出口指示燈（門之兩側及上方）	亮
5L	出口指示燈（門前）	亮
5L	地板疏散指示燈（左走道外側）	由左側 4 號至 5 號門間會亮
5R	出口指示燈（門之兩側及上方）	亮
5R	出口指示燈（門前）	亮
5R	地板疏散指示燈（右走道外側）	自第 57 排後會亮

1.16.3　　疏散滑梯/艇檢測

該機之左側 1、2 **號及右側** 4 **號疏散滑梯於九十年二月十五日送至製造廠作進一步檢測，檢測期間，本會發現** SQ006 **之滑梯規格符合廠商規範，進一步之滑梯損壞檢測於同年** 11 **月** 9 **日時進行，發現右側** 4 **號滑梯充氣口處有煤灰及火燒情形。**

1.16.4　　後機身置物箱連桿測試

本會將?下之置物箱連桿送至中科院之實驗室進行金相測試，結果顯示其斷裂之原因為飛機撞擊時承受過大應力而造成。

1.16.5　　05 右跑道邊燈電線測試

本會將位於 RE239 **及** RE240 **尋獲之** 05 **右跑道邊燈電線分別送往中科院及澳洲運輸安全局進行材料測試，以作為鑑定事故當晚跑道邊燈是否開啟之證據。**

中科院利用電子掃描顯微鏡（SEM**）測試結果，發現** RE239 **及** RE240 **之電線末端皆有夾痕和剪力破壞情形，判斷兩者之斷裂並非拉力造成，而係由線夾之剪力產生。在電子掃描顯微鏡檢驗下，兩電線均有夾痕及剪力面特徵。**RE239 **之電線絕緣層因拉扯而斷裂，線束末端有些火燒之痕跡。**RE240 **電線絕緣層離末端有** 16 **公分長遭大火燒燬。**

RE240-1 **線束末端發現三個熔珠（圖** 1.16-4**）。根據中科院之報告，這些熔珠像似放電而產生之局部熔融現象。報告另外提到，對其遭污染之各股電線末端進行掃描電子顯微鏡/能量散佈光譜分析後發現，三個熔珠應是在其它電線末端遭污染後才生成，其中一個熔珠表面有一缺口，比其它未產生熔融現象之電線末端乾淨（圖** 1.16-5**）。**

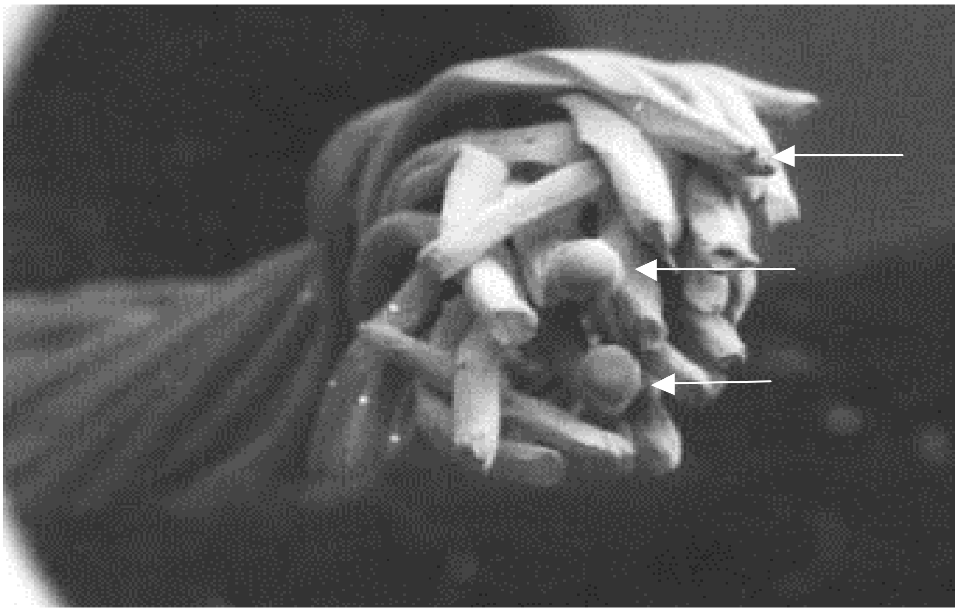

圖 1.16-4　　RE240-1 **電線末端之三處熔珠**

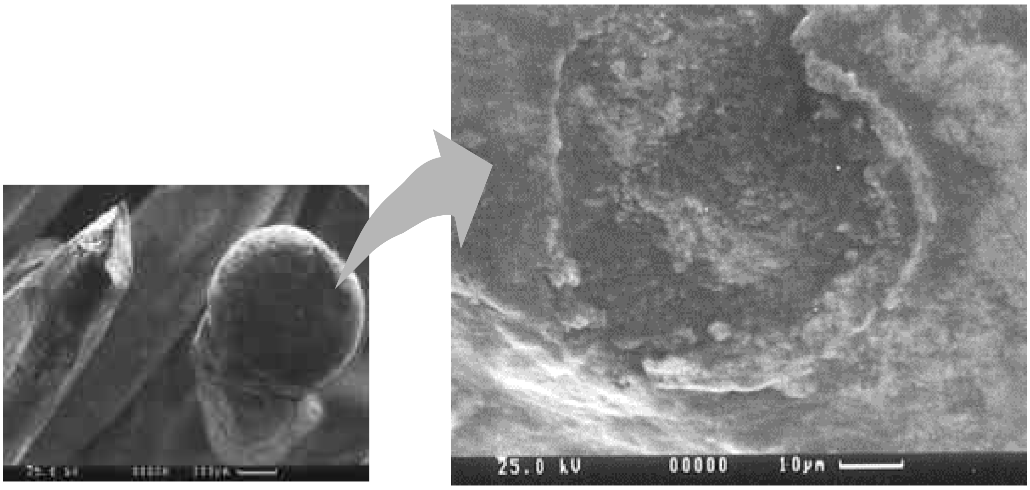

圖 1.16-5　　**其中一熔珠表面缺口之情形**

澳洲運輸安全局之報告指出，RE239 **之兩線束係由拉扯而與燈座線夾分離。報告中敘述，線束末端皆有夾線過程中造成夾痕的特徵，且一致呈現係「剪線過程」的特性。報告中復敘述** RE239 **之兩條電線絕緣層離插頭** 11 **公分處有相似的破裂情形，且明顯地有一段絕緣層因受拉力作用而向電線末端移動。報告中另指出，絕緣層距插頭** 7.5 **公分位置有** V **字型（**chevron-like**）撕裂處。**RE239 **電線未發現放電跡象。**

澳洲運輸安全局之報告亦說明，有關 RE240 **兩條線束因拉扯而脫離線端線夾的情形，與** RE230 **情形相似。兩線束皆有因高熱，也就是「電弧放電」，而產生局部熔融**

現象(如圖 1.16-6)。報告亦提及，大部份絕緣層已脫離電線，脫離過程不明，只剩下離插頭 8 公分以下之絕緣層。剩餘之絕緣層未有表面起泡或焦黑現象。報告又指出，最值得注意的特點是絕緣層末端呈現銳角。顯然這一斜角以上之絕緣層曾受到火燒影響，而造成尖銳角度斜角末端之原因，則係插頭端浸泡在液體中或因某些重疊的燃燒過程而產生的邊界效應。

澳洲運輸安全局的報告認定，RE240 在距插頭 9.5 公分處，殘留之絕緣層附近的電線上有因放電產生之局部熔融現象（圖 1.16-7），但 RE239 並沒有發生類似放電熔融現象。

圖 1.16-6　RE240-1 電線末端熔珠

圖 1.16-7　RE240-1 靠近脫落絕緣層之局部熔融現象

兩份報告皆指出，RE240 電線放電現象發生之時間，無法自測試決定。

為進一步確認 RE240 電線之放電如何產生電線末端金屬融珠之現象，本會安排於九十年七月廿日在中科院實驗室，使用同型跑道邊燈在同樣電力負荷條件下進行了另外的測試。測試結果指出，RE240-1 上之熔珠可以是在電源接通，而電線脫離線夾時產生；或在電線脫離線夾之後，在通電狀態下，線端瞬間接觸地面上的金屬體而產生。

1.16.6 駕駛艙之視野模型之研究

CM-2 及 CM-3 於訪談中表示，由於雨水影響，無法透過擋風玻璃雨刷未掃過部份清楚看到外面景像，本會委託波音公司進行波音 747-400 型機駕駛艙擋風玻璃雨刷掃範圍之視野模型之研究，該研究基於以下幾項假設：

1. 航空器之載重與平衡不計；
2. 擋風玻璃雨刷本身之視障不計；
3. 駕駛員頭部移動量不計；
4. 僅考慮直線視線（不考慮折射/角度偏移之影響）；
5. 滑行道及跑道平坦；
6. 鼻輪支柱/輪胎伸展情況不詳，略而不計；
7. 運用理論「電腦輔助設計」建立雨刷幾何模型；
8. 忽略 AB 中柱襯墊[21]之遮避（駕駛員左內側視野之一小部份）；
9. 圓圈距離係以駕駛員之眼睛位置為準（距飛機之中心線 21 吋）

本研究代表單一角度之視野，實際上當駕駛員頭部移動時，視野會較好。圖 1.16-8 和圖 1.16-9 顯示本視野模型研究之地面視野。

[21] AB 中柱襯墊（AB post padding）為正、副駕駛 1 號窗中間之中柱，上覆蓋一襯墊，此一襯墊對於正駕駛 1 號窗之視線無影響，但對副駕駛 1 號窗內側部份則有約 1/16 吋之遮蓋。

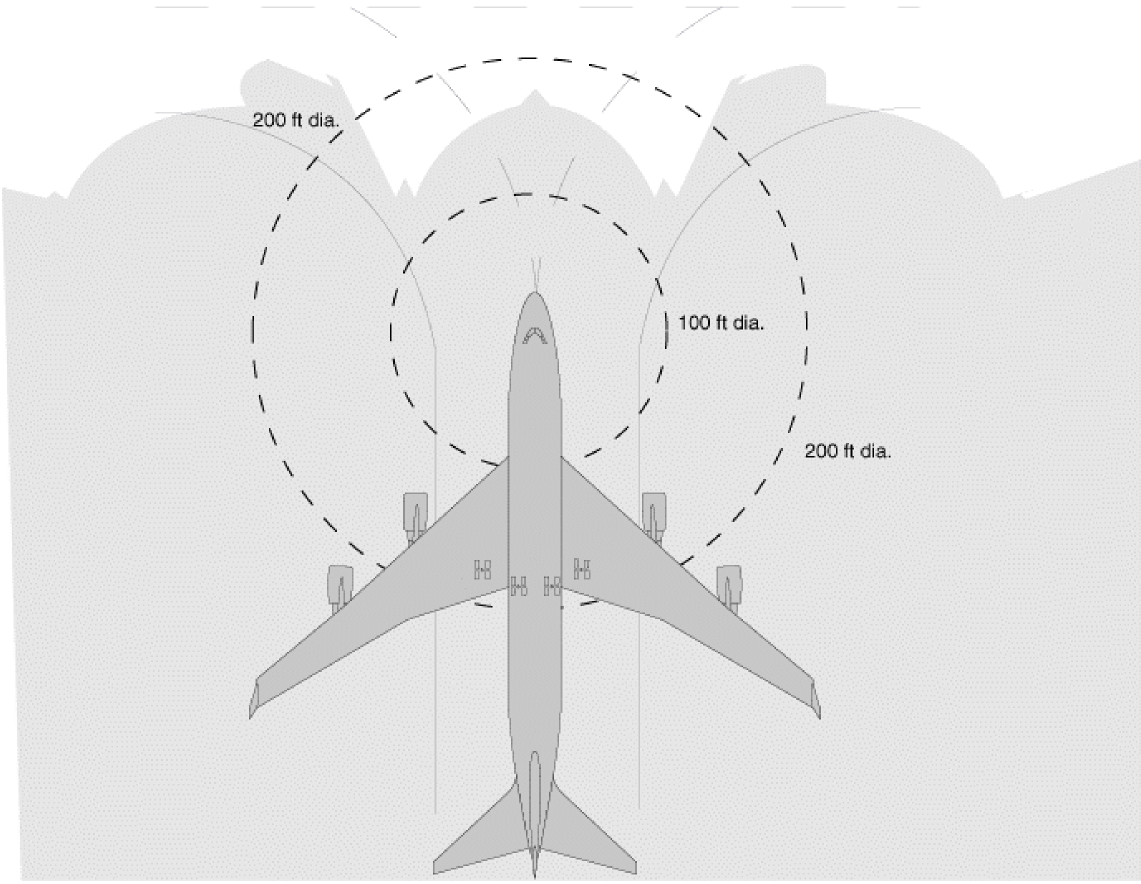

圖 1.16-8　**正駕駛員與副駕駛員之地面視野－限雨刷掃過範圍。灰色部份代表由正駕駛員與副駕駛員視線未涵蓋之區域。同心圓部份不代表視界所及範圍**

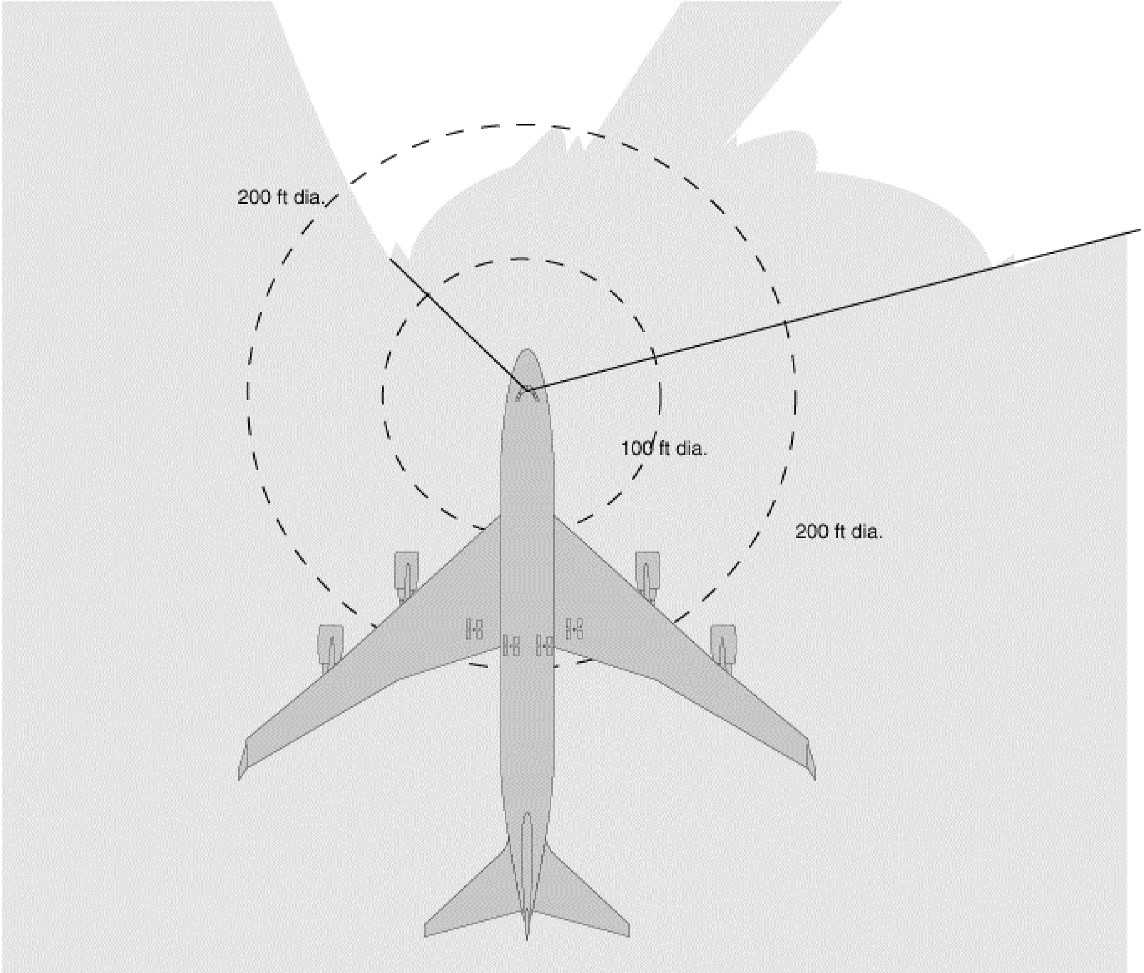

圖 1.16-9　　**正駕駛員之之地面視野－限雨刷掃過範圍。灰色部份代表由正駕駛員視線未涵蓋之區域。同心圓部份並不代表視界所及範圍**

1.16.7　　跑道視程原始數據之計算

中正機場之自動天氣觀測系統稱為機場氣象諮詢系統（AWA），包含風向風速計、跑道視程儀、雲幕儀、氣壓計及乾濕球溫度計。跑道視程儀架設於 05 左/23 右、06/24 跑道之著陸區及 05 左/23 右跑道中點。

跑道視程由其原始數據（消光係數、跑道燈光設定、背景光強度）經機場氣象諮詢系統計算而得，但僅有原始數據錄存於機場氣象諮詢系統。下表為事故發生後機場氣象諮詢系統供應商計算所得之資料[22]：

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[22] **該資料為 1 分鐘平均值。**

表 1.16-2　事故當時所測之跑道視程

時間	05 跑道著陸地帶能見度（公尺）	05/23 跑道中點能見度（公尺）
2312	518	475
2313	504	604
2314	923	420
2315	450	236
2316	360	168
2317	444	192

1.17 組織與管理

1.17.1 新加坡民航局之組織與管理

1.17.1.1 職掌

新加坡民航局（CAAS）隸屬於新加坡交通與資訊科技部，負責規範新加坡境內之民用航空安全規定及在其境外運作之新加坡籍航空器。

新加坡民航局之安全職掌如下：

1. 規範新加坡籍航空器之航務與適航；
2. 規範新加坡之航太工業；
3. 航空與維修人員之給證；及
4. 提供政府民航事務諮詢。

1.17.1.2 航空器作業規範及新加坡籍航空器適航規範

1.17.1.2.1 航空運輸業者營業許可

新加坡民航局核發航空運輸業營業許可證（Air Operator Certificate, AOC）予在新

加坡經營大眾運輸航空器使用人，並依據國際民航公約第六號附約，訂定航空運輸業營業許可條件（Air Operator Certificate Requirement, AOCR）。

1.17.1.2.2 航務督導

所有民航業務，包括管理架構、地勤人員與飛航組員之適任與訓練安排、土地與地上建築物、設備及航空器等，新加坡民航局皆依其運作規模、範圍與條件予以評估。航空器使用人須符合國際民航公約第六號附約之標準及建議措施。

新加坡民航局對每一飛航作業基地（如停機坪與維修機棚等）及業者之外站均有定期檢查計劃。此作業乃是為了評估航空器使用人之組織、基地設施及所有運作標準之適當性，及相關規定與操作手冊之一致性。

新加坡民航局亦執行飛航檢查作業。檢查目的為評估航空器使用人提供之程序與設施，能否使組員執行其空中與地面之任務；檢查組員之駕駛艙管理標準與操作狀況；評估相關規定與操作手冊之一致性。新加坡民航局亦監督其授權檢定人員對組員訓練之考核。

1.17.1.3 工程與維護支援

新加坡民航局於核發或續發航空運輸業營業許可證前，先依據航空器使用人之航空器數量、機型與其複雜度及經營類型與區域等因素，評估其工程與維護支援安排是否適當。

新加坡民航局對航空器使用人與其修維護單位進行定期之安全督導，確保航空器之適航性，及其運作符合國際民航組織與新加坡適航規定。定期之檢查及督導對象包含航空器使用人、修護單位與各外站（line stations）等。

1.17.2 失事調查角色與職責

新航係在新加坡註冊之股票上市公司，依據新航2000年公布之財務報告，Tamasek Group 公司係新加坡政府擁有控股公司，佔有新航 57%之股權，新航董事會 11 席董事中，除董事長與總經理外，有 4 位董事係新加坡政府官員。

1.17.2.1 新加坡交通與資訊科技部之失事調查

新加坡交通與資訊科技部除掌管新加坡運輸事務外，亦負責航空器失事調查，其調查範圍包括發生在新加坡境內及境外之新加坡籍航空器失事案件。失事發生後，交通與資訊科技部會成立調查小組，執行航空器失事調查作業，小組成員包含新加坡民航局負

責航務與適航檢查之檢查員，及負責發展與實施新加坡民航局相關規定及民航安全監理之管理者。

1.17.2.2 獨立調查機關

國際民航公約第十三號附約第 5.4 **節：**

"The accident investigation authority shall have independence in the conduct of the investigation and have unrestricted authority over its conduct, consistent with this Annex."

該附約第 5.4.1 **節：**

"Any judicial or administrative proceedings to apportion blame or liability should be separate from any investigation conducted under the provisions of this Annex."

為達獨立調查目的，許多國家在管制、規範航空法規與安全監理機關之外，另設獨立機關。例如：澳洲、加拿大、獨立國協（代表包含俄羅斯等十二國）、芬蘭、韓國、荷蘭、紐西蘭、瑞典、中華民國、英國、美國。

1994 **年** 11 **月** 21 **日，歐洲聯盟理事會通過指令，要求各成員國應於兩年內，設立常設機關（構）以執行或監督其航空器失事及重大意外事件調查，該機關應獨立於該國負責航空法規及監理機關之外獨立運作。歐盟官員表示，全體十五個會員國均已遵守此一指令設立或規劃設立獨立調查機關。**

美國國會於 1974 **年在設立國家運輸安全委員會之法令中規定：**

"Proper conduct of the responsibilities assigned to the Board [NTSB] requires vigorous investigation of accidents involving transportation modes regulated by other agencies of Government; and calls for the making of conclusions and recommendations that may be critical of or adverse to any such agency or its officials. No Federal agency can properly perform such functions unless it is totally separate and independent from any other department, bureau, commission, or agency of the United States."

針對設立獨立運輸事故調查機關之必要性，Pieter van Vollenhoven **先生在歐盟運輸安全理事會在比利時布魯塞爾會議中發表論文指出**[23]**：**

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[23] **該論文標題「獨立事故調查：每一位公民的權利、社會的責任」。該會議於** 2001 **年** 1 **月** 23 **日舉行，**Pieter van Vollenhoven **先生時任國際運輸安全協會主席。**

"In some cases, to ensure 'independence' of an investigation, the government appointed a special committee, chaired by an independent person, such as a judge. But, the committee was usually made up of government inspectors, or people working for them. After all, they had the expertise that was needed. And society usually accepted this procedure, because, as I have already pointed out, government and safety were regarded as two sides of the same coin. What is more, it was often the only way possible of carrying out an investigation, apart from calling in a private agency or university. It was not until much later that the public began to question the significance or worth of such investigations. For, if the intention was to learn from them, and if so many conflicting interests were involved, they had to meet one very basic condition. They had to be carried out independently of all interests but one. And that one interest was safety. There could not be even the slightest suggestion that any other interest influenced the findings of the investigation, or the committee's recommendations.

Increasingly, people began to realize that government inspectors were not independent. After all, they were closely involved in drafting regulations, and monitoring compliance. They were, in fact, both judge and jury."

Pieter van Vollenhoven **先生並表示：**

"…a permanent independent organization not only guarantees the independence of the investigations. It can also ensure that follow-up is given to its recommendations. And, since prevention is better than a cure, it can carry out the incident studies."

1.17.3 新航組織－航務處

新加坡航空公司乃新航集團之主要公司，航務處（Flight Operations Division**）為該公司所屬八個處之一，其它七個處分別是金融（**Treasury**）、財務（**Finance**）、行政（**Corporate Affairs**）、客艙組員（**Cabin Crew**）、人事（**Personnel**）、機務（**Engineer**）及業務處（**Commercial**）。**

航務處之最高主管為資深副總經理（Senior Vice President, SVP**），依新航飛航管理手冊（**Flight Administration Manual**，**FAM**）其下再細分為部（**Division**）及組（**Section**）。航務處資深副總經理表示，安全與效率乃是航務處及全公司之主要目標。**

航務處下設飛航運作部、飛航組員訓練部、安全、保安與環境部及飛航管制中心，

各主管皆為新航資深駕駛員。

1.17.3.1 飛航運作部

執行副總經理為本部主管，負責飛航運作業務管理，新航機隊中有四種機型，分別由四位總機師（chief pilot）負責管理與監督各機隊日常運作。

飛航運作部職責如下：

- 各機隊飛航運作相關技術及作業事項；
- 飛航運作符合新加坡及國際相關規範；
- 就運作事務與航空器製造商保持聯絡；
- 負責所有線上駕駛員之績效、能力、品行及紀律；
- 有效指派各機隊之駕駛員；
- 本部員工福利；
- 保持所有操作手冊及文件之有效與正確；
- 保持組員符合飛行管理手冊及操作手冊程序執行；
- 保持組員管理系統之現代化；
- 訂定飛航運作之程序與政策；及
- 其它航務處資深副總經理交辦事項。

新航使用之飛航操作手冊（Flight Operation Manual，FOM）由航空器製造商提供；因此，波音 747-400 手冊係新航飛航操作手冊之基礎。新航飛航管理部門僅增加操作及燃油政策之執行程序。正常程序與檢查表係配合新航之修改制定。而新航編製之程序須陳報新加坡民航局核准。

飛航運作部亦負責檢查及確認新航符合航空運輸業營業許可條件（AOCR）所規範事項：

- 檢查組員執勤狀況（Crew Operating Pattern，COP）以符合規定之飛行時間限制，如：最大容許執勤時間與最低之休息時間；
- 使用電腦報到系統（飛航報告與資訊系統「FRAMS」）在執行任何飛航任務前，確認飛航組員之證照、基本考驗、航路考驗、安全裝備及程序訓練適職性證照及所需之近期經歷；

- 檢視飛航記錄文件，確認其合乎規定；及
- 對每位航空運輸業營業許可條件規範之人員實施技術鑑定（基本考驗、儀器檢定考驗、航路考驗、第三類儀降進場/低能見度進場等）以保障其適任性。

1.17.3.2 飛航組員訓練部

飛航組員訓練部（簡稱訓練部）由航務處資深副總經理與訓練部副總經理負責下列事項：

- 部內人員之訓練及發展；
- 飛航組員訓練中心之管理，負責所有駕駛員之證照轉換；
- 執行精進考驗（基本考驗，儀器檢定及航路考驗）；
- 飛行模擬機之精確度、認證及維修；
- 對所有駕駛員及客艙組員實施安全裝備訓練、給證及複訓；
- 所有教師（飛航及地面訓練）之甄選、任命及標準化；
- 新航訓練中心職員之福利；
- 該部之運作、訓練及其它事務等政策之制度化；及
- 其它由航務處資深副總經理交辦事項。

訓練部提供客艙組員聯合安全與緊急程序訓練及空勤組員資源管理訓練。訓練部也提供選為晉升正駕駛員之副駕駛員之機長訓練及對完成初級飛行訓練，飛行時間 200 小時以上之駕駛員，實施活塞引擎航空器轉為噴射引擎航空器之轉換訓練。

部分訓練部人員，可被選為新加坡民航局委任、代表官方之檢定駕駛員（Check Airman），並代表新加坡民航局執行地面學科考試。

訓練部依據新加坡民航局規定，對所有駕駛員執行每年兩次基本考驗及年度儀器檢定考驗。

本部提供之駕駛員訓練項目：

(a) 航空器機種訓練（Aircraft Type Training）；

(b) 資格恢復訓練（Reactivation Training）；

(c) 複訓（Recurrent Training）；

(d) **熟習訓練**（Recency Training）**；**

(e) **強化訓練**（Reinforcement Training）**；及**

(f) **低能見度訓練**（Low Visibility Training）**。**

機種檢定訓練（轉換訓練）

正常之機種檢定訓練內容如下：

(a) 2 **至** 3 **週之航空器系統、航空器性能及安全與緊急程序之電腦基本訓練；**

(b) 10 **至** 15 **週的模擬機訓練，正常及不正常程序包括風切、**CFIT、FANS、CAT 3、TCAS**，不正常狀態改正及起飛之安全訓練；**

(c) **航空器基本訓練，包括發動機熄火進場、重飛與落地；**

(d) **地面/模擬機訓練之最後階段，在開始** 4 **至** 5 **週的航路訓練，受訓者需通過航空器機種檢定飛行考驗、儀器檢定及初次航路考驗；及**

(e) **受訓者在航路訓練結束擔任航路任務前，須先通過航路完訓考驗。**

資格恢復訓練

此訓練係對駕駛員恢復曾飛機種或新進組員熟悉新航政策及作業程序之訓練。課程內容為精簡版之機種檢定訓練。

複訓

訓練部提供所有駕駛員一年兩次的複訓課程，內容為六節課之線上適應飛行訓練（Line Oriented Flight Training，LOFT）**，目的是使駕駛員重新複習在機種檢定考驗時未涵蓋之重要正常與不正常程序。**LOFT **之訓練重點為駕駛艙管理、狀況警覺、領導能力與資源管理。**

熟習訓練

熟習訓練提供超過 28 **天未操作航空器之駕駛員，在航空器上或經認可之模擬機中接受訓練。**

強化訓練

訓練部對未通過精進考驗或需針對缺點加強訓練之駕駛員，提供額外的訓練。

低能見度訓練

低能見度訓練之目的在給予駕駛員對第三類儀降進場及目視輔助顯示器操作之合

格能力。其項目包含儀器降落系統臨界區、燈光系統、跑道與滑行道標線及所需裝備。駕駛員須觀看低能見度操作之錄影帶。同時需在經第二級認證之模擬機實施起飛及落地訓練。該訓練中無低能見度滑行訓練。

1.17.3.3 安全、保安及環境部

安全、保安及環境部隸屬於航務處，其主管為安全、保安及環境副總經理，負責向航務處資深副總經理報告，但安全、保安及環境副總經理認為有必要時，可直接向執行長報告。

安全、保安及環境部負責新航之飛航安全，必要時，對重大意外事件及飛航運作事故進行調查。亦負責新航在新加坡之物業及新航所有外站之安全與保安。另外，亦負責調查新航所有之地面失事及意外事件。

安全、保安及環境部提供飛航安全（包括客艙安全）、危險物品管理、地面安全（例如：停機坪及工程施工）、工業與消防安全、地面與空中保安及環境保護等事項之支援服務與訓練。該部負責制定專業及客艙組員對安全裝備訓練之標準及程序，程序相關項目包括緊急出口、水面降落、火警、保安及乘客干擾。該部並不實施查核，亦不推廣特定之風險管理理念，亦不制定航務運作相關政策，因為這是各機隊總機師責任。

安全、保安及環境部負責意外事件強制報告系統，除了鳥擊或雷擊等較輕事件無須採取近一步行動外，大部分之運作事件皆進行調查，通常為對資訊做進一步證實與釐清則需關係到機隊管理或其它相關單位，如機務、客艙組員、業務或其它公司等，協助進行事實之說明與澄清。若屬重大或嚴重之意外事件，該部可成立意外事件諮詢/調查委員會，此時，將傳喚相關人員與目擊者，以確定事件之肇因，調查報告將送相關部門，由其管理階層執行改善措施。

新航提供新加坡民航局所有之意外事件報告，若該局提出要求，新航亦將對其調查結果及採取之改善措施提出報告。另外，新航飛安會議（SIA Air Safety Committee）每兩個月亦將檢視所有報告，並在新航內部之飛航安全評論（Flight Safety Review）雙月刊雜誌中登載安全相關事件摘要及處理情形供組員參閱。新航飛安會議是由航務處資深副總經理主持，成員包括航務處、空服處、機務處及行銷等單位代表。該會除負責審查報告外，並有權裁決是否結案，若認為調查結果不夠完整或深入時，可要求做更深入之調查。結案報告屆時將會公佈，並透過飛航安全評論雜誌，公告所有組員及相關人員。另外，雜誌背頁有匿名報告表格，提供給不願具名之組員報告有關飛安事故。

安全、保安及環境部亦負責運作保密之飛航數據分析程式（Flight Data Analysis Program，FDAP），依程式判斷駕駛員之各項飛航操作參數是否超過標準，作為事故認定之依據。管理階層及駕駛員工會另組一委員會，每月開會一次，負責審查及追蹤所有超過標準之記錄。裝有快速擷取記錄器(QAR)之航空器才可使用此程式進行分析，新

航 90%之航空器裝有 QAR。當發現駕駛員之飛航數據記錄超過標準值之趨勢或傾向時，委員會之工會代表（若駕駛員是工會會員）或安全、保安及環境部副總經理（若是非工會會員）則會私下告之。

機隊管理階層每年舉行兩次「機隊會議」，討論飛航運作事務。若有需要，會中將強調並討論飛安相關議題。另外，每日之安全事項，將於組員離開或到達新加坡時藉由飛航報告與資訊系統（FRAMS）獲取相關資訊。飛航報告與資訊系統係駕駛員出勤簽到及簽退時所使用之電子系統，亦被作為提醒組員證照有效之工具，且在管理階層認為必要時，亦可提供組員緊急之飛航操作資訊及其它重要訊息，如出勤名冊之更改、最新文件修正及飛安公告等。

新航資深管理機師（management pilot）於訪談中指出，新航航務處目前並無負責品質保證專職單位，但正計畫於次年設立品保單位，目前考慮採用幾套系統，係依據美國運輸部提供之指導原則。新航另一個加強飛安措施為計畫執行保密性人為因素意外事件報告方案（Confidential Human Factor Incident Reporting Program），目的在鼓勵組員報告發現之人為因素意外事件。

1.17.3.4 飛航管制中心（FCC）

新航飛航管制中心之主要功能為盡可能避免干擾或延誤班機，若發生干擾或延誤時，負責重新安排班機，使乘客之不便降至最低，且必須以最低成本兼顧飛安、效率及服務。以上任務之達成，必須藉由定期評估與蒐集航路運作相關資訊，如：助導航設施之可用性、機場設施之縮減狀況、加油設施之狀況、氣象預警、組員執勤與飛行時間限制及其它航務上即時性之重要資訊。

飛航管制中心負責決定下列事項：

(a) 取消班機；

(b) 因天候、機場限制、國內異動、組員值班時間或航程限制，重新安排班機；

(c) 因天候、機場限制、國內的騷亂、組員值班時間或航程限制，加派班機；及

(d) 其它相關事項之處理，如延誤、航空器轉降、重新安排航程、班表修訂或恢復、重新調派航空器及組員重新調派等。

飛航管制中心亦負責提供飛航計劃及相關簽派服務，如新加坡境外班機作業及規劃航路變更等（例如：遭遇熱帶低氣壓、火山爆發及機場關閉等）。其中亦包含確保組員執勤時間及組員作業模式更改時（如因班機延誤或班表變更），不會違反任何法令要求。

本中心負責確定航空器上之手冊、文件及航圖為有效版本。

依據新航之飛航管理手冊 2.1.2，為了確保決策之效率，任何事件可能導致班機取

消、延誤或未排定，機長及新航各站經理必須立刻通知飛航管制中心。相關事件列舉如下（不僅限於此）：

- 天氣警告
- 機場關閉或限制；及
- 其它可能造成班機延誤或干擾之事件。

飛航管制中心採 24 小時作業，約有 94 名人員，共分為五個組，每組約 15 至 20 名成員，視值班時段而定。該中心日間尖峰時段人數較多，夜間離峰時段（通常為午夜之後）人數較少，資深管制員每次值班時間為 12 小時，包含用餐及休息時間。

飛航管制中心包含四個組（Section）：

- 飛航管制；
- 飛航服務/計畫；
- 組員任務班表，及
- 航空器文件。

另外，依新航飛航管制中心職員之訪談記錄，該中心對於嚴重之延誤事件，將對有關之業務與技術問題，與機隊、業務及工程部門等聯繫。

飛航管制中心係新航（特別是飛航運作）之通訊、通報及協調工具，其提供 24 小時之航情守望予新航所有班機及其它合約航空公司。該中心亦負責班機簽派及駕駛員班表之重新安排。另外，該中心之航空器文件組負責所有飛航運作文件之更新，例如航空器操作手冊、吉普生航圖。其主管為飛航管制中心資深經理。

1.17.4 飛航操作相關議題

1.17.4.1 組員資源管理

飛航運作/專案副總經理為資深管理機師，負責專案管理。對新航組員資源管理（CRM，即新航所稱之空勤組員資源管理, ARM in SIA）訓練計畫有全盤之監督權，亦曾擔任 B777 機隊總機師。新航於 1984 年發展出其第一套組員資源管理課程，稱為第一階段空勤組員資源管理，陸續於 1987 年完成第二階段空勤組員資源管理及 1998 年完成第三階段空勤組員資源管理。

新航之資深管理機師及教師機師於訪談中指出，第一階段空勤組員資源管理著重在組員之行為模式、有效溝通及團隊合作等，亦強調透過協力合作，解決存在於多重文化

（multi-cultural）駕駛艙[24]內之潛在問題，同時也重視個人價值及人際關係。第二階段空勤組員資源管理則著重在駕駛員決策方面之資訊，包括團隊決策、共識型（consensus）決策及專制型（autocratic）決策等課題，同時也包括配偶支持重要性[25]。第三階段空勤組員資源管理則專為發展機長之領導能力所設計，強調機長個人發展與領導品質。每套空勤組員資源管理課程約為期三至四天。

飛航運作部副總經理表示，新航空勤組員資源管理課程並未反應組員資源管理及人為因素研究之進展而進行更新。並表示，航務管理階層已在考量發展第四階段空勤組員資源管理，以錯誤管理系統（error management system）為發展重點。

所有空勤組員資源管理課程由一位美籍心理學教授負責於新加坡境外教學，一位管理機師擔任課程種子教官。課程設計涵蓋組員應該應用之概念。教師機師於模擬機或飛機之訓練及精進考驗中應用這些概念。教師機師有時亦會在飛行中或模擬機檢定任務提示時與組員討論飛航管制之原則及評論組員資源管理相關議題。除了透過教師機師觀察與評估外，目前新航並無任何評鑑機制，確認組員已具備組員資源管理所教導之技巧。

1.17.4.2 加強飛航組員之職責

波音 747-400 型機在設計上是由兩名駕駛員負責操作（正駕駛員及副駕駛員），但依航程距離情形，可配置額外駕駛員於長途飛行中接替正駕駛員和副駕駛員執行任務。新航航空器有多種組員配置方式，舉例來說，依據新航波音 747-400 總機師所述，波音 747-400 正常組員編制是兩位飛航組員，包括正駕駛員與副駕駛員各一名，部分波音 747-400 型機作業則需要正駕駛員一名及副駕駛員兩名，或正駕駛員兩名及副駕駛員一名。各種組員配置方式是由許多因素所決定，例如：組員飛航時間和執勤時間限制。

新航波音 747-400 總機師指出，加強飛航組員角色係由該次任務機長決定，例如：機長可要求加強飛航組員於起飛及降落時留在駕駛艙內。但對於加強飛航組員未於操控位置時之職責，新航無明確文件規定。一位資深駕駛員於訪談中指出，加強飛航組員與操控飛行組員於駕駛艙內之有效互動及資源運用，係視機長而定。

1.17.4.3 組員提示資料袋之準備

依據長榮航空公司（簡稱長榮）與新航有關新航於台北站運作合約中，長榮負責提

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[24] Karlins, M., Koh, F., McCully, L., & Chan, C. T. （1997）. The aircrew behavioral compass: A descriptive model for categorizing and understanding the personal behavioral styles of pilots. In R. S. Jensen & L A. Rakovan （Eds.）, Proceedings of the Ninth International Symposium on Aviation Psychology （pp. 1116-1119）. Columbus, OH: Ohio State University Press.

[25] *Karlins, M., Koh, F., & McCully, L. （1989）. The spousal factor in pilot stress.* Aviation, Space and Environmental Medicine, 60, *1112-1115.*

供新航台北站之地面勤務服務（包括調整後之簽派業務）。合約中亦指出，長榮提供新航組員適當之提示服務。

長榮負責處理所有新航於中正機場起飛之電腦飛航計畫及簽派文件。SQ006 失事發生前，飛航組員曾獲得標準之飛行前提示資料袋，包括天氣資訊、飛航公告（資料來源為中正諮詢台）、公司之內部飛航通告（INTAM）及北歐航空系統（Scandinavian Airways Systems, SAS）之飛航公告。

長榮負責準備天氣及航空器性能資訊人員，包括有執照之簽派員及無照人員。長榮人員亦提供簽派資訊予新航之飛航組員，該資訊係新航飛航管制中心提供，簽派員傳送簽派放行許可予長榮中正機場航務課前，先進行文件檢查，確保其符合新航政策，中正機場航務課人員隨後將飛行前提示文件交由飛航組員。

長榮簽派員曾受新航簽派政策與程序訓練。新航飛航管制中心於訪談中指出，台北站簽派員提供完整之口頭飛行前提示。新航飛航組員及長榮簽派員表示，台北站之飛行前提示為自我提示，若有必要，起飛前，組員可向簽派員諮詢相關問題。

簽派服務合約中並未明確指出，完全之口頭提示是否必要。另外，依據新航台北站提示（SIA Taipei Station Brief）[新航台北航站夜航資訊（Nightstop Information-TPE），2000 年 3 月 1 日, TPE-2-2，]說法，提示應在航空器邊（aircraft side）實施，SQ006 飛航組員當天之提示地點是在航空器停機位 B5（aircraft' s parking bay）通往等待區走廊上實施，時間是台北時間晚上 21 時 53 分，長榮航務員指出，當時曾用螢光筆將相關與重要天氣預測資訊標記起來，且將正式飛航公告交給新航飛航組員。

1.17.4.4 航空器文件

飛航管制中心航空器文件組負責確保新航每次飛行任務中，所有新航手冊與飛航文件皆為有效及正確。每位組員於新加坡出發前，航空器文件組皆會配給有效之飛航資料，包含該次飛行航線、目的地機場及備降機場等完整航圖及手冊。如於飛行任務中，各航程之航圖或手冊有任何修正或更新，飛行組員將於每個航程起飛前，收到更正資料。本次飛行組員獲得之中正機場機場圖中，05 右及 05 左跑道係顯示為跑道。

1.17.4.5 新航滑行程序

新航波音 747-400 飛航組員訓練手冊（Flight Crew Training Manual，FCTM）提供航空器操作及技術之資訊與建議，手冊第 8.26 頁中，有關「低能見度滑行」之內容如下：

Bear in mind that, in very low RVR values, one would expect to see bright lights at a safe distance but not unlit or poorly lit obstacles, such as aircraft *tails or wing tips. From certain angles, their navigation lights do not show up well. Since aircraft movement rates will be low in these conditions, taxi as slow as necessary for safety. Do not hesitate to request from ATC the positions of other taxiing aircraft or to ask for a “ follow me” car.*

Use utmost care to taxi according to the issued clearance. That is, use the correct taxiway and runway. Switch on taxi/landing lights, even in daylight conditions, to make you more visible to other aircraft and vehicles.

新航教師機師手冊第 5.8 **頁中，有關航路訓練/考驗章節中，要求教師機師須教導駕駛員有關「滑行路徑（**taxi routing**）及狀況與環境警覺（**situational and environmental awareness**）」，但對低能見度狀況滑行無詳細指導。**

新航波音 747-400 **操作手冊無針對低能見度滑行之程序。**

1.17.4.6 外站查核

當問及有關外站簽派服務之查核時，新航飛航管制中心指出，新航對於外站簽派服務之品質查核，主要是依據新航組員之航行記錄系統。飛航管制中心資深經理指出，新加坡民航局亦對新航之雙引擎延程作業航線外站進行定期檢查，尤其對提供之簽派文件（飛航計畫、飛航公告、提示資料袋等）每季進行一次查核，這些文件通常會保留三個月，此係必要文書作業檢查。另外，對於非雙引擎延程作業外站如台北，以不定期的方式檢查。飛航管制中心指出，組員對於長榮簽派服務所提出之報告中，未察覺有任何問題。

新加坡民航局訂有年度工作計畫，對各航站進行定期檢查，每站查核之時間至少三年一次，以台北站而言，新加坡民航局曾於 2000 **年** 2 **月** 29 **日對台北站實施航務檢查，**2000 **年** 3 **月** 31 **日實施適航查核。**

失事時，新航已在中正機場運作廿年以上，當問到第一次到機場運作，對於機場站設施評估以確認是否符合國際標準，例如國際民航公約第十四號附約之標準及建議措施，新加坡交通與資訊科技部之回覆是新航對將開始運作新外站有評估程序。然而，該局及新航皆未能提供本會任何新航開航中正機場前之檢查報告或其開航後之檢查報告。另外，新加坡交通與資訊科技部回覆表示，新加坡民航局對其業者新外站核准程序與其它主要管理機關之程序是一致的。新加坡交通與資訊科技部相信，大部分管理機關對新外站之評估不包含對場站設施之評估，以判斷它是否符合國際民航公約第十四號附約之標準及建議措施。並稱能否符合十四號附約之監督應由該機場相關之政府民航主管機關負責。

1.17.4.7 班機延誤

對新航管理機師、教師機師、失事之飛航組員及飛航管制中心人員訪談時表示，若起飛機場天候不良，機長有權決定是否延後起飛。駕駛員與飛航管制中心管理人員也表示，機長亦能夠直接諮詢飛航管制中心天氣狀況，若需要討論技術方面之問題，飛航管制中心能將機長的問題轉交機隊管理階層討論。若機長對於班機延誤意圖不明確，飛航管制中心則可請機長確認。

當問及有關飛航管制中心班機取消程序時，波音 747-400 總機師表示，若班機發生嚴重延誤時，飛航管制中心會與修護及業務單位進行諮商，機隊主管對於班機取消很少提出意見，但若延誤原因係航空器無法使用所造成，則會告知機隊管理階層。

2000 年 10 月 31 日航空器機長將離場前並未聯絡飛航管制中心或該機隊總機師，此亦非必要之程序。

1.17.5 長榮航行管制部

長榮航行管制部下設班機簽派及航情守望兩個單位。班機簽派職責為確保長榮所有班機均遵守民航局規定及公司政策，並在安全、經濟與有效的方式中運作。航情守望之職責為監控所有班機，避免各班機偏離原訂飛航計畫，且航情守望只提供給長榮之班機，即長榮航行管制部不負責監控新航班機之動態。

長榮航行管制部只負責處理新航班機之簽派及貨物裝載作業。有關長榮航行管制部在台北站之詳細作業內容，載於航行管制部主任簽派員所提供之作業與訓練手冊中。

依據長榮航行管制部人員之訪談記錄，該部通常透過電報與新航聯絡，若有特殊情況，如因天候影響需使用島嶼備降用油，航行管制部門會透過電話聯絡新航飛航管制中心，以取得新航同意。

長榮作業手冊載有颱風程序，但只適用於長榮班機，不適用於新航。訪談中，航行管制部經理與簽派員均表示，不知道新航颱風程序及內容，主任簽派員亦稱，新航並未要求長榮以任何方式將颱風資訊向新航飛航管制中心報告，其在訪談中指出，新航於 1995 年到國內針對新航之作業對長榮簽派員進行訓練時，新航講師亦未提到任何有關颱風程序。另外，新航颱風程序亦未包括在新航地勤服務台北代理商之訓練教材中。

2000 年 10 月 31 日 1821 時，長榮航行管制部以電傳打字通知所有長榮於台北站代理之航空公司（包括新航）有關颱風警告消息，註明日期為 311021（OCT 31, 2000）電傳打字電報發出。

長榮於中正機場之航務課於 2000 年 10 月 31 日 2325 時以電報將失事消息通知新航。（電傳打字日期為 311525, OCT 31, 2000）

主任簽派員及事故發生當晚值班之簽派員均稱，2000 年 10 月 31 日當天，新航並未針對有關颱風消息或颱風警告之事宜與長榮航行管制部聯絡[26]。

1.17.6 新航台北站

依據與新航台北站經理之訪談，其主要職責為確保所有班機能準時且安全起飛，對於到達之班機，則須確保乘客拿到行李。另外，新航台北站亦負責所有組員於台北站之適應、福利、傷病等相關事宜。若有任何緊急或組員飛航時間限制等事宜，特別是需要更換組員時，新航台北站須向新加坡總公司報告。

新航台北站共有 86 名員工，所有乘客服務、貨物裝載、餐點服務，登機門核對都由該站處理。航務作業方面包括班機簽派、飛航計畫、燃油計畫及貨機裝載等，則由長榮代理。修護與維護由中華航空公司代理。

新航台北站須將所有起降於台北站之新航班機動態向飛航管制中心提出報告。「班機動態電傳打字」資訊包括飛機登記號碼、班機到場及離場時間，通訊方法通常使用電話、電傳打字電報或電子郵件。

新航台北站經理在訪談時表示，當接獲颱風消息時，台北站會確認所有可用之旅館房間，另外，亦須規劃航空器停放及固定作業，盡可能增加航空器燃油以增加航空器抗強風能力。

另外，新航台北站經理表示，該站通常不會告知飛航組員有關颱風狀況，長榮對飛航組員實施飛行前提示時會告知颱風動態。若機場因天候影響關閉，台北站則會通知組員不需到機場報到。所有班機之後勤補給為地勤代理公司（長榮）責任，該站只負責乘客與貨物。因此，當該站於 2000 年 10 月 31 日接獲飛航管制中心通知有關颱風狀況時，台北站行動是核對可用旅館。新航台北站未將颱風狀況告知飛航組員。

1.17.7 颱風程序

依據新航飛航管理手冊第 3.41.1 節規定，新航將颱風警告共分為四種狀況，飛航管制中心評估相關航站所提供之資訊後，會統一宣布具體之颱風狀況。若颱風接近時，一般而言，新航各外站及新加坡氣象局會通知飛航管制中心，飛航管制中心則會以電傳打字電報將颱風情況通知所有受影響之外站。

颱風狀況界定如下：

狀況 I　　颱風對某航站被認為在 48 小時內有潛在威脅。

[26] 在對新航飛航管制中心資深經理（SMFCC）訪談中，他聲稱新航飛航管制中心會在 21 點 55 分以電傳打字將颱風狀況 II 通知所有受到影響的航站，包括台北站。

狀況 Ⅱ　**颱風距某航站在** 24 **小時以內。**

狀況 Ⅲ　**颱風距某航站在** 12 **小時以內或已逼近。**

狀況 Ⅳ　**颱風已通過或接近通過風力已減小。狀況** Ⅳ **開始可視為颱風情況影響已趨結束。**

依據 2000 **年** 10 **月** 31 **日** 2100 **時台北航空氣象中心所發布之颱風警報，台北機場警報狀態為** W24**（颱風將於** 24 **小時內到達航站），此已構成新航飛航管制中心宣布進入颱風狀況** Ⅱ**。**

新航飛航管理手冊颱風情況 Ⅱ **之程序中，與本次失事相關部分如下：**

- *The responsible agent should ensure that relevant amendments and changes, whether favorable or adverse, are passed immediately to the FCC as they become available;*

- *The responsible agent should ensure that the Commander of any aircraft on the ground is fully and immediately informed of the situation;*

- *FCC will inform the relevant fleet Chief Pilot（s）, Singapore station or Departure station, Destination station, Diversion station, Senior Manager Ground Services, Manager Schedules and SIA Engineering Co. that Condition II exists; and*

- *The Commander of a flight to an affected station is to be briefed on all available information regarding the typhoon, including ground handling plan at destination station and diversion plan. The briefing should be given before the Commander reports for duty. Where necessary, he shall consult FCC on all matters pertaining to the flight. In offering assistance, FCC must take into account Marketing and Engineering considerations.*

只要航站周圍狀況在新航飛航管理手冊該型機（波音 747-400**）之規定範圍內，颱風警告情況** Ⅱ **並不足以取消班機。**

新加坡飛航管制中心表示，通知外站之標準通訊方式為電傳打字電報，除非有急迫之問題發生，才會用電話聯絡。飛航管制中心於失事當夜 1839 **時，以電傳打字電報向新航台北航站經理宣布進入颱風狀況** Ⅰ**，未將新航颱風狀況** Ⅰ **告知長榮航行管制部。**

2155 時，所有單位（包括台北航站及長榮航行管制部）接獲進入颱風情況 II 之電傳打字電報通知。（電傳打字電報發布颱風消息時，不表示各單位立即看到資料）。

新航飛航管理手冊第 3.41.1.6 節指出，收到註明「緊急」或「必需」之電傳打字電報後，必須進行所有關於颱風程序之傳達作業。在發布颱風狀況 II 後，新航飛航管制中心並未收到相關外站任何回報，飛航管制中心表示，各外站不須作任何回報，除非他們未做好因應颱風之準備。失事當晚，飛航管制中心未接獲台北站立即回報，亦未預期會接獲回報。

失事後，飛航管制中心於 2000 年 11 月 1 日 0159 時宣布颱風狀況 III。

新航波音 747-400 總機師在訪談中表示，任何颱風情況宣布後，機隊本身並不會主動介入組員之決策過程，機長有權決定，但機長亦可以選擇諮詢飛航管制中心及/或總機師。若機長不確定飛航是否安全，其可以選擇延遲該班機，但若是班機取消係商業原因，須由機隊總機師、行銷及工程部門決定。

另外，關於天候不佳時之決策方式，總機師表示，當天候條件在新航規定範圍內時，其交由機長決定。若作業情況中，天氣有不確定或模糊狀況，機長可以考慮延遲班機，觀察天氣後續變化。取消班機乃是最後手段，若天氣狀況超過新航規定，飛航管制中心、行銷部門及機隊總機師將決定是否取消班機。

1.17.8 航行記錄

依據新航飛航管理手冊第 3.28.1 節規定，每一班機均須依照航行記錄表格填寫航行記錄，機長須負責航行記錄內容正確。

若班機發生延誤時，須將導致延誤原因記錄於航行記錄，且須註明導致延誤細節，例如：天候、飛航管制、技術、地勤作業、海關、移民及檢疫。

依據對新航駕駛員訪談，新航規定若延誤超過 3 分鐘，機長必須提出報告，然而，若有正當原因，機長不會因班機延誤而遭到質疑。

1.17.9 中華民國交通部民用航空局組織

如圖 1.17-1 所示。民航局設局長一人，副局長二人，襄理局務。

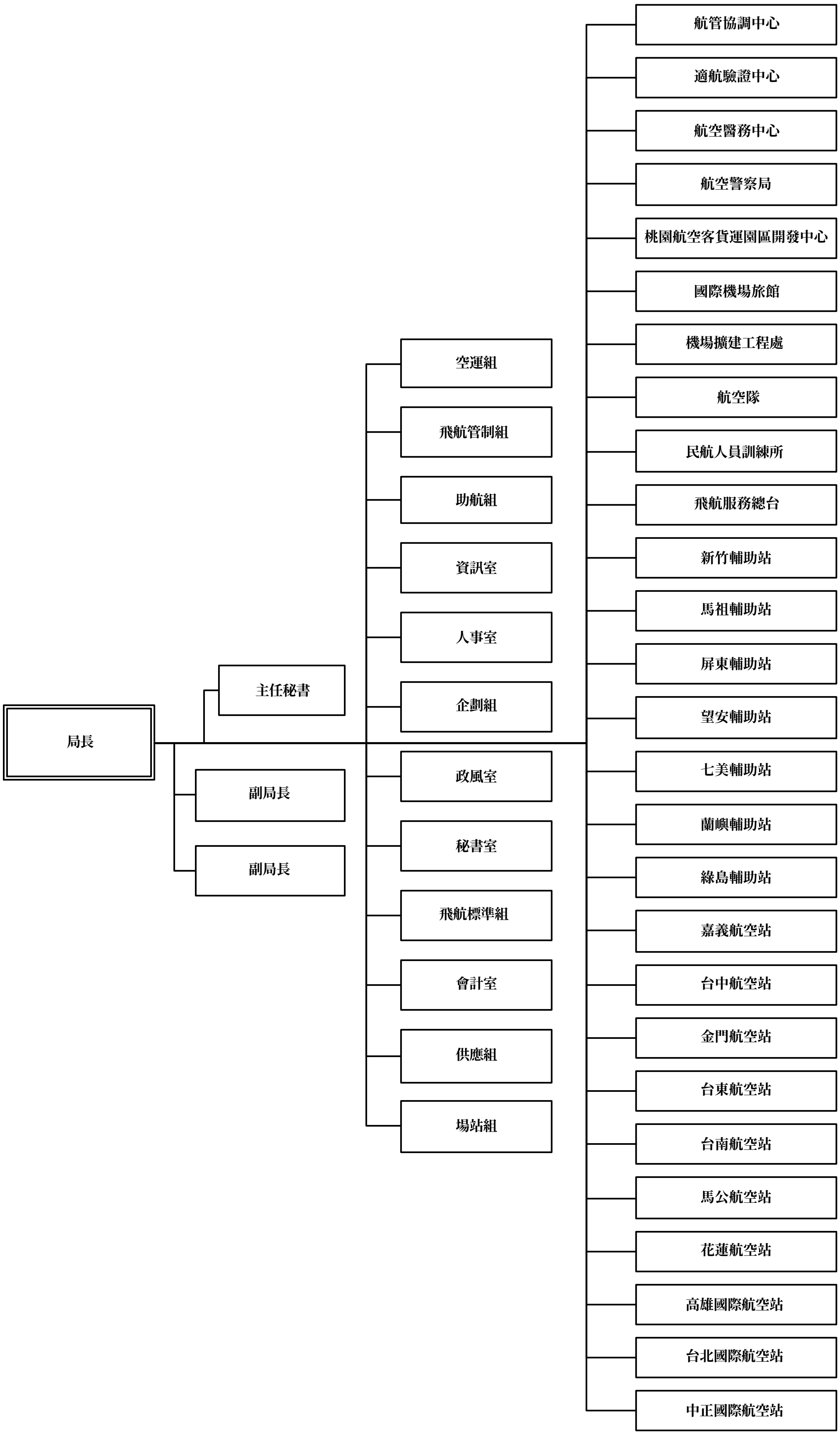

圖 1.17-1　**民航局之組織架構圖**

民航局之組織架構分為局本部單位及局附屬單位兩類。局本部單位負責民航相關規定之制定與監理（例如：政策制定與外部溝通等）；局附屬單位則負責業務執行與服務之提供（例如：機場設施之維護）。各局本部單位依其職權，監理各局外機構之相關業務，例如：飛航標準組負責監理航站之航務組及消防搶救業務，空運組負責監理機場營運及航警單位的協調工作，助航組負責監理飛航服務總台及各機場之助導航設施，場站組負責監理機場維護組及機場維護之相關工作等。局本部單位皆設有專職人員，負責其業務之規劃與協調，局附屬單位也設有相關業務之專職人員，負責業務之執行。

1.17.10 民航局企劃組

依據民航局辦事細則第五條，第四、第七及第八款，民航局企劃組負責有關法律相關事務之作業。有關企劃組之職掌，相關條文規定如下：

第五條

四、有關國際法制規章、合約之研究、會商、會核及處理事項。

七、民航法規之審查、發布及彙編事項。

八、本局有關法律事務之會辦及處理事項。

依民用航空法所衍生之相關規定，其制定、修改或更新乃是由民航局各局本部單位，依其職掌負責訂定之（例如：飛航標準組負責訂定有關飛航運作之相關規定）。各局本部單位擬訂之技術性草案，經公聽之程序後，交由企劃組完成最後之法定程序。企劃組之工作乃是協助各局本部單位，完成擬定相關規定之合法化程序。民航局各局本部單位依其職權範圍，訂定相關規定，而所有新草擬之規定，則須交由交通部正式批准。

民航局因未能加入國際主要的民航組織（如國際民航組織），故當國際上民航法律及規定更新時，民航局可能無法取得最新的資訊。民航局亦因取得國際上相關的民航規定有困難而產生一些問題。例如民航局某單位在訂定規定時採用了美國聯邦航空總署之規範，可能會與另一單位引用歐盟 JAA 之規定產生不一致的現象。在某些狀況下，資源的缺乏則會導致無法及時訂定相關規定及標準。

1.17.11 民航局場站組

場站組負責制定有關機場場面設施（例如：跑道及滑行道等）之設計技術標準。其中也包括跑道及滑行道標線之規格設計。一般而言，民航局使用國際民航組織標準及建議措施之規範，但某些部分則採用美國聯邦航空總署之規範。

場站組於 1987 年編輯一本機場工程施工技術規範手冊。事故發生前，場站組已開始檢視有關機場工程之技術標準規範，以期能夠發展一本符合國際標準之中華民國機場工程施工技術規範手冊，此手冊於事故發生時尚未完成。

民航局局本部負責承辦金額介於新台幣五千萬至一億元間（相當於美金一百四十萬至兩百八十萬）之民航工程業務。場站組可委託外部顧問進行機場場面設施，如跑道、滑行道及航站大廈等之設計工作。(**例如，場站組曾雇用亞聯** “AirPlan” **顧問公司進行機場主計畫之設計工作**)

1.17.12 飛航服務總台

飛航服務總台負責提供飛航情報、飛航管制、航空通信及航空氣象等服務。它也負責管理塔台、飛航情報中心（例如：飛航情報服務）與國內各機場（包括中正機場）之氣象服務。

飛航服務總台亦負責跑/**滑道之燈光系統與機場場面之各種指示牌。總台在中正機場設有維護單位。此單位負責跑**/**滑道燈光系統與指示牌之檢查與更換。它也負責燈光控制系統及恆流變壓器電源供應系統（**Constant Current Regulator, CCR**）之維護工作。**

1.17.13 中正機場管理部門

中正機場管理部門負責維持機場設施每日之正常運作。其中航務組及維護組乃是負責機場場面運作及維護作業的兩個重要部門。航務組負責確保場面運作之順暢與安全，其工作項目包含有場面駕駛人員證照、機場場面之安全檢查及排除障礙物、外物或動物所造成之危險因素等。航務組採 24 **小時輪班制。每日定時巡場三次。任何場面、道面維修需求皆交由維護組執行。**

依據「中正國際航空站航務組作業手冊」第二章「地面安全」，第五條「場面之安全檢查與清潔服務」中，有關航務組之任務簡述於下：

a. ***場面情況由值班航務員每日定時巡察，並列入記錄備查；及***

b. ***為消除外物損傷與危害航空器安全，按航空站訂定之「中正機場場面污損處理須知」執行作業，並劃分權責，切實執行。***

維護組負責場面鋪面之維護工作，包括跑/**滑道道面，場面標線之重漆作業。依據航務組之巡場報告，維護組排定優先順序，並通知承包商進行修護**/**重漆作業。維護組承擔少於新台幣五千萬元之作業。作業範圍乃是依照民航局場站組所訂定的規定辦理，但維護組不直接向場站組報告。維護組負責監督承包商，使其修護作業能夠符合安全規定（包括標示障礙物及障礙物上架設燈光）。維護組一組人員，專責鋪面檢查作業。正在尋求一種比澤西護欄更安全之替代品，須是易碎、較輕且還能夠經得起強風**/**颱風的吹襲。**

中正機場管理部門須每月向民航局場站組提交機場場面損傷報告。場站組除了必須監控修護作業之進度外，每 4 **至** 6 **個月得實施機場設施檢查一次。**

1.18 其它資料

1.18.1 訪談摘要

1.18.1.1 飛航組員訪談

1.18.1.1.1 正駕駛員（CM-1）

與 SQ006 飛航組員訪談中，CM-1 表示，是由新加坡飛往台北任務前一天之簽派提示中，知道「象神」颱風逼近中正機場，同時提到新航也正在追蹤颱風路徑，以及颱風將於翌日表定班機之後抵達台北。閱讀飛航公告和內部飛航通告，知道 N4 及 N5 滑行道間之 05 右跑道部分關閉，以及北機坪 A1 及 A2 之間及後面區域封閉。

CM-1 稱其注意力集中於強烈側風以及低能見度上，並想要知道這些是否在公司限制之內。在和其他兩名駕駛員完成側風計算後，確定是在公司起飛限制之內，也考量電腦飛航計畫（CFP），並且決定飛往洛杉磯航程所需燃油，並將所需燃油量傳達給協助簽派的長榮簽派員。

訪談中，CM-1 表示，他起初想將台北到洛杉磯航程交由 CM-2 負責，但因為台北天候，決定自己起飛，而讓 CM-2 於洛杉磯降落。他將此決定告知 CM-2 後，三名飛航組員隨即登機。

CM-1 表示，CM-3 自願做飛機外部檢查，收聽最新 ATIS，完成側風量計算。CM-1 陳述，CM-2 完成駕駛員飛航前準備工作，因此，CM-1 便專心於天候狀況考量。CM-1 說，曾交叉檢查，以確定 CM-2 飛行前準備無誤。CM-1 與 CM-2 將資料輸入 FMS 中，並且也檢查無線電頻率設定。

CM-1 表示，持續由 ATIS 監聽天氣資料，同時也聽到航管單位將天氣資料報給另外兩架在同時間離場班機（國泰與華航）。CM-1 表示能見度好轉而且「對我們有利」。華航班機亦使用 05 左跑道，而國泰班機則預定使用 06 跑道。

CM-1 表示，曾在中正機場使用不同跑道至少有十次以上之起降，及大約有十次於夜間自該機場起飛經驗。CM-1 表示新航班機通常使用 06 跑道，因為該跑道較靠近該公司停機位。然而 CM-1 選擇 05 左跑道是因為第二類儀降進場允許較低能見度標準，尤其當晚跑道目視距離很低。除此之外，05 左跑道較長，而且能在濕跑道狀況下提供餘裕較大之安全範圍。

CM-1 表示，曾經歷過比中正機場事故當晚更糟天氣，舉例說在安克拉治起飛時所遇到強烈側風、跑道下大雪且結冰等狀況。最近一次到台北是兩、三週之前，不過上次

使用 05 左跑道時間則已是二、三年前。

CM-1 陳述瞭解飛航公告中有關北面停機坪和 05 右跑道正在施工消息。

CM-1 執行程序提示包括：注意發動機排氣溫度（EGT）、滑行及離場路徑等之限制。預計滑行路徑是由 SS 滑行道，向東到 East Cross，經由 East Cross 至 05 右跑道（因為 A1 和 A2 停機坪間部份關閉），自 05 右跑道滑行至 N7 滑行道，再滑行到 NP 滑行道，並轉入 N1 滑行道，然後至 05 左跑道。

管制員頒發給組員之滑行許可係同路徑，CM-1 依照許可路線對組員重新提示。航管滑行許可要求組員在 SS 滑行道上向西滑行至 West Cross 滑行道，然後接 NP 滑行道，繼續沿著 NP 滑行道至 05 左跑道。

CM-1 報告在事故發生當晚並未感到時間壓力，曾告訴其他駕駛員不要急，要「慢慢來」，並且要其正確地做好檢查。CM-1 稱，組員有充裕時間完成檢查表，並且為出發做好準備。較關心的是天氣，因為知道颱風即將登陸國內。

CM-1 稱，該機從停機坪後推至離場，一切程序都正常。滑行後不久，CM-1 要求將襟翼設定為 20，並檢查方向舵，CM-2 檢查副翼及升降舵。然後呼叫起飛前檢查，由 CM-2 完成檢查表項目。

滑行時，CM-1 將雨刷設定在「LO」（低速）位置，雨刷清潔大部分擋風玻璃，所以幾乎可以看清楚整面擋風玻璃。

CM-1 要求 CM-3 監聽 ATIS 並檢查風速分量。飛機朝向 NP 滑行道底端滑行時，CM-3 接獲最新 ATIS，並且使用相關圖表計算左側風速為 28.5 節，當時組員在 NP 滑行道底端，正轉向 N1 滑行道。此時側風量仍在公司規定之 30 節側風限制內。CM-1 報告風速及能見度都不算太差，同時能夠看見要前往之處。

訪談時，CM-1 報告當時告訴自己要比平常更加小心，且要特別留意各種狀況。CM-1 稱，於滑行期間，組員們討論到如果起飛後必須返航之備降場，CM-3 告知高雄及香港機場都已關閉，可以折返台北，因為 05 左跑道天氣仍在第二類儀降進場標準之內。CM-1 表示，如果風速超過公司作業限制時，會延遲起飛，也提到擔心台北天氣會變得更糟。

在完成起飛檢查項目前，該機已穿越 NP 滑行道待命線（holding line），並通過 N2 滑行道，此時 CM-1 請 CM-2 通知塔台說他們已準備好。在與塔台連絡後，塔台指示其進入跑道等待。就在這滑行期間，CM-1 以為塔台在發出指示之前已經看見飛機。CM-1 將飛機右轉到 N1 滑行道，並專注於右邊跑道上景象，未注意到前面以及沿著 N1 滑行道延伸線上任何綠燈。說是跟著中心線燈曲線進入 05 右跑道，而在轉彎時，「鋼琴鍵」之影像曾掠過眼前，說他被跑道明亮中心線燈所導引，如同轉彎時一樣，不記得曾看見跑道上有任何識別跑道的指示牌或標線等。在跑道上 CM-1 拉上手煞車、啟動所有落地燈，並將雨刷定在 HI（高速）位置上，CM-1 覺得能見度並未因雨而受影響，甚

至連雨刷刷不到區域也能看見。

CM-1 回憶當他從 N1 滑行道右轉至 05 右跑道時，是非常小心保持滑行速度在 5 浬，以免航機在塗有「鋼琴鍵」之標線上打滑。

CM-1 表示，飛機對正跑道時，在他前面之景象是跑道，說可以看見沿著跑道中心線燈，而且百分之八十地確定看見跑道邊燈。

訪談時，CM-1 確信當時是在 05 左跑道上，而且在他視界內，並未看見任物體阻礙在跑道。CM-1 稱，當飛機接近跑道頭時，航管頒發起飛許可，使其確信塔台看見他們。當時該機航向大約是 50 度，這更使其相信是對正著起飛方向。CM-1 表示，對他而言，在落地燈照射之大雨中，景象看起來就像是一條正常跑道。

要求 CM-1 形容關閉中之 05 右跑道在他心中景象時，他表示關閉之 05 右跑道是不應該像跑道一樣亮著燈，且在「鋼琴鍵」後應有路障或警告標誌之設置，以及於跑道入口架設跑道指示牌。

CM-1 表示，當飛機轉入並對正跑道時，CM-2 完成起飛前檢查表項目後，注意到 PVD 未正常運作。CM-3 表示 PVD 只有在飛機方向和跑道方向夾角在 45 度以內時才會作用，但是當飛機對正跑道後，PVD 還是未作用。CM-1 表示他相信在低能見度情狀下起飛時，PVD 是很有用之輔助工具，但決定在起飛時不使用 PVD 引導，因為當時能見度足以使用目視起飛。

CM-1 表示曾受過低能見度起飛訓練，但未受過低能見度時滑行訓練。

CM-1 稱與同事及上司工作時並無任何困難，於訪談中表示曾與 CM-2 及 CM-3 飛過，非常滿意與這兩人之工作關係，同時他認為在駕駛艙中同事間應保持開放溝通，也試著將駕駛艙提昇為輕鬆又有紀律之環境。

在後續訪談中，CM-1 對下列幾個議題回應如下：

<u>簽派作業</u>

新航於中正機場之簽派作業是由長榮代理，除非有作業問題須簽派員澄清，否則係由組員自行做任務提示。

CM-1 不記得曾看見內部飛航通告及飛航公告上有重點標記地方，但他表示某些氣象資料可能有重點標記。

CM-1 記得飛航公告中有關於 05 跑道資訊，特別是 N4 至 N5 滑行道間之 05 右跑道關閉及北機坪部分地區關閉等，但不記得在飛航公告或內部飛航通告中看到任何關於 05 右跑道燈光之敘述。

濕跑道 VS.污染跑道

CM-1 **陳述，將跑道道面之情況提供給駕駛員是機場主管單位責任，而他認為跑道道面狀況資料，通常應由** ATIS **所提供。例如跑道積水、積雪、積泥或其他污染情況等。失事當晚飛航組員並未從** ATIS **或塔台管制員獲得這些訊息。**

颱風程序

CM-1 **瞭解新航颱風程序，但當** CM-1 **仍在旅館時，簽派員未將颱風即將登陸情形告知** CM-1**，然而** CM-1 **已瞭解颱風即將來襲。**

決定延後或繼續飛行

CM-1 **決定延後起飛與否有幾個考量因素如：一般天候狀況、風、能見度及他航起飛等因素。而氣象資料必須符合公司規定才能繼續飛行。**

PVD

CM-1 **稱其能目視跑道，因此對** PVD **之異常顯示，並未作過多思考，亦未繼續探討原因。**

一般導航：從後推至跑道

CM-1 **通常使用下列資訊做為滑行時導引依據**

1. **飛行前提示及導航等圖表**
2. **綠色中心線燈，尤其是在低能見度及惡劣天候下**
3. **指示牌**
4. **與副駕駛員交叉檢查**
5. **塔台指示－**ATC **將監控飛機滑行**
6. **地面雷達**
7. “Follow me”**引導車（它主要是用於低能見度情況下降落後之引導，特別是沒有地面雷達引導時）**

注意力焦點

事故當晚，CM-1 **主要注意力在滑行道綠色中心線燈上。陳述正常使用綠燈引導至起飛跑道。談到由於大雨及低能見度之影響，無法看清楚滑行道及跑道指示牌。**

CM-1 **於事故當晚注意力集中在低能見度、大雨、強風之情況。想確認這情況是否符合公司起飛規定。**

CM-1 舉出之要點

CM-1 認為 NP 滑行道引導至 05 右跑道綠色中心線燈，以及到 05 左跑道之不連續滑行道線與燈是個「陷阱」。

CM-1 再度表示，不確定 05 右跑道邊燈在起飛時是否亮著，回想起中心線燈非常亮，並提到在低能見度情況下，是較仰賴跑道中心線燈導引而非跑道邊燈。

1.18.1.1.2 副駕駛員（CM-2）

在前一天飛往台北班機上，CM-2 注意到天氣很差，該機在 1,000 呎穿出雲層、風很強，尤其是頂風，CM-2 表示 CM-1 降落很好。稱 CM-1 不認為台北到洛杉磯（TPE-LAX）班機會被取消，也記得曾感謝 CM-1 讓他飛下一航程（TPE-LAX）。CM-2 表示，事故當日飛航前即已在旅館裡看過飛航公告和氣象等資料。

根據 CM-2 所述，當天晚上，飛航組員由旅館到機場途中曾討論飛航中之休息安排。CM-2 提到，因登陸後颱風風力增強，故 CM-1 決定親自執行起飛任務，CM-2 則被指定執行至洛杉磯進場與降落。在簽派任務提示時，CM-1 與 CM-3 計算起飛之側風分力，並在計算結果出來後，決定繼續該次飛航。

當 CM-2 走向駕駛艙時注意到，因天候關係餐勤人員在裝載上有些困難，CM-2 稱，CM-1 告訴他們慢慢來。CM-2 表示覺得 CM-1 口氣是要組員不要急。

CM-2 表示，於駕駛艙任務提示時，CM-1 向組員簡報其預計採取之滑行路徑，包括 05 右跑道之滑行。而 CM-2 認為 05 右跑道已經關閉，但 CM-3 澄清說 05 右跑道只有部分關閉。CM-1 和及 CM-3 擔心的是風速，不知道風速是否仍在限制內，同時也擔心跑道的濕滑，也討論有關備降場，及返航台北時之能見度等問題。

CM-2 表示，CM-3 完成了飛機外部檢查回到駕駛艙時鞋子是濕的，故他請求將鞋子脫下只穿襪子。CM-2 與 CM-3 輸入電腦資料後，完成空速卡設定（bug card），CM-3 校正濕跑道起飛速度，同時，CM-1 與 CM-3 則專心在側風計算上。CM-2 決定設定駕駛艙儀表，打開 PVD，CM-2 看見 CM-1 也打開其 PVD 感覺很好。CM-2 的確也警覺到陣風正強烈地吹著，且風向也迅速地在改變。CM-2 注意到在其速度趨勢指示（speed trend vector）與 CM-1 指示不一樣，面談中 CM-2 表示當時正思考著此系統以及造成此一現象原因。

航管單位頒發滑行路徑指示時，CM-1 向組員簡報新的路線。面談中 CM-2 表示，感覺這個路線比預計路線好，因為這是較容易滑行路徑。CM-2 說他已經有好一段時間未到台北，因此 CM-2 關心的是應如何支援 CM-1，他說，若被要求執行起飛任務，他會要求由 CM-1 來執行，因為覺得當時應由較有經驗之駕駛員起飛較好。

CM-2 表示對 CM-1 及 CM-3 有信心，且側風量並未超過規定之起飛限度。飛機後

推之後沿著 SS 滑行道滑行時，將襟翼設定在 20，並且檢查副翼及升降舵，兩次檢查飛操系統以確定操縱活動自如，同時也做飛操系統檢查，並且完成儀表檢查以確保其正常運作，同時也使用滑行圖確定滑行路徑正確，並負責整個滑行過程無線電通訊。

滑行至 West Cross 滑行道時，CM-2 完成第一部分起飛前檢查表項目及進行無線電通訊。訪談時，CM-2 稱並未注意飛機前面遠處燈光，沿著 NP 滑行道滑行時，記得等待塔台管制員發出對正跑道及起飛許可，當接近 N2 滑行道轉彎處時，CM-2 說”Next right”，但 CM-1 提醒應說”Second right”。此時，航管單位頒發對正跑道及起飛許可。

CM-2 開始執行起飛前檢查表其餘項目，CM-2 報告，當 CM-1 與其執行檢查表逐項檢查時，CM-1 對檢查表中項目反應很快，在逐項進行檢查時，CM-2 注意到 CM-1 已經打開了閃燈及落地燈。CM-2 說很謹慎並確定每個項目都已完成，但眼光也不時注意著 CM-1 滑行。CM-2 提到，接下來檢查地面速度，並將注意力集中在駕駛艙內。再一次注意到 CM-1 速度趨勢指示和其不一樣，這事引起其注意。當完成檢查表項目後，看到飛機已對正跑道。

CM-2 表示，在對正跑道時，注意到 PVD 並未啟動，CM-3 向組員解釋 PVD 須於飛機與跑道夾角小於 45 度才會作動。CM-2 說到，CM-1 決定起飛不需要 PVD，因為覺得跑道上能見度很好，CM-2 也認同 CM-1 決定，因為在 CM-2 前方之跑道看到十分明亮之中心線燈。但不記得看見任何跑道邊燈，同時也說，看見右邊導引至跑道之綠燈（當飛機轉入跑道時），未注意到其他燈光，但看見跑道頭「鋼琴鍵」標線，並且記得它們看起來有些”雜亂”。

與組員的面談中，CM-2 稱在主要飛航顯示器[27]（PFD）上未注意到有任何左右定位台位移情況，同時提到以前曾在模擬機中使用過 PVD，但在實際飛行時未用過 PVD 起飛。

CM-2 打開氣象雷達，注意到整個區域因雨而變成綠色，也檢查雨刷是設定在「HI」（高速）位置，且注意到 CM-1 也將之打開。飛機燈光正常，但能見度並不如晴朗天氣時那麼好。

CM-2 稱知道只有 06 和 05 左跑道是使用中之跑道，且 05 右跑道是關閉的。當問到關閉之 05 右跑道於腦海中景象時，答說關閉跑道應該是”黑暗”而且是無燈光。還表示機場任何進行中工程都應有警示燈。

CM-2 描述使他認為在 05 左跑道上原因；跑道景象是「正確的」。記得看見跑道中間有燈光，且十分明亮。說在飛機前方並未看見障礙物，估計能夠看到跑道前面約 200 到 300 公尺距離，且有滑行燈引導進入跑道，但除引導到跑道之曲形滑行線道燈光之外，CM-2 稱未注意到任何其他燈光，且未看到任何識別跑道之指示牌或跑道方位標

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[27] 波音 747-400 操作手冊或新航公司皆無此一檢查程序。

線。CM-2 稱依據當時視覺線索顯示，飛機正在使用中之跑道上。目視起飛時，操作上並無要求使用 PVD 做跑道中心線之引導。在面談中 CM-2 指出，他準備告訴 CM-1，如果跑道景像不對就不要起飛，也記得，飛機從後推到起飛過程中是風強雨大。CM-2 記得，除雨刷可刷到部分外，其他部分則因大雨而模糊不清。

CM-2 稱與同事及上司工作時沒有任何困難。於訪談中表示曾與 CM-1 同飛，滿意與 CM-1 工作關係，沒有文化上問題。

於後續訪談中，CM-2 對下列幾個議題回應如下。

<u>簽派作業</u>

在新加坡，飛行前任務提示是由組員自行做的。而在台北，地勤代理公司則會提供航組員一份任務簡報資料，簽派員會在場回答組員問題。

CM-2 不記得看到地勤代理公司在文件上做重點標示，且不記得看到任何飛航公告或內部飛航通告中有關 05 跑道或滑行道及跑道燈光等資料。

<u>備降場討論</u>

CM-2 已無法想起，飛機滑行時組員討論有關備降場之詳細情形，但記得計畫中包括折返台北。不過說討論備降場問題，應在飛行前任務提示時，而非在滑行時。

<u>PVD</u>

CM-2 陳述，注意到 PVD 未如預期運作，但 CM-3 立刻對此作了解釋，因此 CM-2 便不把這個問題放在心上，以致當飛機對正跑道後 PVD 未運作之現象，就不再考慮。

<u>一般導航：從後推至跑道</u>

通常他使用下列資訊作為導航依據：

1. 圖表
2. 滑行道上的連接點，用以確定方向及路徑
3. 指示牌
4. 燈光，滑行道中心線燈，讓其有所遵循，並導引飛機至預期跑道
5. 只有某些機場才有明顯建築物
6. 磁羅盤用來校正航向（大略位置）。

<u>CM-2 舉出要點</u>

事故當晚，因惡劣天氣及低能見度使其備加謹慎，CM-2 想知道中正機場滑行道配

置情況。失事前，在滑行時記得看到 West Cross 滑行道指示牌，但對 NP 滑行道指示牌卻無印象。之後談到因低能見度與天氣惡劣影響，致滑行時係依賴綠色中心線燈導引。於 NP 滑行道上接近 N2 滑行道時，CM-2 呼出 " NEXT RIGHT"但隨即為 CM-1 糾正為" first right"及" second right"，之後 CM-2 完成起飛前檢查表項目，此時他報告雨越下越大（視野越模糊），且從四方傾流而下。

CM-2 陳述，隨著綠色滑行道中心線燈之導引，到起飛跑道、落地或是回到停機坪都是正常經驗。

1.18.1.1.3 加強飛航組員（CM-3）

從 CM-3 訪談中發現以下資訊；CM-3 參與在登機門前有關飛航資料組員任務提示。CM-3 聲稱，看過飛航公告、內部飛航通告及燃油飛航計畫。花了大約 15 分鐘時間做飛機外部檢查，因為天氣關係比平常多花了些時間。CM-3 說, CM-1 請其監聽 ATIS 以及持續注意天氣狀況，CM-1 也請其在滑行時檢查風速並且計算側風量。CM-3 也監看 CM-2 以確保所有檢查表及程序都確實完成。CM-3 稱，拿出中正機場備份地圖，並且監看滑行路徑。但當從 ATIS[28]接獲最新風速資料時，就停止監控滑行路徑工作，放下航圖，開始計算起飛側風量。

當進行飛機外部檢查時，CM-3 體驗到天候情況，說他選擇不將其對天候之瞭解告訴 CM-1, 是因為不想增加 CM-1 額外壓力，CM-3 說起飛側風在公司規定限度內，CM-3 說知道起飛耽誤得愈久，颱風情況就會愈糟。說到飛機在如此天氣情況下起飛可以放心，CM-3 認為 CM-1 決定起飛是正確決定。

CM-3 覺得加強飛航組員主要職責就是為第三對眼睛，以監看 CM-1 之 CM-2 之操作並支援他們。也表示 CM-1 及 CM-2 飛行管理方式很好。注意到 CM-1 最初簡報之滑行路徑與航管單位指示不同。此外，他知道 05 右跑道只可用來滑行。CM-3 說，距上一次在中正機場 05 左跑道起降，約有二至三年之久，以前曾經與CM-1 飛過，而與CM-2 則是第一次。

CM-3 表示很瞭解中正機場滑行道，倘若風速或能見度超過規定限度，準備將其考量告訴 CM-1，然而當時能見度良好。CM-3 稱只能看見飛機前面，因為坐在兩個駕駛員間後面之觀察員座位（也就是第一觀察員座位）上。

CM-3 陳述，滑行照計劃進行，當飛機在 West Cross 滑行道接近 NP 滑行道時，注意到明亮綠燈就在前面，其餘一片漆黑。當飛機在沿著 NP 滑行道滑行時，CM-3 記得曾聽到塔台與使用 06 跑道之飛香港國泰班機通話，以及與另一航機間無線電通話，

[28] 根據 座艙語音記錄器，飛航組員最後一個風向風速資料是由航管在頒佈起飛許可時提供的。1515:22 - TWR Singapore Six, runway zero five left, wind zero two zero at two eight, gust to five zero, clear for takeoff.

提及陣風風速已達 50 節。CM-3 表示為此憂心，直到檢查側風分量後，發現仍在公司規定操作限制內方才釋懷。

當航管單位對飛航組員發出進入 05 左跑道等待命指示時，CM-3 並無航管能夠看見其飛機想法。

當飛機接近 N1 及 N2 滑行道時，CM-3 正集中注意力計算最新起飛側風量。CM-3 指出，滑行時注意力是集中於駕駛艙內。根據 CM-3 所說，當時雨很大，但雨刷能夠清潔擋風玻璃，因此側窗能見度較差，而陣風很強，CM-3 說當時 CM-1 掌控所有情況。

當飛機轉入 N1 滑行道時，CM-3 從 ATIS 接獲另一風速資訊，於是再次計算側風量，算完後發現非常接近最大側風速限。在檢視完側風量後，飛機已轉進跑道，他表示，見了一個非常明亮環境，注意到那是中心線燈，但卻未注意到跑道邊燈。說那時能見度好到足以讓航機起飛，而這時 CM-2 注意力被變動之速度指示器所吸引，CM-3 說，他看著主要飛航顯示儀 PFD，其儀降系統（ILS）頻率設定正確。

當 CM-2 提到 PVD 未啟動時，CM-3 解釋是因為飛機方向不在跑道 45 度之內。CM-3 表示並不擔心 PVD 顯示，因能見度足夠以目視起飛，而且只有在第三類儀器天氣狀況才需使用 PVD，CM-3 覺得 CM-1 對不用 PVD 起飛感到放心。CM-3 也認為飛機就在有著明亮燈光跑道上。根據 CM-3 所說，眼前呈現的就是一條有著明亮中心線燈典型跑道，且從他所在之處，無法看見 piano keys 跑道頭指示牌或標線等。

CM-3 知道只有兩條跑道是開放使用，那就是 06 和 05 左跑道，也知道 05 右跑道關閉，但可用作滑行道。當被問及對關閉之 05 右跑道心中之景象作描述時，CM-3 說該跑道燈光不應該是亮的，進一步說，在施工區域應有障礙燈及柵欄，並且應設禁止進入之號誌燈。

CM-3 報告與同事及上司工作時沒有任何困難，CM-3 特別表示組員間無文化上問題存在。

於後續訪談中，CM-3 對下列幾個議題之回應。

<u>簽派作業</u>

CM-3 不記得地勤代理公司提供之內部飛航通告有任何重點標記，然記得在飛航公告看到關於 05 右跑道資訊重點標記，特別是沿 N4 至 N5 滑行道間之 05 右跑道關閉。還記得在飛航公告或內部飛航通告有 05 右跑道綠色中心線資訊。並未將此資訊與另兩位駕駛員組員溝通，CM-3 也不知其它兩位是否也瞭解這些訊息。

<u>滑行道燈之使用</u>

CM-3 陳述，在夜中和低能見度情況下，航管單位會打開滑行道綠色中心線燈，沿路直至起飛跑道。

PVD

當飛機轉入對正跑道時，CM-2 表示 PVD 沒有運作。CM-3 曾告訴他們此係因為飛機還尚未在跑道方向 45 度夾角內，CM-1 表示因為能目視跑道，致組員未繼續考慮此問題，CM-3 說當時他正思考其它問題，故未考慮到 PVD 關閉問題。

一般導航：從後推到跑道

通常使用下列資料作為導航依據

1. 圖表
2. 指示牌
3. 環境之一般方位，包括建築物及
4. 滑行道中心線燈

加強飛航組員之角色

CM-3 陳述，加強飛航組員並無正式操作程序，其角色是由機長決定，一般而言，加強飛航組員在飛機起降時應該在駕駛艙內。

1.18.1.2 訪談曾與 SQ006 飛航組員同飛或考核之駕駛員

訪談最近與 SQ006 駕駛員同飛或執行考核之新航駕駛員，並綜合每位駕駛員觀點摘要如下：

1. CM-1-一位技術熟練、有紀律且資歷完整之駕駛員。是新航優良駕駛員之一，而且他在值勤時或下班後都是友善及容易親近。
2. CM-2-一位高於平均水準、有紀律之駕駛員。也是位成熟且在飛行時能毫不猶豫地提出飛安議題。
3. CM-3-一位成熟、有紀律以及飛行技術良好駕駛員，為人坦率、有禮貌。同時他也有晉升為機長之潛力。

1.18.1.3 值班航管人員訪談

依據中正塔台事故當時之值班表，SQ006 失事當時值班管制席位如下：

1. 管制員甲-機場管制席（LC）
2. 管制員乙-地面管制席（GC）

3. **管制員丙-飛航資料席**（FD）

4. **管制員丁-許可頒發席**（CD）

5. **航管分組於八十九年十一月四日同時訪談管制員甲及乙，十一月十日二度訪談甲管制員，十一月二十九日訪談管制員乙及丙，十一月三十日訪談管制員丁。訪談時塔台長及業務室主任均在場。**

1.18.1.3.1 值班管制員甲訪談摘要

管制員甲稱他接機場管制席時天候惡劣，SQ006 **滑出時另有兩架航機從登機門後推。**

該班機約在 West Cross **滑行道轉進** NP **滑行道時以** 129.3MHz **與中正塔台聯絡。此時管制員甲僅能目視該機之燈光，當該機滑向** N1 **滑行道後燈光逐漸消失。**

由於當時無其他進場及滑行航機，管制員甲在 SQ006 **回報準備好時，即許可其由** 05 **左跑道起飛，該機組員亦複誦正確。管制員甲稱因為能見度低而無法目視該機對正跑道滾行起飛。在頒發起飛許可後，管制員甲再度看到該機時已發生火花及爆炸。管制員甲稱立即按下警鈴，管制員丙則以第一頻道對講機與消防隊聯絡。管制員甲也稱管制員乙曾通知近場雷達管制員。**

管制員甲稱是按照置於塔台席位燈光操控制板旁之燈光亮度選擇表選用 05 **左跑道、紅黃區之燈光亮度（參考飛航管制程序** ATP-88**，第** 3-4-10 **節，表** 3-4-4**）。**

航管分組於八十九年十一月十日再次訪談管制員甲。訪談中，該員稱機場燈光係由維護單位每日檢查，管制員依維護人員要求開啟或關閉每區之燈光。

值班管制員稱八十九年十月三十一日當天他於 1840 **抵塔台開始上班。每小時執勤四十分鐘後接著休息二十分鐘，如此週而復始。在** 2300 **時，他已經依序擔任過飛航資料席與許可頒發席，接著開始接機場管制席。負責管制** SQ006**。當時，他檢查滑行道燈均在**"**開啟**"**位置，**05 **左跑道中心線及邊燈，亮度選擇為第四級時兩者均會亮起，管制員記得紅區（標示為** NTWR**）及黃區（標示為** NTWY**）之滑行道燈均開啟（這些燈由地面管制席負責）。也記得機場紅、黃區段指示燈亮著，但到底選擇那一級亮度已無印象。**

在燈光控制板邊有「管制條」，提醒管制員 05 **右**/23 **左跑道暫停使用。管制條為白底黑字「**Runway 05R/23L**」且有紅色中文註記「暫停使用」。**

失事當晚有四人在塔台值班分別為：機場管制席（LC**）、地面管制席（**GC**）、飛航資料席（**FD**）及許可頒發席（**CD**）。管制員甲記得接管** SQ006 **時跑道視程（**RVR**）為** 450 **公尺。在該機由** West Cross **滑行道轉入** NP **滑行道時，管制員甲稱就看不見飛**

機。指示 SQ006 在 05 左跑道外等待並提供其最新風速資料，並問該機意圖，數秒後 SQ006 稱準備起飛，因為附近沒有其他航空器，管制員甲隨即頒發起飛許可。

當晚管制塔台設備如無線電通訊、跑道燈光控制、風及天氣顯示器及雷達顯示器等設備均無異常情形。

起飛許可頒發不久後，管制員甲聽見滑行道 NP 及 05 右跑道之爆炸聲及火光，立即按下緊急警鈴，同時間另一管制員正聯絡消防隊，地面管制席（GC）關閉 05 左跑道，隨後航站當局電告塔台機場關閉。管制員甲關閉起降跑道，並稱未觸及任何跑道燈光控制開關。

管制員甲回想起當晚能見度很差，失事前無法看到 05 右跑道中心線燈與邊燈。同樣也看不見塔台與 05 左跑道間之任何東西（包括 05 右跑道內施工區）。當時天氣惡劣，強來襲使得塔台天花板懸吊之燈具搖擺不定。

管制員甲稱在晴朗夜晚，可以看到跑道盡頭，甚至連跑道指示牌亦可看見，但無法辨識板上文字。並稱晴朗夜晚 05 右跑道施工區之障礙燈亦可看見。

民國八十九年九月中旬起， 05 右跑道燈光控制開關加上標籤，以避免誤觸。SQ006 失事後，05 左跑道亦加上類似標籤，用以提醒管制員勿開啟此兩種燈光。

管制員甲瞭解中正機場已將 05 右跑道轉換為 NC 滑行道之飛航公告暫緩實施。因此失事當晚跑滑道操作指示與往常無異。

1.18.1.3.2 值班管制員乙訪談摘要

失事當天，管制員乙於晚間十一時接地面管制席，當時該席頻率（121.7MHz）中僅有 SQ006 與另兩架班機。管制員乙稱指示 SQ006 經由 SS 滑行道、 West Cross 滑行道、NP 滑行道及 N1 滑行道滑至 05 左跑道。

在輪值地面管制席時，負責操作相關滑行道燈光如白、黃及紅區之燈光。而機場管制席則負責操作跑道燈光。原則上，燈光在降落航機約距著陸區十五浬時開啟。如有航機連續降落，進場燈及跑道燈保持開啟狀態，並不頻頻開啟及關閉。標準作業程序未規定進場燈需為起飛航機開啟。

第二次訪談地面管制員係澄清當主任航務員要求關閉跑道 05 左/右之後，航管人員執行有關 05 右跑道中心線燈及邊燈動作。

訪談中，地面管制員表示 05 左/右跑道燈之開關是依據下列順序：

1. SQ006 失事後，05 左跑道邊燈及中心線燈開啟，05 右跑道邊燈關閉，05 右跑道中心線燈開啟。

2. 主任航務員在 SQ006 失事後立刻呼叫關閉 05 跑道，地面管制員關閉 05 左跑道所有邊燈及中心線燈，05 跑道中心線燈及所有滑行道燈。

3. 當主任航務員發現 05 右跑道（事故現場）太暗無法進行救援作業，要求更多燈光。地面管制員開啟 05 左及 05 右跑道所有邊燈及中心線燈，及所有滑行道燈。

1.18.1.3.3 值班管制員丙訪談摘要

管制員丙記得她先接飛航資料席，然後再接地面管制席。在地面管制席時管制 SQ006。先指示 SQ006 預期使用 06 跑道起飛，稍後同意 SQ006 要求以 05 左跑道離場，駕駛員未說明選擇 05 左跑道之理由。

失事後，管制員丙指示地面管制員通知近場台 SQ006 失事，05 左跑道同時關閉。之後應管制員甲要求接管機場管制席。

管制員丙稱，在席位時未開開啟任何燈光，因燈光操作非飛航資料席責任。地面管制席負責滑行道燈光，跑道相關燈光則係機場管制席責任。

管制員丙稱失事後接管機場管制席，之後未曾開啟或關閉任何跑滑道燈光。至於航務組黃車要求開啟燈光時，地面管制席曾配合作業，但不清楚開啟何種燈光。

有關機場燈光之維護，管制員丙稱維護人員並無固定模式要求塔台如何開啟燈光以進行檢查。據其所知，塔台係依維護人員不定期之要求開啟及關閉燈光。失事當晚，未曾執行任何燈光開關測試。

1.18.1.3.4 值班管制員丁訪談摘要

失事時，管制員丁正在休息，但仍監聽許可頒發席頻率[29]。

管制員丁稱當他剛報完 ATIS 時，就聽到爆炸聲並看見跑道上之火光，立即以無線電通知消防隊。

未注意到那些滑行道燈光是開啟的，因為失事後忙於接聽各方電話。該員稱不清楚失事前 05 右跑道邊燈是否開啟。

管制員丁稱，依據中正塔台標準作業程序，在無航機起降時，跑道及滑行道燈光將關閉。在問到失事當時 05 左跑道之進場燈光是否開啟時，該員稱依據標準作業程序，無到場航機時，05 左跑道進場燈光應未開啟。

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[29]雖然，台北飛航情報區飛航指南規定許可頒發席每晚十時之後停止工作，但值班人員仍然監聽該席之無線電頻率。

1.18.1.4 值班航務員訪談摘要

失事當時，航務組主任航務員正在 B 停機坪。他駕駛黃色公務車。該員稱其採取最近路徑馳往失事現場，是經由 N7 滑行道抵達現場。

主任航務員稱失事不久後，曾要求塔台開啟 05 跑道所有燈光，（但未指明是 05 左或是 05 右跑道）。燈光開啟後，才發現自己身處 N6 滑行道邊草地上。

1.18.1.5 其他訪談

1.18.1.5.1 事故當時正滑行準備離場之某班機

失事發生當晚，某飛航亞太地區之航空公司 Boeing747-400 航機沿 NP 滑行道滑行至 05 左跑道起飛，該機長報告有陣風及豪大雨等情況，該機長陳述，起飛是依據污染跑道性能計算，也表示能見度不算太壞，不認為跑道視程（RVR）如 ATIS 報告的那麼差。回想從 A7 登機門可以看到 NP 滑行道之盡頭。

機長報告當其飛機與 A7 登機門平行時，看到 05 右跑道上飛機落地燈光，緊接著發生爆炸，由於能見度並不太差，所以未將雨刷打開，記得看到事故飛機落地燈，其餘為一片漆黑，不記得在 05 右跑道或 05 左跑道上看到任何燈光。NP 滑行道燈是開著的。

該機機長陳述，其在中正機場三年起降經驗中，未曾看過使用 05 右跑道起降，不記得 05 右跑道邊燈是否曾開啟。機長還說每個人皆需具備對該機場區域之基本認識及警覺意識，否則飛機可能將對正在錯誤之 05 右跑道上。

1.18.1.5.2 早 SQ006 十六分鐘離場之某班機

某亞太地區航空公司 Boeing 747-400 航機於事故前十六分鐘離場，機長回想從 A5 或 A7 登機門後推，其獲頒之滑行許可係沿 NP 滑行道至 05 左跑道，機長報告其起飛標準係以跑道上有 1/2 吋積水計算，在離場時正下著大雨。

機長回想時表示，當時機場是低於落地標準，當飛機沿 NP 滑行道在 West Cross 滑行道附近滑行時，管制員似乎無法以目視監控其動態，因而要求飛機報告位置。

機長回想到當時機場風向與風速相當不穩定，瞬間側風有時超過起飛限制。當機長收到起飛許可時，側風量超過最大許容許範圍，因此在跑道頭等待，他表示，如果情況好轉將會起飛，天氣如果繼續惡化便將飛機滑回停機坪。

跑道附近之能見度至少有 600—700 公尺，故機長並未要求提高跑道燈亮度離場。

機長記得當飛機從 NP 滑行道轉入 N1 滑行道時，05 左跑道燈亮度正常。確認 05 左跑道燈光符合第二類儀降進場跑道標準。這些燈光包含跑道邊燈、中心線燈及著陸區燈，不記得 05 右跑道邊燈是否亮著。

1.18.1.5.3 SQ006 事件八天前離場之某班機

民國八十九年十月廿三日晚約 1045 時，一架 MD-11 貨機，其許可滑行至 05 左跑道之路徑為：經由 NS 滑行道進入 05 右跑道反向滑行，至 N6 滑行道左轉，沿 N6 滑行道滑行，之後右轉進入 NP 滑行道，再右轉沿 N1 滑行道至 05 左跑道起飛。

機長沿 05 右跑道至 N6 滑行道，注意到 05 右跑道頭之中心線與邊燈均亮著，機長稱當晚有風有雨，因為中度雨勢致能見度不佳。

機長在 N1 滑行道上遇到的第一條跑道是 05 右跑道，由於該跑道的中心線及邊燈被開啟，使他相信這是條使用中跑道，機長稱 05 右跑道上看不到阻擋護欄及警示燈光。

機長之所以能夠拒絕這些資訊，其原因為 05 右跑道太窄、且沒有著陸區燈、以及其中心線燈為綠色。

該貨機機長並未向中正機場管制員報告此意外事件。民國八十九年十二月該機長與新加坡交通與資訊科技部聯絡，經新加坡交通與資訊科技部之請求，於九十年二月十六日進行電話訪談，並於在九十年七月十九日於本會進行第二次訪談。依據中正機場於八十九年十月廿三日晚上約 11:00 之天氣觀測記錄：風向 050 度，7 浬/時，能見度 10 公里，2 疏雲 500 呎，裂雲 30,000 呎，未下雨。

1.18.2 飛航管制作業

1.18.2.1 航管人員人力佈署

失事當時，中正機場塔台有四位管制員值班，包括：機場管制席、地面管制席、許可頒發席及飛航資料席。

中正機場塔台夜班不設協調席，航行情況需要時，由近場台班務督導負責所需業務。

1.18.2.2 飛航管制工作量

失事前，係由機場管制員與 SQ006 聯絡，該機為機場管制員該時段唯一管制班機。但地面管制員與其他兩架已開車之航機聯絡。機場管制員觀察到失事後即按下警鈴。其他兩位管制員則分別在許可頒發席及飛航資料席工作。

1.18.2.3 飛航管制程序

中正近場管制塔台業務手冊規定，在能見度低於 2,000 公尺時，塔台之地面管制席管制員應通知操作區內之航機，相關術語如下：

『塔台無法目視部份機場，請注意慢速滑行。』

飛航管制程序規定（ATP-88）：

管制員於以下情況頒發進一步滑行與地面活動之指示：

1．駕駛員/操作員請求時。

2．因相關航情或場面狀況如施工或滑行道關閉，管制員認為有必要時。

3．當能見度降低時，尤其是塔台無法目視滑行路徑時。

當日未頒發進一步滑行指示予 SQ006。

訪談時，中正機場塔台長告訴本會在低能見度作業時，航管主要之考量在保護使用中之跑道。特別是落地後飛機盡快脫離跑道以及滑行飛機除非獲得許可，否則不得進入跑道。

塔台長表示，確保滑行航機之隔離非常重要。倘使兩架以上之航機同時在附近活動，航管單位會要求航機在不同之滑行道交叉點等待以確保隔離，此項作業包括要其報告在機場滑行之位置。如無其他航機，航管單位並無相關之程序或建議措施協助飛航組員滑行。塔台長稱在某些情況下，場內精確滑行係飛航組員責任。航管單位僅告知能見度降低及小心滑行。在惡劣天候時，無法目視航機位置，航管單位祇能由組員無線電報告中決定航機位置。

1.18.2.4 機場場面偵測裝備（ASDE）

飛航管制程序 ATP-88 第 3-6 節有關機場場面偵測程序如下：

3-6-1 裝備之使用

使用機場地面偵測裝備，以輔助目視觀察跑道／滑行道，或其他活動區內之航空器及車輛之活動：

a.當使用中活動區的最遠處已無法目視時，及

b.當管制員認為使用它將有助於執行工作時。

c.機場地面偵測裝備-3，於日落至日出之間不論任何能見度，應持續使用。

3-6-2 資料之運用

a.使用從機場地面偵測裝備獲得之資料以：

1. ***對活動區中之航空器與車輛，頒發明確之許可或指示。***
2. ***在航空器起降前，掌握跑道上的航空器或車輛何時可清除。***
3. ***安排活動區內航空器與車輛。***
4. ***確定活動區內航空器與車輛之確實位置，或是與其他航空器／車輛之相關位置。***
5. ***監看滑行道與跑道上，航空器與車輛是否依航管指示操作。***
6. ***確認駕駛員報告之位置。***
7. ***應駕駛員請求提供滑行方向之資料。***

術語－

從前面的滑行道／跑道（左／右）轉。

b.除非遇緊急情況，或經駕駛員同意，不可提供特定之引導（精確之航向）。

註－

憑目視駕駛，循路到達管制員指定之路徑限制點，避讓其他停放或滑行中之航空器，或活動區內之車輛、人員，是駕駛員的責任。

3-6-3 識別

識別從機場地面偵測裝備上看到的目標，其位置必須與以下條件中至少一項相符：

a. ***駕駛員報告***

b. ***管制員目視看到***

c. ***在機場搜索雷達上，或塔台雷達顯示器／塔台數位雷達顯示器上看到已經識別的目標。***

機場場面偵測程序明白敘述 ASDE 確定活動區內航空器與車輛之確實位置。訪談中值班管制員稱如果中正機場配備 ASDE 或相同系統，類似 SQ006 事故或可預防。

民航局於民國八十三年飛航服務總台（簡稱總台）獲得民航局預算辦理中正機場 ASDE 採購案。總台以中正機場平流霧現象並不嚴重，ASDE 使用時間有限無架設必要，因此建請民航局撤回該筆預算。之後，民航局再函請總台重新考慮架設中正機場 ASDE，總台重申因濃霧發生機會並不頻繁，中正機場無架設 ASDE 之必要。總台又指出塔台視野良好，如需架設 ASDE，現有塔台結構並無承受 ASDE 重量之設計，需另覓適當位置架設獨立鐵塔以架設天線。此鐵塔之費用極高，該預算無法支應。民航局因而建請交通部准予停止辦理本案並將預算悉數交回。

民國八十五年總台建請民航局架設中正機場 ASDE，以增進飛安及提昇航管服務品質。總台說明由於該機場日益增多之航機及地面車輛，在能見度下降時，航管人員對地面車輛行動監控能力將受限制。經過會勘後，民航局與總台同意於中正機場選擇適當地點興建新塔台以架設 ASDE。

民國八十七年民航局函請總台於該年五月前完成中正機場 ASDE 建置計劃，並編列八十九年度預算。八十九年初因預算排擠，並考量總台尚有三座終端雷達，二座航路雷達、以及之汰換中正機場氣象雷達等案正在執行。本案因而緩延一年辦理。總台於民國九十年函請民航局同意補編預算，民航局指示總台自九十一年起分期辦理 ASDE 採購相關事項。

民國九十年二月一日民航局陳報交通部提前於九十年度辦理，「建置中正機場新建機場場面偵測裝備乙案」相關作業事項。交通部於兩週內回覆，請民航局提出該案採購及建置之評估計劃。民航局於該年四月二十四日陳報交通部。而交通部又請民航局修改該案。民航局修改之，後交通部於九十年八月十五日核准該案。

1.18.2.5 安全管理（意外事件報告與追蹤）

意外事件報告係由駕駛員、航管及航空站管理階層填報。重大意外事件報告亦通報本會與民航局。

民航局規定駕駛員可經由航管頻率直接報告意外事件或在各航站諮詢台及航務組填寫駕駛員地面報告（Pilot Ground Report），這兩單位收到報告登記後應儘速傳真至民航局。相關單位調查後將初步調查報告陳報局本部。初步調查報告經審查後，民航局會將處置情況與改善措書面通知報告人。

本會取得自民國八十七年三月以後之六份有關中正機場之意外事件報告。（如附錄5）。

1.18.2.6 飛航公告及飛航指南補充資料

1.18.2.6.1 相關飛航公告

八十九年八月三十一日台北飛航情報區所發布之 A0606 號飛航公告（取代 A0604 號公告）稱：八十九年九月十三日 09:00LT 起至同年十一月二十二日 09:00 L T 止，05 右/23 左跑道之部份區域從 N4 至 N5 滑行道間關閉施工。但 N4 與 N5 滑行道仍然開放。

八十九年十一月一日發布之 A0758 及 A0759 號飛航公告稱：05 左/23 右跑道、NP 及 NS 滑行道因外物損害而關閉。

八十九年十二月二十二日發布之 A907 **號飛航公告（取代** A0860 **號公告）稱：**05 **右**/23 **左跑道即日起改為** NC **滑行道，禁止航空器起降。**

1.18.2.6.2 相關飛航指南補充資料

八十九年十月三日發布之 A007 C015/00 **號飛航指南補充資料稱：自八十九年十一月二日** 01:00LT **起生效，**05 **右**/23 **左跑道更改名稱為** NC **滑行道。跑道中心線燈（綠色）及跑道邊燈（白色）保持在** NC **滑行道上，另候通知。跑道標線將予更換。**

八十九年十月二十三日民航局航管組發布飛航公告稱：05 **右**/23 **左跑道更改名稱為** NC **滑行道作業延後，另候通知。**

1.18.2.7 跑道燈光操作標準程序

根據民航局飛航管制程序（ATP-88**）第** 4 **節之機場燈光，進場燈及跑道燈相關程序如下：**

3-4-4 進場燈

開啟進場燈：

a. ***日落至日出期間，在下述任一情況時：***

1. ***為降落跑道之進場燈。***

2. ***為進場跑道之進場燈，但是航空器將在另一跑道降落。***

b. ***日出至日落之間，當雲幕高低於*** *1000* ***呎或能見度低於*** *8* ***公里，且航空器正在進場至：***

1. ***該進場燈所屬之降落跑道。***

2. ***該進場燈所屬之跑道；但是航空器將在另一條跑道降落。***

3. ***機場，但是航空器在該進場燈所屬之跑道降落。***

c. ***應駕駛員要求。***

d. ***管制員認為必要且與駕駛員之要求無抵觸時。***

註*-* ***為了節約能源，當航空器不再需要進場燈時，應予關閉。***

參考 *–* ***進場燈光系統亮度之設定，****3-4-5*。

3-4-10 高亮度跑道燈、跑道中心線燈及著陸區燈

按表 3-4-4 操作高亮度跑道燈、相關之跑道中心線燈與著陸區燈，除：

a. 按業務手冊規定操作以配合當地狀況。

b. 應駕駛員要求。

c. 管制員認為必要，而與駕駛員之要求無抵觸時。

表 3-4-4

高亮度跑道燈、跑道中心線及著陸區燈之亮度設定		
亮度	能見度	
	日間	夜間
5	低於 1600 公尺.*	被要求時
4	1600 公尺至低於 3200 公尺	低於 1600 公尺*
3	3200 公尺至低於 4800 公尺	1.600 公尺至低於 4800 公尺*
2	被要求時	4800 公尺至 8 公里（含）
1	被要求時	大於 8 公里
*及（或）等值之跑道視程		

1.18.2.8 中正近場管制塔台業務手冊

為節省能源而不影響飛航安全，中正近場管制塔台業務手冊訂有機場燈光啟閉時間作業規定：不啟用無需要之燈光。

1.18.2.9 跑道視程

八十九年十月三十一日跑道視程儀列印之記錄顯示：05 左跑道燈光曾於 2313 開啟，於 23:24 關閉。當時之燈光亮度為第三級（共有五級）。

1.18.3 機場航圖

駕駛艙中組員所使用的吉普生航圖已遭火災焚毀。依據對三位駕駛員訪談，於八十九年十月卅一日所使用的航圖是標示 05 左與 05 右跑道。日期為公元 2000 年 7 月 7 日航圖中之中正機場航圖中之 05 右跑道係標示為跑道〈圖 1.18-1〉。

組員之航圖並沒有修定之黃頁（yellow page supplement，一般稱為 yellow sheet），陳述關於 05 右跑道有工程進行。

日期為公元 2000 **年** 10 **月** 27 **日中正機場更新之航圖，其生效日期為該年** 11 **月** 1 **日** 1700 **時。原本之** 05 **右跑道將改為** NC **滑行道。**

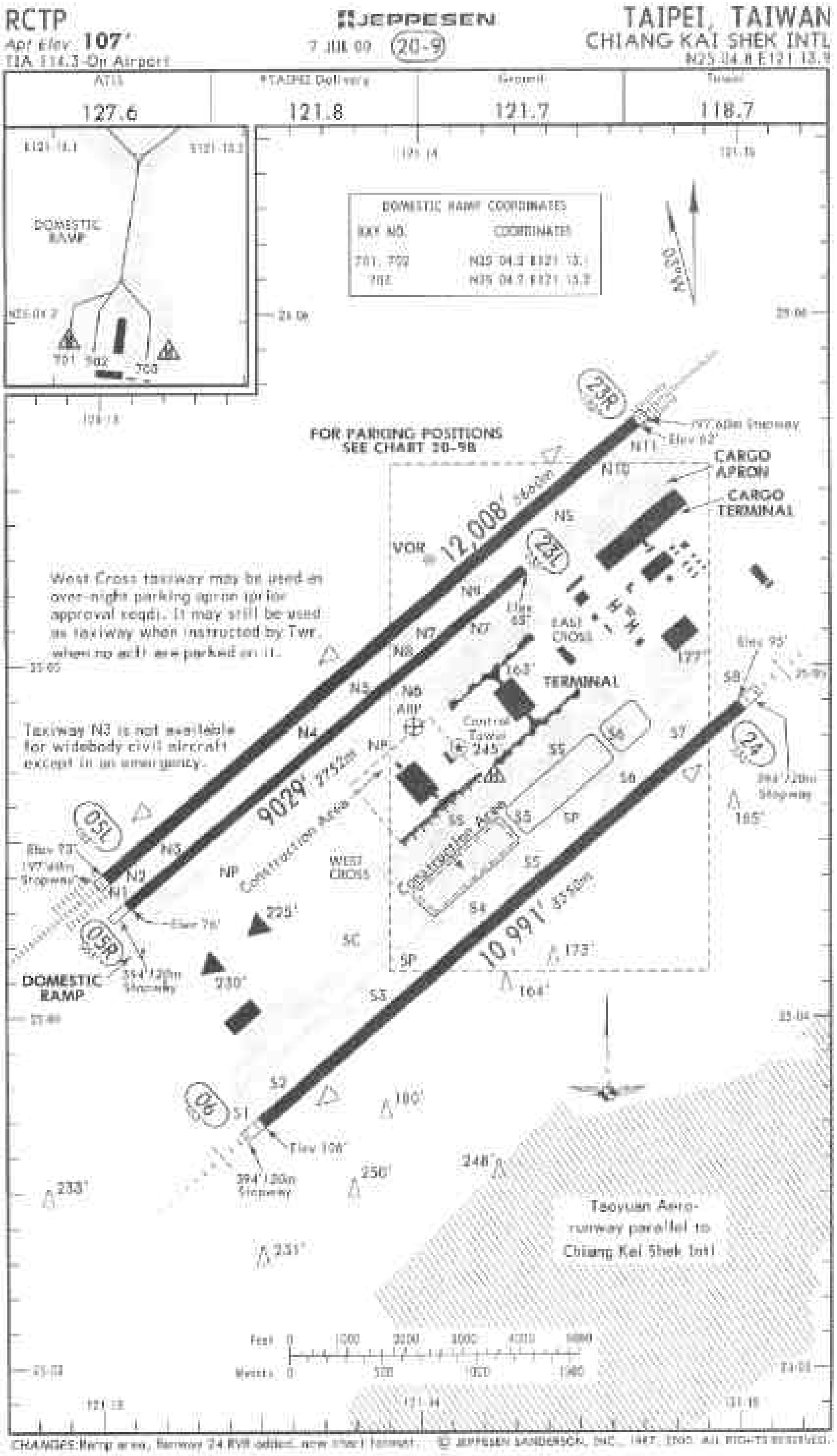

圖 1.18-1　　**公元** 2000 **年** 7 **月** 7 **日中正機場航圖**

1.18.4 跑道狀況與側風限制

中正機場航管單位管制員未提供任何有關跑滑道狀況資訊予飛航組員，也無規定必須提供此項資料。而飛航組員當時亦未提出有關跑滑道狀況資訊之要求。其他駕駛員亦未提出 05 左跑道狀況報告。

與航管單位訪談顯示，中正機場並無測量跑道積水深度設備，因此航管人員由駕駛員起降跑道及場站維護組定期檢視跑道後回報等兩種管道獲得跑道狀況資料。

當問及如何判別污染跑道時，新航波音 747-400 總機師表示，航管單位應將跑道狀況通報組員。當問及航管單位未提供此項服務新航是否有協助駕駛員評估濕滑跑道狀況程序，波音 747-400 總機師稱，組員倚賴航管單位提供該項資訊。總機師稱組員所在位置無法精確評估跑道是否受污染。此外，總機師表示，大部分跑道（除非是有缺陷）設計都應是能夠完善排水以防止跑道表面大量積水。

當問及波音 747-400 對側風限度，總機師確認了新航組員訓練手冊所規定下列數據，但總機師說這些只是訓練指南：

- 乾跑道 30 節
- 濕跑道 25 節
- 污染跑道 15 節

新航作業手冊規定側風限度為 30 節，且乾、濕跑道並無差別，這符合波音波音 747-400 飛航手冊的限制規定。新航操作係依波音程序和性能限制，並採用波音作業手冊作為其正式作業文件。新航在其作業及燃油政策增加自用章節，並修訂波音正常檢查表，使之能更符該公司作業要求。

1.18.4.1 新航跑道狀況定義

新航波音 747-400 作業手冊第 4.10 節作業方針中定義污染跑道為:

"4.10.1 A contaminated runway is a runway that is partially or entirely covered with standing water of more than 1 mm, slush, snow or ice, or a "wet" runway with sand or dust."

濕跑道定義為:

"4.11.1 Wet runway is a runway that is well-soaked but with no standing water."

新航在波音 747-400 作業手冊或其它飛航作業手冊中沒有提供程序讓組員來決定

「濕跑道」或「污染跑道」。

1.18.4.2 他航「跑道狀況之決定」

根據一亞太地區航空公司之飛航作業手冊第 5 **章作業方針中，污染跑道定義為**:

"A runway where more than 25 percent of the required field, within the width being used, is covered by standing water or slush more than 0.125 inch (3.2mm) deep, or that has an accumulation of snow or ice."

該公司並且提供飛行員評估跑道情況之方法:

"While flight planning, pilots should anticipate runway conditions for planned departure and arrival airports. Generally, non-grooved runways will be considered to be "wet" if moderate rain (RA or SHRA) is forecast at or shortly before the time of departure or arrival. If heavy rain or thunderstorms are forecast, standing water should be expected. The presence of standing water, snow, slush, or ice generally indicate the need for application of contaminated runway performance adjustments."

另一家亞太地區航空公司波音 747-438 **作業手冊中也提供評估跑道狀況方法**:

"When in doubt about the condition of the runway, be conservative.

When landing in very heavy rain on runways which are not grooved…, the runway should be treated as "contaminated" with "poor" braking."

1.18.5 目視輔助系統（PVD）

1.18.5.1 操作觀念

根據新航波音 747-400 **飛航組員訓練手冊第** 8.32 **頁，**PVD **能夠讓駕駛員往窗外找尋熟悉的景物時，同時還可以在艙內儀表板上得到航機方向的資訊。**PVD **兩個元件安裝在駕駛員前方儀表板上，一左一右。圖** 1.18-2 **係** CM-2 **之** PVD **位置。圖中左下角即為** PVD **近照。**

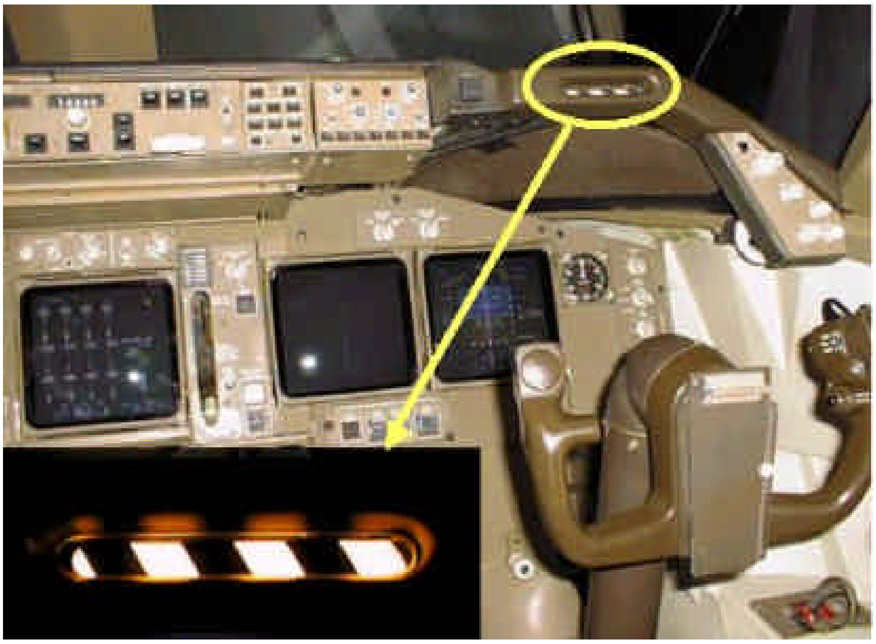

圖 1.18-2　　目視輔助系統（PVD）

PVD 實際上是一種裝有黑白相間旋轉桿柱（像理髮店的標誌）之裝置，桿柱旋轉予人向左或向右感覺。

如果跑道能見度不良（低於 50 公尺），PVD 便成為起飛時極有價值的指示。PVD 調到起飛跑道的儀降系統（ILS）頻率，只要飛機是在跑道的中線上，「理髮店的旋轉桿柱」便穩定不動，但如果飛機向左或向右偏離中線，旋轉桿柱就會轉動以導引駕駛員操縱。舉例來說，如果飛機是向右偏離中線，PVD 會向左轉動，指出方向應向左轉回至中心線。

PVD 係一高可靠度跑道對正輔助工具，而駕駛員對正跑道主要依據是跑道標線及燈光等目視資訊。當飛機對正跑道中線時，PVD 即應該開啟，且開始正常運作。只要收到有效之操控參數，就能繼續其功能。未被使用時，或收不到儀器降落系統訊號（例如超出距離、信號被阻斷，或系統故障）時，PVD 便關閉。

新航所使用之波音 747-400 操作手冊中，並無以 PVD 來辨識跑道之程序。

根據其他裝置 PVD 航空公司波音 747-400 操作手冊（修正日期 1998 年 6 月 12 日及 2000 年 2 月 11 日）載明「Using the runway localizer tuned on the Navigation Radio page, the PVD provides guidance to runway centerline during ground operations.」

1.18.5.2　操作程序

根據新航波音 747-400 飛航組員訓練手冊第 8.33 頁，當駕駛員滑行到「待命區」

時，應將 PVD 打開，同時亦須設定起飛跑道左右定位台頻率。PVD 打開後，電腦會自我測試。此測試會將 PVD 開啟，並且朝每個方向轉動 1.5 秒。組員必須監控測試有無何異常。有必要時，組員也可調整 PVD 亮度。

當一個或兩個 PVD 都打開時，訊息 PVD CAPT ON、PVD F/O ON，或 PVD BOTH ON 會出現在 EICAS（Engine Indication and Crew Alert System ）顯示上。若任一個 PVD 故障，PVD SYS CAPT 或 PVD SYS F/O 故障訊息會出現在 EICAS 顯示上。

1.18.5.3 PVD 附錄

根據波音 747-400 飛航手冊（AFM）第 1 章第 15 頁：

"PARA VISUAL DISPLAY (PVD) SYSTEM

If operating under Civil Aviation Authority of Singapore jurisdiction then refer to Civil Aviation Authority of Singapore (CAAS) Supplement for information which supercedes the data in the following paragraph.

Low weather minima operations shall not be predicated on the use of the PVD system, since the FAA has not evaluated the PVD system."

本會檢視新加坡交通與資訊科技部提供之波音 747-400 飛航手冊後，發現手冊中並未載明任何有關 PVD 的附錄說明。新加坡交通與資訊科技部表示，1994 年 10 月 31 日新加坡民航局核准此附錄文件，並置於飛航手冊第 2 冊附錄章節中。失事時該章節版本為第 15 版。新加坡民航局核准的附錄第 3 節第 1 頁載明（參考附錄 6）：

"The flight crew should confirm that when the PVD is selected ON, the display streams right, left and then stops momentarily. The display will then either provide guidance to the localizer centerline or will shutter dependent upon whether the airplane is in a position for takeoff or not."

新加坡民航局表示新航曾申請於其波音 747-400 型機使用 PVD 適航驗證。新加坡民航局為此諮詢美國聯邦航空總署，由於美國尚無航空公司使用 PVD，故該署並未驗證 PVD。該署建議新加坡民航局徵詢其它國家監理機關。於是新加坡民航局詢問英德兩國民航機關 PVD 驗證經驗，以確保該局驗證符合國際最佳標準。新航波音 747-400 飛航手冊中序言稱，其 PVD 已獲核准。

新加坡民航局表示該手冊於設計國驗證後，該局才會接受。因此，航空器製造商在獲得設計國驗證後，才將飛航手冊提供給新加坡民航局。該局再根據該手冊頒布 Flight Manual Approval 予航空器使用人。飛航手冊修訂程序亦同。對於未被驗證之設備如 PVD，新加坡民航局則會對該設備及其操作驗證。完成驗證後，該局會要求飛機製造廠發布新的飛航手冊附錄內容供其核准。

1.18.5.4 PVD 可靠度

由於 PVD 是一種跑道復歸（reversionary）儀器，因此須有高可靠度。其可靠度資料有幾個來源：新航波音 747-400 駕駛員，其他使用 PVD 的航空公司，以及 PVD 製造廠商史密斯公司（Smiths Industry）。波音公司本身無此儀器可靠度資料。

與新航駕駛員數度面談（包括新航五位正駕駛員和一位副駕駛），獲得下列資料：只有一受訪者聽說有駕駛員使用 PVD 時遇到問題，其他人都表示，若跑道符合以 PVD 協助起飛要求，只要左右定位台信號未被遮蔽，PVD 是可靠系統。未聽說此系統失效過，聽說 PVD 有問題的駕駛員也無法認定問題何在。

調查小組詢問其他裝置 PVD 之波音 747-400 或 767 機隊，亦無 PVD 失效報告。

PVD 製造商，史密斯工業公司（ Smith Industry），提供 1998 年 1 月至 2000 年 11 月回廠維修之 13 個 PVD 資料。其中一個 PVD 送回原因是在起飛時無法開啟，第二個 PVD 送回原因是起飛時 EICAS 之失效訊息。其餘送回是因不同狀況，包括七個因軟硬體升級，而該公司在 13 個送回之 PVD 未發現任何故障。

1.18.6 主要飛航顯示器（PFD）

當設定為起飛跑道儀器降落系統頻率（PVD 使用之規定），有兩個指示會出現在 PFD 上。圖 1.18-3 為 PFD 顯示兩種不同情況：左邊圖為飛機對正跑道，而右邊是飛機未對正跑道。第一個指示為姿態儀下方左右定位台指示和刻度。此指示是一個紫紅色實心鑽石，顯示飛機與左右定位台之相對位置。

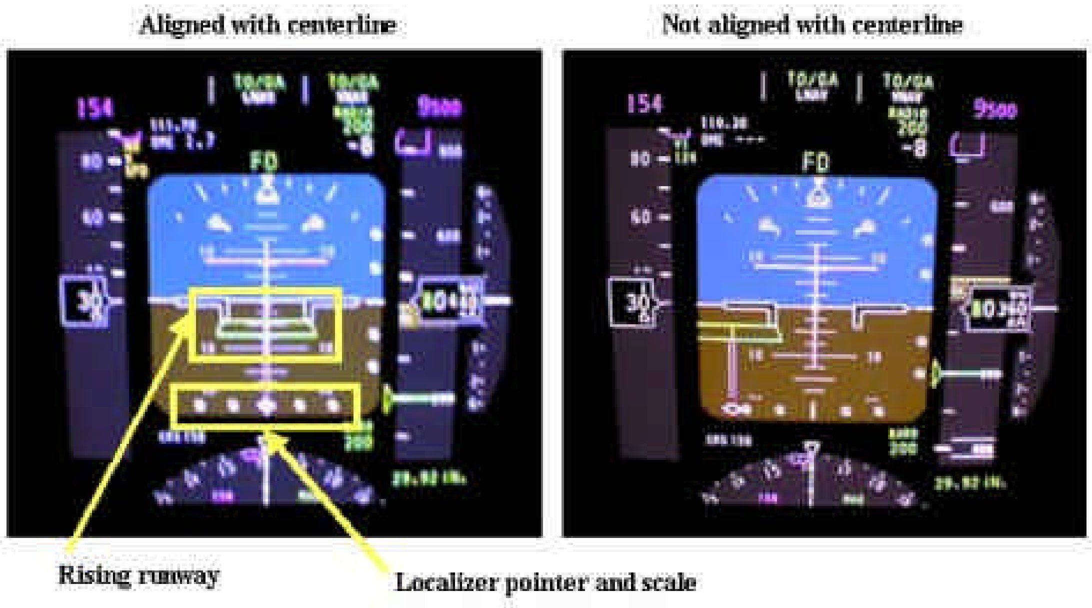

圖 1.18-3　PFD 之顯示

當飛機未對正跑道，左右定位台鑽石符號會移至左邊，且實心轉為空心。第二個指示是一綠色梯形跑道符號及其下方兩條平行的紫紅色線條。此跑道符號於對正跑道時會出現在水平線正下方，當偏移時跑道符號則會偏移。

1.18.7 導航顯示器（ND）

ND 提供完整顯示以確保航機導航之精確性。它提供左右及垂直導航指示、航路圖、氣象雷達、無線電設施、風向與風速、地速、真空速及預測航路等功能。它同時顯示飛機符號與目前航跡。當選擇跑道後，ND 螢幕上將顯示跑道符號。飛機與跑道相對位置也會顯示出來。ND 顯示範圍從 10 到 640 海浬，跑道與飛機符號大小與顯示範圍成反比，範圍越大符號就越小。

八十九年十一月六日模擬滑行時, 調查小組選擇 05 左跑道為離場跑道。因此,「05L」跑道標示顯示在 ND 上。由於飛機當時對正 05 右跑道，飛機符號顯示在 05 左跑道符號右邊，但 05 左跑道標示維持不變。調查小組無法確認 SQ006 導航顯示器在航機對正跑道前或對正跑道當時所設定顯示範圍。圖 1.18-4 為飛機對正 05 右跑道時 ND 顯示。

圖 1.18-4　飛行計劃為 05 左跑道而 ND 上顯示飛機對正 05 右跑道

1.18.8 地面導引及導航科技

由於科技進展，對飛航安全及民航作業效率之提昇，特別是在低能見度的情況下，有相當助益。而依據駕駛艙場面導引科技實驗顯示，如果將電子動態地圖（EMM）與

抬頭顯示器（HUD）結合，將大量降低飛航組員在機場運作範圍內關於導航方面之疏失[30]。經驗法則同樣證明；類似系統如滑行道助導航及狀況覺察（T-NASA）系統，不但能減輕駕駛員滑行期間導航工作量，尚能提高飛航組員狀況警察，且與航空器現行之導航方式實驗比較，亦節省滑行所需時間[31,32]。精確即時位置資訊已可由全球定位系統（GPS）獲得，但要將精確動態資訊提供予駕駛艙中飛航組員時，必須具備包括機場及地形之資料庫、先進航廈區域系統及資料連結等設施[33]。

駕駛艙 ND 係提供飛航組員航空器在低能見度時於機場精確位置之資訊界面。例如，將機場航空器之位置地面圖置於電子動態地圖（EMM），涵蓋如跑道、滑行道及航廈區域等資料。呈現航空器沿機場表面滑行情形，亦即它將目前如滑行圖及進一步滑行指示等不完整資訊，以視覺描述方式呈現。這種動態地圖顯示器對人類行為表現之價值在於：將各種複雜資料整合為清楚及精確之航空器計劃路徑並予以呈現。動態地圖能提供駕駛員精確航空器位置圖像，特別是在低能見度狀況下，因而幫助駕駛員發展及維持狀況警覺。依據業界研究成果，本會瞭解此一系統及技術已相當成熟。

1.18.9 失事現場相關錄影帶

1.18.9.1 乘客提供之錄影帶

事故發生時，提供錄影乘客當時坐在另一波音 747-400 班機上艙第 12 排位置。失事時，該機正從停機門 A5 後推，沿著 NP 滑行道朝向 N1 滑行道滑行。事故發生後，該機即轉入 A8 停機門。約一分鐘錄影中，可見失事航空器於跑道上起火燃燒。乘客從機尾機身斷裂處倉促疏散。整個錄影帶中未看出跑道邊有燈亮。

1.18.9.2 中正機場提供之錄影帶

機場提供數卷事故當時之保安錄影帶予本會。

77 號保安攝影機設置在 A6 登機門上方，面向機坪及 NP 滑行道。顯示航機爆炸時

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[30] McCann, R. S., Hooey, B. L., Parke, B., Foyle, D. C., Andre, A. D., and Kanki, B. (1998). An evaluation of the Taxiway Navigation and Situation Awareness (T-NASA) system in high-fidelity simulation. *SAE Transactions: Journal of Aerospace, 107,* 1612-1625.

[31] Andre, A. D., Hooey, B. L., Foyle, D. C., and McCann, R. S. (1998). Field evaluation of T-NASA: Taxi Navigation and Situation Awareness system. *Proceedings of the AIAA/IEEE/SAE 17th Digital Avionics System Conference, 47,* 1-8.

[32] Hooey, B. L., Foyle, D. C. and Andre, A. D. (2000). Integration of cockpit displays for surface operations: The final stage of a human-centered design approach. *Proceedings of the AIAA/SAE World Aviation Congress* (Paper 2000-01-5521). SAE International: Warrendale, PA.

[33] McCann, R. S., Hooey, B. L., Parke, B., Foyle, D. C., Andre, A. D., and Kanki, B. (1998). An evaluation of the Taxiway Navigation and Situation Awareness (T-NASA) system in high-fidelity simulation. *SAE Transactions: Journal of Aerospace, 107,* 1612-1625.

間為 2316:17，而該滑行班機出現於螢幕時間為 2318:05，歷時為 1 分 48 秒。

77 號保安攝影機於 2315:23 錄到失事班機由遠處照來燈光，隨著燈光增強直到該機沿跑道行進後之閃光，此時為 2316:17。該機從攝影機螢幕消失時，隨即因爆炸而發出一團白色光芒。

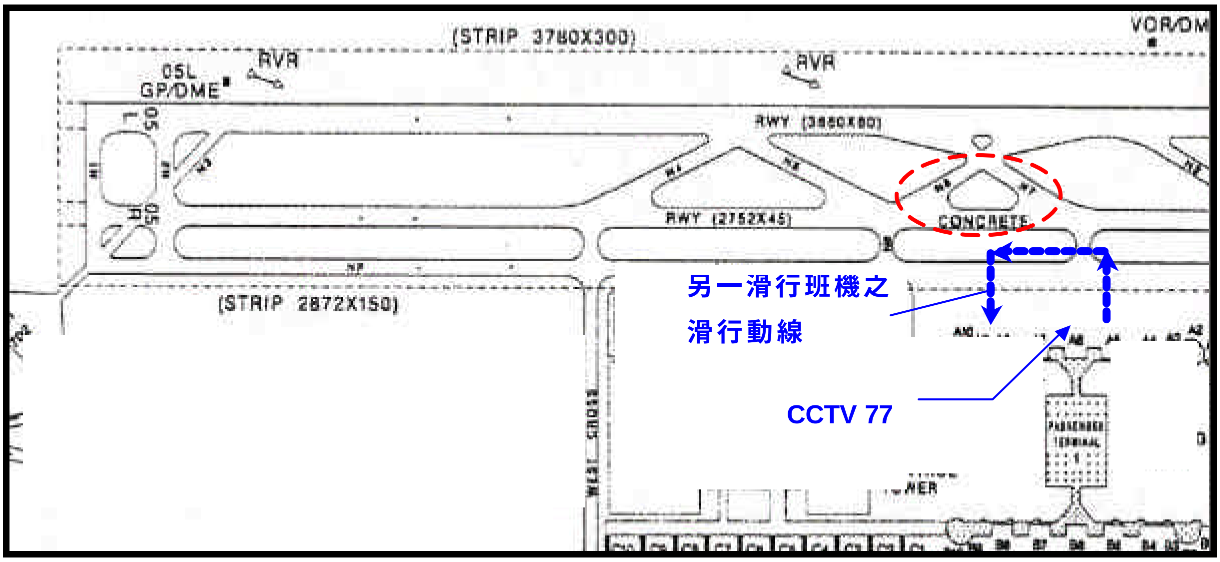

圖 1.18-5　　77 號保安攝影機位置與該班機滑行動線

92 號攝影機位置在國內線機坪靠近 N1 滑行道，當 SQ006 從 NP 滑行道滑入 N1 滑行道時，於 2314:21 可見該機燈光，在 2315:16 時飛機轉入 05 右跑道，錄影帶中看不見跑道燈光。

2 分析

本章針對前述事實資料進行分析，澄清並發掘與事故肇因相關之調查結果，同時亦對調查期間發現危及飛安之缺失進行探討。藉此突顯與肇因相關之調查結果、其它風險及缺失，以保障社會大眾權益。對於調查期間所有對失事預防與降低風險有所助益之經驗，本會將本促進飛安之職責，完全對外公開。

本章內容大綱如下：2.1 **節為調查中被認定與事故無關之一般事實描述；**2.2 **節提供事故航機結構失效過程；**2.3 **及** 2.4 **節分別為事故時機場情況與飛航管制經過，並檢討當時中正國際航空站及民航局之組織與管理；**2.5 **節為事故飛航組員之表現、相關訓練、協調及行動、不安全作為及與事故相關之重要預防措施；**2.6 **節為失事後之消防及搶救作業、醫療急救及生還因素探討；**2.7 **節為本會認為對改善飛安有重要影響之其它安全議題。**

本會參照國際民航公約第十三號附約及國際慣例作法，利用整體性方法進行調查，此乃依循國際民航公約第十三號附約、國際民航組織人為因素訓練手冊[34]**及** Reason **博士相關研究**[35]**等指導原則，對民航系統中所有要素進行檢驗，本調查係運用此方法於跑道安全分析之標準案例。美國聯邦航空總署跑道安全國家藍圖**[36]**中提及：「跑道入侵絕非單一獨立因子可造成，亦非單一獨立因子可防堵」。該藍圖之論點為，若要加強跑道安全，則需改善所有個別系統，所以在該籃圖中建議之改善項目，完整地包括飛航組員及航管訓練、通信、程序、場面相關科技、場站設施（如指示牌、標線和燈光等）以及隨著資訊科技進步，而持續發展之安全管理系統。本章即針對以上所提包括組織因素在內等議題進行分析。**

調查過程中，當資料不足、不完整或無法取得時，本會採合理歸納之邏輯方式，對事件做合理解釋，此外，分析中引用之所有資料均經適當評估與求證。國際民航組織人為因素訓練手冊第 2 **冊第** 4 **章第** 4.3.43 **至** 4.3.54 **節即提供對飛安調查資料之相關性及可用性評估原則。**

2.1 概述

SQ006 **飛航組員皆具備合格之駕駛員資格及適當證照，符合新加坡民航法及公司要求，亦符國際民航組織標準及建議措施。**

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[34] Human Factors Training Manual, 1998. International Civil Aviation Organization Montreal, Quebec
[35] Reason, J. 1997. Managing the Risks of Organizational Accidents. Ashgate Publishing Company.

駕駛員執勤時間、飛行時間、休息時間及個人生活情形等資料，皆未顯示任何既有之醫藥、行為、或心理等問題，而可能影響其失事當天表現。

SQ006 客艙組員皆達公司訓練要求，符合客艙組員資格。

事故當時之值班管制員持有適當證照為合格管制員，由座艙語音記錄器、飛航資料記錄器資料以及訪談管制員與駕駛員記錄顯示，管制員之滑行指示及起飛許可頒發，未誤導駕駛員從部份道面關閉之 05 右跑道起飛，管制員之作業程序、機場設施和民航局之管理將在之後章節討論。

失事航空器之認證、裝載及維修皆符合新加坡民航法規定及新加坡民航局核可，符合國際民航組織標準及建議措施，無證據顯示該機存在既有之機械故障或其他結構、飛操系統、發動機等問題而導致事故發生，該機在事故前亦符適航標準。

本會認為，無證據顯示在失事發生當晚，駕駛員曾受公司過度壓力而必須在當時起飛。

2.2 結構失效順序說明

本會根據殘骸分佈情形、05 右跑道上刮痕、施工機具分佈及現場量測等，推導出該機之結構失效順序如下（詳圖 2.2-1 至 2.2-8）：

[36] National Blueprint for Runway Safety. 2000. Federal Aviation Administration.

1. 右機腹起落架門（應係右側門）撞至澤西護欄，左起落架在越過 1 號坑洞時，輪胎撞擊坑洞北側邊緣，造成至少一個輪胎損壞（1 號坑洞如下圖紅色方塊所示）。

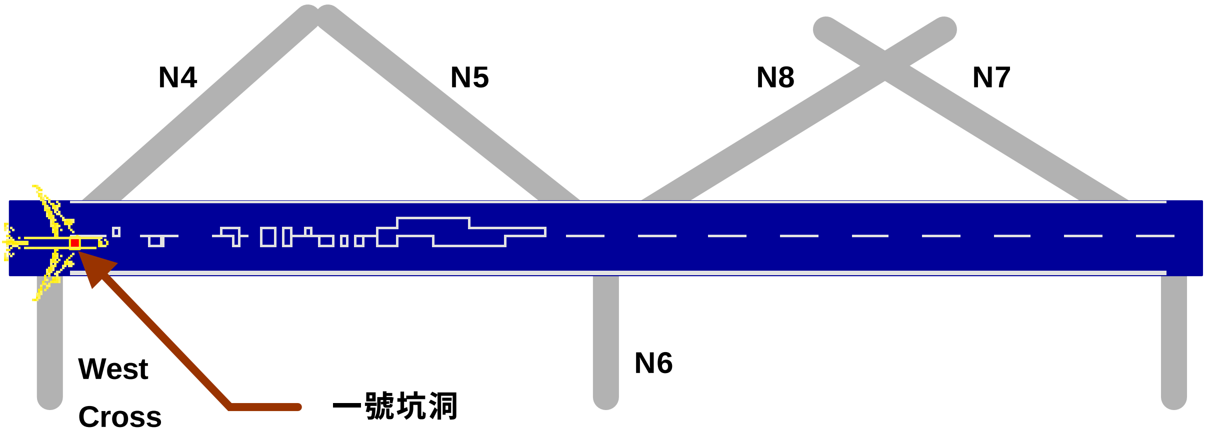

圖 2.2-1　　結構失效順序說明-1

2. 左下機腹撞擊第一輛挖土機（紅色方塊所示），造成左下方機身、電子艙及貨艙損?。

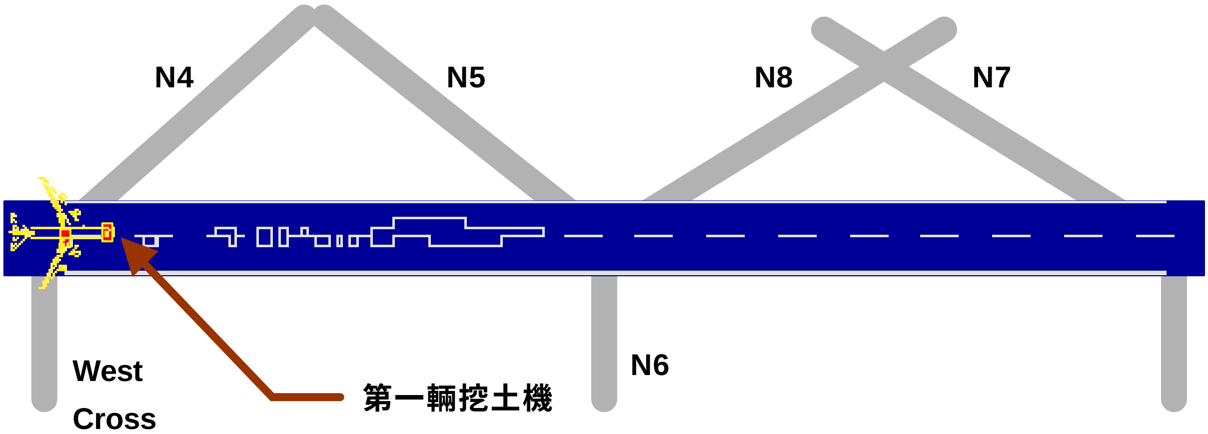

圖 2.2-2　　結構失效順序說明-2

3. **隨後滾行過程中，飛機水平尾翼亦遭第一輛挖土機撞及前緣及其它結構，以致斷裂掉落，翼內燃油外洩燃燒。**

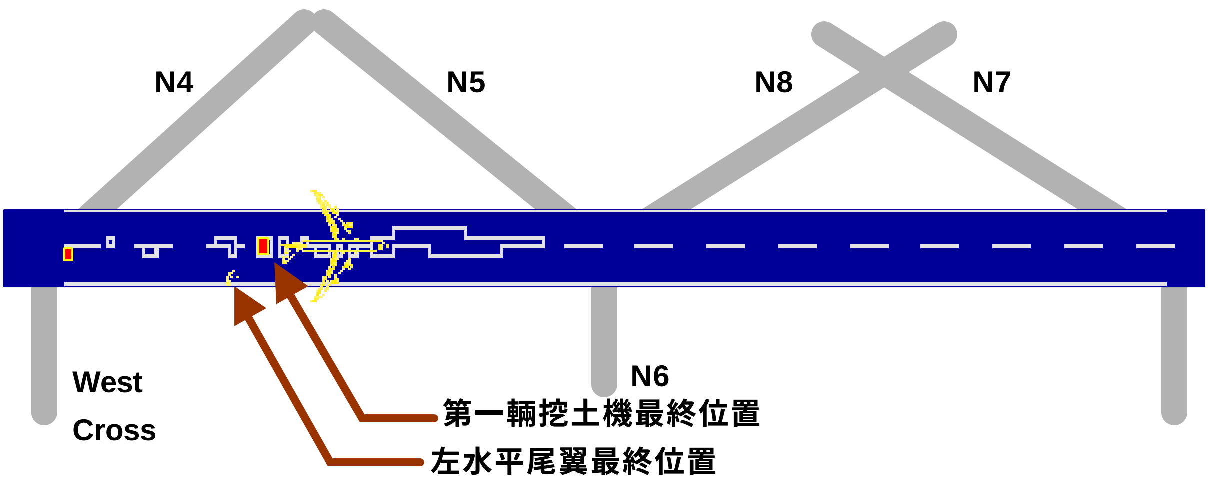

圖 2.2-3　　**結構失效順序說明**-3

4. 1 **號及** 2 **號發動機撞擊** 11 **號坑洞旁之鋼筋與第二輛挖土機（紅色方塊所示）後掉落，由於機身撞擊及推力不平衡緣故，機身開始反時鐘旋轉。**3 **號發動機亦於** 11 **號坑洞附近擦撞地面與機翼飛離，掉在停機坪。**

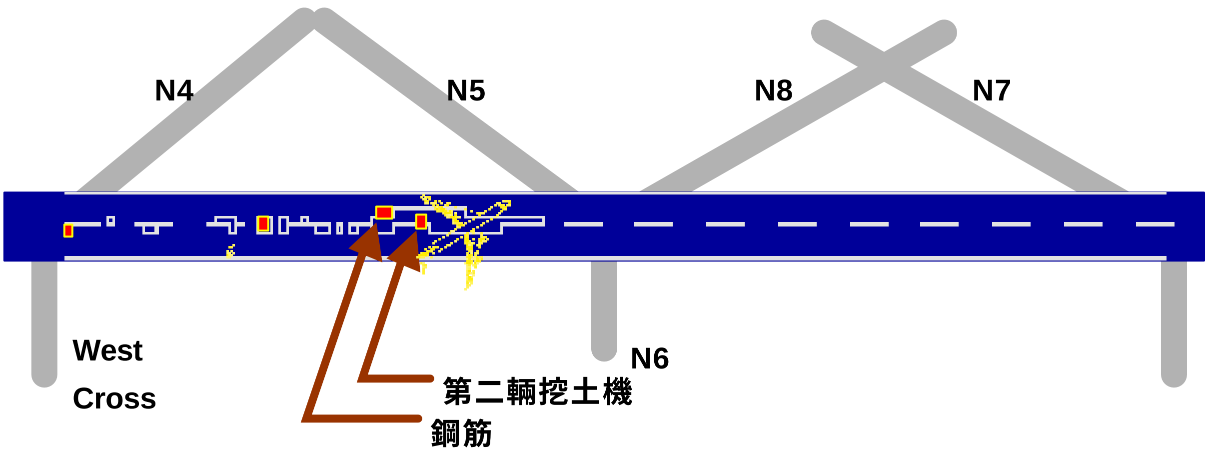

圖 2.2-4　　**結構失效順序說明**-4

5. **滾行至** N6 **滑行道前，旋轉之機身與兩台壓路機（紅色方塊所示）撞擊後致使機身斷裂，後機身隨後滑至該滑行道左側。距跑道頭** 1430 **英呎處之草坪上開始有火燒之跡象，及散落燒?之貨物。**

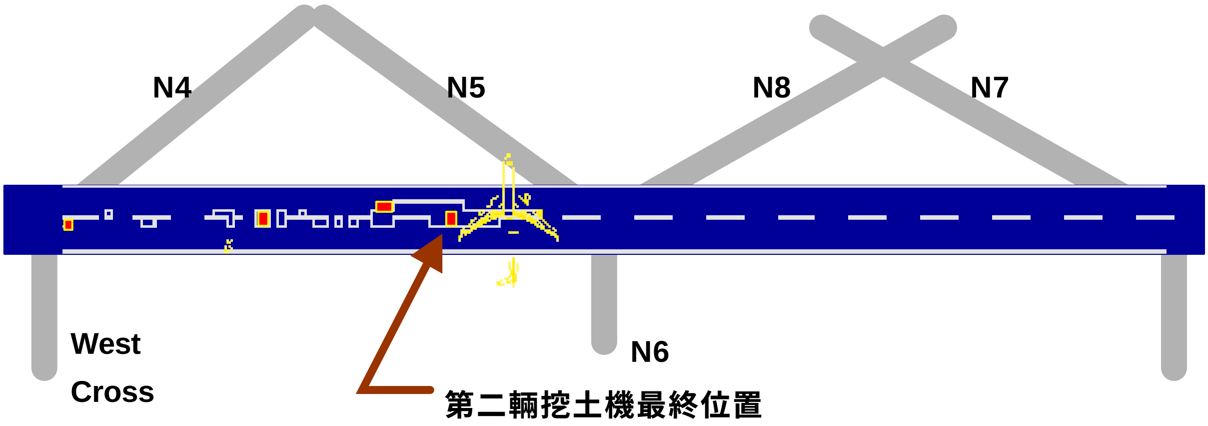

圖 2.2-5　　**結構失效順序說明**-5

6. **當前段機身繼續旋轉向前時，左翼尖撞及南方之水泥人孔（紅色方塊所示）後解體脫離，並使該機停止反時鐘旋轉，繼續向後滑行。**

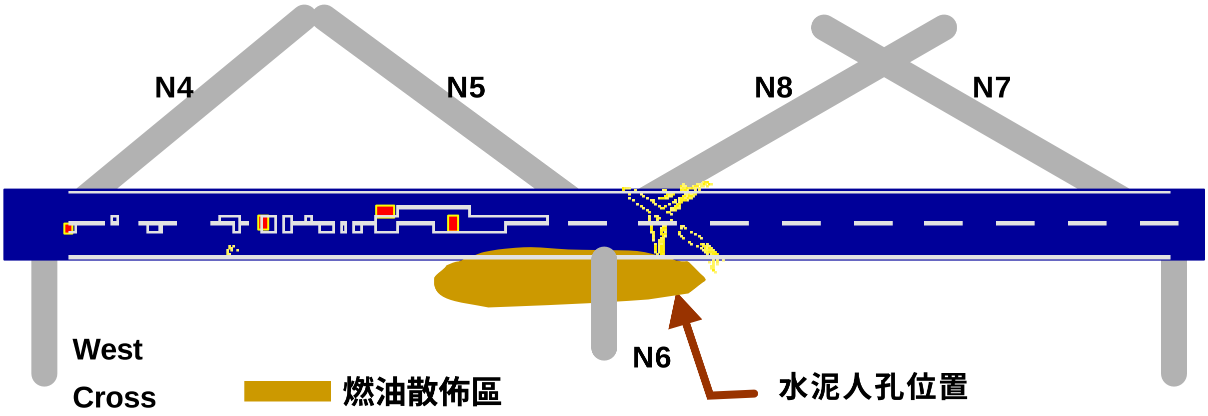

圖 2.2-6　　**結構失效順序說明**-6

7. 4 **號發動機在該機向後滑行中撞擊地面水泥塊（紅色方塊所示）後自右翼解體脫離。**

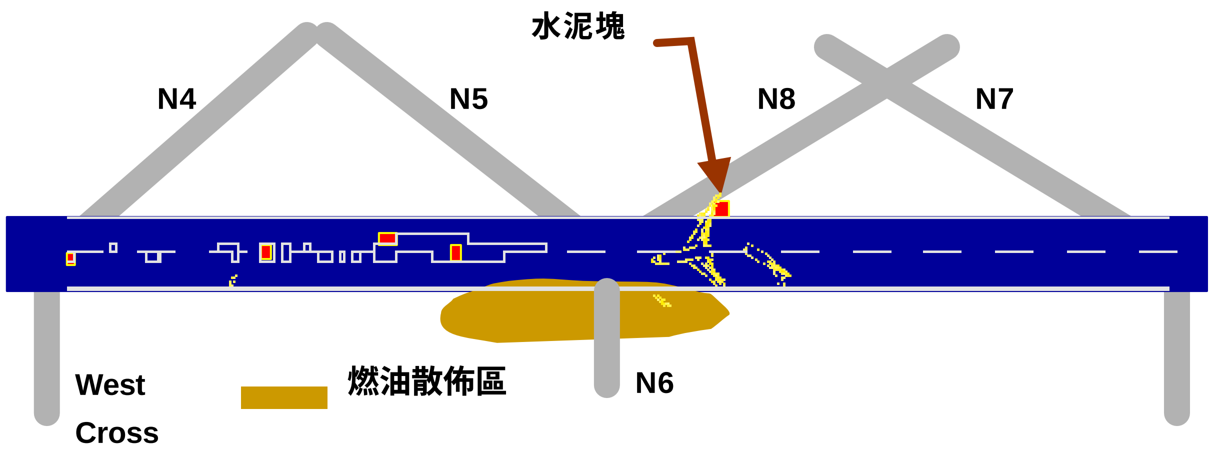

圖 2.2-7 **結構失效順序說明**-7

8. **當** 4 **號發動機脫離右機翼後，前段機身因撞擊力量再度反時鐘旋轉，直至最終停止位置。**

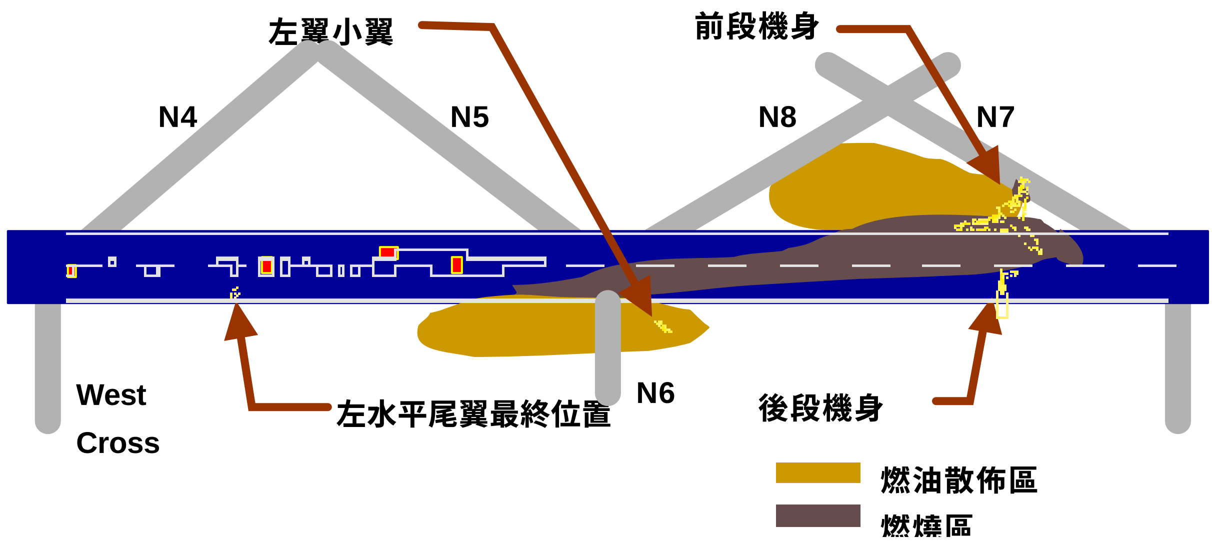

圖 2.2-8 **結構失效順序說明**-8

2.3 事故當時之中正機場

事故發生時，中正機場 05 右跑道 N4 及 N5 滑行道間因部份道面整修而關閉。之前，曾有計畫將 05 右跑道改成 NC 滑行道，但於事故發生時尚未實施。因此，05 右跑道除了局部路段作為滑行之用外，仍然為一跑道。

2.3.1 N1 滑行道中心線標線及中心線燈

2.3.1.1 N1 滑行道中心線標線設計

民航局民航機場土木設施設計標準規範、國際民航公約第十四號附約及美國聯邦航空總署民航通告均對滑行道中心線標線設計及設置有標準規範，詳如第 1.10 節。

由 N1 滑行道轉入 05 右跑道之滑行道中心線彎道切線點至 05 右跑道頭之南側邊緣距離為 32 公尺，而由 05 右跑道頭之北側邊至由 05 右跑道轉入 N1 滑行道之滑行道中心線彎道切線點之距離為 35 公尺。根據民航局民航機場土木設施設計標準規範第 3.8.5.1 節，N1 滑行道中心線標線應由 N1 滑行道轉入 05 右跑道之滑行道中心線彎道切線點向 05 左跑道方向再延伸 20 公尺，且由距 05 右跑道頭之北側邊 23 公尺至 05 右跑道轉入 N1 滑行道之滑行道中心線彎道切線點亦需繪製滑行道中心線標線。

根據國際民航公約第十四號附約第 1 冊第 5.2.1.3 節之標準規範，中正機場滑行道中心線標線設計應由 N1 滑行道中心線導引至 05 右跑道頭及 05 左跑道頭。但 N1 滑行道中心線標線在 05 右跑道頭標線區域應中斷。

美國聯邦航空總署民航通告 AC150/5340-1H 指出，滑行道中心線標線應於跑道邊中止；但在低能見度情況下（跑道視程低於 360 公尺）之滑行道，其中心線標線可橫越除跑道方位標線外之所有跑道標線。

顯然中正機場之 N1 滑行道中心線之設置不符合民航局、國際民航組織及美國聯邦航空總署之相關規定。此一不符要求條件情形在規範審查、完工驗收及日後作業時均未發現。本會認為民航局缺乏場站設施專業人員負責機場安全監視工作及缺乏安全監控機制為主要原因。

2.3.1.2 N1 滑行道中心線燈

2.3.1.2.1 滑行道燈光系統與 05 右跑道燈光系統互鎖機制

根據國際民航公約第十四號附約第 1 冊第 8.2.3 節（標準）:

"Where a runway forming part of a standard taxi-route is provided with runway lighting and taxiway lighting, the lighting systems shall be interlocked to preclude the possibility of simultaneous operation of both forms of lighting."

如第 1.10 **節所述，中正機場** 05 **右**/23 **左跑道原本設計作滑行道使用，因此，在跑道中心線上架設滑行道中心線綠燈。但因其亦用作跑道，故亦架設白色跑道邊燈。按設計當時（**1973 **年）之國際民航組織標準，兩種燈光系統不須具備互鎖裝置以避免其同時操作。然而，從** 1995 **年開始，國際民航公約第十四號附約之標準及建議措施修訂要求機場架設燈光互鎖機制，中正機場之燈光設備及時配合改變。**

本會認為未能配合國際民航組織標準更新，係因未明確指定單位負責定期檢視國際民航組織標準及更新國內法規所致。

2.3.1.2.2 滑行道中心線燈間距

根據國際民航公約第十四號附約第 1 **冊第** 5.3.15.13 **節：**

"*Recommendation - On a taxiway intended for use in RVR conditions of less than a value of 350m, the lights on a curve should not exceed a spacing of 15m and on a curve of less than 400m radius the lights should be spaced at intervals of not greater than 7.5m. This spacing should extend for 60m before and after the curve."*

由 NP **滑行道進入** N1 **滑行道及由** N1 **滑行道進入** 05 **右跑道之滑行道中心線曲率半徑均為** 60 **公尺。根據國際民航組織建議，半徑為** 60 **公尺之彎道，其滑行道中心線燈之間隔應不大於** 7.5 **公尺。**

由 NP **滑行道進入** N1 **滑行道之滑行道中心線彎道切線點（直線延伸往** 05 **左跑道）至** 05 **右跑道轉入** N1 **滑行道之滑行道中心線彎道切線點距離為** 114 **公尺。當時中正機場** 05 **左跑道宣告最低起飛標準為跑道視程** 200 **公尺。根據國際民航組織建議，該線段應有** 16 **個滑行道中心線燈。然而中正機場當時該區段僅設置不等距之** 4 **個滑行道中心線燈。不符國際民航組織標準及建議措施。**

本會將在第 2.5 **節討論失事當時滑行道中心線燈間距是否增加航機安全操作之風險。**

2.3.1.2.3 故障之滑行道中心線燈

國際民航公約第十四號附約第 1 **冊第** 9.4.23 **節指出，於跑道視程低於** 350 **公尺時，不允許相鄰兩盞滑行道中心線燈故障。本會於事件發生後第四天（**11 **月** 4 **日），發現**

N1 滑行道中心線燈離彎道切線點後之第 2 盞燈故障，第 3 盞燈亮度不足。但據中正機場航務組及機電設備台事件發生前之巡場記錄，及前幾班由 05 左跑道起飛之機長報告，並未發現於 SQ006 起飛前，該二燈有故障情形。當晚事故發生前，亦未有任何飛航組員提出 N1 滑行道中心線燈可能有安全顧慮之報告。

因此，本會僅能認為在 11 月 4 日時，N1 滑行道中心線燈離彎道切線點後之第 2 盞燈故障及第 3 盞燈亮度不足，但無法得知事故發生當晚燈光狀況。

2.3.2 跑道警戒燈之設置

根據 1999 年版之國際民航公約第十四號附約第 1 冊第 5.3.20.1 節，中正機場應架設 A 型之跑道警戒燈（如圖 2.3-1 所示）。依美國聯邦航空總署民航通告 AC120-57A 第 8b 段所述，跑道視程低於 365 公尺時，應使用跑道警戒燈。民航通告 AC150/5340-28 亦提及跑道警戒燈為明確警告任何人已接近使用中跑道之等待位置。中正機場未於 N1 滑行道距 05 左/23 右跑道中心線大於 75 公尺之距離處設置 A 型跑道警戒燈，不符國際民航公約第十四號附約之標準。

若中正機場能按國際民航公約第十四號附約之標準，於 N1 滑行道兩側距 05 左/23 右跑道中心線 75 公尺處架設跑道警戒燈，則該燈距 NP 滑行道中心線為 249 公尺，距 N1 滑行道轉入 05 右跑道處約 175 公尺。失事當晚跑道視程為 450 公尺，飛航組員或能增加一前方為第二類儀降跑道（即 05 左）之線索，詳如第 2.5 節。

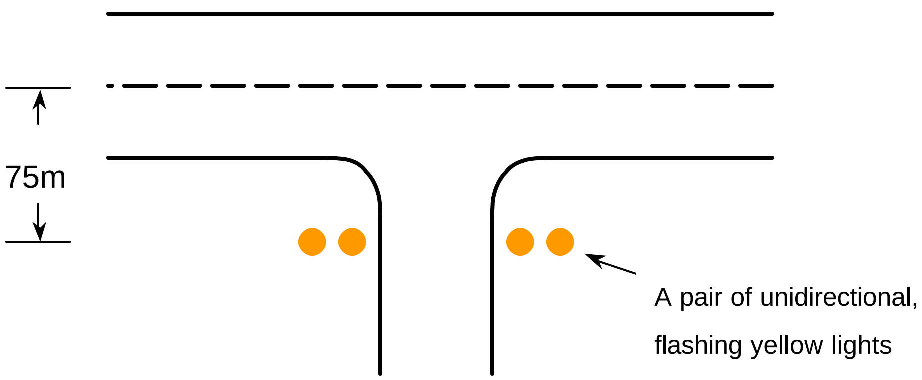

圖 2.3-1 A 型之跑道警戒燈

2.3.3 暫時關閉部分跑道之安全考量

民航局官員說明，05 右跑道除施工部分，其餘仍供滑行之用。對於用 23 右跑道落地之航空器，從 N2 或 N1 滑行道脫離後，朝東經由 05 右跑道滑行至停機坪非常有用。05 右跑道兩端，係貨機使用 05 左跑道起飛時，由貨機坪西向滑行加入 NP 滑行道前之主要滑行路徑（圖 2.3-2）。使用 05 右跑道施工區以外部分滑行，可增加滑行容量，

並確保安全隔離。

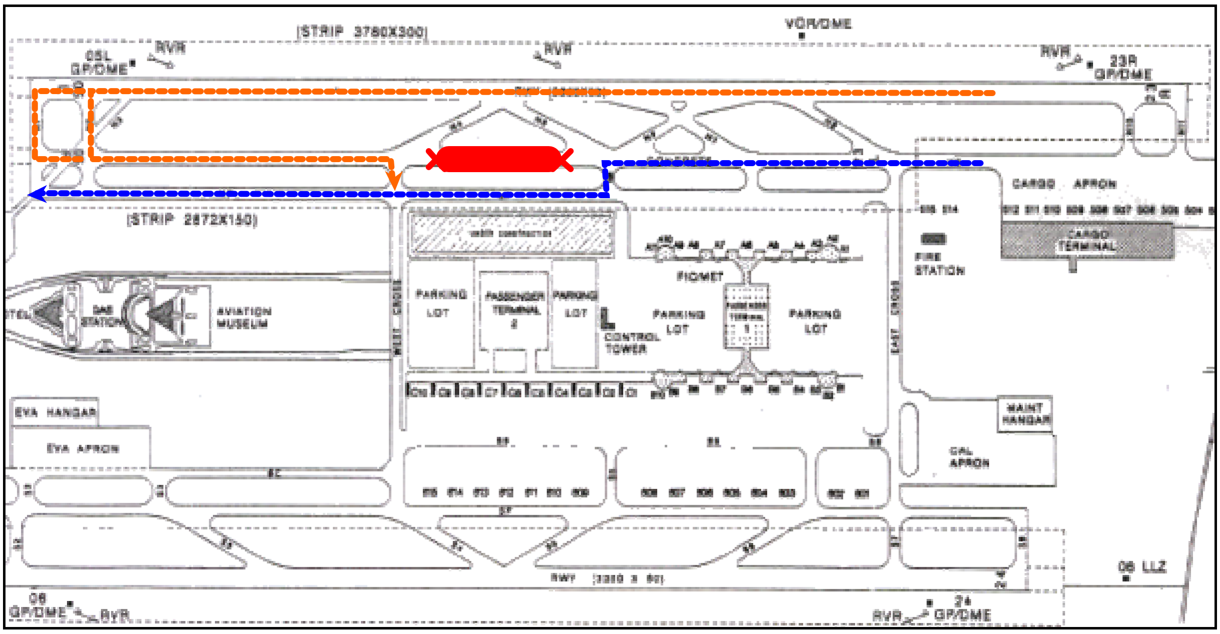

圖 2.3-2　　05 右跑道施工時之滑行路徑

然而，本會認為 05 右跑道施工區有兩項安全缺失。首先，根據國際民航公約第十四號附約第 1 冊第 7.1.3 節（標準），緊鄰施工區應有關閉標線，但並無在 05 右跑道頭標線處漆上關閉標線之要求。其次，根據同一標準第 7.1.4 節，施工區設置之護欄必須易碎。混凝土材質護欄不合國際民航組織標準及建議措施。雖此兩項缺失並未涉及 SQ006 失事。

本會認為國際民航公約第十四號附約中，有關暫時性關閉部分跑道或滑行道之標線指導原則亦有缺失。本會認為國際民航公約第十四號附約第 1 冊第 7.1.2 節條款模糊，因有「…若屬短期間關閉，且飛航服務已提供適當的警告，則標線可省略」用語。第十四號附約並未定義或解釋何謂「短期間」。該原則亦未說明一條暫時性關閉部分跑道但保留部分開放供滑行之用時，該如何處置。因此，國際民航公約第十四號附約，並無類似在 05 右跑道頭設置警示之標準及建議措施。

雖然如此，本會相信中正機場管理部門，在策劃及執行 05 右跑道施工計畫時，應從事風險評估，並考慮採取飛航組員可能因疏忽而從部分關閉跑道起飛之防範措施。發布關閉部分跑道之飛航公告及 ATIS，雖已根據國際民航公約第十四號附約之標準及建議措施發布跑道維修訊息，然而，明確之警告或警示將更加有效。本會同意，如在 05 右跑道入口處設置永久性跑道關閉障礙物難切實際，因對滑行作業有不利影響，但若能在 N1、N2 滑行道及 05 右跑道入口處任一邊，設置暫時性清楚之警告或警示，或許可提供一道重要防線，避免飛航組員進入錯誤跑道。此一暫時性防範措施，應在飛航公告及 ATIS 中說明。因此，本會認為中正機場在 05 右跑道入口處，未作適當警告。從場站設施觀點而言，未能提供可能防範之最後防線，以避免飛航組員誤入 05 右跑道。

2.3.4 於事故發生時 05 右跑道邊燈開啟與否

2.3.4.1 與 05 右跑道邊燈是否開啟之相關證據

本會經審閱所有蒐集資料，以鑑定 SQ006 於滑行進入 05 右跑道起飛時，跑道邊燈是否開啟。

事故發生前後，自機場保安攝影及另一波音 747-400 班機上乘客拍攝之錄影帶，記錄事故發生時 05 右跑道所發生之狀況。從錄影畫面，並無法辨認出 05 右跑道邊燈燈光。本報告第 1.18 節所述機場第 77 號保安攝影所錄畫面，明顯可見 SQ006 機外燈光，若 05 右跑道邊燈為亮著的，畫面中應亦同時顯示。雖當時天氣狀況不良，影像品質不佳，故難對跑道邊燈開啟與否作出結論，但證據強烈顯示，當 SQ006 起飛滾行時，05 右跑道邊燈沒亮。

05 右跑道邊燈與滑行道中心線燈雖無互鎖機制，以避免兩者在事故當時同時操作。但管制員證詞指出，並無任何人曾經開啟 05 右跑道邊燈。此一說法似乎可信，因事故發生時，05 右跑道邊燈並無開啟需要。惟本會無法確定管制員之記憶是否正確。

曾詢問於 SQ006 失事前後，亦於中正機場執行任務之兩位波音 747-400 班機機長，關於 05 右跑道燈光狀況。其中一位機長正沿 NP 滑行道滑行，並準備用 05 左跑道起飛，該機機長稱：「約在滑經 A7 空橋時，看到 SQ006，當時 SQ006 已經在起飛滾行。能看到該機落地燈，但不確定該機是否已離地。當時能見度好，但雨勢很大，雖然是『一陣一陣地』。未見 05 右或 05 左跑道有亮燈，雖然記得 NP 滑行道滑行燈是亮的。當 SQ006 沿著跑道移動時，可見該機落地燈，其他則一片漆黑」。既然該班機機長可看到 SQ006 起飛時之落地燈，則與 NP 滑行道僅距約 110 公尺之 05 右跑道邊燈應是未亮，否則應該看得見。

另一波音 747-400 班機在事故發生前 16 分鐘，從 05 左跑道離場。該機機長稱不記得當通過 05 右跑道時，其跑道邊燈是亮或不亮。

05 左/23 右跑道燈光系統之操作記錄，係為提供跑道視程儀校驗而作。跑道視程列印資料之 05 左跑道燈光系統狀況顯示，05 左跑道於 2313 時（事故發生前 4 分鐘）開啟，約當 SQ006 沿 NP 滑行道滑行，由地面管制轉換到機場管制頻率時。跑道視程列印記錄亦顯示，事故發生不久，機場當局宣布機場關閉後，05 左跑道燈光系統也告關閉。05 右/23 左跑道因僅供非儀器起飛之用，故未架設跑道視程儀。因此無 05 右/23 左跑道邊燈操作狀況之任何記錄。

根據航管通信記錄，約於失事後 40 分鐘，中正航務組主任航務員以手提無線電呼叫中正塔台，要求將 05 跑道燈光開啟（他並未特別指明 05 左或 05 右），證明當時 05 右跑道邊燈未亮。跑道視程列印記錄亦顯示此時 05 左跑道燈未亮，而是在主任航務

員要求將 05 跑道燈光開啟後不久才亮。按證據所示，本會無法判定失事時跑道邊燈之狀況。

跑道上蒐集之兩截跑道邊燈電線 RE239 及 RE240 所作測試結果，呈現互相矛盾情形。RE239 電線上未發現任何電弧損壞，強烈顯示事故發生當時或其後之機場消救車輛活動，該跑道邊燈被撞擊而脫離燈座時並未通電。RE239 線端無電弧情形，似足以顯示當 SQ006 起飛時，05 右跑道邊燈未亮。

在 RE240 位置尋獲的電線線端及線段上的電弧現象，從某些觀點來看，燈被破壞時，線是通電的。事故後所作的測試檢驗顯示，該線有電弧損害情形。假設 RE240 位置之跑道邊燈於飛機殘骸撞擊或消救車輛輾過時是亮的，則當電線脫離線夾時，可能產生電弧。此情節很容易解釋線端上電弧產生的來由，然而卻無法解釋受絕緣層保護的線段上，需待事故發生後，絕緣層被燒毀時，才有可能產生電弧的事實。澳洲運輸安全局實驗室認為 RE240 線束被火燒灼的損壞有一種「邊界效應」的情形，就是線束的插頭端部分絕緣層，因浸泡在某種液體中受保護而未被燒毀，其他部分絕緣層均燒光。若情形確為如此，則線段上的電弧應可能是在失事的 40 分鐘後，當燈光系統被重新開啟，而電線絕緣層已經燒掉的情況下才會形成。中科院所作進一步的測試顯示，線端金屬熔珠的形成，也可能是脫離線夾的線端，隨後於通電狀態下，觸及地面金屬引發電弧而產生。

關于 RE240 電線線段上發生的電弧損害，及其線端上發現的金屬熔珠，本會認為其形成的可能來源如下：

1. RE240 位置的燈具，因受移動物體（如飛機殘骸或地面消救車輛）撞擊而脫離地面燈座，電線連插頭留在插座上，接線端因拉扯離開線夾，此時電線絕緣層仍然完整；
2. 暴露於火場之絕緣層，因燒灼而部分毀損；
3. 失事後 40 分鐘，航務員請求塔台管制員開 05 跑道燈提供照明；
4. 消救作業或強風導致電線線段在通電狀態下相互碰觸，形成短路而產生電弧。
5. 同時，線束線端因碰觸地面金屬物體產生電弧，而形成金屬熔珠。

2.3.4.2 綜合分析

有關 05 右跑道邊燈是否開啟的直接、間接證據經綜整如表 2.3-1.

表 2.3-1　　綜整 05 右跑道邊燈是否開啟的直、間接證據

	證據來源	內容	佐證	無法佐證
1	航管員訪談	未曾開啟 05 右跑道邊燈	無特殊理由開啟 05 右跑道邊燈。程序、訓練及作業上，當 05 右作為滑行道時，不開邊燈。	回憶未必正確
2	航務員要求開燈	事故發生後約 40 分鐘時，塔臺開燈	未要求開燈前，跑道邊燈是關的	燈也可能是開了又關。在失事後 7 分鐘機場關閉時，05 左跑道燈也關閉。
3	電源線 RE239	無放電現象	被航空器殘骸撞擊而脫離線夾時未通電	無法確定該電源線插頭何時脫離插座
4	電源線 RE240	線段上有因電弧損害現象； 線端有金屬熔珠	1)絕緣層燒掉後才有可能 2)扯脫時產生電弧；或開燈後碰觸金屬物體	無法決定何時發生
5	機場第 77 號保安錄影記錄	爆炸火焰及滑行班機在畫面中	航機起飛滾行至失事全程未發現有跑道邊燈	能見度不佳
6	另一滑行中班機乘客錄影	爆炸後 30 秒開始錄，攝錄 58 秒	爆炸後 30 秒開始攝錄的畫面中，未發現有跑道邊燈	不知開始攝錄前 30 秒的狀況
7	另一滑行中班機機長訪談	準備朝 05 左跑道起飛，沿 NP 滑行道滑行至 A7 時，看見 SQ006 的落地燈	未見 05 左或 05 右跑道燈光，但見 NP 滑行道燈亮著。	回憶可能不正確
8	飛航組員回憶	無人確定邊燈是否亮的	第三駕駛員在 West Cross 滑行道時，曾注意到除了前頭很亮的綠燈外，前面一片漆黑。	第一駕駛員認為他記得 05 右跑道邊燈是亮的（有八成確定）。

綜觀上列證據，雖說關於 SQ006 起飛時，05 右跑道邊燈是否開啟的某些證據並無定論，本會認為證據顯示該機起飛時，05 右跑道邊燈未開啟的可能性較高。

2.3.5 交通部民航局及中正國際航空站組織

2.3.5.1 民航局組織

局內平行單位之間（組室與組室或航站與航站），其業務協調係以承辦人對承辦人的方式為之。單位之間出現溝通障礙，無法解決時，即交由雙方主管予以協調。若仍無法解決，則直接轉呈副局長或局長裁示。

兩單位之間（如飛航標準組與航空站航務組）牽涉職務劃分不清問題時，局本部組室可以公文直接要求局屬單位辦理。調查發現局外單位之間，在監理工作的指定及分配上，時有模糊不清情形。例如，局內場站組與每個航空站維護組人員之間，關於場站設施工作分配就不確定。調查也發現，對於業務職掌及工作分配問題的解決，經常被拖延且過於官僚化。例如，局屬單位轄下平行部門之間，無權直接溝通，經常因而導致計畫實施之延誤。所有溝通均嚴守階級模式。

2.3.5.2 民航法規之制定與修訂機制

2.3.5.2.1 民航法規之制、修訂及更新作業

民用航空法相關子法之增、修訂或更新，皆由各業務單位承辦人員自行負責；然而承辦人員多數不具法制實務背景。此情形導致制訂之法規不夠周延，形成法規制、修訂之時間延誤。此外，民航局蒐集有關民航資訊來源的管道，亦受阻於因無法參與如國際民航組織之類的主要國際機構。這也是造成無法及時修訂法規的原因。

業務單位於制訂相關法規時，常利用航空業者之資源（如部分業者之法規部門），衍生法規內涵偏頗及違反公平原則等問題。

民航局組織條例及辦事細則中，均未明確指定一權責單位，負責蒐集、整理有關國際（如國際民航組織、美國聯邦航空總署）相關法規變動之資訊，交由相關單位辦理後，據以更新國內相關法規。甚且，各單位亦未指定專責人員進行相關法規之檢視及更新等工作。

2.3.5.2.2 國內民航法規之制修訂及更新作業現況

民航局於民國七十六年九月三日訂頒「民航機場土木設施設計標準規範」及「民用飛行場助航燈光設置標準規範」以來，即未再依循國際法規更新本國機場設施之規範。訪談民航局相關人員時發現，直至民國八十八年，民航局始恢復對國際相關法規進行瞭解，並計劃於民國九十年底前完成修訂。從飛航安全著眼，遵循國際民航組織之標準及

建議措施作業是很重要的一環；然而，臺灣自從因政治原因退出國際民航組織後，即失去與該組織之聯繫。這種被由主要國際民航諮詢及標準機構隔離的困境，對於臺灣想與國際民航組織之標準及建議措施一致的努力，有負面效應。

2.3.5.3 中正機場之維護督導與安全監督

2.3.5.3.1 機場助航設施之維護督導

中正機場助航燈光系統之維護係歸機電設備台負責，由中正裝修區台督導，中正裝修區台隸屬飛航服務總臺。飛航服務總台與國內各航站同屬民航局之附屬單位。本會認為雖然中正機場負責航站之營運及管理，惟對於該機場內助航設施之維護及人員卻不具管轄權（此一權責屬飛航服務總台）。此外，民航局助航組雖負責技術督導中正機場之助航設施維護，但對機場內助航設施之維護及人員亦不具管轄權。

2.3.5.3.2 安全監督 - 道面施工期間之安全防範措施

如本報告第 1.17.13 **節所述，道面施工時，場站之安全應由航空站航務組負責。工程承包商則負責提供安全措施計畫，由航務組進行審核。航務組及維護組人員於訪談時表示，不熟悉國際民航公約附約中有關於場站施工時之安全措施規範。**

2.3.6 與組織管理相關之機場缺失摘要

1. **設計時符合當時國際民航公約附約標準，但未跟隨國際規範同步修改者**
    - **跑滑道燈互鎖機制；**
    - **等待位置標線處停止線燈。**
    - **跑道警示燈；**
2. **原設計即不合國際民航公約附約標準或建議，在規範審查、施工驗收及啟用後均未察覺者：**
    - **強制指示牌；**
    - **滑行道中心線標線；**
3. **行政管理不當導致之缺失：**
    - **場站施工期間之安全措施；**

- 05右跑道改為NC滑行道之變更過程；
- 未能與國際民航組織之標準及建議措施同步修訂更新：
- 缺乏因應低能見度作業之地面活動導引及管制系統計畫。

本會認為民航局不適當之組織架構及管理，是導致缺失存在之因素。

2.4 飛航管制程序與防範措施

2.4.1 低能見度時之滑行與地面活動指示

民航局之飛航管制程序（ATP-88）訂有滑行與地面活動指示程序，規定管制員在駕駛員或航空器使用人請求時、管制員認為航情或場面狀況需要時，如施工或滑行道關閉時，應頒發進一步滑行/地面活動指示。進一步地面活動指示包括逐步之路線指示。

此一程序亦規定塔台管制員在能見度降低時，尤其是塔台無法目視滑行路徑時，應頒發此一指示。依據座艙語音錄音抄件，當日 SQ006 滑出時，值班管制員未頒發進一步地面活動指示。

中正近場管制塔台業務手冊訂有低能見度時之管制作業注意事項，要求管制員於能見度低於 2,000 公尺時，應使用專用術語「*塔台無法目視部份機場，請注意慢速滑行*」提醒航空器。當日值班管制員未對 SQ006 使用此專用術語。

中正近場管制塔台塔台長表示：航管之低能見度滑行程序係為防止地面航空器碰撞而訂。當地面管制員頒發滑行指示予 SQ006 時，該機為當時地面唯一航空器。此外，地面管制員表示在該機加入 NP 滑行道並交管予機場管制員前，一直能夠目視該機。因此，地面管制員未使用「*塔台無法目視部份機場，請注意慢速滑行*」術語。塔台長進一步表示：國際民航組織之空中導航業務程序（ICAO Doc 4444）及地面活動導引及管制系統手冊（ICAO Doc 9476）均未規定地面管制員在塔台無法目視航空器時應通知該航空器駕駛員。

依據天氣資料，SQ006 滑向 05 左跑道時之能見度為 600 公尺（05 左跑道視程為 450 公尺），中正塔台與 05 左跑道頭之距離約為 2,000 公尺。明確可知，當該機滑近 05 右跑道頭時，塔台管制員無法目視該機。但是，CM-1 在接受訪談時，稱印象中塔台管制員可以看到該機，因在接近 NP 滑行道時收到起飛許可。即使地面管制員曾告知該機「*塔台無法目視部份機場*」，本會亦無法決定此舉對失事之影響為何。然而，本會認為如管制員告知駕駛員「*塔台無法目視航空器*」，CM-1 可能不致產生錯誤印象，以為管制員可以看到航空器，而因此對其所在位置更有警覺。

值班管制員未頒發進一步地面活動指示及低能見度滑行術語，提醒航空器注意慢速

滑行。證據顯示，飛航組員在座艙通話錄音中已自我提醒注意滑行速度，因此本會認為 SQ006 之滑行速度與失事無關。然而，如管制員曾頒發進一步地面活動指示予該機，將可能增強飛航組員之狀況警覺。

2.4.2 機場場面偵測裝備（ASDE）

民航局自民國八十三年七月十九日起開始辦理 ASDE 採購作業，儘管航管作業單位始終對此裝備有所需求，航管程序（ATP-88）亦定有作業程序，ASDE 之採購與架設仍遭延宕。但中正機場架設 ASDE 是否能防止 SQ006 之失事，尚難確定。

在大雨天氣情況下，因電磁波不規則反射，ASDE 顯示幕將因訊號嚴重衰減而難以觀察地面滑行航機動態。SQ006 失事前，中正機場受颱風影響，機場有大量降水情況，因此，ASDE 是否能提供管制員有效資訊以防止 SQ006 失事之發生尚不明確，即使機場管制員曾於訪談時指出 ASDE 可能防止類似失事案件。如機場架設 ASDE 且能提供管制員使用，則仍可能警示管制員 SQ006 錯誤之滑行路徑，從而防止失事發生。

然而，塔台管制員的確能在低能見度時，利用 ASDE 得到訊息，確定機場活動區內航空器與車輛之確實位置，或是與其他航空器／車輛之相關位置。並能監看滑行道與跑道上之航空器與車輛是否依航管指示操作。因此，本會認為民航局應優先編列預算，加速採購作業，儘快在國內航行量較大之機場架設 ASDE。本會並建議該局修正現有機場設計規範，儘速將 ASDE 列為機場標準裝備。基於同樣理由，亦建議國際民航組織將 ASDE 列為機場標準裝備，尤其在能見度低、航行量大之機場。

民航局在 SQ006 失事四個月後，即函請交通部核准於九十年初辦理 ASDE 採購案。然而直到九十年八月十五日該案始獲准許，此時已是失事後十個月。架設 ASDE 之安全措施未能適時推動，係交通部未能體認架設 ASDE 之重要性。缺乏助航設施專業知識及對民航局強化飛安計畫未主動積極支持亦為因素之一。

2.5 飛航組員行為表現相關議題

2.5.1 概述

本節提出與飛航組員行為表現相關之人為因素及組織議題，尤其針對飛航組員可獲得之資訊、組員訓練、新航程序、場站設施、組員狀況警覺及有關組織之安全考量等提出討論。將人為因素分析與飛航操作資料整合可避免資訊重複，亦有助於以一更有條理、合邏輯、精確且嚴謹之架構，探討飛航組員相關議題。此節除提供讀者瞭解事故當晚與肇因及風險相關之因素外，亦提供航空器使用人作為失事預防及安全措施之依據。

2.5.2 飛航組員可取得之機場資訊相關文件

2.5.2.1 飛航公告及內部飛航通告

負責新航中正機場簽派業務之長榮簽派員於訪談中表示，SQ006 **新航組員於起飛前曾收到多份文件，包括電腦飛航計畫、民航局飛航公告、北歐航空系統飛航公告、新航內部飛航通告及天氣資訊等。簽派員表示，為協助飛航組員歸納重點，會在重要資訊上加註標記，例如失事當晚，長榮航務人員曾標記了天氣預測及飛航公告中相關且重要之資訊，但在新航內部飛航通告中有關** 05 **右跑道中心線燈及邊燈狀況則未加標記。與飛航組員** 2000 **年** 11 **月** 3 **日之訪談中發現，**CM-1 **及** CM-2 **皆不記得新航內部飛航通告有任何關於中正機場** 05 **右跑道及滑行道燈之資訊。**

飛航組員須由長榮簽派員準備之各式文件中獲取資訊，但要從多份文件中取得關鍵資訊並不容易。因此，飛航組員可能無法從這些文件中取得 05 **右跑道燈之相關資訊。此外，簽派員所標記之「重要資訊」，亦可能轉移飛航組員對** 05 **右跑道燈資訊之注意力。若簽派員經常加註標記，則可能造成飛航組員習慣性將注意力集中在簽派員所標記之資訊。雖然如此，飛航組員皆表示已知** 05 **右跑道因施工僅供滑行使用。**

2.5.2.2 中正機場航圖

依據與飛航組員之訪談，三位組員皆表示失事當日使用之航圖顯示 05 **左與** 05 **右跑道。出版日期公元** 2000 **年** 7 **月** 7 **日之吉普生中正機場航圖中，**05 **右跑道標示為跑道(詳圖** 1.18-1**)；公元** 2000 **年** 10 **月** 27 **日之修訂版中(生效日期為** 11 **月** 1 **日** 1700Z**)，**05 **右跑道則已改為** NC **滑行道。雖然** SQ006 **飛航組員所使用之航圖已焚毀，但證據顯示，失事當時組員於駕駛艙內使用之航圖為公元** 2000 **年** 7 **月** 7 **日之有效版本。**

失事當晚，航圖中並無說明 05 **右跑道施工之黃頁。吉普生公司表示，該公司發行暫時性黃頁以提醒駕駛員注意相關資訊，包括暫時之進場程序、特殊事件或當一條主要跑道宣告將動工等。然而，吉普生公司並無製作黃頁之義務。**

吉普生公司所發行之黃頁，其資料來源為各國機場當局。黃頁提供駕駛員清楚之機場配置，包括施工位置、跑道關閉部分及其他相關資訊等，作為飛航公告之輔助，然由於吉普生公司正依據民航局發布之飛航指南補充通知書 A007 C015/00**（其中並無跑道施工之相關資訊）修訂其中正機場航圖，將** 05 **右**/23 **左跑道名稱改為** NC **滑行道，因此並未另外製作中正機場之黃頁。雖然如此，飛航組員仍表示皆瞭解** 05 **右跑道施工中。**

2.5.3 飛行前準備

由上節可知，飛航組員皆知 05 右跑道因施工僅供滑行使用，相關資訊除於飛航公告、內部飛航通告及 ATIS 曾經發布外，CM-1 於起飛前對 CM-2 及 CM-3 所作之任務提示亦曾提及。

失事當晚，CM-1 申請使用 05 左跑道起飛。依據與飛航組員之訪談，CM-1 計畫使用 05 左跑道之原因為該跑道可用長度較長且起飛能見度限制較低。當時 05 左跑道之能見度、風速與側風都在新航規定之操作限制內。考慮當時之天氣與跑道狀況，飛航組員選擇 05 左跑道起飛為適當之決定。

飛行前準備其間，飛航組員曾詳讀機場航圖及提示停機坪至跑道頭之滑行路徑，然而航管修改了其申請之滑行路徑。飛航組員於飛行前，會在腦中建立滑行藍圖，包括滑行路徑、檢查點及交叉口等。訪談記錄顯示，失事當晚，CM-1 再次提示其他飛航組員變更後之滑行路徑為：「滑行至 NP 滑行道盡頭後，轉入 N1 滑行道，然後滑行到 05 左跑道」。依據座艙語音記錄器抄件，飛航組員未曾討論及滑行時必須經過 05 右跑道，方可到達 05 左跑道。CM-1 很可能未考慮以航機通過 05 右跑道作為進入 05 左跑道前之提示點，因而直接由 NP 滑行道滑入 05 右跑道。然而，CM-1 於訪談中表示，其最早規劃之滑行路徑為沿平行 05 左跑道之 05 右跑道，抵 05 左跑道頭。因此，CM-1 在滑行前應瞭解 05 右與 05 左跑道間之關係。

2.5.3.1 颱風逼近之起飛壓力

失事發生時，象神颱風在中正機場南方約 360 公里處，並以 12 浬/時之速度向北北東方移動，中正機場天氣狀況為大雨、低能見度且有強風。當颱風更為接近時，天氣狀況將更加惡劣。由座艙語音記錄器抄件及訪談資料顯示，滑行期間，飛航組員曾討論颱風狀況[37]，並瞭解天氣狀況逐漸惡化。CM-1 進一步表示，若延遲起飛，天氣狀況將因颱風逼近而更加惡劣，CM-3 亦有相同考量。雖然 CM-1 指示組員不要心急並小心執行檢查表作業及其他程序，但由於飛航組員擔心颱風影響並希望避開，可能未將適當注意力置於跑道辨識及確認上。

2.5.4 滑行導航

公元 2001 年 6 月，美國聯邦航空總署民航通告 AC120-74 提供了發展與執行滑行操作安全標準作業程序之指導原則，尤指飛航組員於駕駛艙內之作業，本會參考該通告所提供之相關準則，評估 SQ006 飛航組員低能見度滑行時之表現。有關飛航組員之操

作程序記載於該通告第五篇。依據該通告，SQ006 **飛航組員之滑行操作表現及新航操作程序或訓練皆有改進之必要。整體而言，無論飛航組員或新航皆不符民航通告** AC120-74 **所列之要求。**

2.5.4.1 滑行

依據美國聯邦航空總署民航通告 AC120-74**：「運用所有可用資源（包括航向指示器、航站指示牌、標線、燈光及機場航圖等）以確保航機滑行於指定之滑行路徑」。此外，美國聯邦航空總署跑道安全網站之安全提示中指出：「使用儀表以確認在機場中之方位」。在此次事故中，**SQ006 **飛航組員與中正機場在資源運用或場站設施方面皆有所不足。**

失事當晚，飛航組員依循新航波音 747-400 **操作手冊之滑行檢查與程序，將航機正確導引至** NP **滑行道盡頭，當該機由** NP **滑行道經由** N1 **滑行道轉入** 05 **右跑道時，**CM-1 **與** CM-2 **開始執行起飛前檢查程序，**CM-3 **開始執行側風計算，三名飛航組員並未依航圖或相關航向指示參考監控最後滑行階段。此外，組員亦未檢查滑行道與跑道之標線及指示牌，以協助其確認航機位置。飛航組員自** NP **滑行道轉入** 05 **右跑道時之視野狀況將於本報告第** 2.5.7.1 **節討論。**

2.5.4.2 飛航組員之警覺

美國聯邦航空總署民航通告 AC120-74 **指出：**

> "*Flight crews should use a continuous loop process for actively monitoring and updating their progress and location during taxi. This includes knowing the aircraft's present location on the route that will require increased attention. For example, a turn onto another taxiway, an intersecting runway, or any other transition points. As the 'continuous loop' is updated, flight crewmembers should verbally share relevant information with each other.*"

依據座艙語音記錄器抄件，滑行過程中，直至航機由 NP **經** N1 **滑行道轉入** 05 **右跑道止，飛航組員間皆進行資訊交換及交互確認。**

依據飛航組員訪談及座艙語音記錄器抄件，當航機轉入 05 **右跑道時，**CM-1 **正執行起飛前檢查表項目，此時其注意力除集中於檢查表外，尚必須跟隨著綠色滑行道中心線燈，並保持約** 5 **浬之滑行速度以防航機在濕滑跑道及強風情形下打滑**[38]**。除了跑道上**

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[37] CVR 15:10:21, CM-3 said "Yah, it【typhoon】is coming in ah, the longer they delay the worse it is lah". CM-1 replied "Yah, worse if we are going to get out, if don't take off ah ….."

[38] CVR 15:15:52 CM-1 stated "It going to be wet slippery I am going to slow down a bit slow turn here"

的「鋼琴鍵」標線外，CM-1 不記得有看見任何標線或指示牌。除跑道中心線燈外，CM-1 無法確定是否看到其它燈光。

當航機轉入 05 右跑道時，CM-2 專注於執行起飛前檢查表。當檢查表項目完成時，航機繼續轉彎並對正 05 右跑道，此時 CM-2 發現 PVD 未正常運作，並將該資訊告知 CM-1。CM-2 表示，當時注意力集中於 PVD 未正常運作一事。在最後這段期間，CM-2 注意力集中在駕駛艙內，相對降低了觀察機外情形之機會。CM-2 並表示，當時未注意到任何跑道方位標線或指示牌，看見 CM-1 跟隨跑道中心線燈導引轉入跑道，跑道中心線燈非常亮，感覺所見即為跑道之「正確影像（correct picture）」。

當航機轉入 05 右跑道時，CM-3 表示正在計算當時之側風，以確定側風量符合公司 30 浬/時之起飛限制。當完成計算時，航機正對正跑道，看見跑道中心線燈，但由於坐在觀察員座位，以致無法看見航機附近之滑行道燈及地面情形。

因此，當航機轉入跑道時，三名飛航組員皆未察覺航機並非位於 05 左跑道。CM-2 及 CM-3 之注意力皆集中於駕駛艙內，CM-1 則專注於使航機保持極低速滑行，並跟隨著綠色滑行道中心線燈轉入跑道，由於三名飛航組員皆未將注意力放在跑道標線及指示牌上，導致喪失航機所在位置之狀況警覺。

狀況警覺喪失可歸因於無法取得或瞭解某一特定狀況所需之必要資訊。對於航空業複雜、機動之工作環境，瞭解並保持狀況警覺非常重要。研究報告指出，人類之工作記憶力（working memory）與注意力有限[39]，因此對於某方面之注意力增加時（如側風量、低能見度、濕滑跑道、跟隨綠色中心線燈滑行、檢查表），對其它事物之注意力（如跑道標線、指示牌、N1 滑行道延伸至 05 左跑道之中心線燈）則相對降低。因此，當注意力及理解力因高工作負荷及環境壓力到達極限時，狀況警覺往往會喪失。

依據座艙語音記錄器抄件及語音分析（linguistic discourse analysis）[40]，飛航組員之談話內容主要與風速及能見度等天氣因素有關。CM-1 談話之 38%、CM-2 談話之 17% 及 CM-3 談話之 81%皆與天氣有關。在當時狀況下，飛航組員專注於天氣狀況為合理現象，但組員應有更好之分工，以確保對其它重要資訊之注意力。

本會認為，飛航組員在天氣惡劣之工作環境下，注意力變得狹隘且專注於天氣狀況上，因此可能未注意到其它重要資訊。飛航組員忽略了機場內顯示航機轉入不正確跑道之相關訊息。

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[39] Endsley, Mica. 1996. Situation awareness in aircraft. In Brent J. Hayward and Andrew R. Lowe（Eds.）, Applied aviation psychology: achievement, change, and challenge: proceedings of the Third Australian Aviation Psychology Symposium. P403-417. Aldershot; Brookfield, Vt: Avebury.

[40] The linguistic discourse analysis was conducted by Dr. Frances Trix, an anthropological linguist specializing in oral discourse analysis, along with Carolyn Psenka, a graduate student in anthropology who has been conducting research in aviation and aerospace, both of Wayne State University, USA.

2.5.4.3 駕駛艙內口頭協調

美國聯邦航空總署民航通告 AC-120-74 **亦指出：「進入起飛跑道前，飛航組員應該口頭上相互協調，以確保跑道之正確及接收到適當之航管許可使用該跑道」。**

航機進入 05 **右跑道前，飛航組員不僅知道其位置，亦相互透過口頭協調確定起飛跑道為** 05 **左跑道，組員亦已獲得航管頒發之** 05 **左跑道使用許可。然而，當航機轉入起飛位置時，組員未利用駕駛艙儀表顯示、跑、滑行道指示牌或跑道配置等資訊，確認其所在位置是否為** 05 **左跑道。**

2.5.4.4 滑行程序

依據新航波音 747-400 **操作手冊、飛航資料記錄器資料及座艙語音記錄器抄件等進行分析，飛航組員之滑行許可、滑行路徑、滑行速度及座艙談話等皆符合例行程序，唯一異於例行程序者為滑行時討論有關備降場事宜。依據座艙語音記錄器抄件、中正機場塔台錄音抄件及三位飛航組員之訪談記錄，該機獲許可之滑行路徑為沿** SS、West Cross、NP **滑行道至** 05 **左跑道，滑行許可中並未提及** N1 **滑行道**[41]**。飛航組員執行滑行檢查與程序時，除由** NP **滑行道轉入** 05 **右跑道外，其餘皆符合新航波音** 747-400 **操作手冊要求。此外，飛航組員並未要求進一步滑行指示（**progressive taxi instruction**），以增加低能見度時導航之正確性。**

依據第 1.17.4.5 **節所述，新航教導駕駛員須使用正確之跑道及滑行道，在複雜之社會科技（**socio-technical**）產業中常見類似標語。然而，除非提供達成目標之具體方法，否則類似之標語，通常只是一種缺乏效率的避免失事或意外事件對策**[42]**。新航之飛航教練手冊（**SIA Flight Instructor Manual**）中規定，教師機師須教導駕駛員有關「滑行路徑安排及狀況與環境警覺」，但對於低能見度滑行作業並無詳細指導原則。新航波音** 747-400 **操作手冊中，亦沒有訂定有關低能見度滑行作業之操作程序。新加坡交通與資訊科技部表示，航機滑行操作應屬駕駛員基本之本質學能（**airmanship**），無必要建立具體之低能見度滑行技巧。此外，新航表示國際民航組織標準及建議措施、歐盟聯合航空法、聯邦航空法或主要航機製造商所公布之文件中，皆無明確規定駕駛員須接受低能見度滑行訓練，而新航係依循業界最佳作法。**

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[41] **中正機場地面控制席（**CKS Ground Control**）頒佈給** SQ006 **之滑行許可為「**…taxi to Runway 05L by Taxiway SS, West Cross and NP**」，管制員於許可中未提及「**cross Runway 05R**」。依據民航局** ATP-88，3-7-2 b**，同意航空器滑行至指定之起飛跑道，而未頒發等待指示時，應特別指明「滑行至」那一條跑道，必要時頒發滑行指示。上述之滑行指示即准許航空器「通過」除了起飛跑道以外之所有與滑行路徑交叉之跑道或滑行道。**

[42] Reason, J. （1997）. Managing the risk of organizational accidents. Aldershot, UK: Ashgate.

2.5.4.5 新航低能見度滑行訓練

雖然事故發生前，業界並無低能見度滑行訓練之相關標準與規範，但依據座艙語音記錄器抄件，飛航組員之滑行操作並不符美國聯邦航空總署民航通告 AC120-74 指導原則（第 8 頁）。新航操作手冊並未對低能見度操作提供指導原則，其飛航組員訓練手冊之低能見度訓練則教導飛航組員「為求安全，必要時應放慢滑行速度；請求航管告知其它班機滑行位置或提供引導車（follow me car）」，但 CM-1 表示，他過去並未受低能見度滑行訓練。

美國聯邦航空總署之跑道安全國家藍圖清楚建議：為協助飛航組員對狀況認知（尤指需自行以航圖辨識場面位置時），確實需要相關訓練。另外，該藍圖建議地面操作行為表現之評估及機場指示牌、標線與燈光等相關知識之測驗，應納入所有關於駕駛員之考驗、認證及每半年之飛航複訓中。標準化之訓練文件及訓練計畫中皆應該包含這些課題（第 10 頁）。此外，*Blueprint* 明確的建議，為了能夠減少潛在的跑道入侵事件，應該發展及實施場面活動訓練計畫，以強調良好之操作技巧及具體的駕駛員行為。這些建議的訓練資料包含以下項目：

- 低能見度滑行（適當時使用駕駛艙模擬器）
- 溝通
- 組員資源管理
- 標準作業程序
- 機場場面指示牌、標線及燈光
- 鋪面配置（Pavement Configuration）
- 近距離間隔之平行跑道
- 等待位置之視覺輔助設施

SQ006 飛航組員並未完整評估機場之天氣狀況對其於地面正確導引航機能力所造成之影響。必須強調，有很多因素會導致複雜系統之崩潰。美國聯邦航空總署跑道安全國家藍圖對所有系統要素（包括飛航組員、航管、機場基礎建設及安全管理系統）皆提出參考依據，關於飛航組員表現方面，新航並無完整機場場面滑行活動訓練。

2.5.4.6 小結

依據美國聯邦航空總署民航通告 AC120-74 之指導原則，發現不論是飛航組員之滑行操作表現，或是新航滑行操作程序及訓練都有改善需要。整體來看，不論是飛航組員

或新航都無法符合民航通告 AC120-74 之基本要求。證據顯示，太多因素導致航空器滑入 05 右跑道而非 05 左跑道，其中部分因素是與飛航組員操作表現有關。概括而論，新航之低能見度滑行訓練與程序並未包含所有目前於航空器滑行方面，被視為最安全且最適當之相關要素。

2.5.5 起飛前檢查

依據座艙語音記錄器抄件指出，三位飛航組員皆未以口頭確認方式，確定進入跑道是 05 左跑道。當航機獲得起飛許可時，飛航組員若執行跑道確認動作，將對安全提供一個額外保障。但飛航組員於對正跑道時，未以中正機場航圖與航機外景像進行交叉確認。

飛航組員應該知道航機位於 05 左跑道時，由駕駛艙看出去景象應有白色中心線燈。此外，05 左跑道前段區域應該有明亮之跑道落地區（TDZ）燈。依據座艙語音記錄器所獲證據顯示，飛航組員曾計劃使用 05 左跑道作為返航時備降跑道，因為 05 左跑道上配置有第二類儀降進場設施。SQ006 起飛前 16 分鐘，有一架亞太地區航空公司波音 747-400 型機由 05 左跑道起飛，當時 05 左跑道第二類儀降跑道燈皆被開啟。在夜間將落地區燈開啟是中正機場的標準作業程序[43]。

新航波音 747-400 操作手冊中，起飛前檢查項目未包含「確認使用跑道檢查」。於操作環境中缺少此檢查項目，可能導致飛航組員無法發掘跑道選擇方面錯誤。若有此項檢查項目，對飛航組員而言，等於多了一項確認航機是否處於正確跑道之方法。依據新航波音 747-400 操作手冊、飛行資料記錄器參數及座艙語音記錄器抄件指出，飛航組員係按照新航訂定程序執行滑行任務。

2.5.6 飛航組員可取得之航機系統資訊

2.5.6.1 主要飛航顯示器（PFD）

PFD 上之儀器降落系統左右定位台指示標記（ILS localizer indicator）和升起之跑道標記（rising runway symbol）提供飛航組員有關航空器位置資訊。本會在滑行模擬時發現，當航機位於 05 右跑道起點但將左右定位頻率設定為 05 左跑道頭時，儀器降落系統左右定位台指示標記與升起之跑道標記，不論是在正駕駛員或副駕駛員 PFD 上，都呈現全刻度（full scale）左偏現象。

起飛前，ATIS 所報雲高為 200 英呎，因此飛行組員於航機離地升空幾秒鐘後，必

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[43] 依據民航於所公佈之 ATP-88 日期 03/01/99 3-4-10,在夜間或白天當能見度低於 4,800 公尺時，應開啟 05 左跑道落地區燈（touchdown zone lights）。參考第 1.18.2.7 中正機場燈光操作程序。

需將目視飛航改為儀器飛航，航機飛行需要關鍵資料（如：航跡、航向、高度、爬升率、空速及其他相關資料等）皆會顯示在兩位駕駛員之 PFD 上。由於 05 左跑道與 SQ006 起飛之 05 右跑道相距 214 公尺（650 英尺），因此儀器降落系統左右定位台指示標記呈現左偏指示。同樣，升起之跑道標示亦非位於中間而是偏左。這些偏移指出航機於起飛前可能不在正確位置。

然而，PFD 之儀器降落系統左右定位台指示標記與升起之跑道標記，通常被駕駛員使用於落地時對正跑道之參考資訊。新航目前並無任何程序規定駕駛員於起飛前必須檢查這兩項指示。

2.5.6.2 導航顯示器（ND）

航機飛行需要之導航資訊（如；航跡、航點、橫向與垂直導航指示，風速及風向及其他相關資訊等）皆會顯示在兩位駕駛員前方之 ND 上。當選定跑道時，ND 上會出現跑道符號，其呈現方式為兩條白線。航機相對於跑道位置則可由航機符號（白色三角形）及標記（如 05L）兩者呈現位置間得知。由於 05 左跑道被選定為起飛跑道，其距離實際意圖起飛之 05 右跑道中心線 214 公尺（650 英尺），因此，航機符號呈現位置是在跑道符號右邊，表示該機很可能不在 05 左跑道，而 05 左跑道標記未改變。

模擬滑行時，ND 於 10 海浬（nm）範圍內呈現一微幅圖像誤差（map error）。ND 呈現範圍可由 10 海浬到 640 海浬。模擬滑行時，當起飛/重飛（TOGA）鈕被按下時，飛航管理電腦（Flight Management Computer, FMC）之經緯度並無改變（無圖像移動）。即使 ND 上航機符號之位置偏離，表示航機不在正確起飛跑道，但 ND 上呈現之位置偏離於 10 海浬的範圍內幾乎無法辨識。另外，05 左跑道標示依然沒有改變。最後，飛航組員都無法回想起於失事當晚航機進行滑行、對正跑道及起飛時，ND 所設定之顯示範圍為何。

2.5.6.3 目視輔助系統（PVD）

2.5.6.3.1 PVD 資訊

新加坡民航局核准之波音 747-400 飛航手冊附錄，第 3 章「正常及異常程序」，第 1 頁敘述：

> "*The flight crew should confirm that when the PVD is selected ON, the display streams right, left and then stops momentarily. The display will then either provide guidance to the localizer centerline or will shutter dependent upon whether the aircraft is in a position for takeoff or not.*"

此程序並未被明訂為有關第三類之運作，而是 PVD 使用之一般程序。新加坡民航局核准之波音 747-400 飛航手冊附錄指出，PVD 可協助飛航組員判斷航機是否位於正確的起飛位置上。

依據座艙語音記錄器抄件、飛航資料記錄器參數及訪談記錄顯示，當 SQ006 自 N1 滑行道轉入 05 右跑道時，CM-2 發現 PVD 並未正常的運作，於是 CM-2 向 CM-1 和 CM-3 報告：PVD 尚未運作。CM-3 回答：PVD 必需在航機機頭方向和跑道的夾角在 45 度內才會作用[44]。然而當航機對正 05 右跑道時，PVD 依然沒有運作，CM-1 表示，既然可以目視跑道，就無須考量 PVD 為何無法正常運作[45]。因此，CM-1 並未考慮 PVD 沒有運作的原因而決定繼續起飛。CM-1 表示他能夠看到跑道，且未將 PVD 作為協助起飛之工具，因此，CM-1 依賴主要的目視線索（中心線燈）執行起飛動作。

從其他亞太地區使用波音 747-400 型機之業者（基於商業考量，刪除識別資訊），取得 PVD 使用之相關資訊。特別是其中一家業者波音 747-400 操作手冊中敘述「使用跑道左右定位台打開導航無線電（Navigation Radio）頁，PVD 提供於地面運作時跑道中心線之指引」。此資訊與前述新加坡民航局核准之波音 747-400 飛航手冊附錄內容一致，兩者皆指出 PVD 可協助飛航組員決定是否位於正確起飛跑道上。

新航運作並不符合新加坡民航局核准之波音 747-400 飛航手冊 PVD 附錄內容，此附錄資訊並未反應在新航操作手冊及訓練文件中。SQ006 飛航組員及新航其他駕駛員（包括資深管理機師）於訪談中皆表示，不知道新加坡民航局核准之飛航手冊 PVD 附錄內容。

2.5.6.3.2 PVD 使用程序

訪談資料及新航波音 747-400 操作手冊中指出，PVD 是一種高可信度之輔助工具，可協助駕駛員於低能見度下，將航機保持在跑道中線。操作手冊中亦指出，波音 747-400 航機若配置有 PVD 時, 必需搭配第三類儀降進場左右定位台，才可在跑道能見度（RVR）不低於 100 公尺的情況下執行 PVD 協助起飛（中正機場 05 左跑道是屬於第二類儀降跑道）。另外，操作手冊中規定，當側風分量超過 10 浬時，不得使用 PVD 協助起飛。因此，SQ006 飛航組員並不被允許於 05 左跑道以 PVD 協助起飛。基於以上環境與操作方面的考量，PVD 於失事當晚只能作為練習協助起飛之用。CM-1 及 CM-2 於失事當晚將 PVD 視為另一項參考的資訊。並沒有任何規定限制駕駛員將 PVD 視為額外的參考資訊以練習 PVD 協助起飛。

機隊中配置有 PVD 之航機，每隔 28 天都必須確認一次 PVD 之可靠度。PVD 確認

[44] CVR 15:16:07 CM-2 “And the PVD hasn’t lined up ah”
CVR 15:16:10 CM-1 “Yeah we gotta line up first”
CVR 15:16:12 CM-3 “We need forty five degrees”

[45] CVR 15:16:23 CM-1 “Not on yet er PVD huh never mind we can see the runway, not so bad…”

作業乃是利用 PVD 協助起飛練習時進行，且練習環境的條件必須優於實際以 PVD 協助起飛時規定之最低能見度限制。而 PVD 可靠度的確認方式為比較 PVD 之指示與視覺上獲得之跑道中心線兩者差異。新航操作手冊中並無規定，PVD 協助起飛練習時必須要有正式宣告。此外，並無證據顯示，失事當晚飛航組員使用 PVD 目的是為了進行 PVD 可靠度確認。

數位新航駕駛員訪談記錄指出（包含三位 SQ006 飛航組員），所有受訪駕駛員皆表示，未曾於線上飛行時，在 CATIII 低能見度狀況下使用 PVD 協助起飛。三位 SQ006 飛航組員表示，平均而言，每年在線上飛行時會練習三至四次 PVD 儀器起飛。另外，新航波音 747-400 操作手冊中指出，新航允許駕駛員使用 PVD 協助起飛在全世界只有 10 個國家。而新航駕駛員為了達到新加坡民航局規定，平均每年練習約四次 PVD 協助起飛。

依據幾位新航教師機師與管理機師之訪談記錄，若在對正跑道時，發現 PVD 未如預期的運作或有不正常顯示，他們應該會思考其中隱含意義。此外，這些受訪駕駛員亦表示，他們應該會在繼續執行起飛任務前，試著找出 PVD 未如預期運作原因。然而這種論點可能都是種後見之明。亦有部分受訪駕駛員表示，他們或許會忽視 PVD 未正常運作情形，因為 PVD 並非必要儀器，目視資訊對起飛而言才是最重要依據。

本會無法判斷三位 SQ006 飛航組員對 PVD 瞭解程度，飛航組員並未提到新加坡民航局核准之波音 747-400 飛航手冊附錄中「PVD 是否運作將視航機是否位於正確的起飛位置而定」。依據新加坡民航局核准之波音 747-400 飛航手冊附錄中之資訊，本會認為，PVD 無法正常運作應可告知飛航組員航機未在正確起飛位置上。然而，由於長久以來對 PVD 使用習慣導致飛行組員不重視 PVD 無法正常運作情形。

2.5.6.3.3 PVD 程序

新航波音 747-400 操作手冊或公司其他操作手冊中，皆無任何處理 PVD 無法正常運作之資訊。

新航波音 747-400 QRH（Quick Reference Handbook）第 NNC.10.6 頁，不正常檢查表－飛航儀器顯示中指出：

EICAS message > PVD SYS CAPT, F/O

這項訊息代表當 PVD 發生故障時，駕駛員並不需要採取任何改正措施去解決此問題，若能見度許可，他們還是可以採用非 PVD 協助目視方式起飛。

PVD 是一種簡單儀器，當航機偏離 ILS 中心線時，它能夠提供一個視覺訊號作為對正跑道中心線之導引。此儀器亦提供駕駛員一些有價值資訊，例如，當航機對正跑道且 PVD 正常運作時，代表航機位於左右定位台訊號有效範圍內（訊號未被遮蔽時）、

航機航向與跑道方向夾角小於 45 度，ILS 頻率已正確設定，且航機位於地面上。相反的，當航機對正跑道而 PVD 無法正常運作，可能表示：

- ILS 頻率未正確設定；或
- 航機不在左右定位台有效範圍內；或
- 航機航向和跑道方向夾角大於 45 度；或
- PVD 發生故障；或
- 其他航機阻擋了 ILS 訊號

因此，當航機對正跑道時，發現 PVD 無法正常運作，若 ILS 頻率設定正確且 EICAS 上無故障訊息顯示，PVD 資訊即告知飛航組員航機未在正確起飛位置。

此次事故中，當航機對正 05 右跑道時，PVD 無法正常運作，因為 PVD 並未在 05 左跑道左右定位台有效範圍內。此 PVD 資訊顯示航機未在正確起飛跑道上。新加坡交通與資訊科技部及新加坡民航局提交許多意見予本會調查小組，強調 PVD 並非作為跑道確認指示器之用。儘管新加坡方面一再強調此一觀點，但新加坡民航局核准之 PVD 附錄所陳述文字很明確表示「PVD 運作與否將視航機是否於正確起飛位置而定」，新加坡民航局核准之 PVD 附錄所陳述文字並未反映出 PVD 並不是作為跑道確認指示器之用。更明確的說，新加坡民航局核准之 PVD 附錄所陳述文字指出，PVD 將提供組員有關航機是否位於起飛位置方面資訊。

若新加坡民航局核准之 PVD 附錄中之資訊能夠落實到新航訓練與操作文件，甚至反應到實際操作上，或許 SQ006 飛航組員可能會參考 PVD 所提示資訊，且更進一步地意識到航機可能不在起飛位置上。失事當晚飛航組員所做評估及行為顯示飛航組員對 PVD、PVD 使用操作原理、注意力限制、高任務負荷及惡劣環境影響等相關知識有限。

2.5.6.4 航機航向參考資訊

航機滑行與對正跑道期間, 飛航組員可藉由磁羅盤上之指針指示及航向指示器得知航機航向，而航機之航向指示器架設於 PFD 上。由於 NP 滑行道與 05 右/23 左跑道平行，因此，當航機沿著 NP 滑行道滑行時，航機之航向指示應為 230 度。當航機由 NP 滑行道轉入 N1 滑行道後，飛航組員原應保持航向 320 度，滑行約 270 公尺後到達 05 左跑道。然而，失事當晚，航機並未如機場航圖顯示由 NP 滑行道 90 度彎入 N1 滑行道, CM-1 由原本航向 230 度作 180 度轉彎，直接滑入航向指示為 050 度之 05 右跑道。

美國聯邦航空總署跑道安全網站上，提供許多安全提示以協助駕駛員滑行時之導航，其中特別指出：「航向指示器在空中或地面皆非常有用，將其與航圖一起使用以保持航機之導航」。另外亦指出：「使用儀表確認在機場之方位」。美國聯邦航空總署民

航通告 AC120-74 亦進一步指出：「航機羅盤或航向顯示器為確認正確滑行道或跑道之極佳目視導引輔助。應該時常使用它，尤其在複雜之交叉口或兩條跑道跑道頭非常接近時」。

雖然 CM-2 曾表示，羅盤於滑行時可以幫助保持方位，但是在最關鍵的滑行階段中（SQ006 由 NP 滑行道經 N1 滑行道直接轉入 05 右跑道），CM-2 並沒有使用航機航向指示器及/或羅盤去確認目視導航的方位。訪談中，CM-1 及 CM-3 亦沒有提到有使用航機航向指示器及/或羅盤去作為滑行時目視導航的輔助工具。羅盤與航向指示器是相當有用的輔助工具，可以幫助飛航組員於滑行時加強他們航機定位及導航的正確性，特別是在低能見度的狀況時。於複雜的滑行路徑及/或不佳的能見度狀況中，運用航向指示器及/或羅盤去協助進行地面導航，在航空業界是種標準的作法。

2.5.7 中正機場場面配置相關議題

2.5.7.1 標線與指示牌

訪談中，三位駕駛員均表示，當航機自 NP 滑行道滑入 05 右跑道時，除了「鋼琴鍵」外，他們不記得看到任何標線或指示牌。

於機場進行現場調查時，觀察到 05 右跑道頭附近設置標線與指示牌，分述於下：

1. 一個黑/紅色指示牌標示「N1/5R-23L」，位於 N1 滑行道西南方；其位置為距離 05 右跑道中心線 54 公尺及 N1 滑行道邊左側 20 公尺處。
2. 05 右跑道上一白色標線標示「05」與「R」；其位置為 05 右跑道上距離 N1 滑行道中心線 60 公尺處。
3. 一紅色「CAT 2」指示牌，位於 05 右和 05 左跑道中間 N1 滑行道左側處；其位置為距離 05 右跑道中心線 140 公尺及 N1 滑行道邊左側 20 公尺處。
4. 一紅/黑色指示牌標示「5L-23R|N1」，位於 05 右和 05 左跑道中間的 N1 滑行道東北側；其位置為距離 05 右跑道中心線 140 公尺及 N1 滑行道邊右側 20 公尺處。

在第 1.16.6 節駕駛員視野研究中指出，駕駛員於駕駛艙內透過擋風玻璃上雨刷清除部分往外看時，能清楚看到機場之視野有限。然而，該研究指出，當航機由 NP 滑行道經由 N1 滑行道轉入 05 右跑道時，以下項目應該是可以從駕駛艙內看到：N1 滑行道指示牌及指引往 05 左跑道之 N1 滑行道中心線燈；05 右跑道指示牌；05 右跑道頭標線與跑道方位標線；及 05 左跑道指示牌。調查指出，當航機由 NP 滑行道轉入 N1 滑行道時(詳見圖 2.5-1)，由 CM-1 之目視參考點應該可以透過擋風玻璃看到「N1/5R-23L」指示牌，圖 2.5-1 中清楚的區域代表 CM-1 於滑行時眼睛能夠看見的範圍。CM-1 表示，航機由 NP 滑行道轉入跑道期間，他一直看著駕駛艙外面並以滑行道中心線燈作為航機

滑行參考。

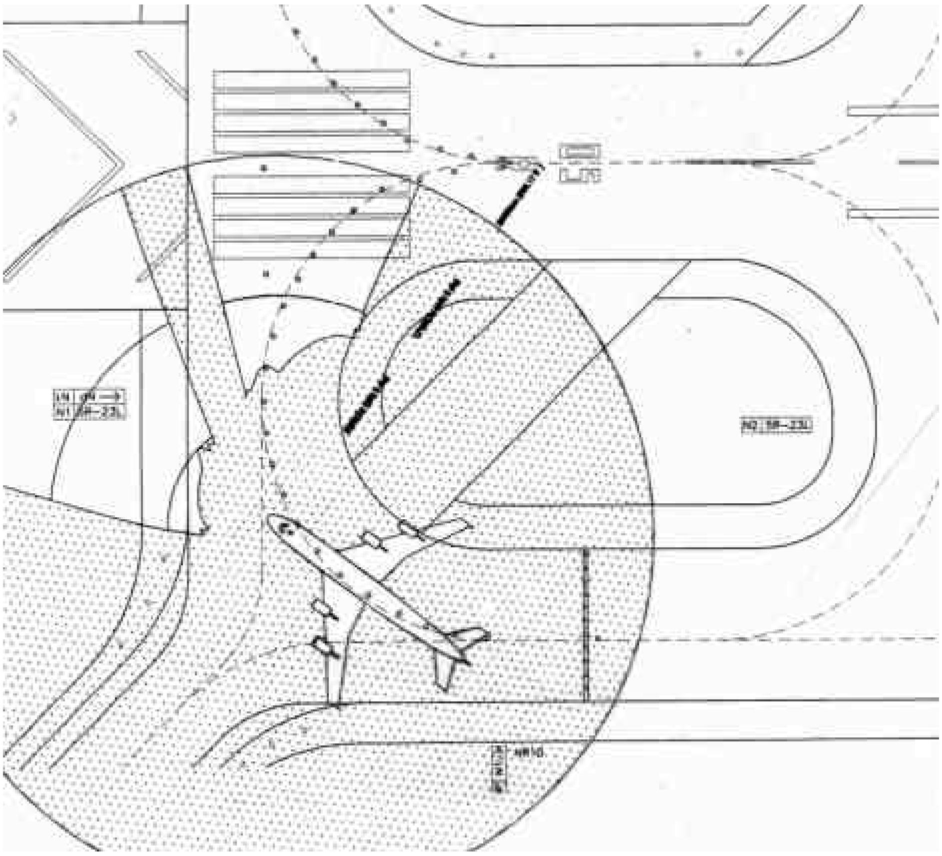

圖 2.5-1 **由** NP **滑行道轉入** N1 **滑行道接近** 05 **右跑道時，正駕駛員之視野。其中環繞航機的圓圈代表以** CM-1 **目視參考點為圓心之** 100 **公尺半徑範圍內。此參考圖係假設駕駛員直視正前方且未移動頭部。**

另外，「N1/5R-23L**」指示牌本身會發光，且當航機轉彎時，該指示牌與航機間的距離約為** 60 **公尺，以當時跑道能見度（**RVR**）**450 **公尺的情況判斷，當航機由** NP **滑行道轉入** N1 **滑行道時，從駕駛艙內應該能夠看得見該指示牌。**

當航機行進入 N1 **滑行道，正要轉入** 05 **右跑道時（詳見圖** 2.5-2**），由** CM-1 **之目視參考點，應該可以透過擋風玻璃看到** 05 **右跑道上之「鋼琴鍵」與指引往** 05 **左跑道之** N1 **滑行道中心線燈。**CM-1 **之目視參考點亦應可透過** CM-2 **擋風玻璃看到跑道方位標線「**05**」與「**R**」，且駕駛艙與** 05 **右跑道方位標線、指引往** 05 **左跑道之** N1 **滑行道中心線燈及** 05 **右跑道上之「鋼琴鍵」間之距離皆在** 120 **公尺內。**

基於以上證據及模擬滑行資料，本會認為，當航機由 NP **滑行道轉入** 05 **右跑道時，若飛航組員有試著向機外搜尋，當時之能見度應該足以讓駕駛員看見跑道方位標線或指示牌，以作為駕駛員確認航機當時位置及地面導航之依據。**

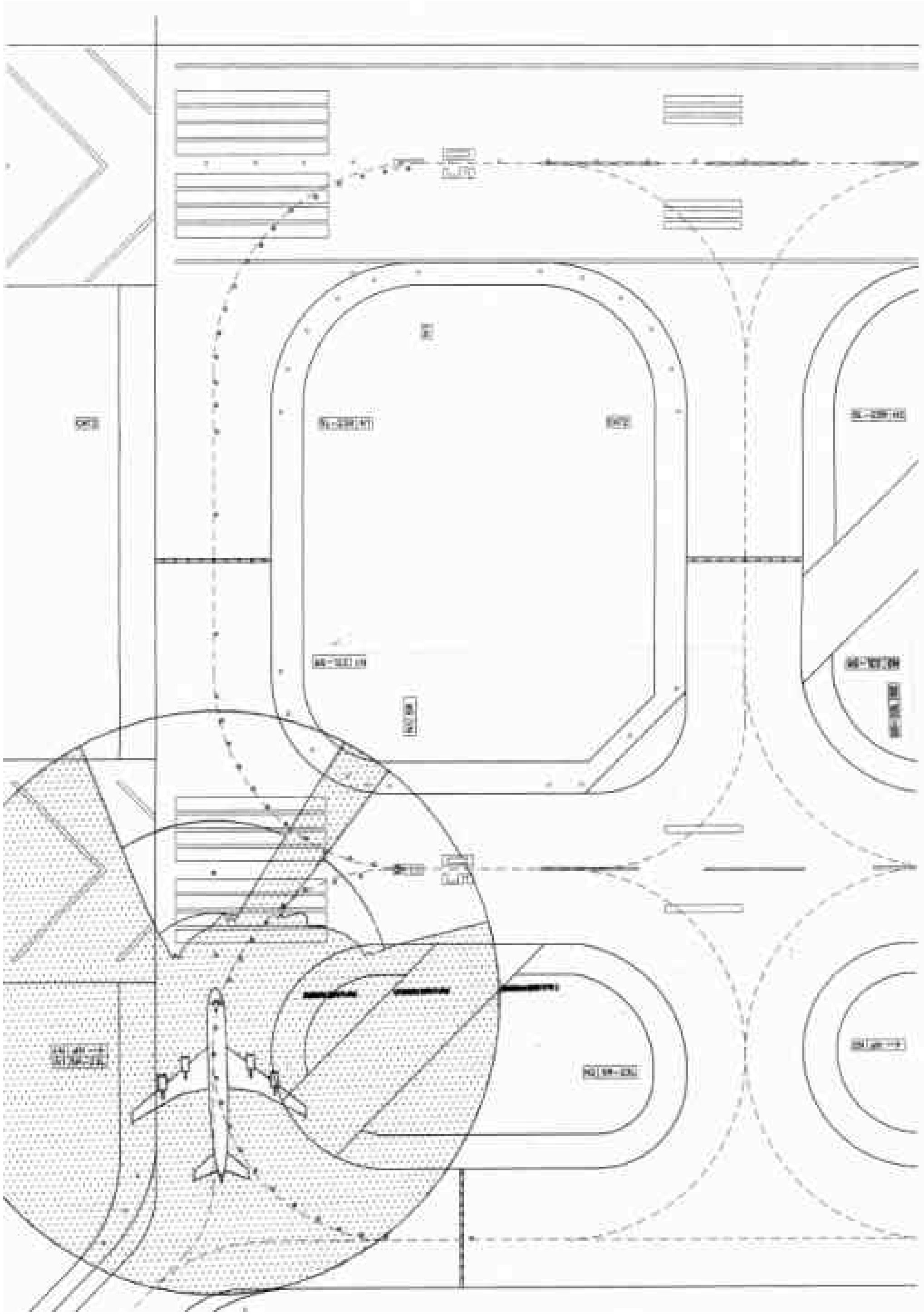

圖 2.5-2　**沿著** N1 **滑行道接近** 05 **右跑道頭及** 05 **左跑道時，正駕駛員之視野。此時** 05 **左跑道能見度為** 450 **公尺，**N1 **滑行道於** 05 **右及** 05 **左跑道間之距離為** 214 **公尺。此參考圖係假設駕駛員直視正前方且未移動頭部。**

2.5.7.2　滑行道燈

2.5.7.2.1　滑行道中心線燈

當航機轉入 05 右跑道時，N1 滑行道上之滑行道中心線燈（其功能為指引航機通往 05 左跑道）應可提醒飛航組員 05 左跑道實際位置比航機目前所在位置更偏西北方。本會已於前一節中表示，失事當晚能見度為 600 公尺及跑道能見度為 450 公尺情況下，飛航組員應該可以從駕駛艙內看見 05 右跑道與 05 左跑道間之滑行道中心線燈。然而，訪談記錄指出，飛航組員皆表示當航機由 NP 滑行道右轉至 N1 滑行道再轉入 05 右跑道時，他們都沒有注意到 N1 滑行道繼續往前延伸的部分有綠色滑行道中心線燈。

依據 2.5.4.2 節所述，當航機轉入 05 右跑道時，CM-2 及 CM-3 注意力放在駕駛艙「內部」有關檢查表作業及側風分量計算方面。另外，CM-1 則專注於保持航機最小滑行速度並且依循綠燈指引滑行進入跑道。滑行期間，飛航組員注意力並未作最有效運用，且未將其注意力專注於重要線索與資訊方面，而該線索與資訊可能有助於飛航組員持續掌握航機所處確切位置。滑行時，飛航組員有限注意力可能專注於：檢查卡與操作程序中要求；於濕滑跑道的狀況下正確地執行滑行操作；持續惡化且不穩定能見度；側風分量計算與公司要求；及在轉入與對正跑道時 PVD 的運作狀況。因此，飛航組員並未意識到各項可取得資訊及其代表意義，亦無利用該資訊於起飛前確認跑道。

2.5.7.2.2　滑行道中心線燈之間隔距離

導引至 05 右跑道之滑行道中心線燈，與 N1 滑行道上導引至 05 左跑道之滑行道中心線燈，兩者間隔上的差異可能是使飛航組員相信其滑入的是正確跑道的一個重要的影響因素。依據中正機場的現場調查資料指出，綠色的滑行道中心線燈是 NP 滑行道上唯一的燈光系統，當滑行道右彎進入 N1 滑行道後，滑行道中心線燈於 N1 滑行道上繼續沿著弧線轉入 05 右跑道，其間隔距離為每 7.5 公尺一個燈。然而，於 N1 滑行道上繼續直行至 05 左跑道之滑行道中心線燈，其間隔距離為 N1 滑行道上轉入 05 右跑道部分之四倍寬。因此，轉入 05 右跑道之滑行道中心線燈在視覺上會比直行到 05 左跑道之滑行道燈更為明顯，因為前者之間隔距離比後者較為密集。此較密集之滑行道中心線燈形成了一條清楚的路徑轉入 05 右跑道，因此，如同平常將航機轉入跑道時一般，CM-1 沿著此一明顯的綠色滑行道中心線燈所形成的路徑，將航機由 NP 滑行道轉入 05 右跑道。

研究報告指出，人類的注意力會被明顯的事物吸引而忽略不明顯的事物[46]。本會認

[46] Wickens, C. D. 2001. Attention to Safety and the Psychology of Surprise. University of Illinois, Aviation Human Factors Division. Savoy, Illinois.

為，當航機自 NP 滑行道轉入 05 右跑道時，轉入 05 右跑道之綠色滑行道中心線燈吸引了 CM-1 的注意力，因此，CM-1 未能注意到導引至 05 左跑道之滑行道中心線燈及所有位於 05 右跑道頭附近地區之指示牌與標線等。

依據 2.3 節有關場站設施中所述，若遵循國際民航組織所建議的作法，於 N1 滑行道直線部分（由 NP 與 N1 滑行道連接之弧形轉彎處往前至 05 左跑道間），應該會有 16 個間隔距離為 7.5 公尺之滑行道中心線燈，如此一來，N1 滑行道上較密集的中心線燈將可能幫助駕駛員們瞭解他們所在的位置，並降低滑行錯誤發生的可能性。

2.5.7.2.3　跟隨綠燈滑行

當 CM-1 被問及為何在機場圖中顯示自 NP 滑行道至 N1 滑行道需直行 324 公尺後方能到達 05 左跑道中心線，而他卻由 NP 滑行道直接轉入 05 右跑道時，CM-1 表示，只是跟著綠色滑行道中心線燈，自 NP 滑行道連續右轉進入 05 右跑道，而且當時他相信進入之跑道即為 05 左跑道。

樟宜機場是新航總部的所在地，該機場為了提供安全且有效率之機場服務，採用機場燈光控制和監視系統[47]（Airfield Lighting Control and Monitoring System），其滑行道燈光控制系統（Taxiway Lighting Control System）是利用滑行道中心線燈進行控制，並配合著停止線裝置，避免在滑行道連接處行進的航機有接近的情形發生。當航機飛抵樟宜機場或離場往其他機場時，塔台管制員會將指定的航機滑行路徑上之滑行道中心線燈開啟，並要求飛航組員「跟隨著綠色滑行道燈滑行」。而其他非指定的滑行路徑上之滑行道中心線燈則會被關閉、被停止線燈及其他裝置阻隔、或是其燈光比指定路徑之燈光較不明顯。因此，飛航組員可以很容易的跟隨著塔台管制人員設定的滑行道中心線燈，滑行至指定的停機坪或是起飛跑道。

但是中正機場並無此類的設施，當航機抵達中正機場或離場時，他們必須自己目視判斷正確的滑行路徑，並利用機場圖、駕駛艙內儀表（如羅盤、航向指示器）及滑行道燈、指示牌與標線等協助進行航機滑行操作，以導引航機滑行至他們想要去或被指定去的地方。

有關狀況警覺方面的研究指出，當人類重複地經歷某些工作經驗或工作環境時，會自我發展出相關的內在運作模式[48]，這種內在模式，有助於人類有效的運用有限的注意力，使人類在不需加重工作記憶力的情況下，就可以將所得的資訊進行整合，產生一種能夠預測事情發展的機制。

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[47] Koh Ming Sue, 2001. The New Airfield Lighting Control and Monitoring System at Singapore Changi Airport. 2001 International Symposium on Airport Infrastructure Development and Management, April 25-26, Singapore.

[48] Endsley, Mica R. 1995. Toward a Theory of Situation Awareness in Dynamic Systems. Human Factors, 37（1）, 32-64.

環境中有些重要的提示可能會和人類腦中建立的模式相吻合，而達到狀況警覺之目的。隨著經驗的增長，這種認知模式（pattern-recognition）與行為選擇（action-selection）很可能會變成某種自發性之自主行為[49,50,51]（automaticity）。這種自發性自主行為，可使人類在熟悉的工作環境中，只需極少的注意力，即能達到較高的工作效率。在這種情形下，自發性自主行為將可減少對注意力之需求量，因而對於提升狀況警覺有正面的影響。但這種自發性自主行為對於新的刺激物（novel stimuli）則往往較不會去注意，如此一來，自發性自主行為對狀況警覺就會有負面的影響，因為自主行為對於新的資訊較不會去注意，當此資訊與例行的工作順序、熟悉的環境無關時就容易被忽略，若被忽略的是一項重要的資訊時，狀況警覺喪失的情況就會發生。

三位飛航組員在新航擔任飛航任務皆至少有五年的時間，他們對樟宜機場「跟隨綠色滑行道中心線燈滑行」的系統都非常熟悉[52]。訪談時，三位飛航組員都表示，他們認為綠色的滑行道中心線燈會導引他們到指定的起飛跑道。當航機由 NP 滑行道經 N1 滑行道轉入 05 右跑道時，在飛航組員的注意力專注於在強烈的側風、低能見度、及濕滑跑道上起飛的情況下，CM-1 可能因為明顯的 N1 滑行道中心線燈，及依循著過去所建立「跟隨綠燈滑行」的行為模式，跟隨著綠色滑行道中心線燈滑行進入 05 右跑道。

當飛航組員跟隨著滑行道中心線燈至 05 右跑道時，他們看見了跑道上的「鋼琴鍵」標線，此時他們都相信他們已經抵達起飛跑道，即 05 左跑道。當他們確信已到達他們將離場之跑道後，即自該跑道起飛。

2.5.7.2.4 中心線燈顏色

滑行道中心線燈的顏色為綠色，其中亦包括 05 右跑道上之滑行道中心線燈。然而，05 左跑道之中心線燈為白色。訪談記錄與座艙語音記錄器資料顯示，飛航組員沿著綠色的中心線燈將航機轉入 05 右跑道，當航機停在 05 右跑道時，三位駕駛員皆表示有看見跑道的中心線燈，然而，並沒有任何一位駕駛員意識到 05 左跑道中心線燈應該是白色而非綠色。在航機轉入跑道時，CM-1 看見沿著跑道之綠色滑行道中心線燈。

「顏色不變（color constancy）」指的是外觀所呈現的顏色不會因亮度改變而不同，例如：中正機場的綠色滑行道燈因晝夜的變化，其亮度會改變，但滑行道燈所呈現的顏色是相同的，即使照射出來的光線其波長分佈產生變化，或者因為光線穿過雨水或/及

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49 Automaticity occurs when routine, familiar, highly practiced skills-based tasks become automatic or habitual with experience. Automaticity enables fast, autonomous, and effortless processing of information （Endsley, 1995; Reason, 1990）.

50 Reason, James. 1990. Human Error. Cambridge UK; Cambridge University Press.

51 Endsley, Mica R. 1995. Toward a Theory of Situation Awareness in Dynamic Systems. Human Factors, 37（1）, 32-64.

52 MCIT 無法提供最近三年飛航組員的電腦飛航紀錄。但是，根據 CM-1 和 CM-2 自八十九年八月至十月之班表顯示，CM-1 飛航的機場中，有 44% (19/43)是具備了「跟隨綠燈滑行」的導引系統。CM-2 飛航的機場中，則有 54% (29/54)是具備了「跟隨綠燈滑行」的導引系統。

刮傷、變形或不潔之擋風玻璃造成波長分佈的變化，物體呈現的色彩（hue[53]）仍然不變。「顏色不變」也意謂著當亮度改變時，人所看到的色彩通常只會有極小的改變[54, 55]。然而，當夜間滑行時，加上散落的雨點、擋風玻璃雨刷留下的痕跡或其他視覺上的雜訊，此時若與被照亮的滑行道或跑道比較起來，確實會導致較低的對比與明視度。但在 SQ006 之前的飛航組員指出，當雨天時於中正機場場面活動時，並不會有判斷燈光顏色方面的困難。

眼睛是由視網膜（rods）與瞳孔（cones）兩種基本的感覺器官所組成的，但兩者在感光度（sensitivity）方面的作用並不相同。高亮度時，視網膜與瞳孔會同時作用（photopic vision），此時眼睛最敏感的波長約為 550nm[56]（綠色）。然而，當亮度降低時，瞳孔會降低它的作用，由視網膜負責視覺的功能（scotopic vision），此時眼睛最敏感的波長約為 500nm（藍-綠色）。感光度由「photopic vision」變為「scotopic vision」的現象稱為「Purkinje」作用，此作用於實務上的應用乃是將路牌做成綠色或藍綠色以提高夜間察覺的機率[57]，此亦為機場場面指引燈光（如滑行道中心線燈及/或邊燈）通常是綠色或藍色的原因之一。因此，當航機對正 05 右跑道時，雖有航機落地燈照射及水滴反射出來的強光，沿著 05 右跑道的綠色滑行道中心線燈應該依然可以清楚的識別。所以，並無所謂「wash-out」作用，亦即不會有飛航組員於航機落地燈之照射範圍內，可能無法辨別綠色滑行道中心線燈顏色之情形產生。事實上，CM-2 於航機轉入 N1 滑行道至對正 05 右跑道期間[58]，已經在航機落地燈開啟的作用下辨別出滑行道中心線燈的顏色，此外，飛航組員亦表示可以清楚的看見跑道中心線燈。

當航機轉入並停止在 05 右跑道頭時，飛航組員的注意力集中在：持續惡化且不穩定的能見度；迫近中的颱風；側風起飛；及 PVD 不正常的運作狀況等。因此，飛航組員並未意識到若他們是在正確的跑道上，中心線燈應為白色的，而非綠色。

2.5.7.3 滑行道中心線標線

N1 滑行道直行至 05 左跑道部分缺少一段 20 公尺長之滑行道中心線標線，然而，本會無法判斷缺乏該段滑行道中心線標線是否會對飛航組員將航機轉入錯誤的跑道中造成影響。證據顯示，航機自停機坪滑行至 05 右跑道期間，飛航組員並未提到過黃色

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[53] Hue is the experience of a chromatic color such as red, green, yellow and blue.

[54] Foster, D. H., Nascimento, S. M. C., Craven, B. J., Linnell, K. J., Cornelissen, F. W., & Brenner, E.（1997）. Four issues concerning color constancy and relational color constancy. *Vision Research*, *37*, 1341-1345.

[55] Goldstein, E. B. （1989）. *Sensation and perception* （3rd edition）. Belmont, CA: Wadsworth Publishing.

[56] Nanometer =nm=10^{-7}cm.

[57] Saunders, M. S., & McCormick., E. J. （1992）. *Human factors in engineering and design* （7th Edition）. Singapore: McGraw-Hill.

[58] CVR 151540 CM-2 Strobes on, landing lights all on
……………………

的滑行道中心線標線。座艙語音記錄器抄件顯示，滑行時，沒有任何一位 SQ006 飛航組員提到滑行道中心線標線。在當時能見度不佳的情況下，黃色的滑行道中心線標線對飛航組員於滑行時之幫助有限。而以場站設施的觀點而言，滑行道及跑道燈乃是飛航組員於夜間滑行時更顯眼的的主要導引工具。

當三位駕駛員被問及通常在夜間是如何將航機正確的由停機坪導引至指定的起飛跑道時，三位駕駛員皆表示，他們會跟隨綠色滑行道中心線燈。沒有任何一位駕駛員表示，會跟隨黃色滑行道中心線。此外，CM-1 表示，當航機自 NP 滑行道轉入 N1 滑行道時，他正注視著航機的右側以確保航機能保持在滑行道的中間，此時 CM-1 在夜間，下著大雨與低能見度的情況下，要藉由 CM-2 的擋風玻璃看見一段距離外不會發亮的黃色中心線，應是非常困難的一件事。

有關人類察覺（human perception）之相關研究指出，在低亮度的狀況下要察覺到不會發光的物體是有困難的[59]。這種視覺系統上的限制是造成跑道需要照明的原因。依據此項研究，飛航組員在晚上能察覺到黃色的滑行道中心線的機率是很低的。若失事當晚，N1 滑行道上有畫著黃色中心線，應該亦不會對飛航組員發現前方還有一條直行的滑行道的機會產生影響。

2.5.7.4 跑道差異相關議題

依據吉普生中正機場圖和民航局 AIP，05 左與 05 右跑道在跑道表面配置上有下列幾項不同處（圖 2.5-3）：

(a) 05 左跑道比 05 右跑道寬 15 公尺（60 公尺對 45 公尺）

(b) 05 左跑道之燈光系統有高強度跑道燈（HIRL），中心線燈（CL），落地區燈（TDZ），和四個燈的精確進場下滑指示燈（PAPI）。而 05 右跑道只有跑道燈（RL[60]）。

(c) 05 左跑道中心線燈為白色。05 右跑道並沒有跑道中心線燈，然而，由於 05 右跑道可作為滑行道使用，因此設置了滑行道中心線燈於跑道中央，且滑行道中心線燈為綠色。

(d) 05 左跑道是屬於第二類儀降進場跑道，05 右跑道只是目視起飛跑道，且兩條跑道在落地區的標線並不相同。

CVR 151550 CM-2 OK green lights are here

59 Goldstein, E. B. （1989）. *Sensation and perception* （3rd edition）. Belmont, CA: Wadsworth Publishing.

60 當 05 右跑道作為滑行使用時，綠色中心線燈則被定義為滑行道中心線燈。

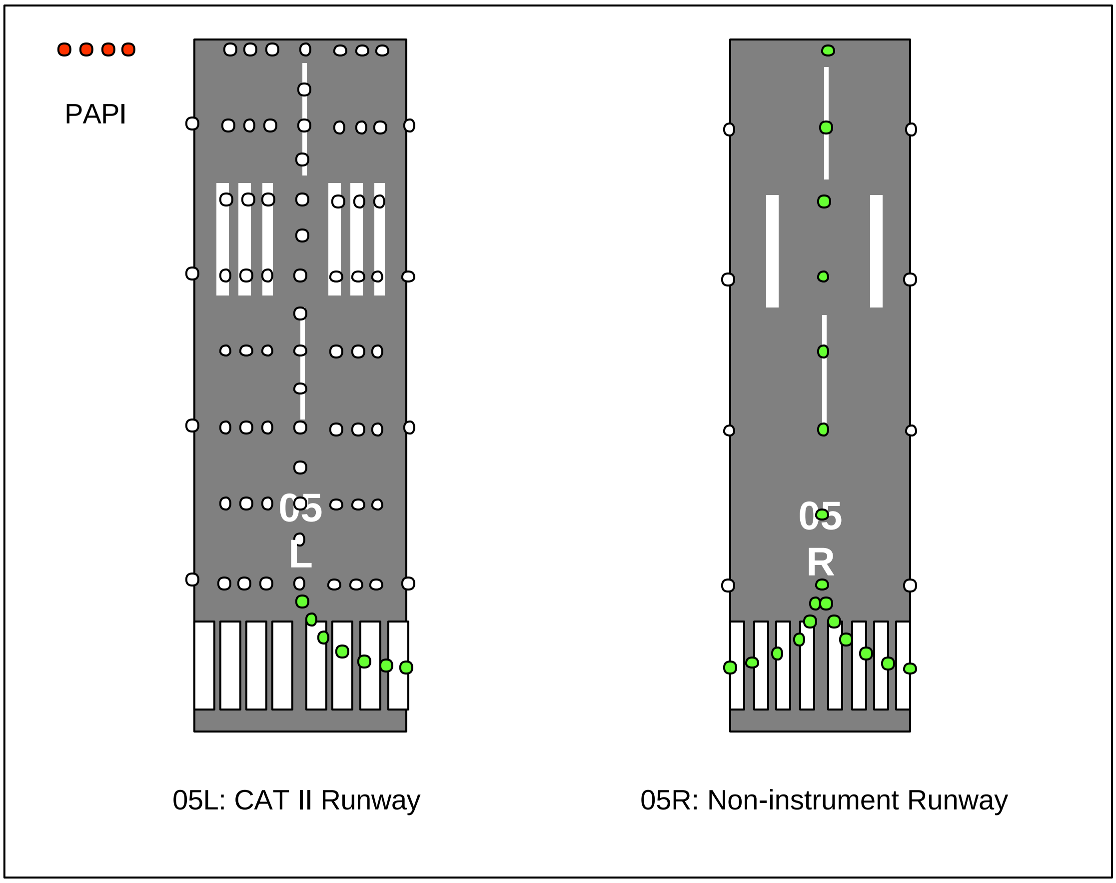

圖 2.5-3　　05 左及 05 右跑道之表面配置圖

訪談記錄指出，新航班機於中正機場通常使用 06 跑道，因為該跑道與新航使用之停機坪距離較近（因此滑行時較節省時間及耗油）。三位駕駛員皆表示，於此次事故發生前，約有二至三年未曾使用過 05 左跑道。然而，飛航組員應知 05 左跑道之表面配置，包含白色中心線燈及明亮之落地區燈。此項事實證據乃依據座艙語音記錄器抄件所指出，飛航組員曾計劃使用 05 左跑道作為返航時之備降跑道，因為 05 左跑道上配置有第二類儀降設施。因此，飛航組員應可辨別所看到之 05 右跑道並不符合第二類儀降跑道表面配置。而且，依據飛航組員夜間飛航經驗，對滑行道與跑道燈光系統應相當熟悉，並應知道典型滑行道中心線燈為綠色而跑道中心線燈為白色。然而，由於不熟悉 05 左與 05 右跑道之表面配置且注意力集中於起飛前準備工作上，使飛航組員未能運用跑道配置不同之資訊。

2.5.7.5　　05 左跑道警戒燈

依據 2.3 節所述，中正機場於 05 左跑道等待區兩側應設置跑道警戒燈。跑道警戒燈是由交替的閃黃燈所組成，用來提醒駕駛員將要進入使用中跑道及作為跑道等待區之指示標誌。如 1.10 節所述，跑道警戒燈位於 N1 滑行道兩側，其距離 05 左跑道中心線 75 公尺及 NP 滑行道中心線 249 公尺。飛航組員由 N1 滑行道轉入 05 右跑道前，航機

距離前方跑道警戒燈之滑行距離為 175 公尺[61]。失事當晚的能見度介於 400 與 600 公尺間。因此，跑道警戒燈對飛航組員而言，應該是另一項告知第二類儀降跑道依然在前方的指引。

依據證據顯示，當航機接近 05 右跑道頭時，由於飛航組員的注意力集中在天氣狀況、起飛前程序、PVD 資訊及跟隨著綠色滑行道中心線燈滑行，他們並不記得當時曾看到任何跑道指示牌、跑道標線、以及除了轉入 05 右跑道之綠色中心線燈外，05 右跑道頭附近的其他任何燈光。本會並無法認定 05 左跑道警戒燈的存在與否會對飛航組員的狀況警覺造成何種影響。但如果當時有裝置跑道警戒燈且跑道警戒燈有開啟，它們可能會使得 05 左跑道等待區更為顯眼，及可能促使 CM-1 警覺到 05 左跑道的正確位置。

2.5.7.6 05 右跑道邊燈狀況

依據 2.3 節所述，在查驗所有已蒐集的資訊後，本會無法確切的判斷事故發生時 05 右跑道邊燈是否開啟。因此，本會將在此章節中討論這兩種可能的情形。

2.5.7.6.1 若 05 右跑道邊燈是關閉狀況

座艙語音記錄器抄件和訪談資料顯示，當 CM-1 將航機轉入 05 右跑道時，他將雨刷開至高速並打開所有的機外照明燈，飛航組員可以看見跑道和綠色的中心線燈。CM-3 表示當完成側風量的計算後，抬頭看到一個非常明亮的環境（bright environment[62]）。飛航組員表示，他們沒有看見任何障礙物在前方的跑道上，他們都相信航機正位於 05 左跑道上，因為機外的影像看來就是像一條「正常的跑道」。

研究顯示，人類在某些情況下，可能會對他們應該看到的景象有某種預期的認知，而在一個環境中重複的經驗，會讓人對未來的事物產生預期的認知[63,64]。基於這種預期的認知，人類往往會看見他們所預期會看到的景象。

失事發生當晚，當航機由 NP 滑行道轉入 05 右跑道時，三位飛航組員都相信綠色的中心線燈會引導他們滑行到起飛的跑道。當 CM-1 跟隨著綠色中心線燈通過 05 右跑

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[61] NP 滑行道至 05 左跑道應設置跑道警戒燈位置的距離為 249 公尺(324-75)；05 右跑道中心線至 05 左跑道中心線的距離為 214 公尺(324-110)；05 右跑道中心線至 05 左跑道應設置跑道警戒燈位置的距離為 139 公尺(214-75)；因此，當航機自 N1 滑行道轉入 05 右跑道時距 05 左跑道應設置跑道警戒燈位置的距離為 139 公尺+22.5 公尺(1/2 05 右跑道寬度)+13.5 公尺(05 右跑道路肩寬度)=175 公尺。

[62] 明亮的環境可能是因為光線在雨滴上反射所造成的。

[63] Jones, D. G. 1977. Self-fulfilling prophecies: Social, psychological and physiological effects of experiences. Hillsdale, NJ: Lawrence Erlbaum Associates.

[64] Endsley, M. R. 2000. Theoretical Underpinnings of Situation Awareness: A Critical Review. In M. R. Endsley; D. J. Garland （Eds.）. Situation Awareness Analysis and Measurement: Analysis and Measurement. Mahwah: NJ. Lawrence Erlbaum Assoc.

道頭的跑道頭標線時，三位飛航組員都相信他們正滑行進入指定起飛的 05 左跑道[65]。

本會認為，飛航組員都確信他們是在 05 左跑道上，且亦無立即或明顯的指示告知他們前方是一條因施工而關閉的跑道。因此，他們看見了預期會看到的影像「一條正常的跑道」，加上飛航組員的注意力都集中在 PVD 的指示、跑道上的能見度、檢查表的完成、及如何在強烈的側風中起飛等事務上，使得他們很可能沒有注意到跑道邊燈沒有開啟的資訊，進而瞭解到他們是在一條錯誤的跑道上。

2.5.7.6.2 若 05 右跑道邊燈是開啟狀況

05 右跑道寬為 45 公尺，而中正機場 05 左、06 跑道之寬度與新加坡樟宜機場的兩條跑道皆為 60 公尺。若失事當晚 05 右跑道邊燈是在開啟的狀況，05 右跑道的寬度與前面提到的四條飛航組員熟悉的跑道寬度比較起來，將顯得較為狹窄[66]。此項跑道寬度差異的訊息，或許可以提醒飛航組員航機是在錯誤的跑道上，但是，在低能見度的夜晚要辨別出跑道寬度的差異並不是件容易的事。然而該項跑道寬度差異的訊息曾被用於八十九年十月廿三日晚上 10 點 45 分。

依據一位在中正機場有定期班機之貨機機長報告指出，該貨機當時獲得塔台許可，經由 NP 滑行道滑行至 05 左跑道準備起飛，該機長表示當天晚上是下雨且有風的天氣，能見度也因下雨的關係而降低。該貨機於 N1 滑行道經過的第一條跑道為 05 右跑道，該機長回想當時的情況，他感覺 05 右跑道像是一條使用中的跑道，因為該跑道中心線燈及跑道邊燈皆開啟得非常的明亮。他無法看到 05 右跑道前方之圍欄及其上之警示燈。該機長表示，他之所以能抗拒這麼有說服力的訊息，是因為他停下來思考並意識到以下的矛盾：05 右跑道寬度太窄；而且也沒有落地區燈；及他意識到跑道的中心線燈是綠色的。

本會認為，當 SQ006 對正 05 右跑道時，如果 05 右跑道邊燈是在開啟的狀況下，飛航組員應該會看見白色的跑道邊燈和綠色的中心線燈，但他們無法看見跑道上之工程標示或設施。在惡劣天氣狀況起飛的情況下，加上飛航組員都認為他們是在 05 左跑道上，因此他們可能無法察覺到其所在的跑道比 05 左跑道窄，而且跑道上沒有落地區燈，及跑道中心線燈是綠色的等資訊，且進一步辨別出綠色的燈應是滑行道中心線燈。飛航組員相信他們是在 05 左跑道上而自該跑道上起飛。

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[65] 例如：於 23:15:50 時，CM-2 關於引導進入 05 右跑道之弧形滑行道燈之評論「OK green lights are here」。滑行道燈於轉彎時，可由航機的右邊看見，且 CM-2 的評論意謂著要協助 CM-1 將航機對正於跑道上。

[66] 本會認為，飛行線上的駕駛員應該有由駕駛艙看出去的 60 公尺寬跑道應是什麼樣子的心像模組，這種心像模組是透過日常的飛行經驗所建立起來的。

2.5.7.7 預期之關閉跑道

座艙語音記錄器抄件及訪談記錄顯示，當航機在 NP 滑行道時，CM-2 告知中正塔台他們已經完成起飛前準備，中正塔台隨即頒佈許可允許航機進入 05 左跑道並於跑道頭等待。當航機接近 N1 滑行道時，塔台頒佈准許於 05 左跑道起飛的許可。CM-2 表示：當時中正塔台頒佈許可的時機給他一個一切均依程序進行的印象。而 CM-1 亦表示：塔台在航機接近 N1 滑行道時下達准許起飛的許可，使他以為管制員可以目視他們。

三位飛航組員都確信他們是在 05 左跑道上，而且他們也知道，05 右跑道 N4 至 N5 滑行道間因施工而關閉，但其餘的 05 右跑道仍可作為滑行道使用。當問到他們認為關閉中的 05 右跑道看起來應該是什麼樣子時，飛航組員表示，一條關閉中的跑道不應該是亮著的。另外，CM-1 表示在跑道「鋼琴鍵」後面應有圍籬或跑道關閉標線。CM-3 表示施工區應有障礙燈和圍籬，而且應有禁止進入之標線或燈號。但是，05 右跑道在失事當晚仍可用來滑行，在飛航公告中已有公告。

民航局表示，失事當晚因 05 右跑道部份區域仍可作為滑行之用，故未於跑道頭放置跑道關閉標線。此外，由於颱風來襲，設置移動式跑道關閉標線可能會被吹起而影響滑行之航機。當時是以警示燈以區別 05 右跑道上之施工區域，但是，從 05 右跑道頭到施工區域的距離太遠，以致於飛航組員無法看到警示燈。

2.5.7.7.1 肯正偏見

此次 SQ006 失事事故中，肯正偏見（confirmation bias）可能影響了飛航組員的判斷能力，這種有關個人假設方面之偏見將會在需減少應變時間或須同時處理數個工作時，降低決策中所需使用的腦部資源[67]。此型態的偏見可能發生於個人或群體，如飛航組員。個人或群體通常會接受那些符合他們的期待或假設的資訊，對於那些和他們預期狀況不符合的訊息，則容易被拒絕或忽視。這種偏見會於資料蒐集彙整時產生錯誤，例如，個人或群體可能只傾向蒐集某方面之資料，而未隨著環境而改變資料蒐集的方向，或未先全盤考量就展開細部深入的研究，也就是說，飛航組員可能只會蒐集那些和他們當時對情況的認知相符的資料而已。

在航空業這種複雜的系統中，通常使用標準程序及檢查表以避免肯正偏見這種人類行為的特性。也因此，美國聯邦航空總署民航通告 AC120-74 中表示「在進入跑道起飛前，飛航組員應口頭相互提示以確認使用的跑道」以避免肯正偏見可能造成的影響，並降低喪失狀況警覺的可能。

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[67] Bainbridge, L. （1999）. Processes underlying human performance. In D.J. Garland, J.A.Wise, & V.D.Hopkin （Eds.）, *Handbook of aviation human factors* （pp. 107-172）. Mahwah, NJ: Lawrence Erlbaum.

此次 SQ006 失事事故中，依據訪談與座艙語音記錄器抄件資料顯示：飛航組員只尋求符合他們想法的資料，也就是符合他們是在正確跑道上的資料，對於儀表指示之衝突現象，則未被全盤的考量。CM-1 也相信，當時管制員頒佈航機可滑行至起飛位置並等待起飛之時機，使他更確定他們是在正確的起飛跑道上。同時，CM-1 選擇起飛是因為他可以看到適當長度的 05 右跑道，而且，對他而言，跑道看起來亦符合他心中對使用中跑道之印象。CM-2 和 CM-3 並未表示任何不同意於 CM-1 決定的意見。依據訪談和座艙語音記錄器抄件顯示，CM-1 似乎認為他所獲得之資料，足以使他合理的忽視儀表指示的訊息。這些衝突的訊息因與飛航組員認定他們是在正確跑道上的認知不符而被忽視。此外，當航機由 NP 滑行道穿過 N1 滑行道進入 05 右跑道時，飛航組員的注意力是集中在將航機轉入跑道，而跑道頭上的「鋼琴鍵」及明顯的滑行路徑導引至跑道中心線燈等訊息，使他們更加相信他們是在正確的跑道上。

2.5.7.8 小結

證據顯示，當航機接近 05 右跑道頭時，飛航組員的注意力是集中在側風量的計算，起飛時之能見度，PVD 的資訊及起飛前之檢查項目等。飛航組員不記得曾看過任何跑道指示牌及跑道方位標線。他們看見綠色的滑行道中心線燈轉入跑道，但是不記得曾看見在 05 右跑道頭附近有其它指示牌或標線（除了跑道都有的「鋼琴鍵」外）。若跑道警戒燈、停止線燈或沿著 N1 滑行道上有較密集之中心線燈，則更能突顯 05 左跑道待命區，亦能增加飛航組員發現 05 左跑道之位置的機會。

飛航組員亦知道，05 左跑道上的景觀應該包括：白色的中心線燈和明亮的落地區燈等。因此，他們應該可以發現他們所看到 05 右跑道並不符合第二類進場之跑道的景象。此外，飛航組員都有夜間飛行的經驗，他們應具有滑行道及跑道燈之知識，及瞭解滑行道燈是綠色的，而跑道燈是白色的。但因為他們最近較欠缺在 05 左及 05 右跑道環境飛航之經驗，加上飛航組員之注意力集中在起飛前工作項目及惡劣的天氣狀況等，這些都影響飛航組員對跑道環境資訊之處理能力。另外，CM-1 選擇起飛是因為他可以看到相當長度的 05 右跑道，而且沒有任何跑道上的目視資訊使他瞭解航機不在正確的跑道上。飛航組員亦未考量儀表指示之矛盾現象。

最後，管制員頒佈許可滑行至起飛位置並等待起飛之時機，似乎使飛航組員更確定他們是在正確的跑道上起飛。

2.5.8 受水影響的跑道相關議題

飛航管制員並沒有被要求必須提供跑道狀況給飛航組員。飛航管制單位判定跑道是否遭受污染（contaminated）大多是仰賴飛航組員提供的報告。雖然飛航組員和飛航管制員都能對跑道狀況進行評估，但是飛航組員有責任謹慎的運用資訊以幫助他們自行對跑道狀況進行判定。新航總機師表示飛航組員依賴飛航管制員提供跑道狀況資訊的說

法，顯示了對於如何判別受水影響的跑道情形的作法的一般見解。

一些亞洲太平洋地區擁有波音 747-400 型機之航空公司訓練飛航組員於遭遇大雨時，使用污染跑道之操作參數執行飛航任務。這是一種既安全又保險的作法，因為此作法可避免飛航組員去猜測跑道應判定為濕跑道或污染的跑道。例如，某家航空公司的操作手冊中表示：「若天氣預報為大雨或大雷雨時，那麼應該預期跑道將會積水，而不論是積水、積雪、積雪泥或積冰等現象，都應使用污染跑道之標準進行航機操作」。另一家航空公司之操作手冊中表示：「當對跑道狀況產生懷疑時，採較保守的作法」及「下大雨時在無溝汶的跑道上操作時，應將跑道定義為污染的跑道且剎車效果將很差」。

大雨的定義是降雨量為 7.6 mm/hr.以上[68]。歐洲 JAA 對污染跑道所作之定義為：

A runway is considered to be contaminated when more than 25% of the runway surface area (whether in isolated areas or not) within the required length and width being used is covered by the following[69]:

- *Surface water more than 3mm deep, or by slush, or loose snow, equivalent to more than 3mm of water;*
- *Snow which has been compressed into a solid mass which resists further compression and will hold together or break into lumps if picked up (compacted snow); or*
- *Ice, including wet ice.*

依據民航局於 311300Z 所發布之 METAR 顯示，當時的雨量為 13.5 mm/hr，在 SQ006 離場前一小時的降雨量為 22.50 mm/hr （METAR at 1500Z）。另外，飛航組員於後推前接收到的中正機場 ATIS Tango 資料顯示當時下著大雨。新航定義污染跑道的準則比歐洲 JAA 之標準更為嚴格，新航將污染跑道的定義為：「一條跑道，部份或全部超過 1 mm 的積水、積雪泥、積雪或積冰或是一條上面有沙及塵土的濕跑道」，但是，當時飛航組員將跑道認定為濕跑道。另外，新航波音 747-400 總機師表示，大部份的跑道（除了有缺陷的之外）都有排水及防止積水的設計，此說法並不是一個避免風險的假設。每位飛航組員皆應評估所有的跑道，因為畢竟每條跑道皆不相同。

研究指出，一條有 1.5%坡度、平滑且無溝汶的跑道（如 05 左跑道），當降雨量低於 10 mm/hr 時即可造成其中心線兩邊 4.5 公尺的區域有超過 3 mm 的積水[70]。因此，在事故發生當時，05 左跑道應該可判定為污染的跑道，因而 SQ006 飛航組員應以污染跑道的標準計算航機性能。當 SQ006 準備起飛時，當時一架正往跑道滑行的波音

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[68] Lankford Terry, 2000 Weather Reports, Forecasts and Flight Planning, McGraw Hills, N.Y..

[69] JAA, JAR-OPS 1, Commercial Air Transportation (Aeroplanes), Section 1, Subpart F, 1.480. (Terminology).

[70] Yager, T. T. （1983）. Factors influencing aircraft ground handling performance. NASA Technical Memorandum 85652.

747-400 型機的機長是以污染跑道計算起飛的標準。一架比 SQ006 早 16 分鐘起飛的波音 747-400 型機的機長也是以污染跑道計算起飛的標準，此機長將航機對正跑道後，等風速降低到最大起飛風速限制內後，才進行航機起飛。

若 SQ006 飛航組員將計畫離場的跑道判定為污染的跑道，他們應該知道，除非風速下降，否則根據 SIA 波音 747-400 型機在污染跑道上起飛的側風限制（15 Knots）是不能起飛的。隨著颱風逐漸近逼，天氣更加惡劣，有可能側風值將不會低於 15 Knots 以符合於污染跑道上起飛的標準。若當時飛航組員判定跑道為污染跑道，當他們在跑道頭等待風速下降時，或許會有額外的時間去評估航機的位置。

2.5.8.1 新航側風限制及跑道狀況判定程序

新航波音 747-400 操作手冊或其他手冊中，並未提供「濕的」或「污染」跑道之認定程序。訪談資料中顯示，新航波音 747-400 總機師及 CM-1 皆認為，提供飛航組員跑道狀況的資訊是機場相關單位的責任。如果飛航管制單位無法提供跑道面或剎車狀況相關資料給予飛航組員時，則可將跑道認定為「濕的」跑道。

航空公司依據航機製造商的建議，將航機操作性能的最大側風限制，依不同的跑道狀況而訂定不同的標準。而污染跑道的起飛側風量限制，比濕或乾跑道側風限制嚴格。因為污染跑道上的方向控制及加速停止的性能，在操控上都比在乾或濕跑道上要困難得多。因此，污染跑道較嚴格的側風限制，提供了航機在惡劣天氣下操作時較大的安全範圍（Safety Margin），尤其是在起飛時發生發動機故障的情況時。

新航對污染跑道的定義較歐洲 JAA 嚴格。這表示新航在受水影響的跑道操作上，採取較高的安全標準。相反的，當在認定跑道是屬於濕的或污染跑道狀況時，SQ006 飛航組員及新航波音 747-400 的總機師採用較低標準的風險管理，也就是，在飛航管制單位未提供跑道狀況資訊時，即將跑道視為濕跑道。

本會的結論是：新航應提供一套程序幫助新航駕駛員在大雨的情況下，對跑道上的積水情況進行判斷。在飛航管制單位未提供資訊的情況下，就將跑道認定為濕跑道，這樣的做法並不是一個安全的風險評估方式，更何況當天 2100 時前的降雨量非常大（降雨量 22.5mm）。

2.5.9 組員合作

飛航組員所忽略的 PVD 指示資訊，為導致飛航組員進入錯誤跑道之一連串事件中最後的防線。依據座艙語音記錄器抄件顯示，CM-2 在該機正要轉入 05 右跑道時，提出 PVD 未正常運作之疑問，當時 CM-1 與 CM-3 對 PVD 之討論內容如下：

CM-1 說：「Yeah, we gotta line up first」；CM-3 說:「We need 45 degrees」；CM-1

接著說:「Not on yet PVD, never mind, we can see the runway, not so bad」，當航機對正跑道後，三位飛航組員皆未解決 PVD 未正常運作的問題。CM-2 並沒有繼續提出 PVD 未正常運作之疑問，CM-1 與 CM-3 亦沒有繼續討論此問題，因而失去了發現航機未在適當的跑道上及預設的左右定位台有效涵蓋範圍內之機會。

2.5.9.1 新航組員資源管理訓練計畫

組員資源管理通常被定義為「有效的運用所有可用的資源，包括設備、工具、程序及人員，達到安全且有效率之目的[71]」。組員資源管理探討的範圍通常包括：溝通技巧、人際關係、壓力管理、工作負荷管理、領導統馭及小組之問題解決方式，而這些理論課程於 1970 年代，即在各大航空公司開始推廣。

組員資源管理訓練計畫通常包括：狀況警覺初訓與複訓、知識與技巧的養成、模擬練習，且亦會在正常的訓練與檢定中，加入組員資源管理相關內容[72]。此課程主要著重於觀念的建立而非技術的養成。

新航的組員資源管理訓練計畫之設計理念，是希望包含飛航組員於飛行線上工作時，所有可能會用到的觀念。新航教師機師於訪談中表示，飛行檢定時，他們會以非正式的方式評量飛航組員如何運用組員資源管理之原則，但此評量方法並不像飛行技術檢定般有一套正式的檢定方式。教師機師表示，他們有時會在熟悉度檢定（proficiency check）之提示中，與飛航組員討論組員資源管理相關的原理及檢討組員運用的狀況。除了以上教師機師所實施的觀察法外，目前新航並無其他有效及可信的方式，評估飛航組員是否具備組員資源管理相關技巧。再加上新航的組員資源管理訓練課程並未參考目前最新的人為因素研究，而進行修改或內容的更新，因此，新航的組員資源管理課程並未包含目前業界認為的最佳組員資源管理教材應有的內容。

美國聯邦航空總署有鑑於傳統組員資源管理訓練所遭遇的問題，於是開創了資格進階計畫（Advanced Qualification Program），要求航空公司透過適應線上飛行訓練（LOFT）中的情境設計，以顯示飛航組員有足夠的能力與技巧，能夠有效地運用組員資源管理與決心下達之原則。

2.5.9.2 新航組員資源管理表現

飛航組員表示，不論是在起飛前或飛行中，他們之間並沒有相處上的困難，且他們

[71] International Civil Aviation Organization.（1992）. Flight crew training: Cockpit resource management（CRM）and Line-Oriented Flight Training *（LOFT）*.（Circular 217-AN/132, Human Factors Digest No. 2）. Montreal, Canada: ICAO.
[72] Wiener, E. L., Kanki, B. G., & Helmreich, R. L.（Eds.）（1993）. Cockpit resource management. San Diego, CA: Academic Press.

認為他們在滑行時的組員資源管理的表現很好。依據座艙語音記錄器抄件顯示，飛航組員間雖然表現出友好的關係，但亦有未主動提供資訊的情況發生，例如，當 CM-3 執行機外飛行前檢查後，他選擇不將其經歷到的環境狀況告知 CM-1。雖然 CM-3 提及他的鞋子被水浸濕，並於駕駛艙中脫掉鞋子，但他們並未對外面的環境可能對安全操作造成的危害作進一步的討論。在任何情況下，飛航組員間完善的溝通是非常重要的。

另外，則是有關飛航組員對於操作上的議題，例如：PFD 上之風速趨勢資訊、PVD 未正常運作及備降機場等。飛航組員並未對 PVD 未正常運作進行更深入的討論。依據 SQ006 飛航組員及新航駕駛員訪談記錄顯示，通常並不會於航機滑行時討論備降機場。如果飛航組員將飛行前備降場之計畫內容計劃得非常完備，則飛航組員於滑行時就可能有多餘的注意力集中在飛航操作上，而非備降場之選擇上。另外，關於天氣的議題則是飛航組員於滑行期間較常討論到的。

由於 SQ006 飛航組員並未依據新加坡民航局所核定之波音 747-400 飛航手冊附錄中有關 PVD 之資訊接受完整的 PVD 訓練，因此，要求飛航組員能夠完全瞭解 PVD 指示所代表的意義是有困難的。然而，失事當晚，確實有足夠的資訊告知飛航組員他們並不在正確的起飛位置上。滑行期間參考助導航設施、所有飛航組員對惡劣天氣進行充分的溝通、監控機外的狀況、交叉檢查航機位置、確認跑道、評估跑道狀況、於滑行間運用機上儀表確認航機位置、及更高標準之組員資源管理等，都是飛航組員可以作到的。CM-3 若能將他在機外進行航機檢查時經歷的天氣狀況，告知其他飛航組員，及組員若能對 PVD 未正常運作的現象作進一步的討論，如此開放的溝通方式也許有助於飛航組員對跑道狀況的認知，並將航機導引至正確的跑道。

新航之組員資源管理訓練計畫若能更加的廣泛，或許能夠幫助飛航組員於滑行與對正跑道時，表現出更好的組員資源管理，但是並無法評估此次的組員資源管理表現是否會影響到此次失事的發生。

2.5.9.3 加強飛航組員角色

雖然 SQ006 機長有要求加強飛航組員協助其計算當時之側風量，但是新航的標準作業程序中，並未對加強飛航組員之職務作具體的定義。新航之管理機師、教師機師及線上之飛航組員都認為，加強飛航組員的工作範圍是由機長決定的；一般而言，為避免影響兩位飛航組員的操作理念，因此在航機起飛和降落時，並不願意將特定的工作或重要的操控責任指派給加強飛航組員。如同其他兩位飛航組員一樣，CM-3 並未注意到航機對正的是錯誤的跑道。因為新航波音 747-400 型機的操作情形可由兩位駕駛員增加到除了兩位駕駛員外還有兩位加強飛航組員，因此作業程序是針對兩位飛航組員設計的。雖然如此，新航的加強飛航組員於航機起降期間，依規定是要待在駕駛艙中，因此，在飛行期間重要的階段，應具體的定義加強飛航組員之角色，並加強相關之檢查與訓練等，使加強飛航組員能夠更有效的被運用。

2.5.10 新加坡民航局飛安督導

依據 1.17 節所述，新加坡民航局負責定期督導航空公司，以確保所有班機之安全運作符合國際民航組織與新加坡民航局之法規要求。新加坡民航局亦負責評估航空公司提供的操作程序與環境，能使飛航組員在空中或地面安全的執行任務，另外，飛航組員的訓練亦在新加坡民航局的督導範圍內。

此次報告中，本會指出了一些新航在飛航操作和訓練方面未被新加坡民航局指出的缺失，這些新加坡民航局負責督導新航飛航操作和訓練方面且和這次事件的道成有關的缺失分述如下：

- 新加坡民航局對其核可之新航飛航手冊附錄的文件管制、分發、及執行等之處置程序並不適當。
- 新航關於 PVD 操作之指導綱領、程序及訓練等，都未能符合新加坡民航局所核定之波音 747-400 飛航手冊 PVD 附錄中之規定。
- 飛航組員在低能見度下滑行之程序和操作訓練不足。

本會認為，新加坡民航局對於新航有關低能見度下滑行、PVD 之程序及訓練等相關督導作業不夠完整，以致於未能在例行督導時發現這些程序與訓練上的缺失。

2.6 生還因素

2.6.1 新航組員之緊急疏散行動與訓練

在本次事件中，組員緊急疏散表現受以下因素影響：強烈撞擊力使航機斷成兩段、撞擊後燃油起火、濃煙、雜物掉落、客艙異常姿態、疏散門打開後緊急疏散滑梯不正常充氣與伸展、艙內地板有異物、部份組員失能、客艙廣播系統失效、組員間溝通困難、兩緊急疏散滑梯在艙內伸展加上颱風、豪雨及黑暗環境。

本會發現兩位客艙組員未開啟所負責之疏散艙門，大部分客艙組員於失事後等待疏散指令而未採取主動。本會相信重要而且是必須之組員緊急訓練、尤其對失事後之危急狀況應加強重視。本會衡量在此次失事中，組員之未達預期表現原因是突如其來之衝擊。本會發現新航「空勤組員緊急裝備及程序手冊」未詳載客艙廣播系統失效後如何指揮及引導疏散程序。致在客艙廣播系統失效後，組員仍然期待駕駛艙或座艙長下達指令，未立即發出緊急疏散指令。雖然如此，本會不能對客艙廣播系統失效是否導致明顯之疏散延誤加以論斷。本會亦無法對客艙廣播系統失效是否間接影響失事後人員存活率作出定論。

雖新航之緊急疏散訓練及程序與業界水準相當，但對於異常天氣、起火、冒濃煙等複合情景之訓練則未曾示範或演練過。本會認為於訓練中模擬較為複雜之情境，並將此列為安全與緊急程序訓練有其必要。這類訓練可加強飛航組員遭遇嚴重緊急狀況之處理技巧、信心與應變能力。

2.6.2 緊急疏散滑梯

2.6.2.1 風速限制

波音 747-400 疏散滑梯依美國聯邦航空法 FAR 25.810 製造。規格要求滑梯在風速 25 浬／小時內，應於六秒鐘內完全伸展。

根據乘客及客艙組員所述，當上艙左側門打開時，滑梯仍留於門上並未立即伸展，經組員推下後始開始充氣，然而由於強風將滑梯吹向上方，該滑梯無法使用。

全球許多航空公司均飛航於風速大於緊急疏散滑梯風速限制地區。於強風時，造成緊急疏散風險相對增加。本會認為，航空業界及政府機關，應考量緊急情況時之風險並研擬降低風險方法。

2.6.2.2 右側 4、5 號門滑梯之非控制下充氣

根據波音公司提供資訊，波音 747 航機疏散滑梯可承受側向之撞擊力為 1.5 G。正常情況下，甚至 90 度側滾時，疏散滑梯不致因本身重量而掉落。然而，若機身承受 90 度滾轉之強烈撞擊加上滑梯本身重量，綜合之側向撞擊力會大於 1.5 G 之設計限制。該機右側 4、5 號門滑梯即因側向撞擊力大於設計限制而在艙內充氣伸展。

疏散滑梯於客艙內發生非操控充氣伸展，會造成人員傷害並有阻礙出口之潛在風險。此次雖未有人因此受傷，但曾困住右側 4、5 號門之客艙組員，造成呼吸困難，所幸該兩員解開安全帶後脫離困境。本會認為航空業界及政府相關部門應評估該風險。

2.6.3 新式緊急裝備

緊急裝備之進步涉及科技創新，其發展常因財務限制而進展緩慢。歷史顯示飛安改善往往來自災難之打擊。本會認為以下觀念可作為改善之生還因素考量。

2.6.3.1 防煙措施

根據生還者所述，在緊急疏散行動初期，大量濃煙與刺激性氣體充斥客艙，只要吸入立即嗆到。毒煙源自燃燒之燃油、客艙配備及乘客攜帶物。要排除此次失事主要危險

如：熱、火、煙及毒性氣體，須有更實際之接方法以發現並減少客艙之危險。

據訪談，上艙很快充滿煙及塵。由於煙囪效應，煙很快就昇到上艙。乘客須無法同時疏散，只能使用有限之通道向疏散出口移動。在此生命威脅情況下，防煙面罩可以求生。防煙面罩觀念非屬新穎，已經多年研究。飛航及客艙組員攜帶安全器材如防煙面罩、滅火器及手電筒等已屬標準作業，然而本次失事，未有任何組員使用防煙面罩。本會發現，客艙組員被訓練在使用滅火器時才戴防煙面罩，飛航組員被訓練在駕駛艙有煙才用防煙面罩。

為使乘客有效利用防煙面罩，此面罩必須輕巧、容易收藏、視線良好、易調整及使用簡單。

本會認為航空業界及相關政府機關應進一步評估乘客及組員使用防煙裝備之需要。

2.6.3.2 高亮度緊急照明燈

在失事後之大火、濃煙及噪音降低人員視覺及聽覺。重要的是，緊急出口及疏散方向立即讓生還者發現。

有些尾艙生還者說未看到緊急疏散門指示燈，另些生還者只看到昏暗緊急燈光。本會認為失事當時，大部分之艙尾緊急疏散燈功能正常。看不見緊急疏散燈係濃煙及灰塵所阻，無法指引生還者疏散方向。現有之緊急燈光系統失事中無法有效發揮作用。

2.6.4 中正國際航空站之緊急醫療與搶救作業

2.6.4.1 緊急醫療程序與醫療協調官

失事時，由於象神颱風正接近台灣北部，中正航空站大部份醫療與救護工作無法依規定運作，在惡劣天候下，中正機場未能在預劃地點安排檢傷分類及進行傷患處理。

本會發現，中正航空站未能按國際民航組織機場服務手冊（ICAO Doc 9137）第 1.1.9, 1.1.10, 3.6.1, 9.2.3 節建議在其「中正國際航空站民用航空器失事處理作業實施要點」及「中正國際航空站航務組消防隊作業手冊」中詳列其緊急醫療程序。惡劣天候之醫療作業與救援程序亦未列入失事處理作業實施要點。

敏盛醫院機場門診部值班人員不清楚誰在失事時應擔任醫療協調官角色。值班人員於 15 分鐘內抵達急救檢傷中心，立即提供急救服務。未有任何敏盛醫院人員受過醫療協調官訓練。

本會發現，中正航空站未按國際民航組織機場服務手冊（ICAO Doc 9137）第 3.6.3, 4.1.6 節建議，明訂醫療協調官之責任及訓練規定。本會認為在規則明訂程序是重要的。.

2.6.4.2　醫院資訊

檢視「中正國際航空站民用航空器失事處理作業實施要點」，發現並未詳列合約醫院之專科醫師及醫療設備，致無足夠資訊決定傷患應送往之醫院。中正航空站與某些合約醫院簽訂之合約，未如國際民航組織機場服務手冊（ICAO Doc 9137）第 3.7.1 節之建議，註明失事時醫院可提供如神經外科手術等各科能力。

中正航空站與合約醫院之合約未指出失事後醫院應提供之特殊醫療協助，亦未詳述事件後之緊急應變程序。然而，民國八十九年七月五日之失事演習手冊未提供此一訊息，本會認為應將其納入「中正國際航空站民用航空器失事處理作業實施要點」。

2.6.4.3　消救人員之人力資源及分工

中正國際航空站所訂之「中正國際航空站民用航空器失事處理作業實施要點」未明訂何人負責救援、使用何種裝備、如何及何時進入機艙，及如何進行後續工作等。例如，該手冊說明軟管手應開闢安全避難通路，供「救護人員」安全登機救人，但手冊其他章節中卻說「搶救人員」應攜帶搶救工具，隨軟管手接近航空器，由此可見，中正國際航空站消救人員之分工不清楚。此外本會亦發現，事故時消防隊員須擔任消防及搶救雙重任務。上述現象皆不符國際民航組織機場服務手冊（ICAO Doc 9137）第 3.3.1 節及 3.6.3 節建議。雖然國際民航組織未明訂消防車或其他車輛最低配置人力，但據實際作業需要，中正國際航空站消防隊至少需 16 人操作 8 輛消防車，2 人操作 1 輛雲梯車，2 人操作 2 輛水箱車，2 人操作 2 輛照明車，8 人操作 4 輛救護車，1 人操作指揮車，另 2 人於消防隊內負責指揮及聯繫工作。因此在重大事故中至少需要 33 人作業。

實際上中正國際航空站消防隊每日輪值人數均少於 30 人，其人力受限於人事制度及勞基法之休假規定，造成該站消防隊每日輪值人數均少於實際所需。由於人力限制，如發生重大失事，該站消防隊人力不足。

本會認為民航局應以此次新航失事教訓，評估中正國際航空站消防隊組織及人力需求。

2.6.5　驗屍

失事後之驗屍工作不但可鑑定傷亡原因，更有助於改善措施，減少未來類似事故中之傷亡。此次失事未充分執行驗屍工作，可能喪失許多有價值之防範資訊。

此次事故後，本會與法務部、內政部協商訂定作業協調文件，以改善驗屍作業及提供主任調查官更多資訊。

2.7 其它飛安議題

2.7.1 座艙語音記錄器電源啟閉時機與相關法規

在此次事件中，由於座艙語音記錄器直到其中一具發動機啟動後才開始記錄，因此並未記錄到本班機起飛前駕駛員在駕駛艙內之準備活動，造成某些與飛航操作及人因分析有關之重要資訊因此流失。

依據新航提供之飛機系統資料，如座艙語音記錄器電源開關設定為「AUTO」（自動）模式而非採手動控制時，其電源開啟時機乃直接受發動機之啟動時機控制。

根據美國聯邦航空法，座艙語音記錄器必須在發動機啟動前，當駕駛員進行飛行前準備工作時，就必須開始運作，且一直連續運作直至飛航結束。

歐盟聯合航空法及美國聯邦航空法對座艙語音記錄器相關規定非常類似，兩者均要求當飛機主電源開啟時，座艙語音記錄器即應開始記錄，從飛行前檢查，一直運作至發動機關閉後之檢查工作完畢止，座艙語音記錄器才可停止運作。

新加坡民航法內，明定機上之飛航記錄器須自起飛滾行始直至落地期間止保持運作，如此之規定並未涵蓋滑行操作以及發動機啟動前之飛航準備階段。SQ006 之座艙語音記錄器啟動時機符合新加坡民航法規定。

國際民航組織之標準與上述情形類似，其規定之記錄時間亦不包括發動機啟動前之檢查階段。因此只要在滑行前開始記錄，即可符合其標準。

基於以上討論，SQ006 之記錄器啟動時機符合新加坡民航法規定及國際民航組織標準。但美國聯邦航空法及歐盟聯合航空法，則要求更早之啟動時間。基於事故調查觀點，座艙語音記錄器若能提早開始記錄，涵蓋至駕駛員起飛前檢查階段之活動，則勢必更有助於事故調查。且目前磁帶式記錄器已逐漸被固態式記錄器所取代，新航維修手冊中所言「為減少記錄器磨損」之問題已不復在。

此外，有關新加坡民航法要求之啟動時間為「自起飛滾行開始」，記錄期間並不包括滑行階段；而國際民航組織之要求則為「飛機藉本身動力開始移動時開始」，則包含了滑行階段，因此有關記錄器啟動時間，新加坡民航法不符合國際民航組織標準。

2.7.2 機場意外事件之報告與追蹤

本會在事實蒐證階段僅蒐集到六件有關飛航服務之意外事件報告。其中包括：兩件航空器落地時進入關閉滑行道案件、三件誤闖跑道案件、一件因資料不全，無法判斷確實原因。

檢視蒐集到之六件意外事件報告，並未發現與 SQ006 失事類似之天氣情況，亦未發現有關聯之處。然而，中正機場啟用長達廿二年，與場站設施相關之意外事件應不只六件。

本會建議民航局建立可靠之意外事件報告系統，推廣系統使用族群，並將此系統之使用列為優先辦理事項。

2.7.3 天氣資料分析

本會於事故發生後，校驗 05 左跑道視程儀（RVR sensor），其準確度符合國際民航組織之規範。依據天氣觀測及該視程儀製造商所計算之結果顯示，在事件當時及之前能見度均大於最低起飛天氣限制（200 公尺）。

跑道視程由消光係數（Extinction Coefficient，跑道視程儀之輸出信號）、跑道燈光設定（Runway Light Setting）以及背景光強度（Background Light）等三個參數，經機場氣象諮詢系統之資料處理工作站計算而得，並傳送至塔台及相關單位之顯示站。因硬體容量的限制，除以上三個參數外，計算而得之跑道視程資料並未錄存。

諸如跑道視程、風向風速、能見度等天氣資料蒐集為事故調查時重點工作之一，世界各主要機場皆能提供適當取樣率之量測及計算數據，以作為研究、分析之參考，中正航空氣象台錄存之氣象參數種類及資料密度，雖符合國際民航組織之標準及建議措施，然對於事故調查或學術研究之需求則尚嫌不足。然而本會於去年九月發布的一份調查報告中，就中正機場氣象站提升其硬體設備以達飛安調查之需求，已提出一改善建議（ASC-AIR-01-09-001）。

2.7.4 新航颱風程序

本會認為新航未明確定義其颱風程序，而執行程序之人員亦未充份瞭解程序內容及本身權責，特別在颱風逼近台北當時，並無一明確之負責單位來執行此項程序，以致事故發生當晚，該程序並未正確地執行。

新航颱風程序將颱風警告分為四個狀況，當公司飛航管制中心發布颱風警告時，各相關單位須以電報方式互相傳遞「緊急」（URGENT）訊息，並在獲知後回報發布單位。依訪談資料及電報檔案顯示，事故前當飛航管制中心以電報方式發布狀況 I 及狀況 II 之颱風警告時，收獲通報之所有相關人員及單位卻未有任何回覆。新航颱風程序中記載，當颱風警告發布時，各相關單位收獲通報後必須回報，但飛航管制中心工作人員解釋，若收獲通報之單位已做好颱風準備，則不需對電報有所回應。本會無法瞭解新航對於颱風警告之實際處理方式及颱風程序中之描述兩者間為何有所差異。

此外，當上述發布颱風警告之電報於下班時間送至各單位時，各單位人員（如新航

波音 747-400 機隊總機師）若已離開辦公室則無法得知並回應此訊息，因此總機師亦並不知事故當晚台北之颱風情形。然而總機師進一步表示，即使得知當晚颱風情形，亦不需與該機機長有所溝通，因為機隊不應干涉機長之決心下達，並應尊重機長執勤時所做之任何決定。

本會同意機長應對其執行之任務須做最後決定，並對該機負完全責任，一位接受充份訓練且合格之機長應能在得到所有可用資訊後，依其專業知識及判斷能力，做出合理之決定。但為確保安全相關資訊皆已傳達，總機師或新航簽派員應確定機長已獲得完整之安全相關資訊。本會認為，若新航能提供一完整之決策機制，並主動提供更多資源協助機長，應能幫助機長在颱風天氣狀況下做出最適當之決定。

根據新航飛航管理手冊，當對機場發布第二級颱風警告時，該機場負責之部門必須立即且完整地告知所有在地面上航機之機長有關颱風的情形。為釐清負責於台北執行新航颱風程序之代理部門，本會分別拜訪了新加坡樟宜機場之新航飛航管制中心、台北中正機場之新航台北站及桃園南崁之長榮飛管部。

經訪談後得知，長榮飛管部為新航於中正機場之地勤代理單位，代理新航包括簽派之飛航作業；新航台北站隸屬於新航客運營業部，提供技術事務以外之飛航服務，當颱風接近中正機場時，新航台北站經理認為應由長榮飛管部告知組員颱風相關狀況，然而，長榮飛管部經理卻表示其負責之主要工作為航務派遣及裝載表準備，並不認為應由其執行新航颱風程序[73]，該名經理更進一步表示，新航並未要求其代為執行颱風程序，亦不知新航之颱風程序為何。之後新航飛航管制中心資深主管澄清，新航之颱風程序為公司內部之程序，並不適用於長榮，但該主管乃無法說明應由何單位負責於台北執行新航颱風程序。

本會無法判定執行颱風程序之缺失對此事件之影響，亦無法判定若於台北負責執行程序之單位被明確指定，且該單位亦確實執行該程序後，事故結果是否會有轉變。但在新航飛航管制中心、長榮飛管部及新航台北站三者間之溝通不良，增加了航空器在颱風情形下操作之風險。

2.7.5 外站派遣作業

如前所述，長榮飛管部為負責新航於中正機場飛航簽派之代理單位，訪談資料顯示 SQ006 之電腦飛航計畫係由長榮一具資格之航空器簽派員於長榮總公司（桃園南崁）所準備。該簽派員蒐集該班次相關天氣資料及新航內部飛航通告後，加上所準備之電腦飛航計畫以電報方式（SITA）傳送至長榮於中正機場之航務課，稱之為天氣資料夾。該室值班人員則將此份天氣資料夾與民航局飛航公告及北歐航空系統飛航公告於候機

[73] 新航及長榮所簽訂地面作業服務之合約乃依循國際航空運輸協會（IATA）之地面作業服務協定（Ground Handling Agreements, AHM810）。

室交由 SQ006 飛航組員。

當簽派員認定所有 SQ006 相關文件皆符合新航之要求後，同意經由長榮航務人員簽放該班機，該航務人員於是代表該簽派員將所有文件交予飛航組員，進行簽放作業。在將文件交遞組員前，航務人員會用螢光筆標示天氣預報及飛航公告相關重點。

訪談時新航飛航管制中心及新航台北站主管皆表示，長榮簽派員於飛行前應對飛航組員進行完整口頭提示，但證據顯示，長榮僅提供飛航組員自我提示（self-briefing）之服務，除交付相關簽派文件外不做口頭提示，但若組員於飛行前有任何問題皆可詢問簽派員。事故發生當晚，交付簽派文件予 SQ006 飛航組員之航務人員並非一符合民航局資格之簽派員，因此，飛航組員對文件內容有所疑問時，須經由電話或公司專用無線電頻率請位於長榮總公司之簽派員解釋。

飛航組員在檢視簽派文件後並未詢問長榮簽派員任何問題，而且飛航組員皆表示知道當時天氣狀況，亦瞭解 05 右跑道因施工而關閉。

本會無法認定事故當晚若能由一位合格簽派員提供完整之提示予飛航組員，對此事件之發展影響為何，但本會認為，若組員必須透過如此不方便之方式才能與合格之簽派員討論簽派事宜，飛航組員可能會在沒有完全瞭解簽派員所提供之資訊下執行任務，其風險將相對提高。

2.7.6 地面導引及導航科技

當空中交通流量增加同時，機場活動區域亦會更加壅塞，如此遽增之航行量將導致航機於低能見度及夜晚等狀況下作業之需求增加。再者，空運服務之需求增加亦反映在機場設計之複雜度上，傳統式設計之程序、技術等並未考慮這些狀況。由跑道入侵事件逐漸上升趨勢顯示，機場設計之可能為跑道入侵事件發生之間接原因。

在複雜之機場環境中，駕駛員若要避免跑道入侵事件之情況發生，最重要之參考資訊應包括：飛機之精確位置及滑行路徑、機場內其他航機位置以及航管單位所發布之活動指示等[74]。八十九年七月六日美國國家運輸安全委員會針對降低跑道入侵事件提出具體之建議；包括建議美國聯邦航空總署「要求所有有定期載客業務之機場應有一套地面活動安全系統以預防跑道入侵事件；此系統應具提供直接警示予飛航組員之功能」[75]。而目前航機上無裝置此類特定技術或系統，協助駕駛員避免跑道入侵事件發生。

[74] Young, S., and Jones, D. "Flight Testing of an Airport Surface Movement Guidance, Navigation, and Control System." In *Proceedings of the Institute of Navigation National Technical Meeting*. Long Beach, California, United States, January 21-23, 1998.

[75] National Transportation Safety Board, *Safety Recommendation Letter to the FAA Administrator*, A-00-66, July 6, 2000.

跑道入侵聯合安全諮詢小組（JSAT）[76]認為；動態式地圖在降低跑道入侵事件方面效果相當好。此外，美國太空總署（NASA）及美國國家運輸安全委員會亦同樣支持這項技術應用於駕駛艙中，以達預防跑道入侵事件之目的。美國聯邦航空總署完成一項評估分析，若於駕駛艙中使用顯示航機機位置之地面動態地圖（加上機場圖），將可減少 43%之跑道入侵事件機會[77]。

駕駛艙內之地面動態地圖顯示器另一項安全特性為：能對未來提供一套完整之地面活動安全系統，同時在系統升級方面，能藉由資訊與技術之連結，增添機場場面所有航機與車輛交通之訊息（架設一相容系統或感應器）等。此外，此系統尚可提供有關飛航公告之圖示描述，例如在因施工而部份關閉之跑道上，顯示不同顏色，這種高層次之技術亦為目前致力發展之方向。因此，地面動態式地圖顯示器及地面活動安全系統之發展不應延宕。許多機場因地面活動安全問題，導致駕駛員於機場內迷失方向，類似此次事故。現今技術顯示，航機上裝有全球衛星定位系統，不但可確認該機位置，同時亦能立即獲得安全上之實質利益。此類系統可幫助駕駛員避開具潛在危險之區域及關閉之跑道，並增進其更精確地在惡劣天氣及低能見度情況下滑行。

駕駛艙地面動態地圖顯示器可提供飛航組員於機場運作時飛機正確位置之資訊，避免類似 SQ006 事故之發生。地面導引及駕駛艙 ND 將更可確保飛航組員滑行至正確跑道。再者，當飛機進入不正確跑道時，可提供飛航組員直接與立即之警告。地面活動導引系統亦可彌補未設立塔台管制雷達系統之不足。如將 ASDE 與駕駛艙地面導引顯示器作比較，管制員使用 ASDE 可能需較多時間方能辨識或偵測出有關機場運作範圍中發生問題之位置。加上管制員必需與飛航組員建立無線電通話及等待飛航組員依航管提供之資料作出反應或採取行動，導致使用 ASDE 系統反應時間加長。

最後，如將駕駛艙地面動態地圖與航管使用之進一步滑行指示比較，則駕駛艙地面動態地圖將可提供 SQ006 飛航組員更完整、更容易獲得、以及更加有效之助導航資訊。

2.7.7 獨立調查機關

依循國際間最佳之作法，許多國家已成立或將成立獨立之航空器事故調查機關。新加坡政府尚未成立類似機關。

依上述國家經驗可知，若一調查機關同時兼具法制及監理角色時，將無法在其調查作業中客觀、徹底地發掘安全上之缺失，並提出適當改善建議。在正常調查程序中，必須對法制監理機關所負責之法規、政策、措施、程序以及該機關在事故中所扮演之角色

[76] As part of the FAA’s “Safer Skies” agenda, the Commercial Aviation Safety Team (CAST) formed the runway incursion Joint Safety Analysis Team (JSAT) in October 1998.

[77] [77] Bergman, Charles K. 2001. At the Breaking Point: The Ever-increasing Risk Associated With Runway Incursions in the Rapidly Expanding Global Aviation Environment. Proceedings of the FSF 54th annual International Conference. P. 215-220. Athens, Greece.

等，進行深入瞭解及評估，透過此一程序，必將對該機關或其官員提出不利或有所責難之調查結果或改善建議，因此許多國家皆已瞭解，除先行獨立於法制監理機關外，否則絕無一調查機關能夠完全地「調查自己」。

因此，許多國家皆已透過立法程序，確保能由一職務上完全獨立於法制與監理職責之機關執行調查工作，此觀念為國際民航組織指導原則所大力支持，亦已在世界上許多國家或地區成功實行。本會認為，新加坡政府應審慎考慮成立一獨立之航空器失事及重大意外事件調查機關，以符目前國際間之最佳作法。

此頁空白

3 結論

本會在此章中依據調查期間所蒐集之事實資料以及綜合分析，總結以下三類之調查結果：「與可能肇因有關之調查結果」、「與風險有關之調查結果」及「其它調查結果」。

與可能肇因有關之調查結果

此類調查結果係屬已經顯示或幾乎可以確定為與本次事故發生有關之重要因素。其中包括：不安全作為、不安全狀況或造成本次事故之安全缺失等。

與風險有關之調查結果

此類調查結果係涉及飛航安全之風險因素，包括未直接導致本次事故發生之不安全作為、不安全條件及組織和整體性之安全缺失等，以及雖與本次事故無直接關連但對促進飛安有益之事項。

其它調查結果

此類調查結果係屬具有促進飛航安全、解決爭議或澄清疑慮之作用者。其中部份調查結果為大眾所關切，且見於國際調查報告之標準格式中，以作為資料分享、安全警示、教育及改善飛航安全之用。

3.1 與可能肇因有關之調查結果

1. **事故當時正值象神颱風來襲，帶來豪雨及強風。台北時間** 2312:02 **時，飛航組員由終端資料廣播服務**（ATIS）**抄收編碼**"Uniform"**之** 05 **左跑道視程為** 450 **公尺。台北時間** 2315:22 **時，飛航組員收到機場管制席頒發之起飛許可及風向** 020 **度，風速** 28 **浬/時，陣風** 50 **浬/時。**（1.1; 1.7）

2. **民航局八十九年八月卅一日發布編號** A0606 **之飛航公告**（NOTAM）**稱自八十九年九月十三日至同年十一月廿二日，**05 **右跑道於** N4 **及** N5 **滑行道間，因道面施工部份關閉。**SQ006 **飛航組員瞭解** 05 **右跑道部份關閉，並且** 05 **右跑道當時僅供滑行之用。**（1.18.2.6; 2.5.2.1; 2.5.3）

3. SQ006 **未完全通過** 05 **右跑道頭標線區，繼續滑行至按預定起飛之** 05 **左跑道。航機進入** 05 **右跑道後，正駕駛員**（CM-1）**即滾行起飛，副駕駛員**（CM-2）**及加強飛航組員**（CM-3）**並未質疑** CM-1 **之決定。**（1.1; 1.18.1.1）

4. **飛航組員未能複查並確實瞭解其在滑至** 05 **左跑道之正確路線上，包括在滑入** 05

左跑道前需先通過 05 **右跑道。**（1.18.1.1; 2.5.3）

5. SQ006 **由停機坪滑向離場跑道時，飛航組員曾參考中正機場航圖。然而，該機由** NP **滑行道轉進** N1 **滑行道，並繼續轉向** 05 **右跑道時，三位組員均未確認滑行路徑。依吉普生**（Jeppesen）**航圖第** 20-9 **頁之中正機場航圖，滑行至** 05 **左跑道之路線須先由** NP **滑行道作** 90 **度右轉彎，再繼續沿** N1 **滑行道直行。而非直接由** NP **滑行道以連續之** 180 **度轉彎進入** 05 **右跑道。且當時亦無任何組員口頭確認進入那條跑道。**（1.18.1.1; 2.5.2.2; 2.5.4.3）

6. CM-1 **接近離場跑道之期望，伴隨著明顯之滑行道燈光引領其滑至** 05 **右跑道，導致** CM-1 **將其注意力著重在滑行道中心線燈上。他跟隨綠色之滑行道中心線燈滑入** 05 **右跑道。**（1.18.1.1; 2.5.7）

7. **趕在颱風進襲前起飛之時間壓力，及強風、低能見度及溼滑跑道等情況，均潛在地影響飛航組員下達決策和維持狀況警覺之能力。**（1.18.1.1; 2.5.6; 2.5.7）

8. **事故當晚，飛航組員可藉由以下資訊瞭解其所處之機場環境：**

   - **中正機場航圖**
   - **飛機航向參考資訊**
   - **跑道及滑行道指示牌**
   - N1 **滑行道連至** 05 **左跑道之滑行道中心線燈**
   - 05 **右跑道中心線燈顏色（綠色）**
   - 05 **右跑道邊燈可能未開啟**
   - 05 **左及** 05 **右跑道之寬度差異**
   - 05 **右和** 05 **左跑道燈光結構差異**
   - **目視輔助系統顯示飛機未對正** 05 **左跑道左右定位台**
   - **主要飛航顯示器資訊**

飛航組員失去狀況警覺而由錯誤跑道起飛。（1.1; 1.18.1; 2.5）

3.2 與風險有關之調查結果

1. **參照現行國際民航公約第十四號附約之標準及建議措施，中正機場得在** 05 **右跑道施工區外圍放置跑道關閉標線，但並無強制規定須在** 05 **右跑道頭放置跑道關閉標線。**（1.10.4.2; 2.3.3）

2. **國際民航公約第十四號附約之標準及建議措施中部分語意不明，未對暫時關閉跑道之「短期」予以明確定義。**（1.10.4.2; 2.3.3）

3. **國際民航公約第十四號附約之標準及建議措施中有關仍作滑行用之暫時關閉跑道章節，未對「除供滑行作業外跑道關閉」提供適當資訊以警示飛航組員。**（1.10.4.2; 2.3.3）

4. **國際民航組織之相關規範中雖無明確規定須在仍作滑行用之暫時關閉跑道上設置警示，但就場站設施而言，由於中正國際航空站未考量於** 05 **右跑道入口處設置警示，以致無法提供最後一道防線，防止飛航組員誤入** 05 **右跑道。**（1.10.4.2; 2.3.3）

5. **根據國際民航公約第十四號附約之標準及建議措施，放置於** 05 **右跑道施工區外之護欄須為易脆材料所製，事故當時** 05 **右跑道施工區外所使用之護欄為非易碎之水泥護欄。**（1.10.4.2; 2.3.3）

6. **事故當時，中正機場有數項設施不符國際接受之標準及建議措施，若予適當重視，或許能加強飛航組員在滑行至** 05 **左跑道期間之狀況警覺，但缺少此項強化措施，並不足以證明** SQ006 **飛航組員因而失去狀況警覺，相關設施如下：**

   - **事故發生四日之後，調查小組發現緊接著** 05 **右跑道入口處，沿** N1 **滑行道往** 05 **左跑道方向之第一盞綠色滑行道中心線燈不亮，下一盞燈則不夠亮。但在事故當晚，前述燈光狀態無法確定。**（1.10.3.2.4; 2.3.1.2.3）

   - NP **滑行道轉向** 05 **右跑道之滑行道中心線燈間距，較** N1 **滑行道連至** 05 **左跑道之滑行道中心線燈間距為密，因此明顯可見。由** NP **與** N1 **滑行道中心線交會點延伸至** 05 **左跑道頭之直線部份應有** 16 **盞間距** 7.5 **公尺之中心線燈，而非** 4 **盞分別距交會點** 30 **公尺、**55 **公尺、**116 **公尺和** 138 **公尺之中心線燈。**（1.10.3.2.4; 2.3.1.2.2）

   - N1 **滑行道中心線直線部分之標線未延伸至** 05 **右跑道頭標線前後各** 12 **公尺處。**（1.10.3.1.2; 2.3.1.1）

   - **中正機場未架設跑道警戒燈及停止線燈。**（1.10.3.2.2; 1.10.3.2.3; 2.3.2）

   - **未架設綠黃交錯之滑行道中心線燈，以區隔儀降系統敏感區。**（1.10.3.2.4）

   - N1 **滑行道兩側之強制性指示牌架設於** 05 **左跑道等待位置前，而非與跑道等待位置標線並列。**（1.10.3.1）

   - **中正機場未架設迴路互鎖系統，以防止** 05 **右跑道之跑道燈及滑行道中心線燈同時開啟。**（1.10.5.1.1; 2.3.1.2.1）

   - **中正機場之場面燈光系統監視機制係電子式，由人工控制。缺乏對個別燈具，或對場面燈光迴路故障燈具百分比監控功能。**（1.10.5.1.2）

7. **機場場面偵測裝備**（ASDE）**在低能見度時能減低機場地面作業風險，但國際民航公約第十四號附約之標準及建議措施未規定機場必須架設此項裝備。本會無法確定是否機場架設** ASDE **即能提供管制員有效資訊，以防止** SQ006 **滑入錯誤跑道。豪雨會造成** ASDE **訊號衰減，顯示效果降低。**（1.18.2.4; 2.4.2）

8. **民航局缺乏安全監督機制以獨立督察及評估中正機場，確保其場站設施符合國際標準及建議措施。**（1.17.9; 2.3.5.2.1; 2.3.5.3.2; 2.3.6）

9. **民航局缺乏特定之安全法規監督組織與機制，致使中正機場之跑道及滑行道燈光、標線及指示牌等不符合國際安全標準及建議措施狀況未受重視。**（1.17.9; 2.3.6）

10. **民航局未組成工作小組，根據國際民航公約第十四號附約，推動全面之「地面活動導引及管制系統」計畫。**（1.10.5.2）

11. **由於中華民國非國際民航組織之會員國，因此無法參與該組織推展有關促進機場安全之各項計畫，以期符合國際標準及建議措施。**（1.17.10; 2.3.5.2.2）

12. **機場管制員未頒發進一步滑行及地面活動指示，亦未使用低能見度滑行術語通知飛航組員減速慢行。**（1.18.2.3; 2.4.1）

13. **飛航組員未請求管制員頒發進一步滑行指示。**（1.1; **附錄** 3）

14. **暗夜及大雨造成能見度減低，但未妨礙駕駛員目視跑道及滑行道燈光、標線和指示牌。**（1.18.1.1; 2.5.7.1）

15. **新航之溼跑道側風限制為** 30 **浬/時，而污染跑道側風限制為** 15 **浬**。CM-1 **準備起飛時評估當時狀況為溼跑道，確定側風未超過公司規定。新航及航管程序均未訂定量化方法以判斷溼跑道與污染跑道，造成飛航組員無法明確估算側風限制。**（1.18.4; 2.5.8）

16. **新航波音** 747-400 **操作手冊中未明載低能見度滑行操作程序。**（1.17.4.5; 2.5.4）

17. **新航未給予波音** 747-400 **駕駛員正式之低能見度滑行技巧訓練。**（1.18.1.1.1）

18. **新航未訂定** PVD **使用程序，以供駕駛員在類似本次失事當晚低能見度情況，以** PVD **確認航機由正確位置起飛。**（1.18.5.1; 2.5.6.3.3）

19. **新航之程序與訓練文件，未反映新加坡民航局核准之波音** 747-400 **飛航手冊附錄中有關使用** PVD **確認正確跑道規定。**（1.18.5.3; 2.5.6.3.3）

20. **新加坡民航局對航務之監督與訓練，未能確保新航已按核准之波音** 747-400 **飛航手冊附錄中有關使用** PVD **確認正確跑道規定，修正其相關文件及航務作業。**（1.18.5.3; 2.5.10）

21. **事故當時，新航操作手冊之起飛前檢查程序未含「確認使用跑道」項目。**（1.18.1.1;

2.5.5）

22. **新航之訓練與程序未能確保其飛航組員獲得適當之知識與技術，在低能見度時，在地面精確操控航機。**（1.17.4.5; 2.5.4.5）

23. **新加坡民航局未充份執行對新航之程序與訓練督導，例行之飛安查核未能發現其在程序與訓練之缺失。**（1.17.1; 2.5.10）

24. **新航未明確定義其颱風程序，而執行程序之人員亦未充份瞭解程序及職責。**（1.17.7; 2.7.4）

25. **嚴重撞擊及快速竄燒之大火與濃煙導致現行緊急疏散訓練、設備及程序失效。**（1.15.1.2; 1.15.1.3; 1.15.1.4; 2.6.1）

26. **廣播系統失效後，**CM-1 **未指示客艙組員及乘客進行緊急疏散。**（1.15.1.2; 2.6.1）

27. **飛航組員與客艙組員一併實施年度緊急疏散複訓，但飛航組員係扮演乘客角色。新航之程序未規定飛航組員下達緊急疏散指令。**（1.15.1.1）

28. **部份組員之緊急疏散作業受到失事後不可預期之狀況影響。**（1.15.1; 2.6.1）

29. **生還者在疏散過程中因濃煙造成呼吸困難，且不易發現緊急燈光。**（1.15.1; 2.6.3.1; 2.6.3.2）

30. **在暗夜疏散情形下，僅** CM-2、CM-3 **及左側** 5 **號門客艙組員攜帶手電筒，其中左側** 5 **號門客艙組員曾利用手電筒協助乘客疏散。**（1.15.1.6）

31. **中正機場未參照國際民航組織建議，明訂機場緊急醫療救護程序及醫療協調官或臨時醫療協調官之職責。**（1.15.3.6; 2.6.4.1）

32. **中正機場未參照國際民航組織之標準及建議措施，提供惡劣天候之醫療與救援應變程序。**（1.15.3.6; 2.6.4.1）

33. **「中正國際航空站民用航空器失事處理作業實施要點」未參照國際民航組織建議建立周邊醫院資訊，如神經外科等。**（1.15.3.5; 2.6.4.2）

34. **疏散滑梯製造廠未在相關手冊中，提供航空器使用人於強風情況下之操作性能資訊。**（1.15.1.5; 2.6.2.2）

35. **失事時，該機因橫向撞擊力過大，造成右側** 4 **號和** 5 **號門疏散滑梯非預期之自動向艙內充氣。**（1.15.1.5; 2.6.2.2）

36. **中正機場消防隊處理重大失事之人力不足。**（1.14.1.2; 1.15.3.2; 2.6.4.3）

3.3 其它調查結果

1. **飛航組員均持有適當證照，符合新加坡民航局法規、新航規定及國際民航組織之標準及建議措施。**（1.5; 2.1）
2. **飛航組員依既有程序獲得完整簽派文件包括：天氣、載重與平衡、飛航公告及公司內部飛航通告等。**（1.18.1.1; 2.1）
3. **客艙組員均依該公司訓練計畫訓練合格。**（1.5; 2.1）
4. **組員之執勤時間、飛航時間、休息時間及非執勤活動等，未顯示曾受醫藥、行為或生理之因素，影響其失事當天之工作表現。**（1.5; 2.1）
5. **失事相關之管制員均持有適當證照，符合執勤資格。其執勤時間、休息時間及非執勤活動等，未顯示曾受影響其失事當天之工作表現。**（1.5.5; 1.5.6; 1.5.7; 1.5.8; 2.1）
6. **失事航空器之給證、裝備及維修均符合新加坡民航局法規及審核程序，及國際民航組織之標準及建議措施。無證據顯示該機存有機械、結構、飛操系統或發動機之失效而導致失事。**（1.6; 2.1）
7. **失事發生當晚，無證據顯示飛航組員曾受公司不當壓力，迫使其在惡劣天候中起飛。**（1.17.8; 1.18.1.1; 2.1）
8. **事故當時，飛航組員使用之吉普生航圖為有效版本。**（1.18.3; 2.5.2.2）
9. **飛航組員使用之滑行檢查及程序符合新航波音** 747-400 **操作手冊。**（1.18.1.1; 2.5.4.4）
10. **失事發生當晚，飛航組員選擇由** 05 **左跑道起飛係為適當。**（1.18.1.1; 2.5.3）
11. **雖然** CM-1 **曾要求加強飛航組員在滑行時確認側風限制，但在新航標準操作程序未明確指派加強飛航組員之任務。**（1.17.4.2; 1.18.1.1; 2.5.9.3）
12. **航管之滑行指示與起飛許可，未誤導飛航組員由部份關閉之** 05 **右跑道起飛。**（1.1; 2.1; **附錄** 2; 3）
13. **多項證據顯示在** SQ006 **起飛當時，**05 **右跑道邊燈未開啟之可能性較高。**（1.12.5; 1.16.5; 2.3.4）
14. **本次失事之死亡率為** 46%**；重傷率為** 22%**；輕傷率為** 18%**；未受傷率為** 14%。（1.2）
15. **失事後油箱起火，客艙中段之第** 31 **至** 48 **排座位屬非生還區，區內** 76 **名乘客中** 64 **人死亡，客艙尾段所有乘客皆生還。**（1.2）

16. **在失事緊急疏散過程中，由於撞擊力量、大火與強風之影響，無疏散滑梯能完全發揮作用。**（1.12.2.2; 1.16.3; 2.6.2）

17. **法務部法醫研究所執行七件驗屍工作，其中六件為嚴重燒傷致死，一件為撞擊致死。**（1.13.2; 2.6.5）

18. **機場救援及消防人員在失事後約三分鐘即抵現場進行消救作業。機尾部份小火迅速撲滅。惡劣天候下，機身前段及中段之火勢於十五分鐘後壓制住，四十分鐘後火勢完全控制。**（1.14.1.1; 1.14.1.2）

19. **失事期間，所有消防與及醫療人員均使用同一無線電頻率通話。**（1.15.3.1）

20. **因象神颱風帶來之豪雨及強風，導致中正機場大部份之醫療及救援行動未能依該站相關程序作業。**（1.15.3.2; 2.6.4）

21. **前十名逃出客艙之生還者，未經適當檢傷分類程序，即由機場救護車送往鄰近醫院。**（1.15.3.2; 2.6.4）

22. **失事後，未對三位飛航組員及四位管制員進行酒精及藥物測試，但無證據顯示酒精或藥物與失事有關。**（1.13.3）

23. **中華民國交通部未積極支持民航局在中正機場架設** ASDE **之建議。**（1.18.2.4; 2.4.2）

24. **中華民國民航局增訂定之法規皆須經過交通部冗長之行政程序。**（1.17.10; 2.4.2）

25. SQ006 **座艙語音記錄器電源開關時機雖符合國際民航組織之標準及建議措施及新加坡民航法，但美國聯邦航空法及歐盟聯合航空法，規定較早之電源啟動時機及較晚之電源切斷時機，較有利於事故後之飛航操作及人為因素調查作業。**（1.11.1.1; 2.7.1）

26. **本會於調查期間蒐集到六件與飛航服務有關之意外事件報告，中正機場開始運作迄今已逾廿二年，與中正機場場站設施相關之報告當不止此數。**（1.18.2.5; 2.4.3）

27. **駕駛艙加裝機場場面導引及導航系統能降低滑行、起飛及落地等飛航失事及意外事件。**（1.18.8; 2.7.6）

28. **新加坡未設獨立之航空器失事調查機關，從事客觀調查、獲致結論並提出改善建議。國際經驗顯示，設置獨立之航空器失事調查機關有利飛航安全。許多國家已採取行動確保航空器之失事調查，由獨立於民航法制與監督機關外之政府機關擔任。**（1.17.2; 2.7.7）

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4 飛安改善建議

本章中分為 4.1 **節之「改善建議」及** 4.2 **節之「已完成或進行中之改善措施」，其中由民航局及新航所提供之** 4.2 **節資料並未經本會確認，再此特作聲明。**

4.1 改善建議

<u>期中飛安通告</u>

本會於八十九年十一月十四日對美國運輸安全委員會、澳洲運輸安全局、新加坡民用航空局及交通部民用航空局等發布以下之事故調查期中飛安通告：

編號：ASC-IFSB-00-11-001

1. **飛航駕駛員對機場設施有改變情況時，起飛前需詳盡提示該情況。**
2. **儀器天氣起飛前應確認使用正確跑道；飛航駕駛員需以「組員呼叫」**（CALLOUT）**方式相互確認。**
3. **請民航主管機關針對上述事項，要求各航空業者列入其飛航標準作業程序執行。**

<u>致新加坡航空公司</u>

本會建議新加坡航空公司：

1. **參考美國聯邦航空總署跑道安全國家藍圖及民航通告** AC120-74**，擬訂並執行場面活動訓練計畫。**（3.1-[3~8];3.2-[16, 17, 22]）-ASC-ASR-02-04-01
2. **確認於低能見度滑行操作程序中，增訂請求管制員提供進一步滑行指示之需要，以協助正確之機場場面活動。**（3.2-[13]）-ASC-ASR-02-04-02
3. **複查現行** PVD **訓練及程序之適當性，確保文件與航務作業中皆能配合新加坡民航局核准之波音** 747-400 **飛航手冊附錄，使用** PVD **確認正確之離場跑道。**（3.2-[18, 19]）-ASC-ASR-02-04-03
4. **擬訂並落實明確之政策，確保飛航組員應用** PFD **及** PVD **等儀器所顯示之資訊，尤其是用在低能見度情況起飛之前。**（3.1-[8]）-ASC-ASR-02-04-04

5. **於所有起飛前檢查表中，加入目視識別及確認正確起飛跑道之檢查項目。**（3.1-[8]; 3.2-[21]）-ASC-ASR-02-04-05

6. **實施進階組員資源管理計畫以符現行作業需要，並依組員資源管理最新發展定期修正計畫。**（3.1-[3, 4]）-ASC-ASR-02-04-06

7. **審視現行跑道狀況判斷程序與作業之適當性，在大雨情況下，提供客觀判斷標準，以判斷溼跑道或污染跑道。**（3.2-[15]）-ASC-ASR-02-04-07

8. **進行程序督察，以消除現行指導原則及程序與公司手冊、管理者期望及實際作業間之衝突，如颱風程序或簽派簡報政策。**（3.2-[24]）-ASC-ASR-02-04-08

9. **修正緊急程序，增訂客艙廣播系統失效時，下達緊急疏散指令之替代方法。**（3.2-[26]）-ASC-ASR-02-04-09

10. **檢討飛航及客艙組員之相關程序與訓練，使 其有效處理各類緊急狀況。**（3.2-[25, 26, 27, 28]）-ASC-ASR-02-04-10

<u>致新加坡民用航空局</u>

本會建議新加坡民用航空局：

1. **要求新航擬訂並落實地面活動訓練計畫，包括在低能見度地面操作時，請求管制員提供進一步滑行指示之程序。**（3.1-[3~8]; 3.2-[13, 16, 17, 22]）-ASC-ASR-02-04-11

2. **檢討新航** PVD **訓練及操作，確認其程序、訓練文件及實際作業符合新加坡民航局核准之波音** 747-400 **飛航手冊有關** PVD **之附錄。**（3.2-[18, 19, 20]）-ASC-ASR-02-04-12

3. **檢討飛航手冊附錄相關之文件審核、控管、分發以及為航空器使用人制定政策及程序等管理機制，適當管理飛航手冊之修正作業。**（3.2-[20]）-ASC-ASR-02-04-13

4. **確保新加坡之航空公司在其監管下執行空勤組員資源管理計畫，以符現行作法，並隨時注意組員資源管理之發展，以定期監控及修訂該計畫。**（3.1-[3，4]）-ASC-ASR-02-04-14

5. **評估並支持適當之技術及方法研發專案，以協助飛航組員在大雨情況下，客觀判斷雨水影響跑道狀況。**（3.2-[15]）-ASC-ASR-02-04-15

6. **修訂新加坡民航局「空中航行法規」第卅七條第三項有關座艙語音記錄器電源提早啟動及延後切斷規定。**（3.3-[25]）-ASC-ASR-02-04-16

致新加坡政府

本會建議新加坡政府：

參考其它國家先例，設一獨立之飛航事故調查機關。（3.3-[28]）-ASC-ASR-02-04-17

致交通部民用航空局

本會建議交通部民用航空局：

1. **要求各塔台主管重新強調低能見度地面作業，進一步滑行及地面活動指示之觀念、訓練及使用時機。**（3.2-[12]）-ASC-ASR-02-04-18
2. **優先編列預算，加速執行在高航行量機場架設** ASDE **計畫。**（3.2-[7]）-ASC-ASR-02-04-19
3. **重新定義局內各組室之職掌，明確劃分各單位及人員之職責。**（3.2-[8，9]）-ASC-ASR-02-04-20
4. **明確指定負責擬訂、修訂及發布民航法規之專責單位。**（3.2-[8]）-ASC-ASR-02-04-21
5. **擬定計畫，持續追縱國際民航組織之標準及建議措施及業界安全改善最佳實例，將所獲訊息傳送有關單位，作為檢討與必要行動以及進度監督之用。**（3.2-[6]）-ASC-ASR-02-04-22
6. **建立整體性風險評估與管理計畫，及監督所有計畫與執行之機制。**（3.2-[6, 7, 8, 9, 10]）-ASC-ASR-02-04-23
7. **評估並支持適當之技術及方法研發專案，以協助飛航組員在大雨情況下，客觀判斷雨水影響跑道狀況。**（3.2-[15]）-ASC-ASR-02-04-24
8. **立即改善中正機場及其它機場所有不符國際民航組織之標準及建議措施或相關規定之場站設施，如地面活動導引及管制系統計畫或緊急醫療程序等。**（3.2-[6, 10, 31, 32, 33]）-ASC-ASR-02-04-25
9. **比照第九級國際機場，確保機場救援及消防單位具有必要人力，以執行指派工作。**（3.2-[36]）-ASC-ASR-02-04-26
10. **檢討國內機場之通訊系統，研發機場各單位間緊急消救作業通訊改善計畫。**（3.3-[19]）-ASC-ASR-02-04-27
11. **建立可靠之意外事件通報系統，推廣此系統至所有使用者，並將系統之有效利用列**

為優先事項。（3.3-[26]）-ASC-ASR-02-04-28

12. **檢視美國聯邦航空總署跑道安全國家藍圖及相關民航通告，作為執行改善之參考。**（3.2-[4, 5, 6, 7, 8, 9, 10]）-ASC-ASR-02-04-29
13. **確實研發適當場面活動相關科技，及中華民國機場及地形資料庫。**（3.3-[27]）-ASC-ASR-02-04-30
14. **頒布法規鼓勵運輸類國籍航空器，於駕駛艙裝置機場場面導引及導航系統，如電子活動地圖顯示器供機場場面活動使用。**（3.2-[27]）-ASC-ASR-02-04-31

致交通部

本會建議交通部：

1. **建立對民航局安全改善方案之專業監督能量，積極推動飛航安全。**（3.2-[23, 24]）-ASC-ASR-02-04-32
2. **主動積極支持民航局飛安改善計畫，如** ASDE **之採購作業。**（3.2-[10]; 3.3-[23]）-ASC-ASR-02-04-33
3. **完全授權民航局進行技術性安全法規之改善及實施，免除冗長繁瑣之行政程序。**（3.3-[24]）-ASC-ASR-02-04-34

致波音公司

本會建議波音公司：

1. **提供航空器使用人適當之技術指導資訊，包括緊急疏散滑梯在強風超過驗證限制時之警告事項。**（3.2-[34]）-ASC-ASR-02-04-35
2. **檢討客艙緊急燈光之有效性，確保失事生還者在濃煙情況中能獲得最大逃生機會。**（3.2-[29]）-ASC-ASR-02-04-36
3. **考慮於即將驗證及新獲驗證之航空器駕駛艙裝置機場場面導引及導航系統，如電子活動地圖顯示器。**（3.3-[27]）-ASC-ASR-02-04-37
4. **發展並提出必要之技術支援，提供客戶（航空公司）於駕駛艙裝置機場場面導引及導航系統，如電子活動地圖顯示器供機場場面活動使用。**（3.3-[27]）-ASC-ASR-02-04-38
5. **研發降低可生還失事中客艙廣播系統失效之方法，並提供航空器使用人改良之客艙**

廣播系統。（3.3-[26]）-ASC-ASR-02-04-39

致國際民航組織

本會建議國際民航組織：

1. **研訂將** ASDE **或類似裝備，列為高航行量民航機場之標準裝備。**（3.2-[7]）-ASC-ASR-02-04-40
2. **修訂第十四號附約，明確定義及預防仍可滑行之部份關閉跑道標準。**（3.2-[3]）-ASC-ASR-02-04-41
3. **基於改善飛安目的，考慮接受中華民國以觀察員身份，參與國際民航組織各種活動。**（3.2-[11]）-ASC-ASR-02-04-42
4. **支持包括飛安基金會、航空公司駕駛員協會國際聯盟、機場作業協會及國際航空運輸協會等組織之政府或航空業界計畫，擬訂一套客觀方法，協助駕駛員在雨天情況下判斷溼跑道或污染跑道。**（3.2-[15]）-ASC-ASR-02-04-43
5. **鼓勵並支持政府或航空業界之研究計畫，改善乘客濃煙防護設備、強風與大火情況之緊急疏散滑梯功能。**（3.2-[29, 35]）-ASC-ASR-02-04-44
6. **擬訂必要之標準及建議措施，知會各會員國之民航主管機關，供其配合修訂相關法規，支持於駕駛艙裝置機場場面導引及導航系統。**（3.3-[27]）-ASC-ASR-02-04-45
7. **鼓勵所有會員國於商業用航空器駕駛艙裝置機場場面導引及導航系統，如電子活動地圖顯示器供機場場面活動使用。**（3.3-[27]）-ASC-ASR-02-04-46
8. **鼓勵所有會員國之民航主管機關，確實研發適當場面活動科技，如機場及地形資料庫於場站設施。**（3.3-[27]）-ASC-ASR-02-04-47

致國際航空運輸協會

本會建議國際航空運輸協會：

1. **由本次失事獲得之教訓，於強風及豪雨環境下，飛機受到嚴重撞擊後產生之大火與濃煙，使得許多緊急疏散系統失效、疏散程序無法作用。建議支持一項由政府或航空業界組成之國際合作研究計畫，藉以擬訂並改進航空器緊急疏散裝備與程序，預防未來類似失事之傷亡。**（3.2-[25]）-ASC-ASR-02-04-48
2. **提供會員航空公司適當技術指導資訊，包括緊急疏散滑梯在強風超過驗證限制時之**

警告事項。（3.2-[34]）-ASC-ASR-02-04-49

3. **為安全保障及風險管理，敦促會員航空公司與其民航主管機關合作，確定其營運之機場符合國際民航公約第十四號附約之標準及建議措施，另敦促會員航空公司與其民航主管機關合作，擬訂評估場站設施程序作為外站督察項目之一。**（3.2-[6]）-ASC-ASR-02-04-50

4. **鼓勵會員航空公司於所屬航空器駕駛艙裝置機場場面導引及導航系統，如電子活動地圖顯示器供機場場面活動使用。**（3.3-[27]）-ASC-ASR-02-04-51

致美國聯邦航空總署

本會建議美國聯邦航空總署：

1. **由本次失事獲得之教訓，於強風及豪雨環境下，飛機受到嚴重撞擊後產生之大火與濃煙，使得許多緊急疏散系統失效、疏散程序無法作用。建議支持一項由政府或航空業界組成之國際合作研究計畫，藉以擬訂並改進航空器緊急疏散裝備與程序，預防未來類似失事之傷亡。**（3.2-[25]）-ASC-ASR-02-04-52

2. **檢討緊急疏散滑梯之設計，減少因橫向撞擊力造成緊急疏散滑梯非預期之自動充氣可能性。**（3.2-[35]）-ASC-ASR-02-04-53

3. **檢討客艙緊急燈光之有效性，確保失事生還者在濃煙情況中能獲得最大疏散機會。**（3.2-[29]）-ASC-ASR-02-04-54

4. **增訂規則，要求改良波音公司航空器之客艙廣播系統，使之在可生還之失事情況下仍可有效使用**[78]**。**（32-[26]）-ASC-ASR-02-04-55

致歐盟聯合航空局

本會建議歐盟聯合航空局：

1. **由本次失事獲得之教訓，於強風及豪雨環境下，飛機受到嚴重撞擊後產生之大火與濃煙，使得許多緊急疏散系統失效、疏散程序無法作用。建議支持一項由政府或航空業界組成之國際合作研究計畫，藉以擬訂並改進航空器緊急疏散裝備與程序，預防未來類似失事之傷亡。**（3.2-[25]）-ASC-ASR-02-04-56

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[78] 2001 **年** 4 **月，澳洲運輸安全局發出第** 20000231 **號改善建議：請美國聯邦航空總署及歐盟聯合航空局檢討高容量航空器之設計需求，確保客艙通話及廣播系統之整體性，特別是在航空器衝出跑道及其他造成起落架與機腹損壞情況之駕駛艙與客艙間通訊。**

2. **檢討緊急疏散滑梯之設計，減少因橫向撞擊力造成緊急疏散滑梯非預期之自動充氣可能性。**（3.2-[35]）-ASC-ASR-02-04-57

3. **檢討客艙緊急燈光之有效性，確保失事生還者在濃煙情況中能獲得最大逃生機會。**（3.2-[29]）-ASC-ASR-02-04-58

4. **增訂規則，要求改良波音公司航空器之客艙廣播系統，使之在可生還之失事情況下仍可有效使用。**（3.2-[26]）-ASC-ASR-02-04-59

4.2 已完成或進行中之改善措施[79]

根據新加坡交通與資訊科技部

新加坡航空公司-

1. **已分別將狀況警覺及誤失管理訓練以獨立之單元納入新訂定並已實行之飛航組員組員資源管理訓練中。**

2. **飛航組員訓練中心正規劃將人為因素及失事預防訓練納入機長訓練計畫中。**

3. **已著手開發並研擬使飛航組員能藉以管理其操作風險之風險評估工具。**

4. **於** 1999 **年** 12 **月時重新設計女性客艙組員之鞋具，並已於失事後開始使用。**

5. **已於公司之起飛前檢查表中，要求所有飛航組員於滾行起飛前目視確認正確起飛跑道。**

6. **已修訂公司飛航組員作業手冊，正式要求飛航組員於航行操作時參考標線及指示牌，其它組員則應參考機場航圖以確認正確之滑行路徑。**

7. **已修訂公司飛航組員訓練手冊，正式加入低能見度時地面作業之程序、指示及訓練課程。**

8. **已修訂公司側風限制政策並配合修改飛航組員作業手冊，提高對「溼跑道」定義之限制。**

9. **已著手蒐集機場特定之作業資訊，以提供吉普生航圖未包涵之操作程序及設施等資訊。**

10. **公司** B777 **及波音** 747-400 **航機，已配置波音公司基於全球衛星定位系統所開發之「起飛跑道錯誤警示功能」**（Take-off Runway Disagree Alerting Function）**。**

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[79] **本會對於所發布之改善建議並無監控權責，對各對象單位所採取之安全措施亦無追蹤能力，本國對本會發布之改善建議監控屬行政院研究發展考核委員會之權責。**

11. **已評估於公司之航機上配置電子動態地圖，提供機場活動區內之動態圖像說明。**

12. **已檢視美國聯邦航空總署民航通告** AC120-74 **相關部份，以強化公司低能見度作業、訓練及程序。**

新加坡民用航空局-

1. **已要求新航檢視其起飛前檢查表。**

2. **已要求新航更新其組員資源訓練以符業界現行之最佳作法。**

3. **已要求新航檢視美國聯邦航空總署民航通告** AC120-74 **相關部份，以強化公司低能見度作業、訓練計畫及程序。**

4. **已提案運輸部修改其現行法規，提早啟動及延後關閉座艙語音記錄器。**

<u>根據交通部民用航空局</u>

1. **法規及程序方面：**

   - **國際民航公約附約之蒐集更新，及本國法規之檢討修訂機制之建立**

     – **有關國際民航公約之附約共十八項，皆已明訂各業管單位，並由專責單位整合。**

     – **由各業管單位參考實際作業需求檢討修訂民航局之相關法規及規範。**

   - **機場單位之認證標準及核發證照程序檢討**

     – **參考美國聯邦航空總署發布之”機場單位認證標準及核發證照手冊”**（Airport Certification Program Handbook）**，並邀請外國顧問協助建立民航局內部督導機制，以為周延。**

     – **依據國際民航公約** Annex 14 **附約及相關文件內容，檢討修訂民航局有關之規範。**

   - **機場設計及運作相關規範之訂定**

     – **八十九年起已完成「跑道及滑行道規範」。**

     – **八十九年度分年分期委託顧問辦理「國內機場規劃設計規範之研究」。**

     – **九十年度增訂助航燈光設施規範。**

     – **九十一年度將辦理「機場選址及主計畫規範」、「機場其他附屬設施設計**

規範」。

- **加強機場場面設施監督管理**
  - 已成立機場場站及助航設施檢查專案小組。
  - 訂定檢查計畫，並分兩階段全面檢查，不符規範者，立即予以改善。
- **加強民航局對機場監理能力**
  - 已邀請美國聯邦航空總署專家於九十一年三月來台針對機場檢查（FAR Part 139）施訓。
  - 已著手規劃建立機場檢查員制度，俾便對機場執行相關檢查。
  - 於九十年二月已辦理運務主管座談會，並落實其有關決議事項。

2. **機場督導管理方面：**
   - **建立航站自我督察及風險管理機制**
     - 各航站設立機場安全檢查小組。
     - 訂定有關航站自我督察及風險管理之航站自我督察手冊，內容包括飛航安全、地面安全、助導航設施、場站及航廈設施等檢查項目。
     - 機場安全小組定期或不定期召集相關單位，檢討修訂航站自我督察手冊。
   - **已邀請美國聯邦航空總署專家於九十一年三月來台協助檢視中正、高雄國際機場場面設施運作並提供改善意見，以便進一步參考辦理。**
   - **成立機場各單位聯合巡場機制，每日定時巡場，並作缺點改善。**
   - **要求施工廠商在跑滑道施工時，確實參考國際民航組織及美國聯邦航空總署相關施工安全規定辦理。**

3. **中正機場場面設施提昇方面：**
   - **機場標線部份：**
     - 參考國際民航組織規範於中正機場南跑道翻修期間，完成機場南側相關標線之更新，並於九十年七月六日完成。
     - 機場北側相關標線之更新作業，於九十年十一月二十七日完工。
     - 參考國際民航組織規範，中正機場已進行部份滑行道中心線標線位置更新，並於九十一年一月三十一日完成。

- **機場助航燈光部份：**
  - **配合中正機場北跑道翻修期間，於** N1 **通往** 05 **左跑道頭處增設滑行道中心線燈兩盞，已於九十一年一月三十一日完成。**
  - **配合跑道更名作業，將** 05 **左**/23 **右更名為** 05/23**，並全面更新跑道相關指示牌，於九十一年一月三十一日完工；另** 06/24 **跑道指示牌亦於九十一年三月一日完成更新。**
  - **中正機場** 05/23 **跑道架設相關之滑行道跑道警戒燈，於九十一年一月三十一日完成。**
  - **已規劃設置** 05/23 **跑道各出口滑行道黃**/**綠中心燈，於九十一年一月三十一日完成。**
  - **中正機場東北角貨運停機坪相關之滑行道已規劃架設停止線燈。**
- **機場道面部份：**
  - **滑行道** S1 **與** S2 **間人孔及指示牌基礎高度工程調整，於九十年七月三十一日完成。**
  - **交通道與滑行道交會處設置有關之標線及牌面，已於九十年七月三十一日設置完成。**
  - **機場南面跑道（**06/24**）及滑行道道面破損、噴漿及道面縫老化等有關之改善作業，於九十年七月三十一日完成改善。**
  - **機場北面跑道（**05/23**）及滑行道道面破損、噴漿及道面縫老化等有關之改善作業，已於九十一年一月三十一日完工。**
  - **重新設置並劃妥** N1 **至** N11 **滑行道間「**A**」型式之停止等待線，並於九十一年一月三十一日完成。**

4. **中正機場消救作業加強項目：**
   - **興建中正機場消防站瞭望塔，並於九十年九月二十六日完工啟用。**
   - **增修訂機場緊急應變計畫**
     - **為求應變計畫之適用，已就原有「中正國際航空站各項緊急應變處理作業程序」及「民用航空器失事處理作業實施要點」重新修訂並已完成。並於八十九年六月二十七日增訂「中正國際航空站航空器緊急降落應變作業程序」，又於八十九年十月十一日增訂「中正國際航空站緊急搶救作業程序」。**

- 民航局已於九十年八月組成機場緊急應變計畫修訂小組，參考國際民航組織規範及鄰近機場之緊急應變計畫進行修訂航空器失事之應變計畫。

5. **強化航管作業**

- **加強督導航管作業，以提昇航管作業安全。**
- **加強管制員之複訓，以提昇航管專業能力。**
- **發布飛航指南補充通知書** A002C003/02 **低能見度作業程序，並自九十一年二月一日起生效。**

6. **改善中正機場緊急通訊**

因應突發之緊急狀況，中正機場規劃以下之緊急無線電通訊頻率：

- **第一頻道：現場指揮（**459.2MHz**）**
- **第三頻道：行政支援（**467.15MHz**）**
- **第六頻道：消救作業（**462.75MHz**）**

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附　　錄

註：為避免失真，本附錄內容以原文呈現，不另中譯。

附錄 1 - 飛航公告 A0606

NOTAM SUMMARY **REPUBLIC OF CHINA**

1ST OCT 2000

NOTAM Summaries: The following NOTAMs are still in force at 0001 UTC 1st OCT 2000

TAIPEI AND VICINITY

TAIPEI/C.K.S. INTL

A0605------31 AUG '00
0009130100/0011220100
TWY NP (FROM BAY A1 TO A3) CLSD DUE TO WIP
RMK/TWY N4, N5 AND E REMAIN AVBL

A0606------31 AUG '00
0009130100/0011220100
PORTION OF RWY 05R/23L(BTN TWY N4 AND N5) CLSD DUE TO WIP
RMK/TWY N4 AND N5 REMAIN AVBL

A0621------05 SEP '00
0009060100/0010050100
RWY 24 LLZ 'ICJN' FREQ 111.9MHZ WITHDRAWN FOR INSTALLATION OF NEW SYSTEM

KAOHSIUNG AND VICINITY

RCKH/KAOHSIUNG

A0130------14 MAR '00
WIE/UFN
OBST ELEV 171FT AT 223434N 1202233E APRX PSN AT 96 DEG MAG/0.6NM OF THR RWY 27R OBST LIGHTED

A0533------10 AUG '00
GUN FIRING WILL TAKE PLACE AS FLWS:
1. AREA: 2225N, 2255N, 11925E, 11945E
2. EFF: 2300-2400 DLY ON 14, 15 AUG, 19, 20, 26, 27 SEP, 3, 4, 17, 18, 24, 25 OCT
0000-0400, 0600-0900 DLY ON 15, 16 AUG, 20, 21, 27, 28 SEP, 4, 5, 18, 19, 25, 26 OCT
3. ALT: SFC UP TO 2000FT
4. RMK: AIRSPACE BLOCKED

附錄 2 - 台北許可頒發管制員陸空通信抄本

頻率： 121.8 MHz

日期：89 **年** 10 **月** 31 **日**

磁帶編號：89 – 7537**；** **音軌編號：**30

UTC 時間	發 話 者	內 容
	CX 2043	DELIVERY, CX 2043 FL390 TO HONG KONG, 5 MINUTES RECEIVED “SIERRA.”
14:53:26	SQ 006	TAIPEI DELIVERY, GOOD EVENING, SQ 006.
14:53:35	SQ 006	TAIPEI, GOOD EVENING, SQ 006.
14:53:38	ATC	GO AHEAD, PLEASE.
14:53:40	SQ 006	SQ 006, POB IS 179, B-5, 5 MINUTES BEFORE TO START FOR LOS ANGELES, REQUESTING FL330.
14:53:47	ATC	SQ 006, ROGER, CLEARANCE ON REQUEST.
14:55:46	ATC	SQ 006, DELIVERY.
	SQ 006	SQ 006, GO AHEAD.
14:55:51	ATC	SQ 006, FOR YOUR INFORMATION, FL330 AIRBORNE TIME AFTER 21 NEXT HOUR, TIME NOW 56, FL290 AVAILABLE, SAY INTENTION.
14:56:03	SQ 006	SQ 006 CAN ACCEPT FL290.
14:56:06	ATC	STAND BY.
14:56:38	ATC	SQ 006, COPY CLEARANCE FOR FL290.
14:56:43	SQ 006	SQ 006, GO AHEAD.
14:56:45	ATC	SQ 006, CLEARED TO LOS ANGELES AIRPORT, VIA ANPU-3 DEPARTURE, KIKIT TRANSITION, A1, CROSS BULAN AT FL290, MAINTAIN FL290, SQUAWK 2657.
14:57:03	SQ 006	CLEARED TO LOS ANGELES AP-3 DEPARTURE, KIKIT TRANSITION, A1CROSSBULAN AT 290, MAINTAIN 290, SQUAWK 2657, SQ 006.
14:57:16	ATC	SQ 006, CLEARANCE READ BACK CORRECT, CONTACT GROUND 121.7.
14:57:19	SQ 006	121.7, GOOD DAY, SIR, SQ 006.

附錄 3 - 座艙語音記錄器抄本

SQ006 座艙語音記錄器抄本圖例說明

CM-1 PF	Channel 3 **左座正駕駛，為操控駕駛員，於駕駛艙左座**
CM-2 PNF	Channel 2 **副駕駛，為非操控駕駛員，於駕駛艙右座**
CM-3 OBS	Channel 1 **加強飛航組員，於觀察員座位**
CAM	Channel 4 P6 panel **之區域麥克風**
RDO-2	CM-2 PNF **之無線電通訊**
MAINT	**地面維修人員內部對講機**
TWR	**中正塔台之無線電通訊**
GND	**中正場面控制席之無線電通訊**
CI 004	**中華航空公司** CI 004 **班機** (Dynasty zero zero four)
CX 2043	**國泰航空公司** CX 2043 **班機** (Cathay two zero four three)
----	**無法辨識**
△	**航管與** CI 004/CX 2043 **班機與航管許可頒發相關之通訊**
****	**無關聯之內容**

UTC 時間	發 話 者	內 容
15:00:53	CM-1 PF	Light up
15:00:54	CM-2 PNF	Check
15:01:12	CAM	(Sound similar to that of starter switch in)
15:01:12	CM-1 PF	Fifty percent N two

UTC時間	發 話 者	內 容
15:01:14	CM-2 PNF	Valve closed
15:01:16	CM-1 PF	Starting Engine two
15:01:18	MAINT	Roger, start two
15:01:18	CM-2 PNF	OK Starting two
15:01:19	CM-1 PF	See if you can get…what's the latest weather. Can you write it down What's the latest... ATIS eh
15:01:23	CM-3 OBS	OK yah
15:01:25	ATIS	Taipei international Airport information Tango one four five four Zulu runway zero five left is in use. Runway zero six for departure only expect ILS runway zero five left category two approach wind zero two zero at three six gust five two visibility five hundred meters, runway zero five left RVR four hundred fifty meters runway zero six five hundred meters with heavy rain cloud broken two hundred feet overcast five hundred feet temperature two one dew point two zero QNH one zero zero one Hectopascal departure frequency one two five point one caution wind shear on runway zero five left final due to radio interference tower frequency change to one two nine point three caution Taxiway November Sierra has been remarked aircraft using November Sierra advise taxi slowly with caution. Taxiway November Papa behind Alpha one and Alpha three closed, runway zero five right between November four and November five closed due to work in progress, Taxiway November four and November five still available. Inform Taipei approach or tower initial contact you have tango.
15:01:29	CM-1 PF	Write up… write behind here
15:01:29	CAM	Write up
15:01:30	CM-3 OBS	I got it.
15:01:33	CAM	(Clicking sound -similar to the sound of chronometer resetting)
15:01:38	MAINT	Number two N one rotation
15:01:40	CM-1 PF	Thank you
15:01:41	CM-2 PNF	Oil pressure number two
15:01:43	CX 2043	Ground Cathay two zero four three request the wind and RVR of

UTC 時間	發 話 者	內 容
		runway zero six
15:01:49	CM-1 PF	Light up
15:01:49	CM-2 PNF	Check
15:01:51	GND	Cathay two zero four three runway zero six RVR five hundred fifty meters and wind zero two zero at three eight gust five one
15:02:04	CM-1 PF	Ok lah, this is better still, Fifty percent N two
15:02:04	CAM	(Sound similar to that of starter switch in)
15:02:06	CX 2043	Cathay two zero four three
15:02:07	CM-2 PNF	Valve closed
15:02:09	CM-1 PF	Ok starting three
15:02:11	MAINT	Roger start three
15:02:12	CM-1 PF	Zero two zero better for us
15:02:13	CM-2 PNF	Ya
15:02:14	CM-1 PF	Starting three please
15:02:16	CM-1 PF	So resolved already it become less
15:02:21	CAM	(Clicking sound -similar to the sound of chronometer resetting)
15:02:31	CM-2 PNF	Oil pressure number three
15:02:31	CAM	(Clicking sound -similar to the sound of chronometer resetting)
15:02:33	CM-1 PF	Roger N one
15:02:38	MAINT	Number three N one rotation and set the brake
15:02:42	CM-1 PF	Confirm set parking brakes
15:02:44	MAINT	Yes
15:02:46	CAM	(Sound similar to that of parking brake being set)
15:02:47	CM-1 PF	OK light up
15:02:48	CM-1 PF	Check, parking brake set
15:02:49	MAINT	Roger
15:03:01	CAM	(Sound similar to that of starter switch in)
15:03:01	CM-1 PF	Fifty percent N two

UTC 時間	發 話 者	內 容
15:03:03	CM-2 PNF	Valve closed
15:03:04	CM-1 PF	Ya
15:03:05	CM-1 PF	Starting four
15:03:08	MAINT	Roger, starting four
15:03:09	CM-1 PF	Ok start first, four
15:03:24	CAM	(Clicking sound -similar to the sound of chronometer resetting)
15:03:27	CM-2 PNF	N one and oil pressure
15:03:30	CM-1 PF	Fuel on
15:03:34	MAINT	Number four N one rotation
15:03:35	CM-1 PF	Thank you
15:03:37	CM-1 PF	Light up
15:03:38	CM-2 PNF	Check
15:03:55	CM-1 PF	Zero two zero is better
15:03:55	CAM	(Sound similar to that of starter switch in)
15:03:56	CM-1 PF	Fifty percent N two
15:03:58	CM-2 PNF	Valve closed
15:04:00	CI 004	(Dynasty Zero zero four conversation with ground control)△
15:04:04	GND	(Ground control conversation with Dynasty zero zero four)△
15:04:06	CI 004	(Dynasty zero zero four conversation with Ground control)△
15:04:14	GND	(Ground control conversation with Dynasty zero zero four)△
15:04:17	CI 004	(Dynasty zero zero four conversation with Ground control)△
15:04:18	CAM	(Clicking sound similar to that of chronometer resetting)
15:04:21	CAM	(Sound similar to that of seat motor)
15:04:26	CM-1 PF	Today can put on
15:04:33	CM-1 PF	Wait first huh
15:04:34	CM-2 PNF	Ok
15:04:35	CM-1 PF	Ok cockpit to ground we normal start, remove ground equipment hand signal thank you bye bye

UTC 時間	發 話 者	內 容
15:04:39	MAINT	Roger all equipment removed standby left bye bye
15:04:42	CM-1 PF	Ok
15:04:43	CM-1 PF	What's the trim you got there, seven point…
15:04:45	CM-2 PNF	Seven point six…
15:04:48	CAM	(Unknown click sound)
15:04:51	CM-1 PF	Seven point..., Waa pretty high huh today
15:04:54	CM-2 PNF	Point six
15:04:56	CM-1 PF	Ok thanks
15:04:57	CM-1 PF	What's the.. ok.. ok
15:04:58	CM-3 OBS	……this is the latest zero two zero three six gust fifty two lah still within limit
15:05:02	CM-1 PF	Yah, zero two zero better
15:05:02	CM-3 OBS	Yah
15:05:02	CM-1 PF	More, more on head wind side
15:05:03	CM-3 OBS	The rest no significant change
15:05:03	CM-1 PF	Ok,
15:05:07	GND	(Cathay two zero four three conversation with ground control)△
15:05:08	CM-3 OBS	Visibility and RVR still the same four fifty meters
15:05:09	GND	(Ground control conversation with Cathay 2043)△
15:05:12	CX 2043	(Cathay 2043 conversation with ground control)△
15:05:15	GND	(Ground control conversation with Cathay 2043)△
15:05:21	CM-1 PF	Ha ha Ok
15:05:22	CM-1 PF	Ok after start check list
15:05:24	CM-2 PNF	After start check, APU
15:05:25	CM-1 PF	Off
15:05:26	CM-2 PNF	Number four demand pump
15:05:27	CM-1 PF	Auto
15:05:28	CM-2 PNF	Anti-ice

UTC 時間	發 話 者	內 容
15:05:29	CM-1 PF	Off
15:05:29	CX 2043	(Cathay 2043 conversation with ground control)△
15:05:30	CM-2 PNF	Aft cargo heat
15:05:31	CM-1 PF	On
15:05:32	CM-2 PNF	Packs
15:05:32	CM-1 PF	Normal
15:05:33	CM-2 PNF	Recall check huh
15:05:34	CM-1 PF	Check
15:05:34	CM-2 PNF	Check
15:05:35	CM-2 PNF	Trims
15:05:36	CM-1 PF	So we got seven point eight, err seven point six units, zero zero set.
15:05:42	CM-2 PNF	Auto brake
15:05:43	CM-1 PF	Ok RTO
15:05:44	CM-2 PNF	Ground equipment
15:05:45	CM-1 PF	Ok, your side gone already ah
15:05:47	CM-1 PF	Is he there, ok alright ok huh gone away
15:05:48	CM-2 PNF	This guy that guy out this side on the right side
15:05:50	CM-1 PF	Ok huh
15:05:50	CM-2 PNF	Ok, wah "terok" (terrible) man
15:05:51	CM-1 PF	Ok lights cabin going off
15:05:52	CAM	(Click)
15:05:53	CM-2 PNF	Ok
15:05:55	RDO-2	Singapore six request taxi.
15:05:57	GND	Singapore six taxi to runway zero six via taxiway.., correction runway zero five left via taxi way Sierra Sierra, West Cross and November Papa.
15:06:08	CM-2 PNF	I missed that man, what is it
15:06:09	CM-1 PF	Sierra Sierra West Cross and November Papa

UTC 時間	發 話 者	內 容
15:06:12	RDO-2	Taxi via Sierra Sierra
15:06:14	CM-1 PF	West Cross
15:06:14	RDO-2	West Cross
15:06:15	CM-1 PF	And November Papa
15:06:15	RDO-2	And November Papa for runway zero five left Singapore six
15:06:21	CM-2 PNF	Sierra Sierra West Cross November Papa
15:06:25	CM-1 PF	Yah, so you go straight down.
15:06:26	CM-2 PNF	Roger that
15:06:26	CM-1 PF	Hit West Cross, go across the West Cross then November Papa all the way down ok
15:06:26	CM-2 PNF	Ok
15:06:29	CM-2 PNF	Then come down further south ah
15:06:29	CM-1 PF	Ok, alright
15:06:30	CM-2 PNF	Ok, yes sir zero five..-----
15:06:34	GND	(Ground conversation with Dynasty Zero zero four)△
15:06:35	CI 004	(Dynasty Zero zero four conversation with Ground)△
15:06:36	GND	(Ground conversation with Dynasty Zero zero four)△
15:06:36	CM-1 PF	Ok, left is clear ah
15:06:38	CM-2 PNF	Ok right side is.. clear, except for this vehicle-lah down here
15:06:42	CM-1 PF	Ok
15:06:49	CI 004	(Dynasty Zero zero four conversation with Ground)△
15:07:00	GND	(Ground conversation with Dynasty Zero zero four)△
15:07:05	CM-1 PF	Taxi slowly
15:07:10	CAM	(Sound similar to that of parking brake release)
15:07:10	CI 004	Taipei ground from Dynasty Zero zero four, can we check out your wind and RVR please.
15:07:13	CM-1 PF	OK turn left skidding right passing heading about zero two four zero now
15:07:13	CM-2 PNF	Checked

UTC 時間	發 話 者	內 容
15:07:16	GND	Dynasty Zero zero four runway zero five left RVR is four hundred fifty meters and wind zero two zero at two five and gust four one
15:07:21	CM-3 OBS	Actually we have to nominate a return alternate because below landing minimum
15:07:25	CM-1 PF	Landing mim…
15:07:25	CM-2 PNF	Below landing minimum
15:07:27	CM-1 PF	Ah, because er Kaohsiung CAT two we still can go CAT two, no problem.
15:07:28	CM-2 PNF	CAT two lah, CAT two…
15:07:33	CI 004	(Dynasty zero zero four conversation with Ground)△
15:07:38	CM-2 PNF	Still ok lah, CAT two
15:07:40	CM-1 PF	CAT two yah, you can look yah...five left huh
15:07:40	GND	(Ground conversation with Dynasty zero zero four)△
15:07:43	CI 004	(Dynasty zero zero four conversation with Ground)△
15:07:47	CM-1 PF	Can still take Kaohsiung you see
15:07:49	CM-2 PNF	Kaohsiung is closed...the airport
15:07:49	CM-1 PF	Kaohsiung I think, is closed is it
15:07:52	CM-2 PNF	We can take Naha or, yah I think CAT two…
15:07:53	CM-1 PF	But we are CAT two, we can still come back, we can still come back
15:07:55	CM-2 PNF	Yah, yah
15:07:56	CM-1 PF	Ok, flaps twenty please.
15:07:56	CAM	(Sound similar to that of flap lever through the detent positions)
15:08:04	CM-1 PF	Ok checking rudder er
15:08:06	CM-1 PF	Full left
15:08:07	CM-2 PNF	Full left
15:08:08	CM-1 PF	Center
15:08:09	CM-2 PNF	Center
15:08:10	CM-1 PF	Ok full right
15:08:11	CM-2 PNF	Full right

UTC 時間	發 話 者	內 容
15:08:12	CM-1 PF	Center
15:08:13	CM-2 PNF	Center
15:08:14	CM-2 PNF	My controls checks ah
15:08:24	CM-1 PF	Hongkong is closed man, ha ha... worse
15:08:27	CM-3 OBS	Hongkong closed ah
15:08:27	CM-1 PF	That' s what he said not accepting any
15:08:29	CM-2 PNF	I see
15:08:30	CM-1 PF	I think some people might have diverted there lah I think
15:08:40	CM-2 PNF	Ok column coming back
15:08:47	CM-1 PF	If the RVR five left was two hundred right just now we checked
15:08:50	CM-3 OBS	RVR yah two hundred
15:08:50	CM-1 PF	Correct, yah two hundred meters ah, ok lah
15:08:54	CAM	(Sound similar to that of seat motor)
15:08:55	CM-1 PF	Ok man before takeoff checklist
15:08:56	CM-2 PNF	Roger sir
15:08:58	CM-2 PNF	Before..takeoff checks, flaps
15:09:02	CM-1 PF	Twenty green
15:09:03	CM-2 PNF	Twenty green
15:09:06	CM-2 PNF	Flight control
15:09:07	CM-1 PF	Check
15:09:07	CM-2 PNF	Check
15:09:08	CM-2 PNF	EPR and speeds
15:09:09	CM-1 PF	Ok, EPR one point five two ah, Vee one, one forty two, Vee R one five six and Vee two, one six nine set
15:09:15	CM-2 PNF	EPR one point five two ah, Vee one, one forty two, rotate one five six and Vee two, one six nine
15:09:19	CX 2043	(Cathay two zero four three conversation with ground control)△
15:09:22	CM-2 PNF	Speed set

UTC 時間	發 話 者	內　容
15:09:24	CM-2 PNF	Departure routing
15:09:25	CM-1 PF	Ok ah Taipei runway zero six left huh
15:09:27	CM-2 PNF	Zero five left
15:09:28	GND	(Ground control conversation with Cathay two zero four three)△
15:09:29	CM-1 PF	Zero five left
15:09:29	CM-3 OBS	Zero five left
15:09:31	CM-1 PF	And er we got Anpu three departure Kikit transition huh
15:09:32	CX 2043	(Cathay 2043 conversation with ground control)△
15:09:34	GND	(Ground control conversation with Cathay 2043)△
15:09:35	CX 2043	(Cathay 2043 conversation with ground control)△
15:09:38	CM-1 PF	Looks like I got to go..
15:09:40	CM-2 PNF	Next one got to go right is it
15:09:41	CM-1 PF	Yah, go right turn right here, all the way to West Cross lah right turn here
15:09:46	CM-2 PNF	Runway is zero five left. Kikit transition initially two hundred ah level alpha one squawk two six five seven, will be two nine zero by Bulan
15:09:58	CM-1 PF	A lot of rudder work man here.. really ah
15:10:01	CM-3 OBS	Cross wind ah..
15:10:02	CM-1 PF	Yah
15:10:03	CM-2 PNF	Transponder TA RA, set, checks down to the line
15:10:06	CM-1 PF	Ok, thanks.
15:10:08	CM-2 PNF	West Cross correct, Sierra Sierra West Cross
15:10:14	CM-1 PF	Everybody waiting for each other for takeoff you see haha
15:10:18	CM-1 PF	The bugger heard us…er going…that fellow also
15:10:21	CM-3 OBS	Yah, it is coming in ah, the longer they delay the worse it is lah
15:10:23	CM-1 PF	Yah, worse if we are going to get out, if don't take off ah…. I am going to go very slow here, ok, because you going get skid
15:10:24	CM-2 PNF	Ok nine knots
15:10:33	CM-3 OBS	Ok, to catch the wind

UTC 時間	發 話 者	內 容
15:10:35	CM-2 PNF	That's all the moisture
15:10:41	CM-2 PNF	Turning left skidding er turning right err skidding left two seven zero
15:10:42	CM-3 OBS	The weather radar will be all red ha ha
15:10:43	CM-1 PF	Ok, passing ah two eight zero now, ah needles tracking and turn right skidding left now ah, past heading of about two.. three hundred now ah
15:10:45	CM-2 PNF	Yah that's right ah
15:10:56	CAM	(Sound of clicks)
15:11:00	CM-2 PNF	My speed excursion is more than the left side, because the wind is coming from here
15:11:03	CM-1 PF	Ah, yah
15:11:03	CM-3 OBS	Your pitot on the other side ah …just pick up
15:11:10	CM-2 PNF	Roger that
15:11:12	CM-1 PF	For the takeoff use autopilot better
15:11:22	CM-1 PF	Typhoon man, ok tomorrow the guys coming in will be "terok" (terrible) man
15:11:28	CM-3 OBS	Yah, tomorrow morning Singapore five
15:11:29	GND	(Ground control conversation with Cathay two zero four three)△
15:11:36	CX 2043	(Cathay two zero four three conversation with ground control)△
15:11:38	GND	(Ground control conversation with Cathay two zero four three)△
15:11:42	CX 2043	(Cathay two zero four three conversation with ground control)△
15:11:47	CX 2043	(Cathay two zero four three conversation with ground control)△
15:11:49	CM-1 PF	The five left also imp..imp.. improve already the visibility to five hundred fifty meters
15:11:52	GND	(Ground control conversation with Cathay two zero four three)△
15:11:54	CX 2043	(Cathay two zero four three conversation with ground control)△
15:11:55	CM-3 OBS	Five left..wait ah
15:11:56	CM-1 PF	Ya, the guys said improved already went up
15:11:59	CM-3 OBS	Now is four fifty

UTC 時間	發 話 者	內 容
15:12:00	CM-1 PF	Just now the guys ask him over the tower
15:12:01	CM-2 PNF	Yah
15:12:02	ATIS	Taipei Chiang Kai Shek International Airport information uniform one five zero zero zulu runway zero six for departure only runway zero five left for category two approach and departure wind zero two zero at three six gust five six visibility six hundred meters runway zero five RVR four hundred fifty meters downward runway zero six RVR five hundred fifty meters downward with heavy rain cloud broken two hundred feet overcast five hundred feet temperature two one dew point two zero QNH one zero zero one Hectopascal
15:12:06	CM-2 PNF	Coming up er.. November Papa eh..
15:12:07	CM-1 PF	Ok, all the way down left turn all the way down
15:12:10	CM-2 PNF	Left ah
15:12:10	CM-1 PF	Yah
15:12:17	CM-2 PNF	One two five one departure
15:12:20	GND	(Ground control conversation with Cathay 2043)△
15:12:21	CAM	(Sound similar to that of radio frequency selection)
15:12:22	CM-1 PF	Ok, first left
15:12:23	CX 2043	(Cathay 2043 conversation with ground control)△
15:12:23	CM-2 PNF	Affirm first left
15:12:24	CM-1 PF	Left
15:12:25	CM-2 PNF	Left
15:12:26	GND	(Ground control conversation with Cathay 2043)△
15:12:33	CAM	(Sound similar to that of seat motor)
15:12:38	CX 2043	(Cathay 2043 conversation with ground control)△
15:12:41	CAM	(Sound similar to that of nose gear scrubbing)
15:12:47	CAM	(Sound similar to that of nose gear scrubbing)
15:12:47	GND	(Ground control conversation with Cathay 2043)△
15:12:56	CM-3 OBS	The latest QNH is one zero zero one

UTC 時間	發 話 者	內　　容
15:12:56	CM-2 PNF	Clearing that huh
15:12:58	GND	Singapore six contact tower one two nine point three, good day.
15:13:02	RDO-2	One two nine point three good day sir, Singapore six.
15:13:13	CM-2 PNF	One zero zero one one two nine point.. one two nine point three ah…..ok ah
15:13:25	RDO-2	Taipei Tower, good evening, Singapore six.
15:13:28	TWR	Singapore six, good evening, Taipei Tower hold short runway zero five left.
15:13:33	RDO-2	Hold short runway zero five left, Singapore six.
15:13:38	TWR	Singapore six, for information now surface wind zero two zero at two four, gust four three, say intention.
15:13:44	CM-1 PF	Gusting four three ah
15:13:46	RDO-2	Thank you sir, Singapore six.
15:13:47	CM-1 PF	Ok, ok better less
15:13:48	CM-3 OBS	Less, less gust already
15:13:54	CM-1 PF	Zero two zero it's from left lah
15:13:56	CM-3 OBS	Two four gust four three
15:14:05	CM-2 PNF	Zero two zero
15:14:08	CM-1 PF	Ok this one will be here ah
15:14:18	CM-1 PF	Zero two zero
15:14:20	CM-3 OBS	Ya, left lah
15:14:21	CM-1 PF	Go right to the end of the runway, end of the runway then turn, ok.
15:14:31	CM-3 OBS	Quite a bit of aileron for the takeoff
15:14:35	CM-2 PNF	OK
15:14:40	CM-2 PNF	The next one
15:14:41	CM-2 PNF	Next one is November one
15:14:42	CM-1 PF	Ok second right
15:14:44	CM-2 PNF	Second right, that’s right
15:14:47	CM-1 PF	In Australia, to them, next one is this, first one you know

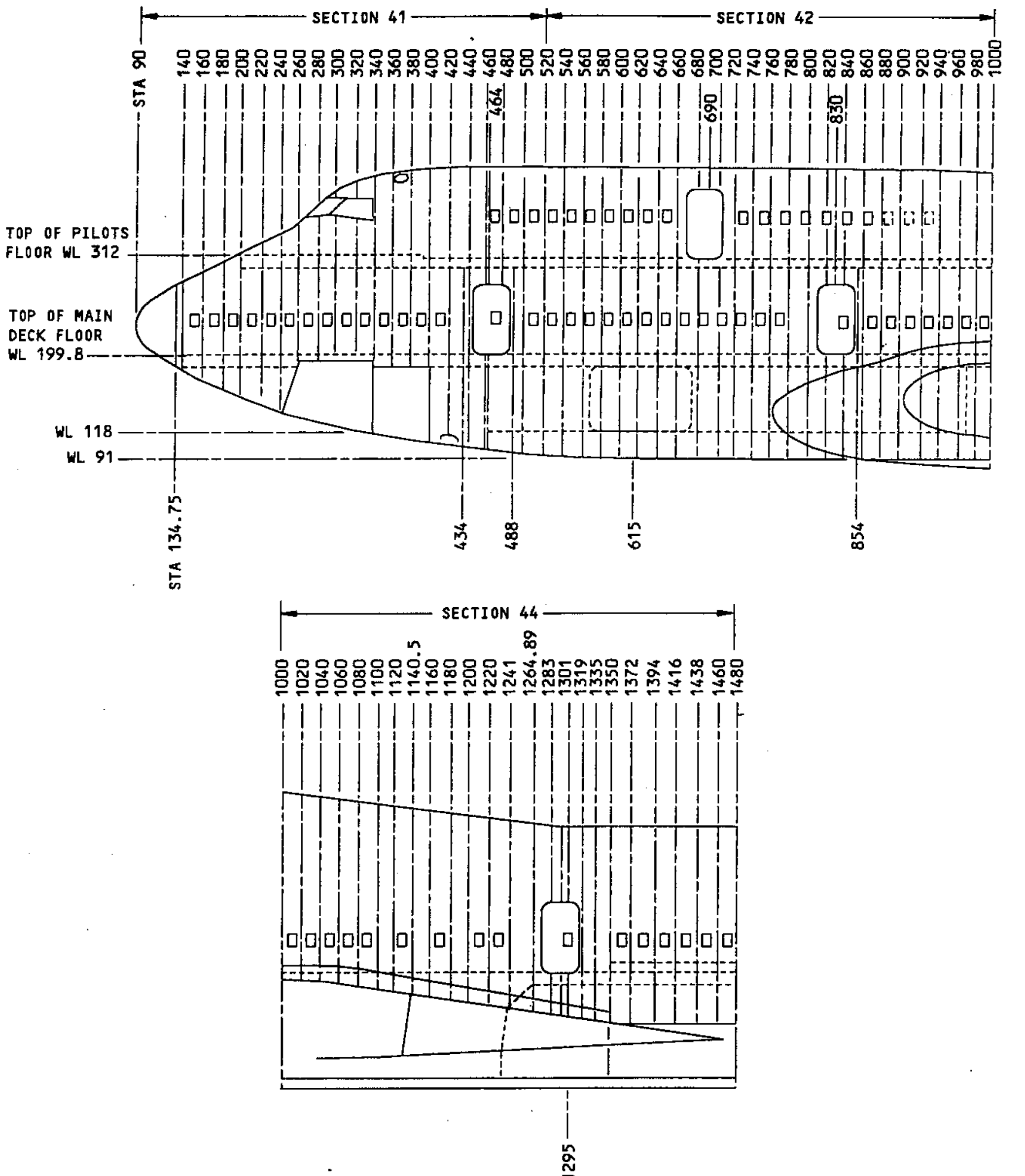
UTC 時間	發 話 者	內　容
15:14:50	CM-2 PNF	Next one this one
15:14:51	CM-1 PF	Yah..ha ha
15:14:52	CM-1 PF	Australian
15:14:53	CM-1 PF	I think the best is to say second right ah first right second right ah
15:14:55	CM-2 PNF	Clearing that Satvoice
15:14:58	CM-1 PF	Tell them we are ready lah
15:15:02	RDO-2	Singapore six ready.
15:15:04	TWR	Singapore six roger, runway zero five left, taxi into position and hold.
15:15:08	RDO-2	Taxi into position and hold, Singapore six
15:15:12	CM-2 PNF	I get them seated ah
15:15:12	CM-1 PF	Ok below the line please …yah
15:15:15	CM-2 PNF	Cabin crew to your takeoff station thanks
15:15:20	CAM	(Sound similar to that of door closing)
15:15:21	CAM	(Sound of chime)
15:15:22	TWR	Singapore six, runway zero five left, wind zero two zero at two eight, gust to five zero, cleared for takeoff.
15:15:30	RDO-2	Cleared for takeoff, Runway zero five left Singapore six.
15:15:31	CM-1 PF	OK man
15:15:34	CM-2 PNF	OK checks below the line, cabin announcement complete
15:15:37	CM-2 PNF	Packs
15:15:38	CM-1 PF	Ok norm eh
15:15:39	CM-2 PNF	Norm
15:15:40	CM-2 PNF	Strobes on, landing lights all on
15:15:44	CM-2 PNF	Takeoff clearance
15:15:45	CM-1 PF	Obtained hah
15:15:46	CM-2 PNF	Obtained sir
15:15:47	CM-1 PF	OK thanks

UTC 時間	發 話 者	內 容
15:15:48	CM-2 PNF	Before takeoff checklist completed
15:15:50	CAM	(Sound of click)
15:15:50	CM-2 PNF	OK green lights are here
15:15:52	CM-1 PF	It going to be very slippery I am going to slow down a bit, slow turn here
15:15:53	CM-2 PNF	Turning that
15:16:07	CM-2 PNF	And the PVD hasn't lined up ah
15:16:10	CM-1 PF	Yeah we gotta line up first
15:16:12	CM-3 OBS	We need forty five degrees
15:16:15	CM-2 PNF	I see, excellent man
15:16:16	CM-1 PF	Yah
15:16:23	CM-1 PF	Not on yet er PVD huh never mind we can see the runway, not so bad. Ok, I am going to put it to high first. OK ready eh, so zero one zero is from the left lah Ok
15:16:27	CM-2 PNF	Ok
15:16:30	CAM	(Sound similar to that of wipers going to high speed)
15:16:31	CM-2 PNF	Ready sir zero two zero check ok
15:16:33	CM-1 PF	Left wing into aileron, left aileron into wind. Huh OK Cabin reported eh.
15:16:37	CM-3 OBS	Yah cabin is ready.
15:16:37	CM-1 PF	Ok thanks
15:16:37	CM-2 PNF	Yup thanks
15:16:43	CM-3 OBS	Ok –thrust ref toga toga
15:16:43	CM-2 PNF	Thrust ref toga toga
15:16:44	CM-1 PF	Ok –thrust ref toga toga
15:16:44	CAM	(Sound similar to that of engines spooling up)
15:16:54	CM-3 OBS	Hold
15:16:54	CM-2 PNF	Hold
15:16:54	CM-1 PF	Roger

UTC 時間	發 話 者	內　　容
15:16:55	CM-3 OBS	Eighty knots
15:16:55	CM-2 PNF	Eighty knots
15:16:56	CM-1 PF	Ok my control
15:17:13	CM-2 PNF	Vee one
15:17:13	CM-3 OBS	Vee one
15:17:16	CM-1 PF	**** something there
15:17:17	CAM	Sound of the first impact
15:17:18	CAM	****waaah****
15:17:18	CAM	Sound of a series of impacts
15:17:22		End of Recording

附錄 4 - 波音 747-400 機型之機身機翼站位說明圖

REF DWG
65B00004



Fuselage Station Diagram
Figure 1 (Sheet 1)

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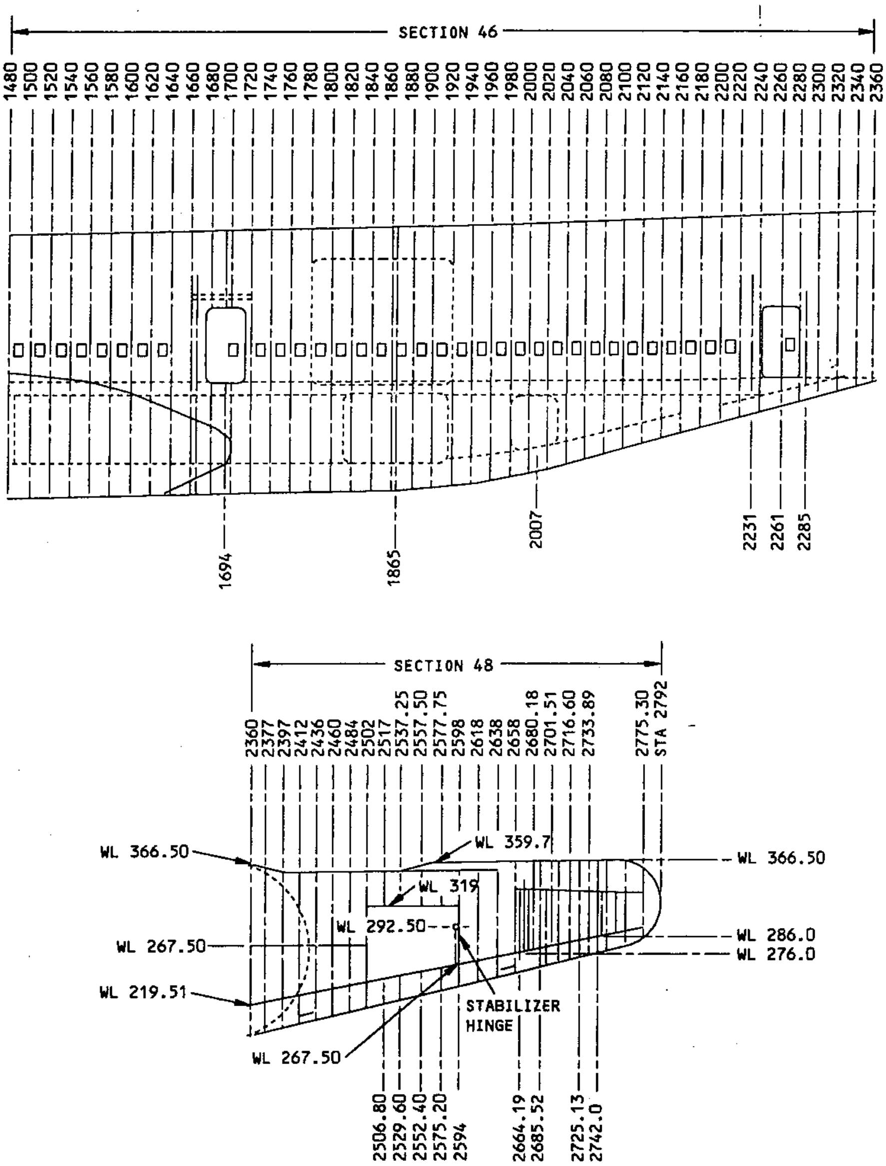
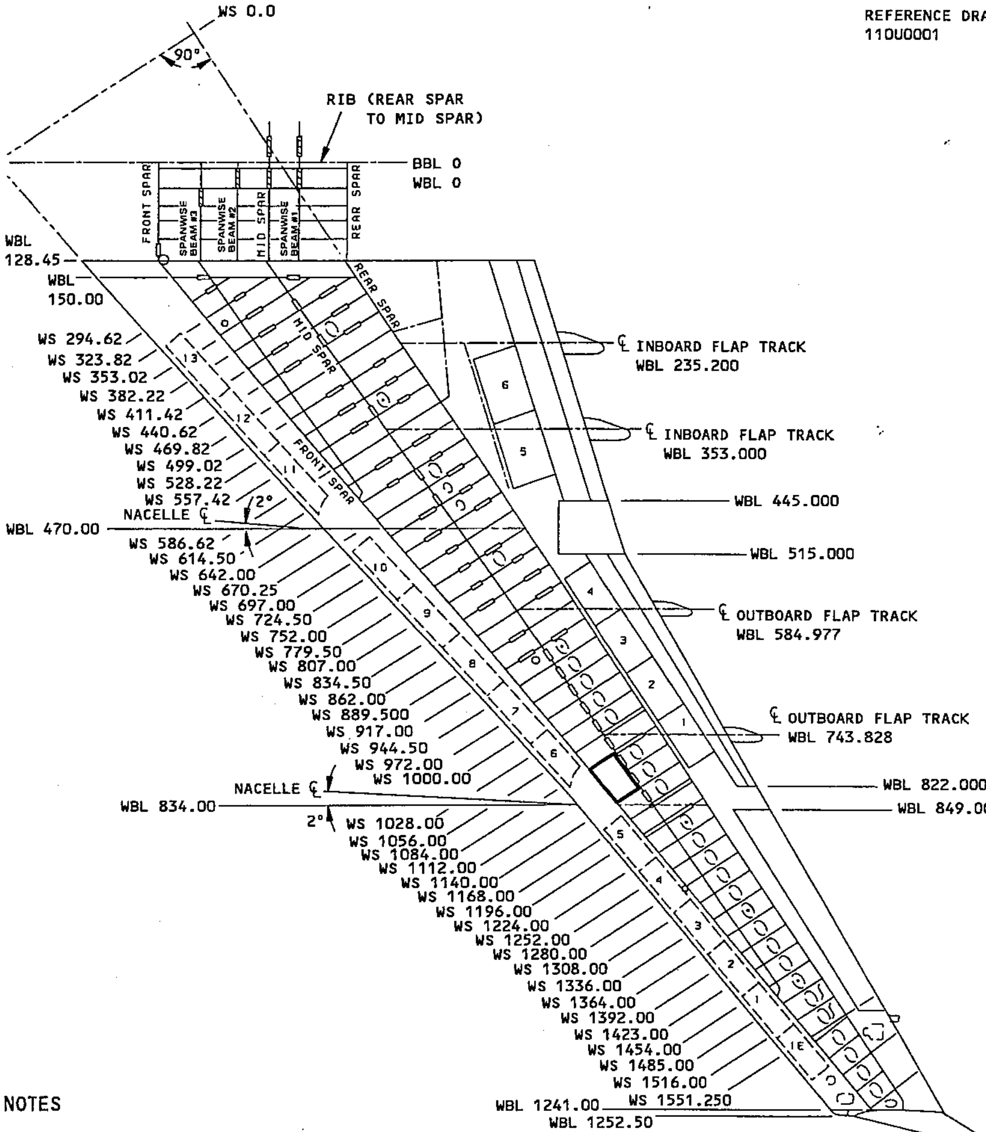


Fuselage Station Diagram
Figure 1 (Sheet 2)

REFERENCE DRAWING
110U0001

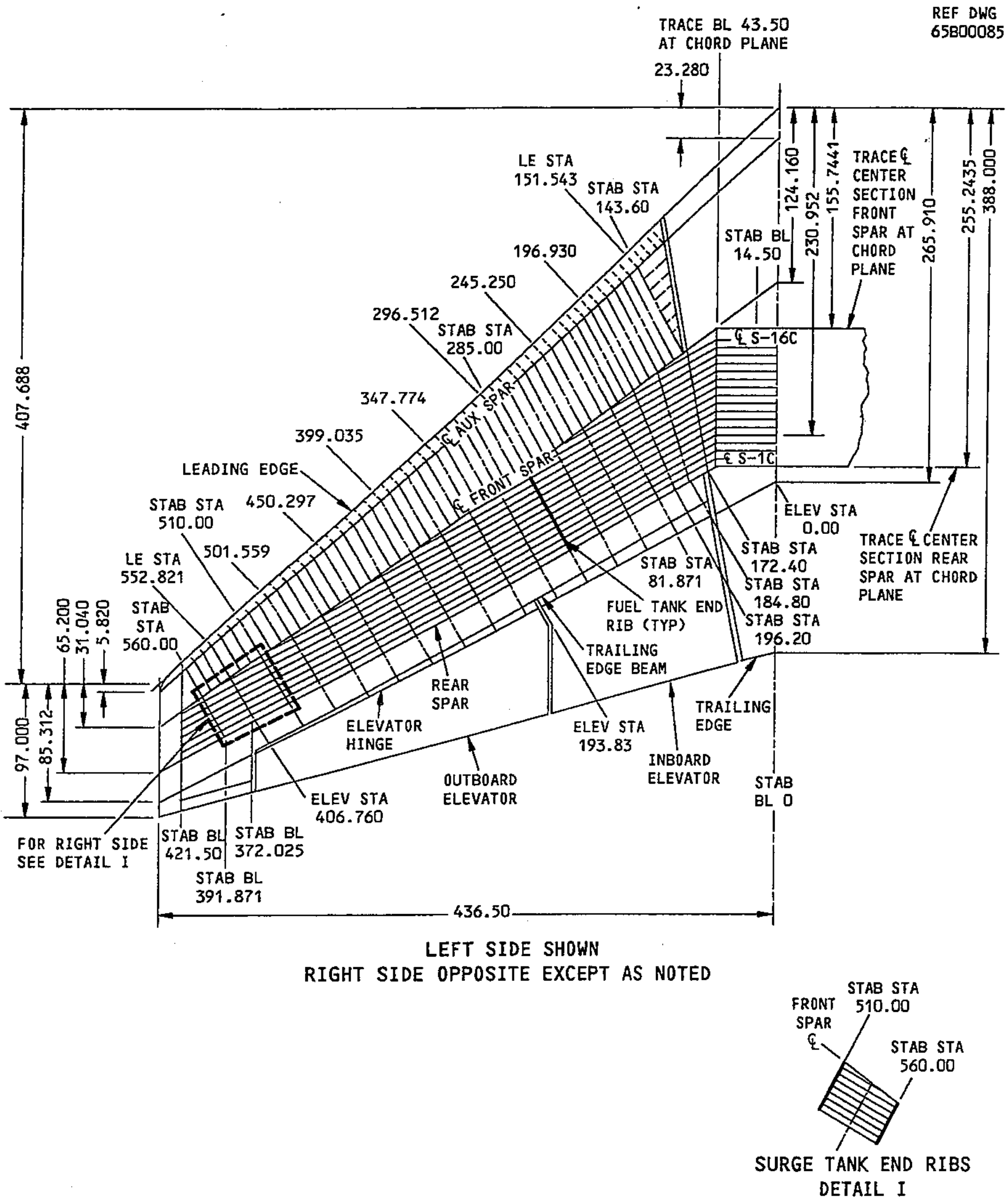


NOTES

- SEE FIGURE 1 FOR THE WING ELEMENT DIAGRAM.
- SEE FIGURE 3 FOR THE WING CENTERLINE DIAGRAM.
- SEE FIGURES 4, 5, AND 6 FOR AIRPLANES THAT DO NOT HAVE WINGLETS.

Wing Station Diagram - Airplane with Winglets
Figure 2

G5564



Horizontal Stabilizer Station Diagram
Figure 1 (Sheet 1)

附錄 5 - 中正機場至 89 年 3 月之意外事件報告

八十七年三月二十七日

國泰航空公司 CX006 **班機/機型** B747**，獲許可由** 05L **跑道起飛時，另有航機尚在跑道上，國泰班機在跑道等待直到另架航機脫離。**

八十七年六月六日

國泰航空公司 CX420 **班機滑入關閉中之滑行道，駕駛員認為本案係語言誤解所引起。駕駛員稱：雖從飛航公告中得知滑行道關閉，但施工區域外圍無障礙燈光標示。**

八十八年三月二十四日

國泰航空公司 CX421 **班機被航管指示滑入關閉中之滑行道（細節不詳）。**

八十九年三月五日

中華航空公司 CI065 **班機**/B747-400 **於** 05L **跑道滾行起飛時，另一架** B747-100 **貨機（**UP7846**）亦滑入同一跑道。**

八十九年三月二十三日

麥克羅尼西亞航空公司 CM922 **班機獲許可由** 05L **跑道起飛時，另一架** MD11**（**BR671**）尚未脫離跑道。在後者警告有航機尚在跑道後，**CM922 **班機起飛許可取消。**

八十九年十月二十二日

新加坡航空公司貨機 SQ7693 **於** 05L **跑道決定高度實施重飛，因組員無法目視跑道。重飛時，該機機長表示** 05L **跑道之進場燈及跑道燈均未開啟，管制員隨即為忘記開起燈光道歉。**

附錄 6 - BOEING 747-400 AFM PVD SUPPLEMENT

BOEING 747-400

AIRPLANE FLIGHT MANUAL

SECTION 3 - NORMAL AND ABNORMAL PROCEDURES

Procedures contained in Section 3 of the basic manual are supplemented by the following:

PARA VISUAL DISPLAY (P V D)

The runway lighting is the primary means of guidance during takeoff. The PVD system can be used as a reversionary source of guidance to the localizer centerline during periods of reduced visibility. The direction of the streaming display is the direction to steer to acquire and maintain the localizer centerline.

The flight crew should confirm that when the PVD is selected ON, the display streams right, left and then stops momentarily. The display will then either provide guidance to the localizer centerline or will shutter dependent upon whether the airplane is in a position for takeoff or not.

The PVD system monitoring will not unshutter the display and provide guidance unless sufficient equipment is available. The minimum requirement for PVD operations is an active display for the flying pilot.

附錄 7 - 飛航安全委員會之調查報告草案意見回覆

附錄7.1　行政院飛航安全委員會之回覆摘要

美國運輸安全委員會、澳洲運輸安全局、新加坡交通與資訊安全部以及我國民航局針對本會英文版調查報告草案所回覆之意見詳附錄 7.2 至附錄 7.5，對於其中與調查報告內容相關部份之意見，本會回覆摘要如下表：

<table>
<tr><td colspan="4">表例說明：

A-接受
R-不接受
PA-部份接受
AC-同意</td></tr>
<tr><td colspan="4" align="center">NTSB</td></tr>
<tr><td></td><td>1</td><td>Section 4 New Recommendations</td><td>A</td></tr>
<tr><td colspan="4" align="center">ATSB</td></tr>
<tr><td></td><td>1</td><td>Section 3.1 Finding 7, Point 9</td><td>A</td></tr>
<tr><td></td><td>2</td><td>Section 3.2 Finding 8</td><td>A</td></tr>
<tr><td></td><td>3</td><td>Section 3.3 Finding 15</td><td>A</td></tr>
<tr><td></td><td>4</td><td>Section 4.1 Recommendation to SIA, Point 3</td><td>A</td></tr>
<tr><td></td><td>5</td><td>Section 4.1 Recommendation to SIA, Point 10</td><td>A</td></tr>
<tr><td></td><td>6</td><td>Section 1.10.3.1.2</td><td>A</td></tr>
<tr><td></td><td>7</td><td>Section 1.17.4.1 Para 4</td><td>A</td></tr>
<tr><td></td><td>8</td><td>Sections 1.18.1.3.1 through to 1.18.1.3.4</td><td>A</td></tr>
<tr><td></td><td>9</td><td>Section 1.18.7</td><td>A</td></tr>
<tr><td></td><td>10</td><td>Section 1.18.8.2</td><td>A</td></tr>
<tr><td></td><td>11</td><td>Section 2.5.6.4 Para 1</td><td>A</td></tr>
<tr><td></td><td>12</td><td>Section 2.5.7.1 Last para</td><td>PA</td></tr>
<tr><td></td><td>13</td><td>Section 2.5.7.2.3 Para 3</td><td>R</td></tr>
<tr><td></td><td>14</td><td>Section 2.5.7.5</td><td>A</td></tr>
<tr><td></td><td>15</td><td>Section 2.5.8.4</td><td>A</td></tr>
<tr><td></td><td>16</td><td>Section 2.5.9</td><td>A</td></tr>
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MCIT			
PART 2	1	Section 3.1 Finding 1	R
	2	Section 3.1 Finding 2	R
	3	Section 3.1 Finding 3	R
	4	Section 3.1 Finding 4	R
	5	Section 3.1 Finding 5	R
	6	Section 3.1 Finding 6	PA
	7	Section 3.1 Finding 7	PA
PART 3	8	Section 3.2 Finding 1	R
	9	Section 3.2 Finding 2	R
	10	Section 3.2 Finding 3	R
	11	Section 3.2 Finding 4	R
	12	Section 3.2 Finding 5	R
	13	Section 3.2 Finding 6	R
	14	Section 3.2 Finding 7	A
	15	Section 3.2 Finding 8	A
	16	Section 3.2 Finding 9	PA
	17	Section 3.2 Finding 10	PA
	18	Section 3.2 Finding 11	R
	19	Section 3.2 Finding 12	AC
	20	Section 3.2 Finding 13	R
	21	Section 3.2 Finding 14	R
	22	Section 3.2 Finding 15	R
	23	Section 3.2 Finding 16	R
	24	Section 3.2 Finding 17	R
	25	Section 3.2 Finding 18	R
	26	Section 3.2 Finding 19	R
	27	Section 3.2 Finding 21	R
	28	Section 3.2 Finding 22	R
	29	Section 3.2 Finding 25	R
	30	Section 3.2 Finding 26	R
	31	Section 3.2 Finding 27	R
	32	Section 3.2 Finding 28	A
	33	Section 3.2 Finding 29	R
	34	Section 3.2 Finding 30	R

	35	**Section 3.3 Finding 2**	**AC**
	36	**Section 3.3 Finding 5**	**R**
	37	**Section 3.3 Finding 10**	**AC**
	38	**Section 3.3 Finding 15**	**A**
	39	**Section 3.3 Finding 23**	**R**
PART 4	40	**Section 4.1 Recommendation to SIA, Point 1**	**AC**
	41	**Section 4.1 Recommendation to SIA, Point 2**	**AC**
	42	**Section 4.1 Recommendation to SIA, Point 3**	**R**
	43	**Section 4.1 Recommendation to SIA, Point 4**	**AC**
	44	**Section 4.1 Recommendation to SIA, Point 5**	**A**
	45	**Section 4.1 Recommendation to SIA, Point 6**	**AC**
	46	**Section 4.1 Recommendation to SIA, Point 7**	**R**
	47	**Section 4.1 Recommendation to SIA, Point 8**	**AC**
	48	**Section 4.1 Recommendation to SIA, Point 9**	**R**
	49	**Section 4.1 Recommendation to SIA, Point 10**	**AC**
	50	**Section 4.1 Recommendation to SIA, Point 11**	**A**
	51	**Section 4.1 Recommendation to CAAS, Point 1**	**R**
	52	**Section 4.1 Recommendation to CAAS, Point 2**	**R**
	53	**Section 4.1 Recommendation to CAAS, Point 3**	**R**
	54	**Section 4.1 Recommendation to CAAS, Point 4**	**AC**
	55	**Section 4.1 Recommendation to CAAS, Point 5**	**AC**
	56	**Section 4.1 Recommendation to CAAS, Point 6**	**AC**
	57	**Section 4.1 Recommendation to Singapore Government**	**R**
	58	**Section 4.1 Recommendation to CAA, Point 1**	**A**
	59	**Section 4.1 Recommendation to CAA, Point 7**	**AC**
	60	**Section 4.1 Recommendation to CAA, Point 9**	**R**
	61	**Section 4.1 Recommendation to CAA, Point 10**	**PA**
	62	**Section 4.1 Recommendation to CAA, Point 11**	**AC**
	63	**Section 4.1 Recommendation to Boeing, Point 1**	**A**
PART 5	64	**Section 2.6.1**	**AC**
	65	**Section 2.6.4**	**R**
	66	**Section 1.12.2.3.2 (3 issues)**	**R**
	67	**Section 1.15.1.1, Para 3**	**A**
	68	**Section 1.15.1.1, Para 6**	**PA**
	69	**Section 1.15.1.1, Para 7**	**PA**
	70	**Section 1.15.1.1, Para 3**	**R**

	71	**Section 1.15.1.1, Para 4**	**R**
	72	**Section 1.15.1.3, Para 2**	**PA**
	73	**Section 1.15.1.6, Para 1**	**R**
	74	**Section 1.15.1.6, Para 2**	**R**
PART 6	75	**Section 2, Para 2**	**A**
	76	**Section 2.1, Para 3**	**R**
	77	**Section 2.3.1.1 Para 2**	**R**
	78	**Section 2.3.1.1 Para 4**	**R**
	79	**Section 2.3.1.2.2 Para 4**	**R**
	80	**Section 2.3.1.2.3 Para 1**	**R**
	81	**Section 2.3.1.2.3 Para 2**	**R**
	82	**Section 2.3.2 Para 1**	**A**
	83	**Section 2.3.2 Para 3**	**A**
	84	**Section 2.3.3 Para 1**	**R**
	85	**Section 2.3.3 Para 2**	**R**
	86	**Section 2.3.4.1 Para 2**	**A**
	87	**Section 2.3.4.1 Para 3**	**R**
	88	**Section 2.3.4.1 Para 3**	**R**
	89	**Section 2.3.4.1 Para 8**	**R**
	90	**Section 2.3.4.1 Para 9**	**R**
	91	**Section 2.3.4.1 Para 10**	**R**
	92	**Section 2.3.4.1 Para 11**	**R**
	93	**Section 2.3.4.2 Para 2**	**R**
	94	**Section 2.3.5.2.2 Para 1**	**AC**
	95	**Section 2.3.6 Para 4**	**R**
	96	**Section 2.4.1 Para 4**	**R**
	97	**Section 2.4.1 Para 6**	**R**
	98	**Section 2.4.2 Para 2**	**PA**
	99	**Section 2.5.4 Para 1**	**R**
	100	**Section 2.5.4.1 Para 1**	**A**
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	103	**Section 2.5.4.3 Para 2**	**R**
	104	**Section 2.5.4.4 Para 1**	**R**
	105	**Section 2.5.4.4 Para 2**	**R**
	106	**Section 2.5.4.5 Para 1**	**R**

	107	**Section 2.5.4.5 Para 11**	**PA**
	108	**Section 2.5.4.6 Para 1**	**R**
	109	**Section 2.5.5 Para 1**	**R**
	110	**Section 2.5.6.2 Para 1**	**R**
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	112	**Section 2.5.6.3.1 Para 5**	**PA**
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	114	**Section 2.5.3.6.2 Para 5**	**PA**
	115	**Section 2.5.6.3.3 Para 11**	**A**
	116	**Section 2.5.6.3.3 Para 12**	**A**
	117	**Section 2.5.6.3.3 Para 13**	**R**
	118	**Section 2.5.6.4 Para 3**	**R**
	119	**Section 2.5.7.1 Para 2**	**R**
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	122	**Section 2.5.7.1 Para 11**	**R**
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	124	**Section 2.5.7.2.1 Para 2**	**R**
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	129	**Section 2.5.7.2.3 Para 4**	**R**
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	136	**Section 2.5.7.6.1.2 Para 2**	**R**
	137	**Section 2.5.7.6.1.2 Para 3**	**R**
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	139	**Section 2.5.7.8 Para 1**	**R**
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	141	**Section 2.5.8.1 Para 1**	**R**
	142	**Section 2.5.8.2 Para 3**	**A**

	143	**Section 2.5.8.2 Para 5**	**R**
	144	**Section 2.5.8.2 Para 6**	**R**
	145	**Section 2.5.8.2 Para 10**	**A**
	146	**Section 2.5.8.3 Para 1**	**A**
	147	**Section 2.5.8.4 Para 2**	**R**
	148	**Section 2.5.8.4 Para 4**	**R**
	149	**Section 2.5.8.5 Para 3**	**A**
	150	**Section 2.5.9 Para 1**	**AC**
	151	**Section 2.5.9 Para 9**	**R**
	152	**Section 2.5.9.1 Para 3**	**R**
	153	**Section 2.5.10 Para 1**	**AC**
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	155	**Section 2.5.10.1 Para 1**	**R**
	156	**Section 2.5.10.1 Para 3**	**R**
	157	**Section 2.5.10.3 Para 1**	**AC**
	158	**Section 2.5.11 Para 6**	**R**
	159	**Section 2.6.1 Para 1**	**A**
	160	**Section 2.6.1 Para 2**	**R**
	161	**Section 2.6.3.1 Para 2**	**R**
	162	**Section 2.6.3.1 Para 3**	**AC**
	163	**Section 2.6.5 Para 3**	**PA**
	164	**Section 2.7.3 Para 1**	**A**
	165	**Section 2.7.4 Para 3**	**AC**
	166	**Section 2.7.4 Para 4**	**PA**
	167	**Section 2.7.4 Para 6**	**R**
	168	**Section 2.7.4 Para 7**	**R**
	169	**Section 2.7.5 Para 4**	**A**
		CAA	
	1	**Section 1.1**	**R**
	2	**Section 1.3**	**PA**
	3	**Section 1.4**	**R**
	4	**Section 1.5.1**	**A**
	5	**Section 1.5.2**	**A**
	6	**Section 1.5.3**	**A**
	7	**Section 1.7.2 issue 1**	**R**

	8	**Section 1.7.2 issue 2**	**R**
	9	**Section 1.10.1**	**R**
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	11	**Section 1.10.2.1 issue 2**	**A**
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	13	**Section 1.10.3.2.3**	**A**
	14	**Section 1.10.3.2.4**	**A**
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	16	**Section 1.13**	**A**
	17	**Section 1.16.6**	**R**
	18	**Section 1.17.3.2**	**R**
	19	**Section 1.17.4.4**	**R**
	20	**Section 1.17.4.5**	**R**
	21	**Section 1.17.4.6**	**R**
	22	**Section 1.17.5**	**R**
	23	**Section 1.17.6**	**R**
	24	**Section 1.17.8**	**R**
	25	**Section 1.17.9**	**R**
	26	**Section 1.17.11**	**A**
	27	**Section 1.18.1.1 issue 1**	**A**
	28	**Section 1.18.1.1 issue 2**	**A**
	29	**Section 1.18.1.3.4**	**R**
	30	**Section 1.18.1.5**	**R**
	31	**Section 1.18.2.3 issue 1**	**PA**
	32	**Section 1.18.2.3 issue 2**	**PA**
	33	**Section 1.18.2.4 issue 1**	**A**
	34	**Section 1.18.2.4 issue 2**	**R**
	35	**Section 1.18.2.4 issue 3**	**R**
	36	**Part 2 Analysis**	**AC**
	37	**Section 2.2**	**R**
	38	**Section 2.3**	**R**
	39	**Section 2.3.1.1 issue 1**	**R**
	40	**Section 2.3.1.1 issue 2**	**PA**
	41	**Section 2.3.1.2.1**	**R**
	42	**Section 2.3.1.2.2 issue 1**	**R**
	43	**Section 2.3.1.2.2 issue 2**	**PA**

	44	**Section 2.3.1.2**	**R**
	45	**Section 2.3.2**	**R**
	46	**Section 2.3.3**	**R**
	47	**Section 2.3.5.2.1**	**A**
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	50	**Section 2.4.1 issue 1**	**PA**
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	53	**Section 2.4.2 issue 1**	**R**
	54	**Section 2.4.2 issue 2**	**R**
	55	**Section 2.5.2.1**	**R**
	56	**Section 2.5.4.1**	**PA**
	57	**Section 2.5.4.2**	**A**
	58	**Section 2.5.4.3**	**A**
	59	**Section 2.5.4.5**	**R**
	60	**Section 2.5.5**	**R**
	61	**Section 2.5.6.1**	**A**
	62	**Section 2.5.6.3.3**	**R**
	63	**Section 2.5.7.1 issue 1**	**A**
	64	**Section 2.5.7.1 issue 2**	**A**
	65	**Section 2.5.7.2.1**	**PA**
	66	**Section 2.5.7.2.2 issue 1**	**PA**
	67	**Section 2.5.7.2.2 issue 2**	**R**
	68	**Section 2.5.7.2.3 issue 1**	**PA**
	69	**Section 2.5.7.4 issue 1**	**A**
	70	**Section 2.5.7.4 issue 2**	**PA**
	71	**Section 2.5.7.5**	**R**
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	74	**Section 2.5.7.6.1.2 issue 1**	**R**
	75	**Section 2.5.7.6.1.2 issue 2**	**PA**
	76	**Section 2.5.7.7 issue 1**	**R**
	77	**Section 2.5.7.7 issue 2**	**PA**
	78	**Section 2.5.7.7.1 issue 1**	**A**
	79	**Section 2.5.7.7.1 issue 2**	**PA**

	80	**Section 2.5.7.8 issue 1**	**A**
	81	**Section 2.5.7.8 issue 2**	**PA**
	82	**Section 2.5.8**	**A**
	83	**Section 2.5.8.1**	**A**
	84	**Section 2.5.8.2 issue 1**	**A**
	85	**Section 2.5.8.2 issue 2**	**R**
	86	**Section 2.5.8.3**	**A**
	87	**Section 2.5.8.4**	**PA**
	88	**Section 2.5.9**	**R**
	89	**Section 2.5.9.1**	**R**
	90	**Section 2.5.10**	**PA**
	91	**Section 2.6.1**	**A**
	92	**Section 2.6.4.3**	**R**
	93	**Section 2.7.2**	**R**
	94	**Section 3**	**R**
	95	**Section 3.1 Finding 1**	**R**
	96	**Section 3.1 Finding 4**	**R**
	97	**Section 3.1 Finding 5**	**A**
	98	**Section 3.1 Finding 6**	**PA**
	99	**Section 3.1 Finding 7 issue 1**	**PA**
	100	**Section 3.1 Finding 7 issue 2**	**PA**
	101	**Section 3.2 Findings 1 & 2 issue 1**	**R**
	102	**Section 3.2 Findings 1 & 2 issue 2**	**R**
	103	**Section 3.2 Finding 4**	**R**
	104	**Section 3.2 Finding 5**	**R**
	105	**Section 3.2 Finding 8**	**A**
	106	**Section 3.2 Finding 9**	**R**
	107	**Section 3.2 Finding 11**	**R**
	108	**Section 3.2 Finding 13 issue 1**	**PA**
	109	**Section 3.2 Finding 13 issue 2**	**PA**
	110	**Section 3.2 Finding 14**	**A**
	111	**Section 3.2 Finding 16**	**R**
	112	**Section 3.2 Finding 18**	**A**
	113	**Section 3.2 Finding 23**	**A**
	114	**Section 3.2 Finding 25**	**A**
	115	**Section 3.2 Finding 31**	**R**

	116	**Section 3.2 Finding 32**	**R**
	117	**Section 3.2 Finding 33**	**R**
	118	**Section 3.2 Finding 36**	**R**
	119	**Section 3.3 Finding 12**	**R**
	120	**Section 3.3 Finding 18**	**PA**
	121	**Section 3.3 General**	**AC**
	122	**Section 4 Recommendation to CAA Point 2**	**R**
	123	**Section 4 Recommendation to CAA Point 7**	**A**
	124	**Section 4 Recommendation to CAA Point 11**	**A**
	125	**Section 4 Recommendation to ICAO Point 1**	**R**
	126	**Section 4.2**	**A**
	127	**Section 4.2 Point 3**	**A**
	128	**Section 4.2 Point 5**	**A**
	129	**Section 4.2 New Item 6**	**A**

附錄7.2　　美國運輸安全委員會之回覆意見

National Transportation Safety Board

Washington, D.C. 20594

Office of Aviation Safety

25 March 2002

Dr. Kay Yong
Managing Director
Aviation Safety Council
16th Floor, 99 Hsing North Road
Taipei, 105
Taiwan R.O.C.

Dear Kay,

Enclosed please find the U.S. team's comments to the "Final Draft" of the investigation of SQ006, the Singapore Airline Boeing 747-400 that crashed on takeoff from CKS Airport, Taoyuan, Taiwan on October 31, 2000.

A National Transportation Safety Board (NTSB) Accredited Representative and staff participated in the investigation and two follow-up meetings as the state of manufacture of the accident airplane, a Boeing 747-400, SQ006, that was involved in the scenario of the accident. Advisors from the Federal Aviation Administration (FAA), the Boeing Company, and Pratt & Whitney (the engine manufacturer) also participated. We wish to express our appreciation for the level of participation afforded to our team. We also wish to congratulate the Aviation Safety Council (ASC) for the excellent job of conducting the investigation and the ample consideration given to all the parties involved.

NTSB staff that participated in the investigation has reviewed the complete draft report. In addition, Boeing personnel that participated in the investigation have submitted comments to the U.S. Accredited Representative.

The report makes a determined effort to examine all unsafe acts, unsafe conditions, and safety deficiencies that were likely to have operated in the accident. It seems especially appropriate that the report explored issues related to both flight crew and airport, since both include significant factors likely to have contributed to the overall system deficiencies.

From a human performance viewpoint, the Taiwan Aviation Safety Council (ASC) may wish to consider an additional area of recommendations: the implementation of cockpit surface moving map displays. Current technology makes such displays possible and, for several reasons, they may represent the single most effective method of preventing a recurrence of this accident.

A cockpit surface moving map display is a navigation aid that would display in the cockpit the airplane's exact position (determined by Global Positioning System (GPS) satellite navigation) superimposed on a map of airport surface features including all runway, taxiway, and terminal areas. The airplane depiction would move as the flight navigated along taxiways and runways on the airport surface, portraying visually information that is now provided in a less complete format in such resources as paper charts and progressive taxi instructions. The human value of a moving map display is that it integrates a variety of complex data into a clear, precise, and intuitive representation of aircraft position with reference to a pre-planned course, allowing the pilot to maintain a mental picture, especially in low visibility conditions.

Such moving map displays have been used with great success and industry acceptance to depict airborne navigation information. One authority on automation has suggested, with regard to cockpit moving map displays already implemented, that "...no single feature has mitigated flight crew cognitive workload as much as these new displays, and it is probable that no technological advance has done as much to make the modern airplane more error-resistant than its predecessor." Research confirms that an electronic map display, if extended to navigation on the airport surface, can significantly decrease navigational errors such as wrong turns in low visibility conditions.

An additional safety feature of the cockpit surface moving map display is that, in the future, it might provide the basis for a complete ground movement safety system. One upgrade to the system, enabled by data link technology, would add traffic information concerning all other aircraft and surface vehicles at the airport (equipped with a compatible system or transponder). Another upgrade would provide graphical depiction of Notices to Airmen (NOTAM) information, for example overlaying a different color on part of a runway closed for construction. Such upgrades are being currently developed. However, implementation of a basic surface moving map display as a basis for a ground movement safety system should not be delayed. Many airport ground movement safety problems involve pilots becoming lost on the airport, as in the present accident. The current technology displays, with GPS location of own aircraft, have immediate safety benefits in that they do not have to wait for an enabling technology or widespread user implementation and can help pilots avoid airport "hot spots" and closed runways and taxi in bad weather.

A cockpit surface moving map display may have prevented the present accident, giving the flight crew a source of precise, current location information to build a mental picture of their route to an unfamiliar runway. It would have provided a direct, timely warning to the flight crew that would not have been available with a control tower radar system such as the Airport Surface Detection Equipment (ASDE), which would require significant time for the controller to detect and identify the safety problem, determine the necessary action, and establish radio contact with the crew as well as for the flight crew to react and take evasive action. It would have provided more complete and accessible navigation information, regardless of visibility conditions, than progressive taxi instructions.

Therefore, from a human performance perspective, the ASC may wish to consider recommendations such as the following:

To the Boeing and Airbus Companies:

1. Incorporate cockpit surface moving map displays into all newly-certified aircraft;
2. Develop retrofit installation options for cockpit surface moving map displays in all previously certified aircraft.

To International Civil Aviation Organization (ICAO):

1. Encourage all member states to survey major airport environments to develop a suitable database for display on a moving map multifunction display;

To the airline industry:

1. Equip all company aircraft with cockpit surface moving map displays

Specific comments from the Safety Board's operations staff were made to an electronic copy of the 'Final Draft' and therefore to large to send electronically with this letter. They have been included on a disk and printed out and sent under separate cover with this letter.

Comments from the Boeing Company have also been included as an attachment to the electronic version and sent under separate cover with the letter.

Pratt and Whitney had no comments to make regarding the 'Final Draft'.

Thank you again for inviting the safety board to present these comments before your staff and board members and we are sorry that we cannot be there for the formal presentation. We all realize how important this investigation is to the ASC and to aviation safety throughout the world.

With best regards,

Alfred W. Dickinson
Accredited Representative, NTSB, USA

17398.pdf

Attachment: Boeing comments

附錄7.3　　澳洲運輸安全局之回覆意見

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Dr Kay Yong
Managing Director
Aviation Safety Council
16th Floor, 99 Fu-Hsing North Road
Taipei 105
Taiwan, R.O.C.

Dear Dr Yong,

SINGAPORE AIRLINES FLIGHT 006, BOEING 747-400, REGISTRATION 9V-SPK, CKS AIRPORT, TAOYUAN, TAIWAN, 31 OCTOBER 2000

Thank you for your letter and final draft report of the accident involving Singapore Airlines Limited Boeing 747-400, registration 9V-SPK, which collided with construction equipment on Runway 05R at Chiang Kai-Shek International Airport, Taiwan, on October 31, 2000.

As the Australian accredited representative, my advisers and I have reviewed the draft final report of the accident in accordance with the provisions of paragraphs 6.3 and 6.4 to Annex 13 (Ninth edition, July 2001) of the Convention on International Civil Aviation. We find the report thorough and the conclusions fully supported by the factual content. We also note that you have proposed recommendations aimed at preventing similar accidents in the future. Our detailed comments are noted below.

With respect to the following paragraphs of the report, we suggest that the paragraphs be amended as follows to ensure the meaning of the statements is correct:

- Executive Summary and Part 3
  Findings related to probable causes

  ATSB suggests that finding 7, bullet point 9, be altered from the incorrect term Parallel Visual Display (PVD) to the correct term Para-Visual Display (PVD).

- Executive Summary and Part 3
  Findings related to risk

  ATSB suggests that finding 8 be deleted for the reasons cited in comments associated with section 2.5.8.4 - Taxiway Lighting Issues. (See comments page 6)

- Executive Summary and Part 3
  Findings related to risk

  ATSB suggests that ASC rewrite finding 16, dot point 7 to form a stand alone finding with respect to runway closed warning/alert markings/indicators, and review the significance of the finding to ensure that it is given appropriate status with respect to findings related to probable causes and findings related to risk.

- Executive Summary, Part 1 and Part 3
  Other findings

  ATSB suggests that other finding 15 and the text in section 1.13.3 from which it is drawn, indicate that while there was no alcohol or drug testing of the three flight crewmembers of SQ006 after the accident, there was no evidence to suggest that alcohol or drugs were factors in the accident.

- Executive Summary and Part 4
  Recommendation 3 to Singapore Airlines

  ATSB suggests that recommendation 3 be amended to state:

  Review the adequacy of current SIA PVD training and procedures and ensure that SIA documentation and operational practices reflect the CAAS approved B747-400 AFM PVD supplement, which stated that the PVD "will shutter dependent upon whether the airplane is in a position for takeoff or not". (3.2-[9, 10]).

- Executive Summary and Part 4
  Recommendation 10 to Singapore Airlines

  ATSB suggests that recommendation 10 be amended to state:

  Review its procedures and training for the crew to effectively handle diversified emergency situations. (3.2-[24, 25, 26, 27]).

- Part 1
  Section 1.10.3.1.2 Taxiway centerline marking

  The picture/diagram Figure 1.10-6 is missing.

- Part 1
  Section 1.17.4.1 Crew Resource Management

  Paragraph 4, line 4:

  They sometimes discuss the ATC principles and critique the crews on the CRM issues during flight or simulator checks debriefings.

  ATSB suggests that the term *ATC principles* be clarified.

- Part 1
  Sections 1.18.1.3.1 through to 1.18.1.3.4

  ATSB suggests that a clear summary statement of the evidence, which indicates whether the Runway 05L approach lights, touchdown zone lights, runway edge and centerline lights, and PAPI were on for SQ006's departure is needed. On the evening of the accident, other flight crews had reported that all Runway 05L approach and runway lighting was illuminated for their departure but the controllers statements indicate uncertainty about the status of the Runway 05L CAT II approach lighting for SQ006's departure.

The RVR printout of the Runway 05L lighting system status revealed that the lights were powered on about 2313 LT (about 4 minutes before the accident). There are implications for analysis section 2.5.5 (Before take-off check) and section 2.5.7.4 (Runway difference issues). The factual is not clear on whether all Cat II lighting for Runway 05L had been illuminated before SQ006 turned from taxiway NP through taxiway N1 onto Runway 05R.

- Part 1
  Section 1.18.7 Navigation Display (ND)

  ATSB suggests that a concluding statement be added as follows:

  The investigation team was unable to determine what range had been set on the Navigation Display prior to or on runway line-up.

- Part 1
  Section 1.18.8.2 Videotapes provided by CKS Airport Office

  ATSB suggests that a concluding statement be added as follows:

  No Runway 05R lights were visible from either CKS airport camera 77 or camera 92.

- Part 2
  Section 2.5.6.4 Heading Indicators

  For accuracy, ATSB suggests the following amendment to replace paragraph 1 text commencing at line 5 (sentence 3):

  When the aircraft completed the turn from Taxiway NP onto Taxiway N1, the flight crew needed to maintain a heading of about 320 degrees magnetic for about 270 meters to reach the turn lead-in for Runway 05L. Instead of making a 90 degree turn from NP onto N1 as the airport chart indicated, CM-1 turned the aircraft through 180 degrees as it traversed from a heading of about 230 degrees magnetic to a heading of about 050 degrees magnetic onto Runway 05R.

- Part 2
  Section 2.5.7.1 Markings and signage

  ATSB suggests that the last paragraph be amended after the word *position*, line 2, to state:

  Based on the above evidence, the Safety Council has concluded that if the flight crew had looked for the runway markings and signage to locate their position, **they would normally have been able to see that information to help them to navigate the aircraft to the correct runway. On the other hand, if the flight crew was not able to clearly see runway markings and signage because of the degraded visibility during the last phase of the taxi from NP through N1 onto Runway 05R, they could have considered alternatives. For example, the crew could have requested some assistance from ATC to verify their position.**

- Part 2
  Section 2.5.7.5. Runway 05L Guard Lights

  ATSB suggests that the report should explain in detail how the figure of 175 meters was derived in the following statement: *The crew would have had the guard lights in front of them for a taxi distance of 175 meters before the turn from Taxiway N1 onto Runway 05R.* Suggested text could include:

  The distance from NP centerline to the theoretical location of 05L runway guard lights is 249 meters (324-75). The distance from runway 05R centerline and 05L centerline is 214 meters (324 - 110). The crew taxied 110 meters along N1 as they turned from NP onto 05R. The distance between the 05R centerline and theoretical location of 05L runway guard lights is 139 meters (214 - 75). The intersection of N1 turn onto Runway 05R to theoretical location of 05L guard light is about 139 meters + 22.5 meters (half the width of Runway 05R) +13.5 meters (shoulder of 05R) = 175m.

Part 2
Section 2.5.8.4 Taxiway Lighting Issues

CM-1 was asked how he had made a continuous turn onto Runway 05R from NP when the airport chart clearly showed Taxiway N1 as a straight line of 214 meters to Runway 05L.

ATSB suggests that the report be amended to reflect the correct distances as in the suggested amendment for 2.5.7.5 above:

The distance between the NP centerline and the Runway 05L centerline is 324 meters as per Figure 1.10-2. The distance from the Runway 05R centerline and 05L centerline is 214 meters.

Additional ATSB comment on the 'follow the green' hypothesis:

However, at CKS airport if the crew had followed the green, the failure would have been safe. They would either have followed the green lights down Runway 05R until they realized their error, or they would have approached the lighted barriers at low speed. In this case, once the crew was convinced they had reached the take-off runway they commenced the takeoff. Whether the 'follow the green' *habit* was triggered during the turn from NP onto 05R cannot be determined with complete confidence. The crew reported following the green during the turn from NP through taxiway N1 onto Runway 05R. There are sufficient alternative explanatory mechanisms discussed in the report with respect to such an action.

- Part 2
  Section 2.5.9 Water-affected Runway issues

Last sentence of paragraph 4 is not correct. It should read:

A pilot must assess all runways since all runways are *not* the same.

- Part 3
  Section 3.2 Findings related to risk

  ATSB suggests that finding 8 be deleted for the reasons cited in comments associated with section 2.5.8.4 - Taxiway Lighting Issues.

- Part 4
  Recommendations

  ATSB suggests that the following additional recommendations be made at Part 4 of the report and included in the Executive Summary.

  The Safety Council recommends that IATA:

  - **for safety assurance and risk management purposes, urge its member airlines to work with their respective regulatory agencies to ensure that airports into which they operate meet the Standards and Recommended Practices of ICAO Annex 14; and**

  - **urge its member airlines to work with their respective regulatory agencies to develop procedures for evaluating the airport infrastructure as part of their out station audits.**

Thank you again for providing us the opportunity to review your report. We look forward to receiving the final version of the report so that we can make it available to others in the Australian aviation community for information and accident prevention purposes. We have appreciated the opportunity to assist you with this investigation and the professional manner with which the process has been managed.

Yours sincerely,

Alan L Stray

Alan L Stray
Deputy Director - Air Safety Investigation
Australian Transport Safety Bureau
12 March 2002

7.4 新加坡交通部之回覆意見

Our ref: MCIT/CA/SQ006

Your ref:

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29 March 2002

Dr Kay Yong
Investigator-in-Charge
SQ 006 Accident Investigation
Aviation Safety Council
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Taipei 105
Taiwan

Dear Dr Yong,

SQ 006 INVESTIGATION

Thank you for the draft Final Report of the SQ 006 accident investigation, upon which you sought Singapore's comments by 31 March 2002.

2 The Singapore Ministry of Transport (MOT) team comprising its investigators, advisers, and consultants appointed through ICAO, Dr Rob Lee and Captain Richard McKinlay, has carefully studied and reviewed the ASC draft Final Report.

3 The sole purpose of the Singapore team's comments is to provide constructive feedback to the ASC on the draft Final Report. Our aim is to achieve a Final Report of the highest possible quality, and one that will make a significant contribution to the enhancement of international aviation safety.

4 Thank you very much for taking in some of the comments that the Singapore team provided earlier.

5 However, many of the key issues raised by the Singapore team in its comments to the ASC on the preliminary Draft Report have not been included in the draft Final Report.

MCIT 6/2001

The ASC draft Final Report

6 The Singapore team considers that:

a) The ASC draft Final Report presents an unbalanced account of the SQ 006 accident. It minimises the significance of the many systemic factors which contributed to the accident, such as the deficiencies in the runway lighting, signage and markings at CKS Airport.

b) The ASC draft Final Report does not adequately address the fundamental systemic error management and risk analysis issues raised by the investigation. These include the absence of warning signs, lights or markings which would have alerted the crew to their mistake, and the lack of physical barriers to prevent aircraft from entering, lining up and taking off on the closed Runway 05R.

c) The ASC draft Final Report contains factual inaccuracies, internal contradictions, and hypothetical statements that are not supported by empirical evidence.

d) The ASC draft Final Report does not highlight the very valuable systemic runway safety lessons from the SQ 006 accident investigation that will benefit the global aviation community.

7 The improvement of runway safety is a major challenge confronting the world aviation industry. The SQ 006 accident was a tragic manifestation of this international systemic safety problem, and therefore it should be considered in that context.

8 The potential safety benefits of the SQ 006 accident investigation will extend well beyond Taiwan and Singapore.

Guiding Principles of the Singapore team's review of the ASC draft Final Report

9 As with the preliminary Draft Report, the primary guidance material against which we have reviewed the ASC draft Final Report is Annex 13 to the Convention on International Civil Aviation. In accordance with the principles and spirit of Annex 13, our aim is to ensure that the Final Report of the SQ 006 investigation is accurate, objective and balanced, and does not apportion blame or liability.

10 We have also considered areas of the ASC draft Final Report in the context of other documents published by ICAO, the guidelines of major regulatory authorities, and where appropriate, industry best practice.

11 In accordance with ICAO guidelines, the Singapore team views the SQ 006 accident as a failure of the aviation system, and not as the failure of a person, or of people. We recognize the fact that human error is inevitable, and that systems must therefore be designed and operated to be error tolerant.

12 We have considered the ASC draft Final Report in the light of established and proven air safety investigation methodology. We have considered whether all of the relevant factual material gathered in the investigation has been included in the ASC draft Final Report. We have also assessed the degree to which the analysis and conclusions are based upon sound investigation procedures and factual evidence.

13 In considering the individual human factors involved in the accident, we have assessed the performance of pilots, cabin crew, air traffic controllers, and fire-fighting and rescue personnel, in terms of what could be realistically expected of such line personnel, especially in the aftermath of a catastrophic accident such as SQ 006.

14 Where errors have occurred, our aim has been to understand the reasons why those errors occurred.

15 In addition, we have considered the equally important broader systems safety issues, such as how the probability of human errors may be reduced, and measures which would prevent such errors, if they do occur, from resulting in accidents.

Singapore Team's Comments

16 The detailed Singapore team's comments are contained in the attachments to this letter. However, we would also like you to refer to the earlier comments that we have submitted on the ASC preliminary Draft Report, and to our written analysis.

17 As per my emails of 15, 18 and 25 March 2002 to you, I would like to request that the Singapore team's comments be appended in full to the ASC Final Report, and that they be published and distributed simultaneously with all copies of the ASC Final Report. We also reiterate our earlier request that the Singapore team be provided with an advance copy of the ASC Final Report, in accordance with established international practice.

Conclusion

18 Finally, may I again express the Singapore team's regret that it has not been permitted to participate in the analysis process, in accordance with its entitlements under Annex 13.

19 If the Singapore team had been able to take part and contribute to the analysis, the accident investigation process would have more efficient, effective, and complete.

20 Both Singapore and Taiwan share the common goal of pursuing excellence in aviation safety. Notwithstanding the difficulties that have been encountered, I hope that the valuable lessons learned by both Singapore and Taiwan from the experience of the SQ 006 investigation will help facilitate greater cooperation and communication in any future air safety investigations.

Thank you

Yours sincerely,

HO SEE HAI
ACCREDITED REPRESENTATIVE, SINGAPORE

cc Mr Chua Kheng Hwa
MOT

Part 1

Comments by the Singapore Ministry of Transport Investigation Team on the ASC Draft Final Report of the Investigation into the Accident to Singapore Airlines Boeing 747 – 400 at Taipei on 31 October 2000

EXECUTIVE SUMMARY

Introduction

1 The Singapore Ministry of Transport (MOT) finds the ASC draft Final Report incomplete, and does not present a full account of the SQ006 accident.

2 The ASC draft Final Report lists seven "findings related to probable causes .. that have been *shown to have operated … or almost certainly operated* in the accident". Six of these refer to the SQ006 flight crew, the seventh refers to the weather. Other significant contributing factors, arising from the major deficiencies in the CKS Airport design, layout and facilities are played down, and categorised only as "findings related to risk … that *cannot be clearly shown to have operated* in the accident". However, the Singapore team believes that the major deficiencies at CKS Airport played a critical role in the accident.

3 As a result, many valuable lessons which could have been learnt from the SQ006 accident have not been explored in the analysis, and clarified in the findings. In fact, the CKS Airport itself has taken measures after the accident to remedy some of these deficiencies. The rapid initiation of these major changes by the Taiwanese authorities is an acknowledgement that many of the deficiencies which have been, or are being, rectified were major causal factors in the accident, yet none appear in the ASC 'findings related to probable causes'.

4 An air safety investigation of an accident or incident should seek to:

– understand why mistakes and errors were made by people in the aviation system;
– recommend measures to reduce the likelihood of such errors; and,
– identify means to prevent such errors, when they do occur, from resulting in accidents.

5 In accordance with paragraph 6.3 of Annex 13 to the Convention on International Civil Aviation (Chicago Convention), Singapore desires that these comments be appended in full to the ASC Final Report.

The accident

6 At night, in inclement weather, believing that they were on the correct runway, the crew of SQ006 mistakenly attempted to take off on a runway (Runway 05R), which was adjacent and parallel to the runway on which they intended to take off (Runway 05L). Just over one kilometre along Runway 05R, and out of sight of the crew at the position from which they commenced their take-off, a section had been closed due to works in progress. During its take-off run, SQ006 collided with heavy construction equipment on the closed portion of Runway 05R.

7 There were no visual warnings or physical barriers to prevent aircraft from lining up and attempting to take off from Runway 05R.

8 If these preventative measures had been in place, in accordance with ICAO Standards and Recommended Practices, and with prudent safety practice, the accident would not have occurred.

9 The runway and taxiway lighting, signage and markings at CKS Airport did not conform to international standards, as set out in ICAO Annex 14. In particular, some critical taxiway signs, markings, and guidance lights in the vicinity of the take-off runway were either missing or not working. As a consequence, there was only a single line of taxiway centreline lights which the crew followed onto Runway 05R. There was no visible alternative path leading to Runway 05L.

10 Although Runway 05R was closed to be permanently redesignated as a taxiway, none of the runway markings had been removed as they should have been. For example, the white runway threshold markings, or 'piano keys' were still present.

11 There were some cues in the cockpit which provided indications that SQ006 had not lined up on the intended take-off runway, Runway 05L. However, due to the powerful visual cues of an operational runway ahead of them, this information was missed by the crew.

12 The SQ006 tragedy was a classic example of an accident occurring on the ground at an airport, involving a complex interaction of many factors, including actions by flight crews and air traffic controllers, the design and layout of the airport, airport facilities, and weather conditions.

Runway safety – a global problem

13 The SQ006 accident should not be seen as an isolated event specific to CKS Airport. Rather, it should be seen as a symptom of the global problem of runway safety.

14 Accidents and incidents involving the confusion of runways and taxiways are an increasingly serious problem facing the world's airline industry. The extent of this problem is graphically illustrated by events which have occurred since the SQ006 accident, such as the collision on the runway at Milan Linate Airport on 8 October 2001. This accident resulted in the loss of an MD87 and a Cessna Citation, with 122 fatalities.

15 The US FAA has specified runway safety as one of its top five priorities, which reflects the serious nature of this world-wide problem.

The ASC Investigation

16 Although Taiwan is not a Contracting State of ICAO, it undertook to investigate the accident in accordance with the provisions of Annex 13 to the Chicago Convention. The ASC of Taiwan was the agency responsible for carrying out the investigation.

17 Under the provisions of Annex 13, aircraft accident investigation is a team effort, pursued in the interests of aviation safety. Annex 13 states that:

> *The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability.* (Annex 13, paragraph 3.1)

18 Under the Annex, the State of Singapore was entitled to appoint an accredited representative to participate in all aspects of the investigation. (Annex 13, paragraphs 5.18, 5.25)

19 Contrary to the provisions of paragraphs 5.18 and 5.25 (h) of Annex 13, the ASC did not permit the Singapore accredited representative and his advisers to participate in the 'deliberations related to analysis, findings, causes and safety recommendations'.

20 The ASC has adopted a format for the Conclusions section which does not conform to Annex 13, or to the format used by other major accident investigation bodies. Annex 13 states that the investigation report should list 'the findings and causes established in the investigation. The list of causes should include both the immediate and the deeper systemic causes' (APP-2, 3).

21 Instead of listing the findings established, immediate causes and deeper systemic causes, the ASC draft Final Report lists only findings, and under three major categories:

(1) "findings related to probable causes" which identify elements that have been shown to operate or almost certainly have operated in the accident;
(2) "findings related to risk" which cannot be clearly shown to have operated in the accident; and
(3) "other findings" that have the potential to enhance aviation safety, resolve an issue of controversy or clarify an issue of unresolved ambiguity.

22 Systemic factors which contributed to the accident, such as deficiencies in the design and layout of the airport, defective or inadequate runway lighting, signage and markings and their non-conformance with ICAO Standards and Recommended Practices, are listed as "findings related to risk" (ie cannot be clearly shown to have operated in the accident) while the Singapore team feels that these factors clearly played a major role in the accident. They should rightfully be categorised as "findings related to probable causes".

Singapore's response to the accident

23 Following the accident, the then Singapore Ministry of Communications and Information Technology (MCIT) assembled a team to participate in the investigation, and immediately despatched it to Taipei to assist the ASC.

24 In accordance with Annex 13, the Singapore investigation team members were appointed by the Minister for the then MCIT. On 23 August 2001, the MCIT became the Ministry of Transport (MOT).

25 The Singapore MOT Investigation Team (Singapore Team), comprised investigators and advisers from different organisations, including Civil Aviation Authority of Singapore (CAAS), the Ministry of Defence, Singapore Airlines, and universities. Subsequently, Singapore requested that ICAO provide specialist consultants to assist the MOT Team.

26 Dr Rob Lee, former Director of the Australian Bureau of Air Safety Investigation, and Capt. Richard McKinlay, Deputy Chief Inspector of the UK Air Accidents Investigation Branch were appointed by ICAO, and commenced duty in April, 2001.

27 The Singapore Team is an independent body, which reports directly to the Minister.

The Singapore Team's approach to the investigation

28 In accordance with the philosophy of Annex 13, the Singapore Team regards the SQ006 accident as a failure of the aviation system, rather than a failure of a person, or people.

29 As stated by Captain Dan Maurino, Co-ordinator of the ICAO Flight Safety and Human Factors Study Programme:

> *To achieve progress in air safety investigation, every accident and incident, no matter how minor, must be considered as a failure of the system and not simply as the failure of a person, or people.*

30 The Singapore Team's analysis of the accident adopts this systemic approach. It is a fact that the crew of SQ006 took off on the wrong runway. The Singapore Team seeks to understand the reasons why this mistake was made by an experienced airline crew, and why it resulted in the accident. The objective is to develop and implement measures to reduce the likelihood of such errors, and, if they do occur, to prevent them resulting in catastrophic accidents.

Cooperation with the ASC

31 From the outset, the Singapore Team cooperated with the ASC, and endeavoured to make a full contribution as a member of the ASC team. For example, Singapore provided a Boeing 747-400 to carry out taxi simulation trials at CKS Airport.

32 The Singapore Team has provided documents and personal presentations to the ASC in Taipei. The Singapore Team also advised the ASC of new factual data as it became available, such as the results of metallurgical tests concerning the runway lighting. These tests were carried out by scientists from the National University of Singapore and the Singapore Defence Science Organisation.

33 During the investigation the Singapore Team provided detailed inputs to the ASC team on many key issues. These included human factors, systems safety, error management, operational procedures, training, documentation, airport issues, air traffic control procedures, and investigation methodology. However, many significant matters raised by the Singapore Team were not accepted by the ASC.

Singapore Team' s Inputs to the ASC investigation

34 On 4-5 July 2001 the Singapore Team presented its preliminary analysis of the accident to the ASC. This was followed by a written analysis, sent to the ASC on 17 September 2001.

35 On 28 September 2001, the Singapore Team received the ASC's preliminary draft report on the accident. Following a comprehensive review of the ASC preliminary draft report, the Singapore Team advised the ASC on 1 November 2001 of a number of significant omissions, inaccuracies, contradictions, and statements which were not supported by empirical evidence.

36 While some of the points raised by the Singapore Team were considered by the ASC, and had been included in the draft Final Report, areas of fundamental disagreement remain concerning the interpretation and analysis of the factual evidence. This is particularly the case with regard to the measures which could have been taken at CKS Airport to prevent mistakes in runway identification by pilots from resulting in accidents, such as the provision of warning lights, signage and physical barriers to stop aircraft from entering closed runways.

37 If the Singapore Team had been allowed by the ASC to participate in the analysis process, as it was entitled to do under Annex 13, the present differences might have been avoided, through open two-way discussion, and ongoing communication at all levels of the investigation.

Overall Review of the ASC Draft Final Report

38 A number of areas of the ASC analysis are not supported by factual evidence. In some instances, judgements are made, hypotheses are put forward, and opinions are expressed which are not based upon either factual evidence or research data.

39 For example, the ASC concludes that *"if the flight crew had looked for the runway markings and signage to locate their position by scanning the outside scene, they would have been able to see that information and consequently navigate the aircraft to the correct runway."* (Section 2.5.7.1 of ASC's draft Final Report.) This conclusion is not based on any objective evidence, simulator tests or research, that replicate the rapidly changing low visibility conditions on the night of the accident. Without any supporting data, this statement in the ASC draft Final Report can only be an opinion, and therefore its validity is questionable.

40 Another example is the ASC's conclusion that *"it was possible that CM-1 (the commander) reverted to the most dominant previously formed mental model under high workload to follow the green taxiway centreline lights."* However, there is no factual evidence to support this "dominant mental model" hypothesis.

41 Approximately ninety percent of the airports to which SIA crews operate do not have a "follow the green" taxiway light guidance system. Consequently, the factual evidence contradicts the ASC conclusion.

42 Several important safety issues relevant to the understanding of the SQ006 accident are not discussed in the analysis section of the ASC draft Final Report.

43 For example, the provision of runway closure markers and barriers are described in the factual information section of the ASC report. However, the significance of these markers and barriers has been down-played in the draft Final Report. By concentrating primarily on the flight crew, the ASC analysis does not consider the accident as a systemic failure, and therefore does not objectively address the combination of factors which contributed to the accident.

44 Some safety recommendations derived from the analysis are not supported by evidence in the draft Final Report. For example, recommendation 4.1.3 states that the CAAS approved B747-400 AFM PVD supplement includes "the use of the PVD to verify the correct departure runway."

45 The AFM PVD supplement does not refer to 'the use of the PVD to verify the correct departure runway'. (See Section 2.5.6.3.1 of ASC's draft Final Report).

46 The ASC draft Final Report describes numerous significant measures which have been taken by the Taiwanese aviation authorities to enhance safety following the accident to SQ006. Some of these measures were put in place immediately after the accident, and others are in the process of being implemented. The rapid initiation of these major changes by the Taiwanese authorities is an acknowledgement that many of the deficiencies which have been, or are being, rectified were major causal factors in the accident, yet none appear in the ASC ' findings related to probable causes'

47 Examples of deficiencies at CKS Airport which have been rectified include:

- painting the missing segment of the Taxiway N1 centreline marking leading to Runway 05L
- removing the Runway 05R threshold markings
- removing the Runway 05R designator marking
- disconnecting the Runway 05R runway edge lights
- adding to taxiway centreline lights from Taxiway N1

48 The Singapore Team commends the actions of Taiwanese aviation authorities to rectify these deficiencies and improve their aviation system. However, these systemic deficiencies, all of which existed at the time of the accident, should have been included in the 'findings related to probable causes' of the accident in the ASC draft Final Report. (Section 3.1 of ASC's draft Final Report.)

Summary

49 The Singapore Team considers that the ASC draft Final Report is deficient in many critical aspects.

50 As noted above, it is a fact that the pilots mistakenly turned onto the wrong runway. However, they took off firm in their belief that they were on the correct runway. Contributing factors and major deficiencies at CKS airport that either led to, and reinforced, their wrong belief, are not included in this probable cause category.

51 The outcome of the human factors analysis of the performance of the flight crew of SQ006 does not provide an understanding of why an experienced and professional airline crew mistakenly commenced take-off on the wrong runway.

52 As in all aviation accidents, deeper systemic factors play a major role in their causation. However, the ASC draft Final Report lists no such factors in its 'findings related to probable causes'.

53 As a result, the potential value of the ASC investigation in contributing to global aviation safety will not be realised.

Documents containing earlier and detailed comments by the Singapore Team on the ASC Draft Final Report

54 The Singapore Team provided earlier comments on the ASC's preliminary draft Report in November 2001, including the submission of a complete separate analysis. The substance of those comments remains essentially valid, and the Singapore Team requests that the ASC refer to these earlier documents, as well as to the comments on the draft Final Report which follow.

55 A separate analysis of the SQ006 accident by the Singapore Team is not included with the comments on the draft Final Report, as the Singapore Team has been advised by the ASC that it would not be prepared to append such an analysis to its Final Report.

56 The Singapore MOT team's comments are presented in the following documents:

- Part 1 – Comments by the Singapore Ministry of Transport Investigation Team on the ASC Draft Final Report of the Investigation into the Accident to Singapore Airlines Boeing 747-400 at Taipei on 31 October 2000.

- Appendix to Part 1 – Singapore Ministry of Transport Investigation Team's submission relating to Safety Actions and Safety Recommendations.

- Part 2 – Comments by the Singapore Ministry of Transport Investigation Team on Overall Format of the Conclusions Section of the ASC draft Final Report and on Section 3.1 relating to 'Findings Related to Probable Causes'.

- Part 3 – Comments by the Singapore Ministry of Transport Investigation Team on Sections 3.2 and 3.3 of ASC draft Final Report 'Findings Related to Risk' and 'Other Finding'.

- Part 4 – Comments by the Singapore Ministry of Transport Investigation Team on Section 4 'Safety Recommendations' of the ASC draft Final Report.

- Part 5 – Comments by the Singapore Ministry of Transport Investigation Team on the 'Survival Aspects' of the ASC Draft Final Report.

- Part 6 – Comments by the Singapore Ministry of Transport Investigation Team on Section 2 of the ASC draft Final Report 'Analysis'.

- Additional document : 'MCIT Investigation Team's Comments on Salient Issues in the ASC preliminary draft Report on the SQ 006 Accident Investigation' (originally submitted on 1 November 2001)

Appendix to Part 1

Singapore Ministry of Transport Investigation Team's Submission Relating to Safety Actions and Safety Recommendations

SAFETY ACTIONS

1 CKS Airport

CKS Airport has advised that since the accident, the following actions have been taken:

a) Efforts have been initiated to set up safety inspection teams and self audit programmes.

b) Runway 05R was decommissioned with effect from 1 February 2001 and has since been reopened as a taxiway.

c) The take-off minima for Runway 05L has been changed to 350m Runway Visual Range (RVR).

d) The Airport Emergency Handling Procedures, Civil Aircraft Accident Handling procedures, and the Emergency Airport Rescue Procedures have been revised.

e) CKS Airport is expediting the installation of Surface Movement Radar (SMR) at the airport.

2 CAA Taiwan

CAA Taiwan has advised that the following actions have been taken since the accident:

a) A review of ICAO Annexes and documents has been carried out, and a mechanism has been set up for follow-up action.

b) Expatriate advisors on airport standards have recently been appointed.

3 Singapore Airlines

SIA has advised that the following actions have been taken since the accident to SQ006:

a) A new CRM training programme for pilots has been developed and implemented, which includes situational awareness and error management training as separate modules.

b) Human factors and accident prevention training for inclusion in the pilot command training programme is being planned by SIA Flight Crew Training Centre.

c) A risk assessment tool to enable crew to manage risk in their operations has been developed and is being evaluated.

d) Redesign of the female cabin crew's footwear had been initiated in December 1999. New footwear has been introduced.

e) Checklists have been amended to require all crew in the cockpit to visually confirm the correct runway designation before commencing the take-off run.

f) The Flight Crew Operating Manual has been amended to formally require the pilot taxiing the aircraft to refer to signage and markings. It also requires the other pilot to confirm the correct taxi route is being used with reference to airport charts.

g) The Flight Crew Training Manual has been amended to formally document procedures, instructions and the training curriculum for ground operations in poor visibility conditions.

h) The Cross Wind Limitation Policy has been revised and the Flight Crew Operating Manual has been amended accordingly. The revision has a more conservative limit for 'wet' runway conditions.

i) An airport specific operational information gathering process has been implemented to provide additional information with regard to operational procedures and facilities specific to the airport not routinely included in Jeppesen route manuals.

j) Boeing's GPS based "Take-off Runway Disagree Alerting Function" has been accepted by the company for installation on B777 and B747-400 aircraft.

k) An Electronic Moving Map system which provides a pictorial depiction of airport movement areas is being evaluated for installation in SIA aircraft.

l) The FAA Advisory Circular on Runway Safety (FAA AC 120-74) has been reviewed with the objective of identifying useful points for incorporation in the SIA low visibility operations, training and procedures.

4 CAAS

CAAS has advised that the following actions have been taken since the accident:

a) Singapore operators have been required to review their 'before take-off' checklists.

b) Singapore operators have been required to update their CRM training programmes in keeping with current industry best practice.

c) Singapore operators have been required to review the FAA Advisory Circular (AC120-74) to assess its suitability to enhance their low visibility operations, training programmes and procedures.

d) A proposal to amend the current regulations to require earlier CVR power-on and later power-off times has been submitted to the Ministry of Transport.

SAFETY RECOMMENDATIONS

1. CKS Airport should ensure that, whenever runways or taxiways are closed to aircraft operations, be it partially or fully, suitable barriers are provided at locations that would physically prevent aircraft from entering such closed movement areas. The relevant ICAO standards and recommended practices (SARPs) concerning runway/taxiway closure markings should be adhered to.

2. A formal mechanism among international airlines needs to be developed by means of which operators can actively seek out and exchange local 'intelligence' on potential safety hazards, and ensure that such information is made available to crews. SIA should initiate coordination with other major airlines to better utilise the present "informal" and "ad hoc" exchange of local knowledge regarding operational safety hazards at airports.

3. SIA should review its emergency safety training programme to determine whether it is possible, and practical, to incorporate more realism, and to inculcate more awareness of the potential difficulties flight and cabin crew may encounter in catastrophic aircraft emergencies.

4. CKS Airport should ensure that its Air Traffic Controllers adhere to their Standard Operating Procedures. In particular, when aircraft cannot be seen from the control tower, controllers should advise pilots of this situation, and that they should taxi with caution.

5. CKS Airport should set up an integrated safety management system, so that systematic safety reviews, hazard analyses, and risk assessments are undertaken before implementing any airside work or changes that could affect aircraft operations.

6. CAA Taiwan and CKS Airport management should establish a joint task force to review the US FAA National Blueprint for Runway Safety (details at: www.faa.gov/runwaysafety), and wherever appropriate, adopt the safety philosophy and operational recommendations of that programme, so as to improve operational safety.

7. CKS Airport should ensure that the contents of all NOTAMs and AIP Supplements pertaining to airfield work contain clear and current information on the actual status of the taxiways/runways, and the configuration of the markings, signage and lighting. This will also facilitate the issuance of supplementary information by airport chart providers.

8. CKS Airport should utilise frangible barriers to demarcate work areas on the airfield.

9. The aviation industry should establish a working group, involving the airport authorities, airlines, regulators, ICAO, Flight Safety Foundation, IFALPA, Airports Council International and the IATA Safety Committee to develop a system to objectively determine whether a runway is "wet" or "contaminated" due to the presence of water. At present, there is no objective method by means of which this can be determined.

10. CKS Airport should formulate a written Surface Movement Guidance and Control System (SMGCS) plan to ensure the safety of aircraft movements on the ground.

11. CKS Airport should clearly define the operational responsibilities and safety accountabilities of the departments involved in the airside operations of the airport, so as to ensure that timely implementation of safety measures and improvements are not delayed due to ambiguities in areas of responsibility.

12. CAA Taiwan, in cooperation with the ASC, should establish and promote a more effective air safety incident reporting programme as part of an overall integrated safety management system. Such an

incident reporting programme would provide a wide range of safety information, including data on airport safety issues.

13. CKS Airport should review its ARFF procedures to ensure that its personnel are able to carry out rescue operations inside aircraft using breathing apparatus.

14. ASC should coordinate with the relevant authorities to ensure that autopsies of all aircraft accident fatalities are performed to determine the survivability aspects of the accident.

15. ASC should ensure that blood toxicology tests are carried out on all relevant personnel such as pilots, air traffic controllers and apron controllers immediately after an accident.

16. ICAO should establish a study group to investigate the parameters affecting the functionality of aircraft escape slides in high wind conditions, with a view to determining a revised basis for the certification of these slides.

17. Aircraft manufacturers should review the design of public address systems so that these systems can continue to function largely independently of airframe or engine system condition in the event of an accident.

Part 2

Comments by the Singapore Ministry of Transport Investigation Team on Overall Format of the Conclusions Section of the ASC draft Final Report and on Section 3.1 relating to ' Findings related to probable causes'

Overall format of the Conclusions section of the ASC draft Final Report

1 Annex 13 to the Chicago Convention (page APP-2 of Appendix) states that the Conclusions section of the Final Report should 'list the findings and causes established in the investigation. The list of causes should include both the immediate and the deeper systemic causes'. The ASC daft Final Report does not conform to this format. Instead of listing the findings established, immediate causes and deeper systemic causes, the ASC draft Final Report lists only "findings" and under three major categories:

(4) "findings related to probable causes" which identify elements that have been shown to operate or almost certainly have operated in the accident;
(5) "findings related to risk" which cannot be clearly shown to have operated in the accident; and
(6) "other findings" that have the potential to enhance aviation safety, resolve an issue of controversy or clarify an issue of unresolved ambiguity.

2 An aircraft accident is a failure of the aviation system, and is always the result of a combination of many contributing factors and causes.

3 From the perspective of flight safety, all these contributing factors and causes must be addressed and appropriately categorised. When arbitrary classification of factors and causes is made, it can direct the focus of attention disproportionately towards particular factors, while downgrading the importance of the other factors that had played a significant part in the accident.

4 This is what has happened in the ASC draft Final Report. Six of the seven 'findings related to probable causes' are in relation to the aircrew; none refer to the major deficiencies in the runway lighting, signage and markings at CKS airport. The result, whether intended or otherwise, is that the flight crew of SQ 006 are effectively 'blamed' for the accident.

5 The format of the Conclusions section in the ASC Draft Final Report therefore results in an unbalanced analysis of why the accident occurred, and is a major defect if it is used again in the Final Report.

6 Consequently, the Singapore Team does not accept the format of the Conclusions used in the ASC Draft Final Report.

Section 3.1 : 'Findings related to probable causes'

7 It is clear from the factual evidence that warning markings and barriers if located at the threshold of the closed runway would have stopped the crew of SQ 006 from commencing to take off, and thus would have prevented the accident.

8 However, the lack of these systemic safety measures is not mentioned in the ASC 'probable causes' findings. This critical factor is relegated to a sub-paragraph of one of the thirty six 'findings related to risk' i.e. factors that "have the potential to degrade safety" but "which cannot be clearly shown to have operated in the accident".

9 The following paragraphs address each of the ASC "probable cause" findings. The remaining findings, and other issues, are addressed elsewhere in the Singapore Team's comments.

10 **ASC Finding 1:** *At the time of the accident, heavy rain and strong winds from typhoon "Xangsane" prevailed and the wind direction was 020 degrees with a magnitude of 36 knots, gusting to 56 knots. RVR was 450 meters on Runway 05L.*

> **Singapore Team's Comment:** It is not clear how this finding relates to a 'probable cause' of the accident. The weather conditions on the night of the accident were a factor in the environment in which the accident occurred. They did not 'cause' the accident.
>
> Furthermore, the winds quoted in this ASC finding are not correct. These were not the wind speeds "at the time of the accident". The accident occurred at 15:17:17. The wind speeds and directions shown in the ASC finding were those which were broadcast on the ATIS at 15:12:02, four minutes 41 sec before the commencement of the takeoff.
>
> There were two further wind speed updates given to the crew of SQ 006 by ATC. The last wind direction and speed given to the crew when they were cleared for takeoff at 15:15:22 were 020 degrees with a magnitude of 28kts, gusting to 50kts. The crew based their decision to take off on the latest advice given to them by ATC. Table 1.7-1, of the ASC draft Final Report shows the wind directions and speeds recorded by the automated weather observation system for CKS Airport. At 23:15 (15:15 UTC) the wind was 029 degrees at 29.6 knots, at 23:16 (15:16 UTC) it was 013 degrees at 29.3kts, and at 23:17 (15:17 UTC) it was 360 degrees at 20.5kts. The ASC finding does not refer to this information, which indicates that very close to the time of the accident the winds were rapidly changing direction and in fact decreasing in strength.

Despite the fact they were varying, the weather conditions at the time of the accident were within the operational limits of the aircraft.

11 **ASC Finding 2:** *On August 31, 2000, CAA of ROC issued a Notice to Airman (NOTAM) A0606 indicating that a portion of the Runway 05R between Taxiway N4 and N5 was closed due to work in progress from September 13 to November 22, 2000. The flight crew of SQ 006 was aware of the fact that a portion of Runway 05R was closed, and that Runway 05R was only available for taxi.*

Singapore Team's Comment: It is not clear how his finding can be considered a 'probable cause'.

This ASC finding omits to mention the INTAM and the other NOTAM that were also provided to the crew of SQ 006 on the night of the accident. These documents gave no clear indication of the actual status of the runway markings, lighting and signage on runway 05R - for example, whether or not any work had been done in removing the runway markings from runway 05R (as stated in the INTAM) before the postponement of the redesignation of runway 05R to a taxiway, as *stated in NOTAM 0740*.

12 **ASC Finding 3:** *The aircraft did not completely pass the Runway 05R threshold marking area and continue to taxi towards Runway 05L for the scheduled takeoff. Instead, it entered Runway 05R and CM-1 commenced the takeoff roll. CM-2 and CM-3 agreed with CM-1's decision to take off.*

Singapore Team's Comment: This finding is misleading because it provides no information as to the context in which the crew made the turn onto, and commenced take-off on Runway 05R. The evidence shows that the crew of SQ 006 followed the continuous line of green taxiway centreline lights leading from Taxiway N1 onto Runway 05R. On lining up, they were presented with a picture of a brightly lit active runway.

In the absence of any indications at the Runway 05R threshold that the runway was closed, the crew of SQ 006 entered Runway 05R and commenced the take-off roll.

This finding also implies that a verbal statement of 'agreement' from CM-2 and CM-3 was required before take off. This was not the case. In accordance with established airline practices, if any member of the crew had not been comfortable with the take off decision, he would have spoken up, as the crew members indicated in their evidence to the investigation.

13 **ASC Finding 4***:* *The flight crew had CKS Airport charts available when taxiing from the parking bay to the departure runway. However, when the aircraft was turning from Taxiway NP to Taxiway N1 and continued turning onto Runway 05R, none of the flight crew verified their taxi route in*

accordance with the airport chart, which would have shown the need to make a 90 degree turn from Taxiway NP and then taxi straight ahead on Taxiway N1, rather than to make a continuous 180 degree turn onto Runway 05R. Further, none of the flight crewmembers confirmed orally whether the runway they entered was Runway 05L.

Singapore Team' s Comment: This finding is misleading because it ignores the context in which the crew's actions took place.

The evidence shows that the crew of SQ 006 had navigated their way accurately to the end of taxiway NP using their Jeppesen airport charts. Having reached this point, and having received the take off clearance from ATC, the final stages of the taxi were carried out using the external visual cues offered by the taxiway and runway lighting. This manner of operation was in accordance with normal airline practice.

Foremost among these visual cues was the single continuous clear line of green lights that provided taxiway guidance. These green centreline lights formed a continuous pathway onto the runway. There was no alternative continuous line of lights to Runway 05L, as there would have been if CKS Airport had conformed to ICAO Annex 14 standards and recommended practices.

14 **ASC Finding 5:** *The flight crew did not build a mental picture of the taxi route to Runway 05L that included the need for the aircraft to pass Runway 05R before taxiing onto Runway 05L.*

Singapore Team' s Comment: The existence or otherwise of an internalised 'mental model' is at best only a hypothesis. It therefore cannot be an unequivocal 'finding related to probable cause'. At best, such a hypothesis is a statement of probability.

This 'finding' is not supported by empirical evidence.

15 **ASC Finding 6:** *The moderate time pressure to take off before the inbound typhoon closed in around CKS Airport, and the high workload of taking off in a strong crosswind, low visibility, and slippery runway conditions subtly influenced the flight crew's decision-making and ability to maintain situational awareness.*

Singapore Team' s comment: This finding is not supported by the evidence. In his evidence CM-1 reported that he 'felt no time pressure on the evening of the accident'. In addition CM-1 stated that '…if the winds had exceeded the company operating limits, he would have postponed the take-off''. It should be noted that the ASC draft Final Report also stated that the captain instructed the crew to 'take their time and to be careful with the checklists and procedures.'

In view of such evidence, this finding can neither be substantiated nor cited as a 'probable cause'.

The finding refers to the crew of SQ 006 being under 'high workload'. This assertion is not supported by the evidence. The B747-400 is designed and certified to be operated by a two-man crew. The presence of CM-3 on the flight deck of SQ 006 provided an additional resource to the normal crew complement. By allocating the tasks of monitoring the weather and calculating the crosswind component during the taxi to CM-3, CM-1 was able to reduce the workload on CM-2 and himself.

16 **ASC Finding 7**: *On the night of the accident, the information available to the flight crew regarding the position of the aircraft was:*

- *CKS Airport navigation chart*
- *Aircraft heading indicators*
- *Runway and Taxiway signage and marking*
- *Taxiway N1 centreline lights leading to Runway 05L*
- *Colour of the centreline lights (green) on Runway 05R*
- *Runway 05R edge lights most probably not on*
- *Width difference between Runway 05L and Runway 05R, if the Runway 05R edge lights were on*
- *Lighting configuration differences between Runway 05L and Runway 05R*
- *Parallel Visual Display (PVD) showing aircraft not properly aligned with the Runway 05L localizer*
- *Primary Flight Display (PFD) information*

The flight crew did not comprehend the available information. They lost situational awareness and commenced takeoff from the wrong runway.

Singapore Team' s Comment: This finding presents a distorted picture of the situation in which the crew of SQ 006 were operating. This 'probable cause' finding only specifies sources of information which were available to the crew. It ignores the significant deficiencies in the information available to the crew of SQ 006.

The ASC draft Final Report identifies and provides a detailed description of these deficiencies at CKS Airport that did not meet the level of internationally accepted standards and recommended practices.

There were also no runway closed markings in the area where SQ 006 entered Runway 05R.

If these external visual warnings had been present, together with physical barriers to prevent aircraft entering Runway 05R from Taxiway N1, the crew would have had the requisite situational awareness to realise that they were on the wrong runway and the accident to SQ 006 would not have occurred.

Warning signs, markings, lights and physical barriers are defences to prevent human errors resulting in accidents. If such defences had been in place as they should have on the night of the accident, the crew of SQ 006 would have been alerted that they were entering the wrong runway. In addition, physical barriers would have made it impossible for the aircraft to commence its take-off on Runway 05R.

The absence of these essential warning signs, markings and physical barriers was the single most important factor which contributed to the accident. If the 'probable causes' format is to be retained in the ASC draft Final Report, these deficiencies should be highlighted as the major causal factor in the SQ 006 accident.

Detailed comments on ASC Finding 7 are as follows:

(a) CKS Airport navigation chart: The crew had the Jeppesen chart for the airport. However, there was no yellow page supplement which would have provided additional information on the works in progress on Runway 05R. The lack of such a supplement is not mentioned in the finding.

(b) Aircraft heading indicators: This information was available to, and used by the crew in accordance with normal procedures at the time of the accident. The crew's evidence states that: 'The aircraft heading was around 050 degrees on line-up, which was the expected direction for take-off…' (p. 143 of ASC draft Final Report). In other words, the crew of SQ 006 were aware that their heading was correct when they lined up.

It should be noted that the crew of SQ 006 navigated their aircraft accurately to the end of Taxiway NP. Beyond this final point of the taxi, the primary means of guidance from the taxiway onto the take-off runway were the external visual cues provided by the then runway and taxiway lighting, signage and markings. Using these cues, the aircraft lined up on the correct take-off heading, without realising that they were on the wrong runway.

(c) Runway and Taxiway signage and marking: The deficiencies associated with the runway and taxiway lighting, signage and marking are covered above. The central issue here is that, while these were a source of information to the crew, the ASC finding did not mention that they did not conform to international standards, and as a result, were seriously deficient – as described in ASC's 'findings related to risk'.

(d) Taxiway N1 centreline lights leading to Runway 05L: This finding does not mention the deficiencies in these lights. These are well described in ASC's "findings related to risk", which states: 'There should have been sixteen centreline lights spaced 7.5m apart along the straight segment of Taxiway N1 where the curved taxiway centreline markings from Taxiway NP meets Taxiway N1 up to the Runway 05L holding position, rather than the four centreline lights spaced at 30m, 55m, 116m and 138m.' The fact that there were only four lights, not all of which were serviceable, meant that there was no alternative line of lights to those leading onto Runway 05R. There was only one visible path – there was no 'fork in the road', as there had been earlier in the taxi.

(e) Colour of the centreline lights (green) on Runway 05R: Even though these lights were green, the factual evidence shows that the crew perceived them as just 'centreline lights'. This perception confirmed their expectation that they were lined up on an active runway.

To illustrate, CM-1 stated in his evidence that 'as the aircraft was lining up the image before him was that of a runway. He reported that he could see the centreline light running down the runway.' In his evidence, CM-2 said: 'The runway picture was correct. He recalled seeing lights down the middle of the runway and they were very bright.... He further stated that the visual cues indicated that the aircraft was on an active runway.'

(f) Runway 05R edge lights most probably not on: This finding is not supported by the factual evidence. The evidence of CM-1, together with the analysis of recorded ATC communications, as well as data from the metallurgical tests carried out on runway edge light wires, indicate that the Runway 05R edge lights probably were illuminated at the time of the accident.

(g) Width difference between Runway 05L and Runway 05R, if the Runway 05R edge lights were on: Pilots do not have an expectation of runway width as a primary visual cue to identify runways, as they operate to airports world wide which have runways of differing widths. Of more critical importance is that if the Runway 05R edge lights were on, a possibility which is acknowledged in this ASC finding, and which is supported by the factual evidence, it would have indicated an active runway, as noted in the Singapore Team's comments above.

(h) Lighting configuration differences between Runway 05L and Runway 05R: Both Runway 05R and 05L had centreline lights. The captain selected Runway 05L because it was a Cat II runway. Cat II runways have centreline lights, so he would have been expecting to line up on a runway with centreline lights, as opposed to Runway 06, which was the normal runway used by SIA. Runway 06 has no centreline lights. On lining up on Runway 05R, the bright centreline lights confirmed his belief that the aircraft had lined up on the correct runway.

(i) Para-Visual Display (PVD) showing aircraft not properly aligned with the Runway 05L localizer: This statement is misleading as it implies that the PVD will at all times 'show' aircraft alignment with the runway localiser. This is not the case.

In the case of SQ 006, the PVD remained shuttered. Consequently, there was no display showing a displacement from the localiser. This could have been a possible cue to the crew regarding the position of the aircraft.

However, as the aircraft lined up on Runway 05R, the crew saw an active runway ahead of the aircraft, as they had expected. Airline pilots are trained to always regard external visual cues as their primary source of information for takeoff. Consequently, this compelling external visual cue of the runway took priority in the captain's decision to commence the take-off. This is shown by the CVR evidence.

(j) Primary Flight Display (PFD) information: As stated in the ASC draft Final Report, 'pilots routinely use the ILS localiser indicator and the rising runway symbol on the PFD as a runway alignment reference during landing. This could have been a cue to the crew regarding the position of the aircraft. However, there were no procedural requirements for the flight crew to check these indications before take-off.'

17 **ASC statement below its Finding 7** *"The flight crew did not comprehend the available information. They lost situational awareness and commenced takeoff from the wrong runway."*

This statement, appearing as a summary statement at the end of the section on findings related to probable causes, implies that the pilots were totally to blame for the accident. The finding specifies the various sources of information available to the pilots, but omits to also point out that these sources of information were for the most part deficient.

Maintenance of situational awareness by flight crew is dependent upon the quality of information on which it is based. Good quality information is the foundation of accurate situational awareness – what has been termed the 'first level' of situational awareness (Endsley, 1995). If this information is not available, or is difficult to detect or perceive, or if it is misperceived, the situational awareness of a crew may not correspond to their actual situation.

In the case of SQ 006 the primary information upon which the crew was relying for situational awareness was defective – for example, the runway lighting, signage and markings. On lining up on Runway 05R, they firmly believed they were on Runway 05L. The CVR confirms this.

The statement by the ASC that *"The flight crew did not comprehend the available information. They lost situational awareness and commenced takeoff from the wrong runway."* is not correct. The evidence shows that the crew of SQ 006 did comprehend the information available to them, and based their situational awareness on this information. Unfortunately, the information available to them was flawed resulting in their comprehension being flawed without their knowledge.

The summary statement of this particular finding implies blame, contrary to the provisions of Annex 13.

Summary comments on the ASC "findings related to probable causes"

18 The ASC draft Final Report does not portray the accident as a failure of the aviation system, rather it is being portrayed as a failure of the crew. In its executive summary, the ASC states that '…the purpose of the investigation report is to enhance aviation safety and not to apportion blame and responsibility…'

19 However, the overall format of the Conclusions section and the content of the ASC 'findings related to probable causes' are so flawed that this objective has not been achieved.

Part 3

Comments by the Singapore Ministry of Transport Investigation Team on Sections 3.2 and 3.3 of ASC draft Final Report entitled 'Findings Related to Risk' and 'Other Finding'

ASC draft Final Report	Singapore Team' s Comments
3.2 Findings Related to Risk 1. The local controller did not issue progressive taxi/ground movement instructions and did not use the low visibility taxi phraseology to inform the flight crew to slow down during taxi.	Should amend as follows: " The local controller did not issue progressive taxi/ground movement instructions *" in accordance with CKS ATC SOPs" ,* and did not use the low visibility taxi phraseology to inform the flight crew to slow down during taxi.
2. The flight crew did not request progressive taxi movement instructions from Air Traffic Controller (ATC).	The flight crew did not make such a request as they are not required to do so by any international standards. The only time a flight crew would make such a request is when they are uncertain of their position. This was not the case in the SQ 006 accident. At all times the crew believed that they knew where they were. At the end of Taxiway NP they were misled by the external visual cues before them, and entered the wrong runway. This finding should be deleted.
3. Reduced visibility in darkness and heavy rain diminished, but did not preclude, the flight crew' s ability to see the taxiway and runway lighting, markings, and signage.	The phrase " did not preclude" is superfluous and should be deleted. In addition, the finding should also point out that the lighting, signage and markings did not conform to international standards. Notwithstanding this fact, this finding is speculative and not supported by any factual or empirical evidence and should be deleted.
4. The SIA crosswind limitation for a " wet" runway was 30 knots and for a " contaminated" runway was 15 knots. CM-1 assessed that the runway condition was " wet" at the time he prepared for takeoff and determined that the crosswind was within company limitations. The lack of SIA and ATC procedures for quantitatively determining a " wet" versus " contaminated" runway creates ambiguity for flight crew when evaluating takeoff crosswind limitations.	There was no evidence from the crew interviews or the CVR that the crew had any ambiguity about the condition of the runway. This finding is irrelevant to the accident and should be deleted. The correct criteria for determining whether a runway is " wet" or " contaminated" is an industry wide issue and should be addressed through the appropriate forum such as ICAO or IATA.

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5. There was no procedure described in the SIA B747-400 Operations Manual for low visibility taxi operations.	Guidance information on low visibility taxi operations is provided in the SIA Flight Crew Training Manual, which is a part of the SIA B747-400 Operations Manual. This finding should be deleted.
6. There was no formal training provided to SIA B747-400 pilots for low visibility taxi techniques.	There is no evidence that this was a ' risk factor' in the accident. This finding is based on incorrect understanding of airline training. A captain who is qualified and current in Cat III operations would have received training in low visibility taxiing techniques as part of his training package. Taxiing the aircraft in low visibility is part and parcel of the overall training package for low visibility operations. However, taxiing in low visibility conditions was, and continues to be, a normal part of an SIA pilot' s introduction to training in low visibility operations. The CVR evidence shows that the crew was taxiing the aircraft in a manner appropriate to the visibility conditions.
7. The SIA SOP did not assign specific duties to the third flight crewmember, although CM-1 requested the third pilot to verify crosswind limitations during taxi.	This finding is unrelated to risk. The B747 is designed and certified for operation by two pilots. If a third crew member is present, it is for the captain to decide what duties may be allocated to the third crew member according to the operational circumstances at the time.
8. It was possible that CM-1 inadvertently reverted to the most dominant previously formed mental model under high workload to follow the green taxiway centerline lights, which generally takes him to where he is supposed to go, and he reverted to this habit while turning from NP onto Runway 05R.	There is no evidence to support this dominant ' mental model' hypothesis. Unless there is such evidence, this ' finding' is only an opinion and is speculative. In the absence of empirical evidence, it should therefore be withdrawn. In the context of the ASC draft Final Report, the " dominant previously formed mental model … to follow the green centerline lights" refers to the " follow the greens (i.e. green taxiway centreline lights)" system at Singapore Changi Airport.

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	Reference to SIA crew rosters shows that the majority of take-offs conducted by SIA B747 pilots takes place at airports other than Singapore Changi Airport. Of these other airports, only approximately 10% of them has a ' follow the greens' system similar to Singapore Changi Airport. Consequently, SIA pilots do not taxi using a ' follow the greens' taxiway lighting system with sufficient frequency for it to become a 'dominant' mental model.
9. SIA did not have a procedure for the pilots to use the PVD as a tool for confirming the correct runway for takeoff in low visibility conditions such as existed for the operation of SQ 006 on the night of the accident.	The PVD was not designed to be a device for identifying runways or the runway threshold. The PVD is used primarily as a reversionary aid to assist pilots to maintain the runway centerline when they conduct take-offs. The PVD will un-shutter anywhere along the runway within the capture zone of the ILS localizer. It will therefore operate at any point along the runway. For this reason it cannot be used to positively identify the position of the runway threshold. This finding is invalid, as any procedure for the pilots to use the PVD as a tool for confirming the correct runway for take off in low visibility conditions would be contrary to the design and approval of the PVD system. This finding should be deleted.
10. SIA procedures and training documentation did not reflect the Civil Aviation Authority of Singapore (CAAS) approved B-747-400 AFM supplement regarding use of the PVD for correct runway identification.	The CAAS did not approve the use of the PVD as a means of runway identification. This is outside the scope for which the PVD system was designed by the system manufacturer or as flight tested by the airframe manufacturer. From a safety standpoint, it would be improper for any regulator to insist on procedures and training documentation which are outside the scope of system design and approvals. Furthermore, the AFM supplement regarding the PVD does not contain the words " correct runway identification" . This finding is based on an incorrect interpretation of the AFM supplement. This finding should be deleted.
11. CAAS oversight of SIA operations and training did not ensure	The PVD is not a mandatory instrument, and is not designed

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that the approved B747-400 AFM supplement regarding use of the PVD for correct runway identification was incorporated into the SIA documentation and operational practices.	for runway identification. Many airlines do not equip their aircraft with PVD. It is designed and certified to aid runway centreline steering and is only to be used for takeoff on a Cat III runway. Accordingly, the approved B747-400 Airplane Flight Manual (AFM) supplement contains instructions on PVD use for runway centreline steering and does not deal with PVD use for runway identification. The primary means for runway identification are the pilots' normal visual cues. The approved B747-400 AFM supplement is incorporated into the SIA documentation and operational practices. Since the PVD is not for runway identification, the issue of CAAS safety oversight of SIA's PVD operations and training on the use of the PVD for runway identification does not arise and is irrelevant. This finding is based on a misinterpretation of the purpose of the PVD and the provisions of the approved B747-400 AFM supplement on the PVD. Accordingly, this finding should be deleted.
12. At the time of the accident, SIA's Aircraft Operations Manual did not include "confirm active runway check" as a before takeoff procedure.	Singapore agrees with this finding, however it needs to be amplified to place it in the correct context. With the benefit of hindsight, subsequent to this accident, it is clearly good practice to have a procedure for positive runway identification. At the time of the accident to SQ 006, the fact that this was not common practice within the aviation industry should be noted in the finding.
13. The deficiencies in SIA training and procedures for low visibility taxi operations precluded the flight crew from possessing the appropriate level of knowledge and skills to accurately navigate the aircraft on the ground.	There is no empirical evidence to indicate such systemic deficiencies. Such evidence could only be obtained by determining whether SIA had any history of air safety incidents connected with low visibility operations. Unless there is valid evidence to sustain this finding, it must be withdrawn and deleted.
14. CAAS had not performed sufficient safety oversight of SIA's procedures and training. Therefore, the deficiencies in SIA	The Singapore Team disagrees with the finding. This is sweeping statement and not based on empirical evidence.

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procedures and training were not discovered during routine CAAS safety oversight.	In referring to section 2.5.11 of the draft Final Report, it would appear that this finding is referring to "inadequate SIA flight crew procedures and training on the PVD that did not reflect the CAAS approved B747-400 PVD supplement and insufficient flight crew training in low visibility taxi procedures and practices." Regarding the PVD procedures and training, as mentioned in the Singapore Team's comments on Finding No. 11 above, the PVD is not for runway identification and the CAAS approved B747-400 PVD supplement therefore does not deal with runway identification. Hence, it was not a deficiency that SIA's PVD procedures and training did not include the use of the PVD for runway identification. It would have been improper for CAAS to approve procedures and training for use of equipment which is outside the scope of the equipment design. Regarding training in low visibility taxiing, as noted in MOT' s earlier response to the ASC' s preliminary draft report, MOT has explained that there is no specific formal training for taxiing in low visibility. Taxiing is part of basic airmanship. Throughout their career, flight crews undergo various training courses and taxiing is part and parcel of such training. Taxiing skills are further reinforced in the course of their flying experience when they operate to different airports in all sorts of weather conditions. There are no International Civil Aviation Organisation Standards and Recommended Practices (ICAO SARPs) or internationally agreed norms on the level and amount of flight crew training in low visibility taxi procedures and practices. There is no basis to conclude that there were deficiencies on SIA' s flight crew training and procedures on the use of the PVD and low visibility taxiing.

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	Consequently, the finding that deficiencies in SIA’ s procedures and training were not discovered during routine CAAS safety oversight is incorrect and this finding should be removed.
15. The preponderance of evidence indicates that the Runway 05R edge lights were most probably not illuminated during the attempted takeoff of SQ 006.	This finding is not valid as it cannot be determined conclusively whether the Runway 05R edge lights were on or off. This finding should be deleted.
16. At the time of the accident, there were a number of items of CKS Airport infrastructure that did not meet the level of internationally accepted standards and recommended practices. Appropriate attention given to these items would have enhanced the situation awareness of the SQ 006 flight crew while taxiing to Runway 05L for takeoff. However, the absence of these enhancements was not deemed sufficient to have caused the loss of situational awareness of the flight crew. Among these items were:	The manner in which the airport deficiencies are listed as bullet points within a single finding diminishes the critical importance of these factors. These CKS Airport factors are so critical to the accident that they should be listed separately as individual findings in the ‘ findings related to probable causes’ . (However, please note Singapore Team’ s comments regarding classification of findings. These are at Part 2 of the Singapore Team’ s comments on the ASC draft Final Report). The lack of any barriers at the threshold to prevent take-off, which on its own would have been sufficient to prevent the accident, is not even mentioned in the findings. These “ infrastructure deficiencies” cannot be relegated to the level of mere “ enhancements” . They are the ICAO standard requirements for international airports. The crew did not perceive that they had lost situational awareness when entering Taxiway N1. Their situational awareness from this point was based upon the information available to them, and this information was flawed. It was only at this stage that the crew’ s situational awareness did not correspond to their actual situation.
• Four days after the accident, the investigation team found the green centerline light immediately after the Runway 05R entry point along Taxiway N1 leading to Runway 05L un-serviceable and the following light was	This should be a ‘ finding related to probable cause’ . It is highly improbable that these two lights only became dim or unserviceable in the short span of time between the time of the accident and the evening of 4 November 2000. For most of this

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dim. It could not be determined what the status of those lights was on the night of the accident.	period of time the lights were switched off. <u>Comment</u>: --The fact that these lights were not inspected by the investigation team until four days after the accident is a serious deficiency in the investigation process. It was clear soon after the accident that the aircraft had commenced take-off on Runway 05R. Consequently, the determination of the visual cues available to the pilots should have been a top priority in the investigation. A four-day delay in obtaining such critical information is unacceptable in a major investigation.
• The green centerline lights leading from Taxiway NP onto Runway 05R were more visible than the Taxiway N1 centerline lights leading toward Runway 05L because they were more densely spaced. There should have been 16 centerline lights spaced 7.5m apart along the straight segment of Taxiway N1 where the curved Taxiway centerline markings from Taxiway NP meets Taxiway N1 up to the Runway 05L holding position, rather than the 4 centerline lights spaced at 30m, 55m, 116m, and 138m.	The absence of a visible line of lights leading to Runway 05L is a fundamental reason why the crew turned on to Runway 05R. Therefore, this finding should be highlighted as a “ finding related to probable cause” .
• Segments of the straight portion of the taxiway centerline marking on Taxiway N1 did not extend all the way down to the Runway 05L threshold markings with interruption stops 12 meters to and from the Runway 05R threshold markings.	The taxiway centerline markings were not compliant with ICAO Standards and Recommended Practices (SARPs). This non-compliance should be stated as an individual finding, rather than as a bullet point within a finding. It should be listed as a ‘ finding related to probable cause’ .
• Runway guard lights and stop bars were not provided at CKS Airport.	The lack of runway guard lights and stop bars lights meant that CKS Airport did not comply with ICAO SARPs. This non-compliance should be stated as an individual finding, rather than as a bullet point within a finding. It should be listed as a ‘ finding related to probable cause’ .
• Alternate green/yellow taxiway centerline lights to demarcate the limits of the ILS sensitive area were not installed.	This situation was not compliant with ICAO SARPs. This non-compliance should be stated as an individual finding, rather than as a bullet point within a finding. It should be listed

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	as a ' finding related to probable cause' .
• The mandatory guidance signs installed on the left and right sides of Taxiway N1 were located after the holding position for Runway 05L and not collocated with runway holding position marking.	This situation was not compliant with ICAO SARPs. This non compliance should be stated as an individual finding, rather than as a bullet point within a finding. It should be listed as a ' finding related to probable cause' .
• Although the flight crew was aware that Runway 05R was closed, there were no runway-closed markings in the area where SQ 006 entered Runway 05R. • Although the construction equipment located on the closed portion of Runway 05R was protected by barriers and marked with lights, the lights were not visible from the takeoff threshold of Runway 05R.	Both of these findings are fundamental to an understanding of the accident. As the crew lined up on Runway 05R, there was nothing to indicate to them that they were on the wrong runway, or to physically prevent them from commencing taking off. Runway-closed markings and lights warning of obstacles on the runway would have been among the critical defences which could have on their own prevented the accident. Their absence contributed to the accident. They fall into the category of deeper systemic causes. These two findings should be listed separately in the ' findings related to probable causes' .
• There was no interlocking system installed at CKS Airport to preclude the possibility of simultaneous operation of the runway lighting and the taxiway centerline lighting.	
• There was a lack of a monitoring feature of individual lights, or percentage of unserviceable lamps, for any circuit for CKS Airport lighting.	
• ASDE is designed to reduce the risk of airport ground operations in low visibility. There is no requirement for installation of Airport Surface Detection Equipment (ASDE) at CKS Airport. The Safety Council was not able to determine whether ASDE would have provided information to the ATC controllers about SQ 006 taxiing onto the incorrect runway because of attenuation of the signal from heavy precipitation that diminishes the	

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effectiveness of the radar presentation.	
17. There is ambiguity in ICAO Annex 14 Standards and Recommended Practices (SARPs) regarding a temporarily closed runway because the term "short term" is not defined.	This finding is not relevant to the accident, because Runway 05R was to be permanently re-designated as a taxiway. There was no intention ever to re-open it as a runway. Further, whether the closure was temporary or permanent was irrelevant because markings and barriers should have been present to indicate that Runway 05R was closed and to physically prevent aircraft attempting to use it for take-off.
18. There was a lack of a specified safety regulation monitoring organization and mechanism within CAA that permitted conditions to exist at CKS Airport for taxiways and runways lightings, markings, and signage that did not meet internationally accepted safety standards and practices.	That the taxiway and runway lightings, markings, and signage did not meet internationally accepted safety standards and practices were deeper systemic factors which contributed to this accident. This should be a finding related to probable cause.
19. There was a lack of a safety oversight mechanism within CAA that could have provided an independent audit/assessment of CKS Airport to ensure that its facilities met internationally accepted safety standards and practices.	That the CKS Airport facilities did not meet internationally accepted safety standards and practices were deeper systemic factors which contributed to this accident. This should be a finding related to probable cause.
20. CAA had not formed a working group for the derivation of a complete Surface Movement Guidance and Control System (SMGCS) plan according to guidance provided by ICAO Annex 14.	
21. Being a non-contracting State, the CAA of ROC does not have the opportunity to join ICAO and participate in the activities in developing its airport safety enhancement programs to correspond with international safety standards and recommended practices.	Non-participation in ICAO activities does not preclude any airport operator from complying with and implementing ICAO Standards and Recommended Practices or to put in place airport safety enhancement programmes to correspond with international safety standards and recommended practices. ICAO documentation is catalogued on its website. It is readily available to any interested party.
22. The SIA typhoon procedure was not well defined and the personnel who were obliged to use the procedures did not fully understand the procedures and their responsibilities.	The aircraft did not take off in typhoon conditions. The SIA typhoon procedures were irrelevant to the accident. This finding should be deleted.
23. The main deck mid cabin from row 31 to 48 was not	

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survivable during this accident due to fuel tank fire and explosion. Sixty-four out of 76 passengers died in this area. All passengers in tail section survived due to much less fire damage.	
24. The circumstances of the SQ 006 accident, involving severe impact forces induced damage and rapidly spreading fire and smoke, rendered much of the existing emergency evacuation training, hardware, and procedures ineffective.	
25. The crewmembers did not use alternative methods to order the emergency evacuation when Public Announcement (PA) system was found inoperative.	The accident was catastrophic, and in this situation the cabin crew were required to use their initiative, as prescribed in the SIA Aircraft Safety and Equipment Procedures manual. When the cabin crew did not hear an evacuation command from the Captain, they used the alternative method of initiating evacuation by shouting to passengers to evacuate, in accordance with the ASEP.
26. During evacuation training, the flight crew did not play their role as a commander to initiate the evacuation.	This has no relevance to the accident. It should not be a finding and should be removed.
27. Some of the crewmembers did not execute SIA’ s evacuation procedures during the evacuation.	The accident was catastrophic. The SQ 006 crew executed those ASEP procedures that were possible in the extreme circumstances of the accident. In this situation the cabin crew were required to use their initiative, as prescribed in the SIA Aircraft Safety and Equipment Procedures manual, which they did.
28. An Upper Deck Left (UDL) cabin crewmember was hampered in her movement during the emergency evacuation because she lost her sandals.	There is no evidence that the cabin crew member who lost her sandals was hampered in her movement during the emergency evacuation. This finding should be removed.
29. During the evacuation in dark conditions, only CM-3, CM-2, and 5L crewmembers carried flashlights. The 5L cabin crewmember used the flashlight to assist during the passenger evacuation. No megaphone was used.	It is not clear why this is a “finding related to risk”. In the immediate aftermath of an accident such as this, when the aircraft came to rest, broken in two and on fire, it is not surprising that some crew members were unable to locate their safety equipment. The fact that some crew members were able to do so suggests that their training and the procedures were effective. Furthermore, there is no direct evidence that

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	this caused any delay in the evacuation. This finding should be deleted.
30. The dense smoke made breathing difficult and the emergency lights less visible for the survivors during the evacuation.	This finding should be expanded to include the non-use of breathing apparatus by the ARFF.
31. CKS Airport did not prescribe in detail the emergency medical treatment procedures and the responsibilities of a medical coordinator or the interim coordinator in accordance with the ICAO recommendations.	
32. CKS Airport did not provide contingency procedures for medical treatment and rescue in adverse weather conditions in accordance with the ICAO recommendations.	
33. The "CKS Airport Civil Aircraft Accident Handling Procedures and Regulations" contained no specific features such as neurosurgical ability or burn treatment of hospitals in accordance with the ICAO recommendations.	
34. There was no information of high wind effect to the slide operation in relevant manual from the manufacturer for the operators' reference to prepare for a suitable response during high wind operation.	
35. The lateral G forces associated with the accident produced an unexpected self-inflation of the 4R and 5R slides in cabin.	
36. The fire-fighting department was understaffed in handling a major accident.	

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3.3 Other Findings 1. The flight crew were properly certificated and qualified in accordance with the applicable CAAS regulations and SIA Company requirements, and ICAO SARPs.	
2. The flight crew were provided with appropriate and complete dispatch documents, including weather, weight and balance information, NOTAMs and SIA INTAMs in accordance with the established procedures.	As no yellow Jeppesen airport plan had been issued, CKS Airport should have provided an airport plan suitably annotated showing works in progress so that crews would be fully briefed on the airfield situation.
3. The cabin crew was qualified in accordance with the SIA training program.	
4. Crew duty time, flight time, rest time, and off duty activity patterns did not indicate influence of pre-existing medical, behavioral, or physiological factors of flight crew' s performance on the day of the accident.	
5. The air traffic controllers involved with the control of SQ 006 were properly certificated, and qualified to perform their duties.	This finding does not accord with the factual information. However, the Singapore Team acknowledges that the lack of a current medical certificate for a controller was not causal to the accident.
6. The aircraft was certificated, equipped, and maintained in accordance with CAAS regulations and approved procedures, and ICAO SARPs. There was no evidence of pre-existing mechanical malfunctions or other failures of the aircraft structure, flight control systems, or power plants that could have contributed to the accident. The accident aircraft was considered airworthy before the accident.	
7. There was no evidence to indicate that there was any undue organizational pressure from SIA placed upon the flight crew to take off the evening of the accident.	
8. The Jeppesen charts used by the flight crew were current at the time of the accident.	
9. The taxi check and procedures used by the SQ 006 flight crew were in accordance with the SIA B747-400 Operations Manual.	

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10. ATC taxi instructions and the takeoff clearance did not mislead the flight crew to take off from the partially closed Runway 05R. SQ 006 was cleared for takeoff on Runway 05L and the flight crew confirmed the clearance before takeoff.	Agreed, however the ATC taxi instructions did not include reference to Taxiway N1 and the crossing of Runway 05R. The timing of the clearance could have given the crew the impression that the next active runway was 05L.
11. It was appropriate for the flight crew to consider Runway 05L for takeoff the evening of the accident.	
12. The fatality rate of this accident was 46%. The serious injury rate was 22%. The minor injury rate was 18%. The no injury rate was 14%.	
13. No slides were fully functional for survivors' evacuation in this accident because of impact forces, fire, and strong wind effects.	
14. The Department of Forensic Pathology conducted a total of 7 autopsies. Out of the 7 autopsies conducted, 6 died from severe burns and one died from impact injuries.	
15. There was no alcohol and drug testing of the three flight crewmembers of SQ 006 after the accident.	ATC personnel were also not tested for alcohol and drugs. The finding should include that ATC personnel were also not tested.
16. Airport Rescue and Fire Fighting (ARFF) personnel arrived at the accident site approximately in 3 minutes and began its fire fighting and rescue efforts. A small fire at tail section was put out immediately. In conditions of severe weather, the fire at forward and mid-section fuselage was suppressed in 15 minutes and positively controlled in 40 minutes.	
17. All fire and medical people used the same frequency to communicate in this accident.	
18. The majority of the CKS Airport medical and rescue operations were not able to function in accordance with CAA regulations and procedures because of very strong wind and heavy rain emanating from approaching typhoon "Xangsane".	
19. The first 10 survivors were sent to hospital by airport's ambulances directly without proper triage procedure.	

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20. The Ministry of Transportation and Communications (MOTC) staff was not proactive in supporting CAA' s requests for the installation of ASDE at CKS Airport.	
21. All new regulations of CAA are subject to lengthy formalities of legitimating approval by MOTC.	
22. Although the SQ 006 CVR power-on and power-off times were in compliance with ICAO SARPs and CAAS regulations, the Federal Aviation Regulations (FARs) and Joint Aviation Regulations (JARs) require an earlier power-on and later power-off times. An earlier power-on time and later power-off time would be desirable for examination of operational and human factors safety issues following accidents and incidents.	
23. Singapore does not have an independent aviation accident investigation authority charged with making objective investigations, conclusions, and recommendations. International experience has shown that an independent investigation authority is a benefit to aviation safety, and many States have taken actions to ensure that investigations are conducted by a government agency that is functionally independent of the authority responsible for regulation and oversight of the aviation system.	The recommendation is irrelevant and inappropriate, as Singapore is not the State leading the SQ 006 investigation. In any accident investigation, recommendations should be based upon factual evidence gathered during the investigation and the analysis of that evidence. While the recommendation that Singapore should consider establishing an independent accident/incident investigation organisation appears in the ASC draft Final Report, there is no evidence or analysis contained in the draft Final Report to either support or justify the recommendation. For example, there is no evidence that there has been any problem with the present administrative arrangement concerning the participation by Singapore in the SQ 006 investigation. Under these arrangements, the Minister for Transport (previously MCIT) appointed an independent investigation team reporting directly to him. The team is made up of investigators from the CAAS, Ministry of Defence, National University of Singapore, and other organisations. In addition, the Minister appointed three international specialist consultants through the International Civil Aviation

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	Organisation (ICAO). The Singapore Team perates completely independent of the aviation regulatory authority. These arrangements are fully in accordance with the Convention on International Civil Aviation. It should also be noted that not many countries have a fully independent, permanent stand-alone air safety investigation organisation. The recommendation should be withdrawn.

Part 4

Comments by the Singapore Ministry of Transport Investigation Team on Section 4 'Safety Recommendations' of ASC Draft Final Report

General Comment: When action has been taken on a particular issue, this should be described in the Safety Actions section of the Final Report. There is no need to make recommendations if action has been, or is being taken, because the recommendation is then redundant. Examples of this redundancy are recommendations to SIA, numbers 1, 2, 5, 6, 8, 10 and 11. Similar examples can be found concerning recommendations to the CAA ROC.

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Safety Recommendations In this chapter, safety recommendations derived as the result of this investigation are listed in 4.1. Safety actions taken, or currently undertaking by both SIA and CAA, ROC are listed in 4.2. It should be noted that those safety actions have not been verified by the Safety Council	
Recommendations **To Singapore Airlines (SIA)** The Safety Council recommends that SIA: 1. Develop and implement a comprehensive surface-movement training program that reflects the current practice in this area, such as the recommendations contained in the FAA' s National Blueprint for Runway Safety and FAA Advisory Circular No. 120-74. (3.1-[3~7]; 3.2-[5, 6, 12])	The FAA National Blueprint for Runway Safety was published in October 2000. FAA AC 120-74 was issued in June 2001. SIA is reviewing these documents with a view to incorporating useful practices and procedures into SIA' s training programme. This information on SIA' s actions should be included in 'Safety Actions' in the Final Report. This recommendation should be withdrawn.

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2. Ensure that procedures for low visibility taxi operations include the need for requesting progressive taxi instructions to aid in correct airport surface movement. (3.2-[1, 2])	This recommendation should be withdrawn. Flight crew were not, at the time of the accident, required to request progressive taxi instructions by any international standards. This procedure is currently being reviewed by SIA, and should be included in 'Safety Actions' . See also our comments on recommendations to CAAS number 1.
3. Review the adequacy of current SIA PVD training and procedures and ensure that SIA documentation and operational practices reflect the CAAS approved B747-400 AFM PVD supplement, which included the use of the PVD to verify the correct departure runway. (3.2-[9, 10])	This recommendation is based on a false premise. The approved AFM PVD supplement does not and should not include the use of the PVD to verify the correct departure runway. The PVD is not designed for runway identification, but for runway centreline steering. It is unnecessary to review SIA training and procedures for a use of the PVD that is outside the scope of the PVD design and certification, and for which it would have been improper for CAAS to so certify. This recommendation should be withdrawn.
4. Develop and implement a clear policy that ensures that flight crews consider the implications of the PFD, and PVD indications whenever the instruments are activated, particularly before commencing takeoff in reduced visibility conditions. (3.1-[7])	This recommendation should include reference to all relevant instruments, not only the PFD and PVD.
5. Include in all company pre-takeoff checklists an item formally requiring positive visual identification and confirmation of the correct takeoff runway. (3.1-[7], 3.2-[12])	This has been done by SIA, and should be included in 'Safety Actions' . This action by SIA should be included in the ' Safety Action' section of the Final Report and this recommendation should be withdrawn.
6. Implement an Advanced Crew Resource Management program to reflect current practices in this area, and ensure that such programs are regularly revised to reflect new developments in CRM. (3.2-[7])	This has been done by SIA, and should be included in 'Safety Actions' . This action by SIA should be included in the ' Safety

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	Action' section of the Final Report and this recommendation should be withdrawn.
7. Review the adequacy of current runway condition determination procedures and practices for determining a water-affected runway to "wet" or "contaminated" in heavy rain situations, by providing objective criteria for such determinations. (3.2-[4])	This recommendation addresses a broader industry issue and should be followed up through the appropriate international aviation organisations such as ICAO and IATA, and not through an individual airline.
8. Conduct a procedural audit to eliminate existing conflicts in the guidance and procedures between the company manuals, the managers' expectations, and the actual practices, such as those contained in the Typhoon Procedures and dispatch briefing policy. (3.2-[22])	SIA's Typhoon Procedures had no bearing on the accident. However, they are under review, and consequently this information should be included in 'Safety Actions'. This recommendation should be withdrawn.
9. Modify the emergency procedures to establish an alternate method for initiating the emergency evacuation command in the event of a PA system malfunction. (3.2-[24, 25])	The SIA procedures already allow for alternate methods to initiate the emergency evacuation command in the event of a PA system malfunction. These procedures were used by the crew of SQ006. An issue in the SQ006 accident was the failure of the PA system, something which has occurred in other accidents involving the B747. It is an industry issue and should be addressed through ICAO and IATA.
10. Reevaluate its procedure and training for the crew to effectively handle diversified emergency situations. (3.2-[24, 25, 26, 27])	SIA trains crew to industry standards. However, no training can simulate the extreme conditions faced by the crew of SQ006 following the accident, a point acknowledged by the ASC. There was no evidence that there were deficiencies in SIA training or emergency procedures. Nevertheless following the accident SIA has reviewed its emergency procedures and training to determine what lessons can be learned from the accident. The actions by SIA should be included in the 'Safety

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	Action' section of the Final Report, and the recommendation withdrawn.
11. Redesign the footwear and skirts of the female cabin crew (that were used at the time of the accident) to provide better protection and maneuverability during emergency evacuations. (3.2-[28])	The redesign of the cabin crew footwear was initiated in 1999 and has since been introduced. This information should be included in the 'Safety Actions' section of the Final Report. There is no evidence that the design of the skirts of the female cabin crew restricted the movement of cabin crew during the evacuation. This recommendation should be withdrawn.
To Civil Aviation Authority of Singapore (CAAS) The Safety Council recommends that the CAAS: 1. Require SIA to develop and implement a comprehensive surface-movement training program, to include a procedure to request progressive taxi instructions during low visibility ground operations. (3.1-[3~7]; 3.2-[5, 6, 13])	SIA has an existing training programme in low visibility operations. The SIA FCTM contains the training procedures and provides appropriate guidelines for low visibility operations. Flight crews are not required to request progressive taxi instructions during low visibility ground operations by any international standards. In conditions of low visibility at airports, it is the Air Traffic Controllers who implement progressive taxi instructions. It is not a flight crew responsibility to request progressive taxi instructions, unless the crew are uncertain of their position. (See, for example, para 5g.(4) of FAA AC 120-74 which was issued on 18 June 2001, well after the SQ 006 accident.) In an extreme case, a pilot may request a 'follow me' vehicle to provide guidance. The recommendation states that there should be a procedure that would require all pilots to request progressive taxi instructions in conditions of low visibility

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	at airports. Such a situation would be operationally impractical. For example, the additional reporting requirements would slow down traffic flow and impede radio communications between aircraft and ATC due to frequency congestion. In addition, the recommendation is not supported by factual evidence from the investigation. At no stage were the crew of SQ006 uncertain of their position. There was no necessity for them to request progressive instructions. However, the CKS Airport ATC SOPs did require the implementation of ' progressive taxi/ground movement instructions' whenever the aircraft could not be seen from the control tower. These procedures were not implemented by CKS ATC in the case of SQ006. This recommendation should be withdrawn.
2. Review the adequacy of current SIA PVD training and practices and ensure that SIA procedural and training documentation and operational practices reflect the CAAS approved B747-400 AFM PVD supplement. (3.2-[9, 10])	This recommendation is not supported by factual evidence from the investigation. SIA procedural and training documentation and operational practices do reflect the CAAS approved B747-400 AFM PVD supplement. The PVD is designed and certified to aid runway centreline steering, not to identify a runway. It should be noted that the CAAS approved B747 AFM PVD supplement does not include the use of the PVD as a runway identifier. CAAS has reviewed the SIA PVD training and practices and found them to be adequate. This recommendation should be withdrawn. (See also

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	comments on recommendation to SIA, number 2).
3. Review AFM supplement document approval, control, distribution, and enactment policies and procedures for operators to ensure that revisions to airline AFMs are adequately managed. (3.2-[11])	The recommendation is not supported by any factual evidence that there is a systemic deficiency in this area. This recommendation arises out of Finding Number 11 that the AFM supplement, which deals with PVD use, was not incorporated into SIA' s documentation and operational practice. The AFM supplement was properly incorporated into the SIA documentation, training or operational practices as appropriate to the design and certified use of the PVD. The draft Final Report shows no evidence that ASC investigators carried out inspections of Aircraft Flight Manuals carried on a representative sample of other SIA B747 aircraft to determine whether the revisions to airline AFMs are adequately managed. This recommendation should be withdrawn.
4. Ensure that all Singaporean commercial airline operators under its regulatory responsibility implement Advanced Crew Resource Management programs to reflect current practices in this area and ensure that such programs are regularly monitored and revised to reflect new developments in CRM. (3.2-[7])	This recommendation has already been implemented. The information should be included under ' Safety Actions' in the Final Report and the recommendation should be withdrawn.
5. Evaluate and support appropriate research to develop technologies and methods for enhancing flight crew' s abilities for objectively determining a water-affected runway condition in heavy rain situations. (3.2-[4])	This recommendation should be withdrawn, as it is not appropriate to address this issue to an individual regulator. Identifying the means to enable the objective determination of a water-affected runway condition is an industry wide issue, and should be addressed through ICAO and IATA.
6. Amend the CAAS Air Navigation Order Paragraph 37 (3) to require an earlier power-on and later power-off times for CVRs.	CAAS is in the process of amending the relevant regulations to require earlier power-on and later power-off

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(3.3-[22])	times for CVRs. This information should be included in the ‘ Safety Actions’ section of the Final Report, and the recommendation should be withdrawn.
To Singapore Government The Safety Council recommends that Singapore Government seriously consider establishing an independent aviation accident/incident investigation organization consistent with many other countries in the world. (3.3-[23])	The recommendation is irrelevant and inappropriate, as Singapore is not the State leading the SQ006 investigation. In any accident investigation, recommendations should be based upon factual evidence gathered during the investigation and the analysis of that evidence. While the recommendation that Singapore should consider establishing an independent accident/incident investigation organisation appears in the ASC draft Final Report, there is no evidence or analysis contained in the draft Final Report to either support or justify the recommendation. For example, there is no evidence that there has been any problem with the present administrative arrangement concerning the participation by Singapore in the SQ 006 investigation. Under these arrangements, the Minister for Transport (previously Minister for Communications and Information Technology) appointed an independent investigation team reporting directly to him. The team is made up of investigators from CAAS, Ministry of Defence, the National University of Singapore, and other organisations. In addition, the Minister appointed three external specialist consultants through the International Civil Aviation Organisation (ICAO).

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	The Singapore SQ006 investigation team operates completely independently of the aviation regulatory authority. These arrangements are fully in accordance with the Convention on International Civil Aviation. It should also be noted that not many countries have a fully independent, permanent stand-alone air safety investigation organisation. The recommendation should be withdrawn.
To Civil Aeronautics Administration, ROC (CAA) The Safety Council recommends that the CAA: **1.** Require that the control tower chiefs re-emphasize the concept, training and the use of progressive taxi/ground movement instructions during low visibility ground operations. (3.2-[1])	<u>General Comments for all the recommendations to CAA ROC:</u> • The recommendations to CAA ROC should include reference to an integrated risk management programme. • The recommendations to CAA ROC should include implementation of FAA National Blueprint for Runway Safety and the relevant advisory circulars.
2. Place priority on budgetary processes and expedite the procurement and installation of ASDE at airports with high traffic volume. (3.2-[16])	
3. Clearly redefine its divisions' job functions to stipulate each individual unit and personnel responsibilities. (3.2-[18])	
4. Specifically appoint an organization within the CAA for the development, modification, and issuance of civil aviation regulations. (3.2-[18])	
5. Organize a program to continuously monitor ICAO SARPs and industry best practices for safety improvement and distribute them to the relevant organizations for applicable review and necessary action and oversight of their progress. (3.2-[18])	
6. Establish an integrated safety assessment and oversight	

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mechanism to supervise all plans and implementations. (3.2-[19])	
7. Evaluate and support appropriate research to develop technologies and methods for enhancing air traffic controllers' abilities in providing objective information regarding water-affected runway conditions (wet versus contaminated) in heavy rain situations to pilots. (3.2-[4])	This is an industry wide issue, and should be addressed through ICAO and IATA. This recommendation should be withdrawn, as it is not appropriate to address this issue to an individual regulator.
8. Immediately implement all items, or acceptable alternative standards, at CKS and other ROC airports, that are not in compliance with ICAO SARPs and applicable documents, such as SMGCS plan, the emergency medical procedure, etc. (3.2-[16, 20, 32])	
9. Ensure that the ARFF at Taiwan airports have the necessary manpower to perform their assigned tasks, as compared to similar level 9 international airports. (3.2-[36])	As well as manpower, this recommendation should also encompass training, equipment and procedures. Reference should be made to equipment, such as a breathing apparatus simulator, and to procedural issues – for example, the need for a contingency plan for effective aircraft disaster management under severe weather conditions.
10. Establish sufficient emergency communication channels for Taiwan airport emergency rescue operations. (3.3-[17])	This recommendation should read as follows: ' Review the communication system at Taiwan airports to develop an integrated plan for improved communications between all agencies involved during emergency rescue operations' .
11. Ensure that its regulations pertaining to post-accident/incident toxicological testing of surviving crewmembers following aircraft accidents in Taiwan is performed for accident/incident prevention purposes. (3.3-[15])	This recommendation should be re-worded for clarification, and should include reference to the testing of air traffic control personnel.
To Ministry of Transportation and Communications, ROC (MOTC) The Safety Council recommends that the MOTC: **1.** Establish professional oversight capabilities for CAA' s safety	

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improvement actions and programs for promoting flight safety. (3.2-[20])	
2. Proactively provide support to the CAA' s safety action plans, such as the ASDE procurement process. (3.2-[20])	
3. Grant full authorization to the CAA to avoid lengthy waiting periods for improving and implementing technical safety regulations. (3.2-[21])	
To the Boeing Company The Safety Council recommends that the Boeing Company: **1.** Provide information for operators' reference regarding emergency evacuation slide operation in high wind conditions. (3.2-[34])	Recommendation needs to be clarified.
2. Consider redesigning the mechanisms of emergency slide packs for lateral G endurance to avoid uncommanded slide inflation during moderate crash forces. (3.2-[35])	
3. Evaluate means to have better illumination of emergency lights for survivors in dense smoke conditions following survivable impact accidents. (3.2-[30])	
To International Civil Aviation Organization (ICAO) The Safety Council recommends that ICAO: **1.** Develop Standards that would require ASDE or comparable equipment as standard equipment at civil airports with high traffic volume. (3.2-[16])	
2. Amend Annex 14 to include clear Standards for defining and protecting a partially closed runway that may be used for taxi purposes. (3.2-[16])	
3. Consider accepting CAA of ROC to participate in various ICAO activities as an observer, solely for the purpose of safety	

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improvement, even though ROC is not a contracting State. (3.2-[21])	
4. Support the establishment of a government/industry program involving Flight Safety Foundation, IFALPA, Airports Council International, and the IATA Safety Committee to develop objective methods to assist pilots in assessing whether a runway is "wet" or "contaminated" due to the presence of water. (3.2-[4])	
5. Encourage and support the establishment of research by governments and industry into improved passenger smoke protection and improved emergency evacuation slide performance in heavy winds and post-accident fire. (3.2-[30, 34])	
To International Air Transport Association (IATA) Based on the lessons learned from the circumstances of the SQ006 accident, including severe impact forces and breakup of the aircraft, strong winds and heavy rain, and heavy smoke and fire, which rendered many emergency evacuation systems inoperative and procedures ineffective, provide support to an international joint government/industry program to develop possible improvements to emergency evacuation equipment and procedures for the prevention of future injuries and death. (3.2-[24])	
To the Federal Aviation Administration (FAA) of the US Based on the lessons learned from the circumstances of the SQ006 accident, including severe impact forces and breakup of the aircraft, strong winds and heavy rain, and heavy smoke and fire, which rendered many emergency evacuation systems inoperative and procedures ineffective, provide support to an international joint government/industry program to develop possible improvements to emergency evacuation equipment and procedures for the prevention of future injuries and death. (3.2-	

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[24])	
To the Joint Airworthiness Authorities (JAA) Based on the lessons learned from the circumstances of the SQ006 accident, including severe impact forces and breakup of the aircraft, strong winds and heavy rain, and heavy smoke and fire, which rendered many emergency evacuation systems inoperative and procedures ineffective, provide support to an international joint government/industry program to develop possible improvements to emergency evacuation equipment and procedures for the prevention of future injuries and death. (3.2-[24])	
Safety Actions Taken or Underway According to Ministry of Communications and Information Technology (MCIT) **1.** SIA has introduced situation awareness training as separate module in it upgraded CRM training. The new CRM training programme for the flight crew will also take into account on-going global developments in aviation human factors training.	With regard to ‘ Safety Actions Taken or Underway’ , see Note above at the beginning of Singapore team’ s comments on the ‘ Safety Recommendations’ section. See also the Singapore’ s team’ s submission on Safety Actions at Appendix 1 to Part 1 of the Singapore team’ s comments.
2. SIA has initiated redesign of the female cabin crew’ s footwear in December 1999. New footwear has been introduced after the accident.	
3. SIA has included in all company pre-takeoff checklists an	

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item formally requiring positive visual identification and confirmation of the correct takeoff runway.	
According to Civil Aeronautics Administration, ROC (CAA) 1. Enhancements to CAA Regulations and Procedures • Reviewed all ICAO Annexes, including collection of information and revising local laws and regulations to meet such requirement as well as to establish a mechanism for such need.	
– A total of 18 items concerning the ICAO Annexes has been tasked to relevant units to look after, and be reviewed and consolidated by appropriate organizations	
– Organizations are required to review and update CAA laws and regulation as required	
• Reviewed Airport Certification Standards and Procedures	
– Based on FAA [Airport Certification Program Handbook] and invited expatriate advisors, the CAA will establish an auditing program for Certification Standards.	
– Revise CAA regulation and specification based on Annex14 and related articles.	
• Developed Airport Design and Operations Regulations	
– Established Runway and Taxiway Specification in 2000	
– Assigned consultant on Domestic Airport Design Spec study, in 2000	
– Established Lighting Specification	
– Airport Selection and Master Plan Spec and Airport and Related Facility Design Spec to be completed in 2002	
• Improved Airport Facility Management	
– Established Airport facility and NAVAID inspection	

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team	
– Established Inspection Plan that requires a two-stage inspection program to improve those areas not meeting requirements	
• Developed CAA Monitoring System for Airport Self-inspection	
– FAA specialist will conduct training on Airport Inspection (FAR Part 139) March 2002	
– Planning to establish Airport Inspector System to perform relevant airport inspections	
– Conducted Ground Handling Management-level Seminar and held a panel discussion to execute a plan for resolving issues - February 2001	
2. Airport Monitor and Management System	
• Developed Airport Self-inspection and Crisis Management System	
– Airports are to set up safety inspection team	
– Developed an Airport Self-audit and Risk Management program in a self-audit handbook, including flight safety, ground safety, NAVAID facility and airport facility, and etc.	
– Developed a Safety Inspection Team schedule to call upon relevant CAA organizations to review/revise the self-audit handbook.	
• Invited FAA Advisor to review CKS Airport and KHH Airport and provide general assessment for further improvement	
• Developed a team of related units to conduct daily inspections of facilities and make effective corrections as required	
• Demanded contractors to strictly adhere to the ICA and FAA’ s safety working procedures	
3. CKS Airport Facility Improvement	

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• Painted new runway and taxiway markings	
– For South section of airport, new markings were completed on July 6, 2001, in accordance with the ICAO standards,	
– North section is under construction and will be completed on November 27, 2001	
– Taxiway centerline marking will be completed March 31, 2002 in accordance with the ICAO standards	
• Airport Lighting	
– Adding to taxiway centerline lights from N1, and will be completed by January 31, 2002	
– Renew sign boards for Runway 05/23 and 06/24, and will be completed by March 1, 2002	
– Installing Runway Guard Lights for Runway 05/23 and will be completed by January 31, 2002	
– Installing yellow-green taxiway centerline lights on Runway 05/23, and will be completed by January 31, 2002	
– Installing Stop Bar on Runway 05/23 and will be completed by December 31, 2003	
• Airport Pavement	
– Taxiway S1-S2 indicating boards base adjustment were completed July 2001	
– Installed signs at the intersections of all service roads and taxiways, and was completed on July 31, 2001	
– Resurfaced Runway 06/24 and related taxiways, and was completed on July 31, 2001	
– Plans to Resurface Runway 05/23 and related taxiways, and will be completed by January 31, 2002	
4. Improvement of CKS Fire Fighting Facilities and Equipment	
• Developed Watch Room Center which was opened on	

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	September 26, 2001		
•	Revised and enhanced Airport Emergency Plan in accordance with the ICAO standards.		
	–	CKS International Airport All Emergencies Handling Procedures and the Civil Aircraft Accident Handling Procedures were amended, the CKS International Airport Aircraft Emergency Landing Procedures were established June 26, 2000, and the CKS International Airport Emergency Rescue Procedures were established October 11, 2001	
	–	CAA organized an Emergencies Procedure Project Team August 2001 based on the ICAO specification to revise Aircraft Accident Handling Plan	
5.	Improvement to Air Traffic Control System		
•	Enhanced air traffic control operations monitoring system on June, July, August and September 2001		
•	Conducted refresher training to air traffic controllers on April and May 2001		

Part 5

Comments by the Singapore Ministry of Transport Investigation Team on the 'Survival Aspects' of the ASC Draft Final Report

Section I

Introduction

1 The ASC has commendably examined the various aspects of the emergency response to the SQ 006 accident. The comments below are intended to assist the ASC to improve these sections of the Final Report.

Comments on Section 2.6.1 of ASC draft Final Report

2 To be more accurate, the analysis of the survival factors in the ASC draft Final Report should acknowledge the extreme circumstances that confronted the crew. Although the SQ 006 accident was a catastrophic accident, the ASC report analyses the actions of the crew in the context of procedures which are primarily applicable to non-catastrophic situations.

3 Additional comments are provided in Section 4 below to highlight certain inaccuracies in the ASC factual information.

Section 2

Emergency Evacuation

4 We suggest that ASC's analysis of the post-accident performance of the crew of SQ 006 (paragraph 2 of 2.6.1 of ASC draft Final Report) should acknowledge the existence of the following statements in the SIA Aircrew Safety Emergency Procedures (ASEP), which apply specifically to extreme circumstances such as those faced by the crew of SQ006:

> *…each emergency is essentially unique, no procedures can include all possible types of accidents or emergencies. The land evacuation procedures should be considered as guidelines for effective and quick action by crew members. These procedures should not preclude the use of initiative in circumstances which dictate a variation from the set procedures.*
>
> *…Neither is it possible to dictate the exact steps to follow in such situations. In an emergency situation, cabin crew should in most circumstances start an emergency procedure only after an order from the captain. However in cases which are clearly catastrophic, individual crew members should be prepared to act immediately on their own initiative.*

5 The severe dynamics of the accident following the initial impact, when the aircraft was rotating, breaking apart and catching fire, were traumatic for both crew and passengers. The factual evidence shows that the crew of SQ 006 carried out their duties to the best of their ability in these catastrophic circumstances.

6 In summary, the analysis and findings of the ASC Final Report with regard to the performance of the SQ 006 crew following the accident should take into consideration the above comments.

<u>Section 3</u>

Comments on Section 2.6.4 of ASC Draft Final Report

7 Evidence shows that the CKS Airport Rescue and Fire Fighting (ARFF) team did not use their breathing apparatus during the rescue operations. The use of breathing apparatus during the rescue operations could have possibly contributed to the rescue of passengers who were trapped in the aircraft. We suggest that appropriate findings and safety recommendations be developed in this area.

<u>Section 4</u>

Comments on ASC Factual Section on Survival Factors

1. Para 1.12.2.3.2 Doors and Evacuation Slide/Rafts (Page 88 of ASC Draft Final Report):

<u>Door 4R</u>

'Soot and fire burnt damage were found at inlet of aspirators to the inner skin of slide. See Figure 1.12-11'.

The above information was not officially verified by the Survival Factors Group.

2. Para 1.12.2.3.2 Doors and Evacuation Slide/Rafts (Page 88-89):

<u>Door 4L</u>

The word "close" should be replaced by " cocked open "

This is based on the Survival Factor Group Report, paragraph 1.3.2.2, Doors and Evacuation Slide/Rafts, which states that: 'Door 4L was found intact and in a "cocked open" position.'

3. Para 1.12.2.3.2 Doors and Evacuation Slide/Rafts (Page 89):

In the table 1.12-2, under the column 'status' it is indicated that the UDR and UDL doors were opened by the UDR cabin crew.

As there are conflicting testimonies regarding the opening of these doors, it could not be determined who opened the UDR and UDL doors. Therefore, the relevant entry in the column 'Opened By' should be 'unknown' .

4. Para 1.15.1.1 SIA Crewmember' s Emergency Evacuation Procedures and Training [Para 3] (Page 97):

***'Land evacuation procedure should be conducted quickly and efficiently**.*
The initiation of an evacuation is the Commander's responsibility. Should a Cabin Crew consider that an evacuation is necessary, he/she should advise the Commander of the situation and await his decision. In cases, where it is obvious that an evacuation is imperative and no contact with the cockpit is possible, the Cabin Crew should initiate the evacuation immediately on his/her own.
(Especially for CIC)'.

The first sentence should be quoted separately from the second sentence onwards as they are extracted from different paragraphs of Chapter 4, Section 4 of the ASEP manual.

The last sentence '(Especially for CIC)' should be deleted as it is not in the content of the ASEP manual.

5. Para 1.15.1.1 SIA Crewmember' s Emergency Evacuation Procedures and Training [Para 6] (Page 98):

This cabin evacuation trainer is programmed with an automated Captain's PA announcement to cabin crew and passengers to prepare for an evacuation, brace for impact and to evacuate the aircraft.

The fourth sentence in paragraph 1.15.1.1 of the ASC draft Final Report should be corrected, as it has incorrectly stated that 'the CIC declared the emergency evacuation'.

6. Para 1.15.1.1 SIA Crewmember' s Emergency Evacuation Procedures and Training [Para 7] (Page 98):

The pilots practise evacuation commands via the PA system in the flight simulator during their regular proficiency checks.

The alternate method of ordering an evacuation in the absence of a pilot's evacuation command is for the cabin crew to initiate the evacuation if contact with the pilot is not possible and an evacuation is imminent. As such, the second and third sentences of this paragraph should be corrected to reflect this.

7. Para 1.15.1.1 SIA Crewmember's Emergency Evacuation Procedures and Training [Para 3] (Page 99):

To reflect accurately the interview report, the phrase in the second last sentence 'since no one took any action to evacuate' should be changed to 'as nobody actually wanted to evacuate'.

8. Para 1.15.1.1 SIA Crewmember's Emergency Evacuation Procedures and Training [Para 4] (Page 99):

'He then turned back and saw the left outside fire starting to diminish and passengers jumping down through the UDL exit. CM-3 did not see CM-1 at that time, but <u>he saw a female cabin crew shaking and weeping near the left side exit</u>. CM-3 instructed this cabin crewmember to jump out.'

The statement: 'he saw a female cabin crew shaking and weeping near the left side exit.' is not in the interview records. It should therefore be deleted.

9. Para 1.15.1.3. Upper Deck Cabin Crew's Emergency Evacuation [Para 2](page 99):

'*The UDL cabin crew saw the UDR crew attempted to open the UDR exit and was forced to move backward because of the fire and smoke from the UDR exit immediately after his opening of this exit. The UDR cabin crew then opened the UDL door. As the UDL door was opened, the slide/raft inflated and the fire burned and deflated this slide/raft immediately.*'

The above statements are incorrect as they are not supported by the evidence of the UDL cabin crew. The UDL crew, in her interview, only stated that she saw the UDR cabin crew attempting to open the UDR door, but he was not successful.

10. Para 1.15.1.6 Emergency Equipment [Para 1] (Page 103):

Not all cabin crew were asked during the interviews by ASC if they carried the torches from their stations during the evacuation. It should be noted that during the breakup of the aircraft, the torches could have dislodged from their place of storage and it would not be possible for cabin crew to locate the torches.

11. Para 1.15.1.6 Emergency Equipment [Para 2] (Page 103):

These statements do not take into consideration the catastrophic circumstances of the accident to SQ 006.

Singapore Ministry of Transport Investigation Team comments on Section 2 of ASC draft Final Report 'Analysis'

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Reference : Analysis, para 2, ASC Draft Final Report page 175	
Chapter 2 starts with a general description of the factors we ruled out from the investigation as it is shown in Section 2.1. Section 2.2 provides the necessary structural failure sequence of this accident. Section 2.3 and 2.4 analyze the condition of the airport at the time of the accident, the ATC procedure during the accident sequence, as well as the organizational; and management factors of the CKS Airport and CAA of ROC. Section 2.5 analyzes the crew performance and the related crew training, coordination, the unsafe acts by the crew, and the defenses that we consider to be important to this accident. Section 2.6 provides analysis of the post accident fire, rescue and medical condition, or the survivor factors analysis. And Section 2.7 provides the analysis of the safety issues that are deemed important for the improvement of aviation safety.	In accordance with current usage of the Reason model, the term ' unsafe acts' should be replaced with ' individual or team actions' .
Reference : 2.1 General, para 3, ASC Draft Final Report page176	
The air traffic controllers involved with flight SQ006 were properly certificated. <u>The evidence from CVR, FDR, interviews with ATC controllers and the flight crew indicated that the ATC taxi instructions and takeoff clearance did not mislead the crew to take off from the partially closed Runway 05R.</u> ATC procedures, airport infrastructure	Suggest replacing with: ' The evidence from CVR, FDR, interviews with ATC controllers and the flight crew indicated that the ATC taxi instructions and takeoff clearance were for Runway 05L.'

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issues and the performance of CAA management are discussed later in this chapter.	
Reference : 2.3.1.1 Design of Taxiway N1 Centreline Marking, para 2, ASC Draft Final Report page181-182	
By calculation, the distance between the south edge of the Runway 05R and the tip of the curvature where N1 centerline made a turn into Runway 05R was 32 meters and the distance between the north edge of the Runway 05R and the tip of the curvature where taxiway centerline marking turned away from Runway 05R to join Taxiway N1 was 35 meters. According to the CAA civil engineering specifications (ATP-AE 1000301: 3.8.5.1) as stated earlier, the N1 centerline marking should have a 20-meter extension from the tip of the curvature toward Runway 05R and a 23-meter extension away from Runway 05R toward Runway 05L.	A diagram should be inserted to illustrate the missing segment of taxiway centre line marking and what ought to have been provided on site according to the specifications of CKS ATP-AE 1000301: 3.8.5.1, ICAO Annex 14 and FAA requirements to guide aircraft from Taxiway NP across the threshold of Runway 05R towards Runway 05L.
Reference : 2.3.1.1 Design of Taxiway N1 Centreline Marking, para 4, ASC Draft Final Report page 182	
The FAA Advisory Circular 150/5340-1H indicates that the taxiway centerline marking should stop at the edge of a runway	FAA AC 150/5340-1H also states that taxiway centreline markings **'shall continue across all runway markings'** for those taxiways used for low visibility (RVR below 360m) with the exception of the runway designation markings (Item 1.10.3.1.2, Page 58 of the Factual Section).
Reference : 2.3.1.2.2 Spacing of Taxiway Centerline Lighting para 4, ASC Draft Final Report page 183	
The Safety Council considers that the spacing of the taxiway centerline	Instead of considering this deficiency as ' increased the risk' , it

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lights at the time of the accident increased the risk of the safety aircraft operations, as it will further be discussed in section 2.5.	should be classified as a factor related to ' probable cause,' that led the crew to taxi into Runway 05R as elaborated in Section 2.5.7.2.2 below.
Reference : 2.3.1.2.3 Unserviceable Taxiway Centerline Lights para 1, ASC Draft Final Report page 183	
ICAO Annex 14, Vol.1, Paragraph 9.4.23 indicated that two adjacent unserviceable lights were not permitted when the RVR is less than 350 meters. The Safety Council found during the site survey on November 4 (four days after the accident) that the second light after N1 departed from the tip of the taxiway curvature was out of service. In addition, the third light' s luminance intensity was substantially degraded. However, there were no reports from the CKS Airport Flight Operations Section, airfield lighting Maintenance Group, or any other flight crew taking off from Runway 05L on the evening of the accident stated that there were two adjacent unserviceable lights along Taxiway N1. Furthermore, flight crews prior to the evening of the accident had submitted no safety concerns or reports about the Taxiway N1 lighting.	It is not a requirement or routine practice for flight crew to report specific unserviceable lights to ATC.
Reference : 2.3.1.2.3 Unserviceable Taxiway Centerline Lights para 2, ASC Draft Final Report page 183-184	
Thus, the Safety Council concluded that although the second Taxiway N1 light was not serviceable and the third light was less intense on the evening of November 4, 2000, the status of these N1 taxiway lights on the night of the accident might or might not be the same as in accordance with the findings of the November 4 inspection.	It is highly improbable that these two lights only became dim or unserviceable in the short span of time between the time of the accident and the evening of 4 November 2000.
Reference : 2.3.2 The Installation of Runway Guard Lights (RGL) **para 1, ASC Draft Final Report page 184**	

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ICAO Annex 14 (third edition-July 1999) Vol. 1, Paragraph 5.3.20.1, stated that a configuration A Runway Guard Light (Figure 2.3-1) shall be provided as a standard. FAA AC 120-57A Paragraph 8b suggests: runway guard lights to be provided when operating below RVR 365 meters. AC 150/5340-28 also mentioned: RGL provides a distinctive warning to anyone approaching the runway holding position that they are about to enter an active runway. CKS Airport didn' t install configuration A RGL at the location greater than 75 meters from the 05L/23R runway centerline along Taxiway N1. Therefore, it does not meet the standard stated by ICAO.	This statement gives an impression that CKS Airport installed runway guard lights, but at an incorrect location, when in fact, there were no runway guard lights at all.
Reference : 2.3.2 The Installation of Runway Guard Lights (RGL) **para 3, ASC Draft Final Report page 184**	
If CKS Airport had installed RGL at the location on both the left and right sides of Taxiway N1 as required by the ICAO standard, that is, 75 meters from the centerline of Runway 05L, the distance from that location to the centerline of Taxiway NP would be 249 meters and the distance to the intersection on Taxiway N1 that turns into Runway 05R is about 175 meters. Since the RVR on the night of the accident was 450 meters, the crew could have had one indication that the CAT II Runway (05L) was still ahead of them, as it will be further discussed in Section 2.5.	This statement gives an impression that CKS Airport installed runway guard lights, but at an incorrect location, when in fact, there were no runway guard lights at all.
Reference : 2.3.3 Safety Considerations for Temporarily and Partially Closed Runway, para 1, ASC Draft Final Report page 184-185	

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ICAO Annex 14 is the source of the generally accepted safety standards for the marking of temporary closures of aerodrome maneuvering surfaces. There can be no question that those operating aircraft and other vehicles on aerodromes need clear indications of temporarily closed maneuvering areas. It is obvious that such indications should provide warning during all operating conditions. One way to do this is through the publishing of NOTAMs and broadcasting on the ATIS. That was done at CKS around the time of the accident. The other form of warning is the physical outlining of the temporarily closed area. Where the area can be marked without disrupting traffic and the approach is generally simple. Where, as at CKS, there would be a major disruption through the closure of the entire length of the runway and the problem was much more complex. In this instance, the problem was not in closing the runway, as a runway, but in closing it in its virtually exclusive use as a main taxiway.	It is possible to provide visual warnings on the temporary closure of Runway 05R-23L and the unserviceable area, without any significant impact on the efficiency of operations. This could have been achieved by closing Runway 05R-23L for taxiing operations between Taxiways N1 and N2.
Reference : 2.3.3 Safety Considerations for Temporarily and Partially Closed Runway, para 2, ASC Draft Final Report page 185	
When an area is temporarily closed, it is preferable to use frangible markers. The lighted Jersey blocks were not frangible. An attempt was made by the airport authority to mark the construction area and maintain operations at a reasonable level at the same time. The efforts of the airport and the knowledge of the crew of the closed area in combination did not prevent the aircraft from attempting to depart into the closed area. The Safety Council believes, in addition to enhance crew training, the airport has an obligation to seek a more compelling form of indicating closed areas.	Earlier NOTAMs and AIP Supplements indicated that the CKS Airport had intended to permanently close Runway 05R/23L and re-open it as Taxiway NC after repair works had been completed. As such, the runway markings should have been removed, the runway lights decommissioned, and more importantly, closure markers should have been strategically placed to prevent crew from entering and taking off from the closed runway.

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	Had these steps been taken, the accident could have been prevented.
Reference : 2.3.4.1 Evidence Regarding Status of Runway 05R Edge Lights, para 2, ASC Draft Final Report page 185	
Although videotapes from airport security and a passenger aboard CI004 recorded events in the general location of Runway 05R about the time of the accident, including the landing lights of SQ006 during its takeoff roll and the initial explosion and subsequent fire, Runway 05R edge lights were not perceptible at the time immediately before, or after, the accident. It was stated in 1.18 that the exterior lights of SQ006 were visible on airport security camera no. 77, if the Runway 05R edge lights were on, they should have been visible on the video as well. Although the quality of the videos in the prevailing weather conditions precludes a definite conclusion regarding the status of the edge lights, this evidence strongly suggests that the Runway 05R edge lights were not on during takeoff roll.	*The status of the 05R runway edge lights could not be conclusively determined.*
Reference : 2.3.4.1 Evidence Regarding Status of Runway 05R Edge Lights, para 3, ASC Draft Final Report page 185	
The absence of an interlocking system to prevent simultaneous operation of the edge lights for Runways 05R and its centerline lights made it possible for both to be powered at the time of the accident, if an error was made in the tower. However, statements from the ATC controllers indicated that none of them had turned on the Runway 05R edge lights. Although this evidence is not conclusive that the lights	The presence of an interlocking system would have prevented the possibility of such human errors on switching of the lights. There had been past reports of mistakes involving the switching on or off of airfield lights.

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were off, it is plausible because there was no need for the edge lights on Runway 05R to be illuminated at the time of the accident.	
Reference : 2.3.4.1 Evidence Regarding Status of Runway 05R Edge Lights, para 3, ASC Draft Final Report page 185	
Two Captains operating near the time of the accident were questioned about their observations of Runway 05R lighting. The Captain of CI004, which was taxiing along Taxiway NP for takeoff on Runway 05L when SQ006 crashed, stated that he first saw SQ006 when his aircraft was abeam A7 gate. He said that SQ006 was already in its takeoff roll. He could see the accident aircraft' s landing lights, but could not determine if the aircraft was airborne. He also said that visibility was good, but the rain was heavy at the gate, although it was " on and off." The Captain of CI004 said that he did not see any lights on either Runway 05R or 05L, although he did recall that Taxiway NP taxi lights were on. He stated that SQ006' s landing lights were visible as it moved down the runway, but " the rest was pitch dark." Since the landing lights of SQ006 during its takeoff roll were visible to the Captain of CI004, it is very likely that the Runway 05R edge lights were not on or he would have seen them, since they were only about 110 m from Taxiway NP.	The Captain of flight CI004 was focused on the aircraft and its bright lights while taxiing on taxiway NP, and as such peripheral details including the runway edge lights might not have registered with him.
Reference : 2.3.4.1 Evidence Regarding Status of Runway 05R Edge Lights, para 8, ASC Draft Final Report page 186	

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According to ATC recorded transmissions, about 40 minutes after the accident, the CKS SFOO called the CKS tower using his hand-held radio and requested that all runway lights of Runway 05 be turned on (he did not specify 05L or 05R). This statement makes it clear that the edge lights for Runway 05R were off at that time. However, the RVR printout revealed that Runway 05L edge lights were also off at this time and came on shortly after the SFOO requested all runway lights to be turned on. Thus, this evidence does not enable the Safety Council to draw a conclusion regarding the status of the edge lights at the time of the accident.	This statement indicates that the edge lights for Runway 05R were off at the time of SFOO' s request. But they may or may not have been on at the time of the accident. The runway edge lights could have been switched off when the runways were closed soon after the accident.
Reference : 2.3.4.1 Evidence Regarding Status of Runway 05R Edge Lights, para 9, ASC Draft Final Report page 186	
The tests and research conducted on the two runway edge light wires from the locations of RE239 and RE240 revealed conflicting evidence. The absence of arcing damage on the wire strands from RE239 suggests strongly that the light was not powered when it was damaged by aircraft debris during the accident, or by AFFR vehicles shortly after the accident. The absence of arcing more likely indicates that the light at the location RE239 was not powered when SQ006 commenced its takeoff.	The absence of arcing damage on the wire strands from RE239 does not necessarily suggest the absence of electrical power at the time when the light fitting was damaged by foreign objects. From test results of arcing experiments conducted by Dr Hsu and Dr Lim of NUS/DSO, the absence of globules when the airfield light wires are separated does not necessarily preclude the possibility of the airfield light being powered on at the time of separation.
Reference : 2.3.4.1 Evidence Regarding Status of Runway 05R Edge Lights, para 10, ASC Draft Final Report page 186-187	
The evidence of arcing on the wire strand ends and along length of the	While the scenario painted is plausible, the arcing damage

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wire from the location of RE240 reveals that, at some point, the wires were connected to a power source and arcing damage occurred. The examinations of RE240 and tests conducted after the accident suggest the possibility for the arcing damage. Assuming that the edge light at location RE240 was on when wreckage or fire and rescue vehicles passed over it, the arcing could have occurred when the wire separated. That scenario could easily explain the arcing noted on the wire strand ends. However, it does not explain the arcing damage along the wire lengths that would have been protected by insulation until the post-accident fire burned the insulation away. The ATSB laboratory report suggests that the fire damage to the wire strands of RE240 involved a "boundary effect" whereby the plug end of the wire was immersed in a liquid, which protected it, while the remainder of the wire insulation burned away. If that were the case, arcing evidence on the wire lengths would have to have occurred sometime after the insulation burned away, possibly after power was re-applied to the lighting system about 40 minutes after the accident. Tests conducted by CSIST revealed that arcing of this nature can occur both along the length of the wire strands, and at the strand ends where globules were found after the wired are separated and subsequently momentarily contact metal to ground with power available.	found at the ends of the wire strand, and those along the sides of the wire, could have been produced as a result of two separate events: the former when the wires were knocked away and pulled apart by the wreckage, and the latter as the result of an after-event.
Reference : 2.3.4.1 Evidence Regarding Status of Runway 05R Edge Lights, para 11, ASC Draft Final Report page 186	
Regarding the arcing damage found on the length of the wires, the Safety Council developed a probable scenario to explain the origin of the damage.	There are other scenarios which are consistent with the evidence, and which indicate that the runway edge lights were on at the time of the accident.

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Reference : 2.3.4.2 Summarized Analysis of the Status of Runway 05R Edge Lights, para 2, ASC Draft Final Report page 187	
In summary, although some of the evidence regarding the status of the Runway 05R edge lights at the time of the takeoff of SQ006 is inconclusive, the Safety Council believes that the preponderance of evidence indicates a high probability that edge lights were off during the SQ006 takeoff.	There is a lack of evidence to determine conclusively whether the lights were on or off at the time of the accident.
Reference : 2.3.5.2.2 Current Status of Modification and Updating of Local Regulations, para 1, ASC Draft Final Report page 190	
On September 3, 1987, the CAA published its "Civilian airport civil engineering design standard and specifications" and "Airfield air navigation lighting specification". The CAA regulations have not been regularly revised to reflect the most recent amendments to ICAO SARPs. Interviews with CAA personnel indicated that an effort to modify domestic regulations to reflect the most recent ICAO SARPs did not begin until 1999. CAA was planning to complete a revision of the civil aviation regulations by the end of 2001. Furthermore, adherence to international standards and recommended practices is an essential component of aviation safety. However, because of political reasons, Taiwan is not an ICAO signatory and receives no direct help or information from ICAO. This isolation from the primary international aviation advisory and standards body has had an adverse bearing on Taiwan's ability to conform to ICAO SARPs.	Although Taiwan is not an ICAO Contracting State, it has stated in the AIP that it is in compliance with ICAO SARPs.
Reference : 2.3.6 Summary of Organization and Management Related Airfield Deficiencies, para 4, ASC Draft Final Report page	

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1. Deficiencies caused by inadequate administrative management: • Safety measures during airfield work in progress; • Process of converting Runway 05R into Taxiway NC; • Fail to revise CAA regulations to reflect updated ICAO SARPs.	Should also include: • Inadequate maintenance and monitoring of airfield lights to keep up with the required standards
Reference : 2.4.1 Low Visibility Taxiing and Ground Movement Instruction, para 4, ASC Draft Final Report page 192	
According to the Chief of CKS Control Tower, the purpose of the ATC low visibility taxi procedure was to prevent aircraft accidentally taxiing into each other. When the CKS Ground Controller issued the taxi clearance to SQ006, SQ006 was the only aircraft taxiing in the area. In addition, the Ground Controller stated that he was able to maintain visual contact with SQ006 until the aircraft was handed off to the Local Controller on Taxiway NP. Therefore, the Ground Controller did not inform the SQ006 crew that part of the airport was invisible from the tower and to slow down the taxi with caution. Furthermore, the Chief of Tower stated that according to the ICAO Procedures for Air Navigation Services (ICAO Doc 4444) and the Manual of Surface Movement Guidance and Control Systems (ICAO Doc 9476), there is no requirement for a Ground Controller to advise pilots that they are not visible from the tower.	The ATP 88 requires air traffic controllers at CKS Airport to advise pilots on the ground when their aircraft are not visible from the tower. However, this was not done on the night of the accident.
Reference : 2.4.1 Low Visibility Taxiing and Ground Movement	

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Instruction, para 6, ASC Draft Final Report page 192-193	
It is apparent that the controller did not issue progressive ground movement instructions and did not use the low visibility taxi phraseology to remind the aircraft to slow down its taxi. Based on the evidence, including the comments made by the flight crew on the CVR about taxi speed, the Safety Council concludes that the taxi speed of SQ006 did not contribute to this accident. However, if the controller had issued progressive taxi instructions to the SQ006 crew, it is likely that this would have significantly enhanced the flight crew' s situational awareness.	As stated in the analysis (Item 2.4.1 of page 192/193), had the ATC complied with the CKS Airport' s SOPs, ' it is likely that this would have significantly enhanced the flight crew' s situational awareness' . This is a significant finding that ought to have been included in the ' findings related to probable causes' .
Reference : 2.4.2 Airport Surface Detection Equipment (ASDE), para 2, ASC Draft Final Report page 193	
In conditions of heavy rain, the presentation of an ASDE display can be diminished considerably by the attenuation of the rain beam. There was extensive precipitation at CKS Airport because of the approaching typhoon weather at the time of accident. Therefore, it is not clear whether the ASDE could have provided useful information to the controllers to prevent the accident. However, during interview, the Controller A believed that ASDE could have prevented this accident. Nonetheless, there is a possibility that had ASDE been installed and used by the controllers, it might have alerted them to the incorrect taxi route of SQ006.	To amend the clause to '… diminished considerably by the attenuation of the radar beam in the rain.' The phrase ' incorrect taxi route of SQ006' is misleading. It should be worded as '… it might have alerted them that SQ006 did not taxi onto the assigned departure runway at the end of its taxi route.'
Reference : 2.4.4 Taxi Navigation Cycle, para 1, ASC Draft Final Report page 196	

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The FAA Advisory Circular (AC) No. 120-74 dated June 2001, provides guidelines for the development and implementation of SOPs for conducting safe aircraft operations during taxiing, focusing on the activities occurring within the cockpit. Sections of the AC provide a useful frame of reference for assessing the low visibility taxiing performance of the crew of SQ006. Flight crew procedures are addressed in Part 5 of the AC. The following paragraphs have examined the performance of the SQ006 crew against relevant criteria outlined in the AC. Measured against the guidelines set out in AC 120-74, the performance of the SQ006 crew revealed some areas in their performance and that of SIA procedures or training that needed improvement. Neither the flight crew nor SIA met the basic benchmarks in their entirety.	This is not correct. The SQ 006 crew met the relevant criteria set out in the FAA AC120-74, as shown by the CVR evidence.
Reference : 2.5.4.1 Taxiing, para 1, ASC Draft Final Report page 196-197	
On the night of the accident, the flight crew followed the taxi checklist and procedures in accordance with the SIA B747-400 Operations Manual and navigated themselves accurately until the aircraft approached the end of Taxiway NP. The flight crew was somewhat distracted by the execution of the before takeoff procedures and tasks, and it was likely that this impacted upon the crew' s monitoring of the final phase of the taxi. Interviews with the flight crew indicated that they did not monitor the final phase of taxi (the turn from Taxiway NP onto Runway 05R via N1) in accordance with the airport chart and associated aircraft-heading indications. Furthermore, the crew did not check the taxiway and runway signage and markings to help verify the	There is no evidence to substantiate that the ' crew was somewhat distracted by the execution of the before takeoff procedures and tasks'. Such tasks are not distractions, they are an essential part of normal operations. Instead, they were misled by the prominence of the taxiway single line of taxiway centreline lights leading onto Runway 05R and the absence of runway closure markings on Runway 05R.

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position of the aircraft when the aircraft turned from Taxiway NP onto Runway 05R via Taxiway N1. The pilots' field of view during the critical turn from NP onto Runway 05R will be discussed in Section 2.5.7.1 of the report.	
Reference : 2.5.4.2 Flight Crew Awareness, para 1, ASC Draft Final Report page 197	
FAA AC 120-74 states; "*Flight crews should use a continuous loop process for actively monitoring and updating their progress and location during taxi. This includes knowing the aircraft's present location on the route that will require increased attention. For example, a turn onto another taxiway, an intersecting runway, or any other transition points. As the 'continuous loop' is updated, flight crewmembers should verbally share relevant information with each other.*"	See comments above.
Reference : 2.5.4.2 Flight Crew Awareness, para 3, ASC Draft Final Report page 197	
The taxi route originally briefed by CM-1 prior to push back was changed by ATC during the issuance of the taxi clearance. CM-1 briefed the new taxi route but he did not include the crossing of Runway 05R before reaching Runway 05L. CM-2 or CM-3 did not challenge this omission.	However, it should be noted that the new taxi route did not include a clearance to cross or hold short of R/W 05R. CM-1's briefing of the taxi route was correct, as cleared by ATC. As there was no error in CM-1's briefing, it was unnecessary for the co-pilots to challenge CM-1's briefing.
Reference : 2.5.4.3 Intra-flight Deck/Cockpit Verbal Coordination, para 2, ASC Draft Final Report page 198	
Reference to the CVR shows that, prior to the turn onto Runway 05R,	The crew was certain that they were on Runway 05L as they

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the crew of SQ006 knew where they were. They had verbally coordinated to ensure they all knew that Runway 05L was the takeoff runway, and they had obtained the required ATC clearance to use it. As the aircraft taxied into position for takeoff, the crew were certain that they were on Runway 05L. However, critical information upon which they had to rely to maintain the accuracy of their situational awareness such as aircraft instrumentation and airport lights and signage was not used effectively.	were misled into believing they were on the correct runway by the visual cues presented. It is incorrect to state that 'critical information' was not used effectively. The information was flawed. The veracity of situational awareness depends upon the quality of the information upon which it is based.
Reference : 2.5.4.4 Taxi Procedures, para 1, ASC Draft Final Report page 198	
Analysis of the procedures in the SIA B747-400 Operations Manual, the FDR parameters, and the CVR transcript, indicated that the taxi clearance which the pilots received, taxi path, taxi speed, and cockpit conversation, were generally routine. One exception to the routine was the flight crew discussion of alternates during taxi. The CVR transcript, the audio recorder transcripts from CKS Airport tower, and interviews with the 3 pilots, confirmed that the revised clearance was to taxi after push back to Runway 05L via Taxiway SS, Taxiway WEST CROSS, and Taxiway NP. Taxiway N1 was not specified in the clearance[1]. The taxi checklist and procedures performed by the flight crew were in accordance with the SIA B747-400 Operations Manual with the exception of the period when the aircraft turned from Taxiway NP onto Runway 05R. Furthermore, the flight crew did not request progressive	*There was no regulatory or operational requirement for the crew to request progressive taxi instructions. They taxied their aircraft accurately to the final turn onto Taxiway N1*

[1] CKS Ground Control issued the taxi clearance to SQ006 as "…taxi to Runway 05L by Taxiway SS, West Cross and NP". The controller did not include "cross Runway 05R" in the clearance. According to CAA ATP-88 Chapter 3-7-2 b., when authorizing an aircraft to taxi to an assigned takeoff runway and hold short instructions are not issued, specify the runway preceded by "taxi to," and issue taxi instructions if necessary. This authorizes the aircraft to "cross" all runways/taxiways, which the taxi route intersects except the assigned takeoff runway.

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taxi instructions to augment their navigation accuracy in low visibility conditions.	
Reference : 2.5.4.4 Taxi Procedures, para 2, ASC Draft Final Report page 198	
As stated in section 1.17.4.5, SIA instructs pilots to use the correct taxiway and runway. Such admonishments are typical in complex socio-technical industries but exhorting people to comply with such directives is generally an ineffective accident or incident countermeasure unless specific methods to achieve the objective are provided[2]. The SIA Flight Instructor Manual requests instructors to teach pilots about the "taxi routing and situational and environmental awareness", but there are no detailed guidelines for taxiing in low visibility conditions. There was no specific procedure for low visibility taxi described in the SIA B747-400 Operations Manual. MCIT submissions to the investigation team indicated that taxiing an aircraft is a part of basic airmanship. There is no specific technique to be applied for taxiing in low visibility. Moreover, SIA stated that there were no specific requirements for low visibility taxi training for pilots stipulated in ICAO SARPs, JAR's, FAR's or promulgated by the major manufacturers and that SIA was following industry best practice.	This analysis does not take into account the fact that taxi guidance information in low visibility is provided in the SIA B747-400 FCTM.

[2] Reason, J. (1997). Managing the risk of organizational accidents. Aldershot, UK: Ashgate.

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Reference : 2.5.4.5 SIA Low Visibility Taxi Training, para 1, ASC Draft Final Report page 199	
Although there was no industry benchmark set for low visibility taxi training before the accident, it was found (from the CVR) that the crew of SQ006 did not measure up to the FAA Advisory Circular AC 120-74 guidelines on taxiing practices (p. 8). The SIA Operations Manual did not provide guidelines for operations in low visibility conditions. The SIA Flight Crew Training Manual' s (FCTM) low visibility training section instructs flight crew to " …taxi slowly as necessary for safety. Do not hesitate to request from ATC the positions of other taxiing aircraft or to ask for a follow me car." However, CM-1 stated that he did not receive low visibility taxi training.	A captain of CM-1' s qualifications and experience in Cat II and Cat III operations has received training in low visibility taxiing operations as an integral part of his training package. This training should have been checked and reviewed by the ASC investigation team.
Reference : 2.5.4.5 SIA Low Visibility Taxi Training, para 11, ASC Draft Final Report page 199	
The flight crew did not possess an appropriate level of knowledge to fully evaluate the effects that weather on the aerodrome might have had on their ability to accurately navigate the aircraft on the ground. It must be emphasized that in any complex system breakdown, there are many factors that contribute to the outcome. The FAA' s *National Blueprint for Runway Safety* offers initiatives that address all system elements including flight crew, ATC operations, and airport infrastructure and safety management systems. With reference to flight crew performance, SIA did not have a comprehensive surface	This statement is not supported by any factual evidence, and is contradicted by the crew's qualifications, training and operational flying experience in all weather conditions. Such statements, which have no basis in fact should be deleted from the Final Report.

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movement training program.	In this case, it was not a lack of knowledge that caused the SQ006 crew to mistake the closed Runway 05R for the assigned take off runway 05L. The most significant factor that contributed to this mistake was the deficient visual aids which misled the pilots into taxiing into a closed runway.
Reference : 2.5.4.6 Summary, para 1, ASC Draft Final Report page 200	
Measured against the guidelines set out in FAA AC 120-74, the taxiing performance of the flight crew of SQ006 revealed some areas in their performance and that of SIA procedures and training that needed improvement. Neither the flight crew nor SIA met the FAA AC benchmarks in their entirety. On the basis of the evidence, there were many factors that led to the aircraft lining up on Runway 05R instead of 05L. Some of these factors were related to the performance of the flight crew. <u>In summary, the SIA low visibility taxi training and procedures did not contain all the elements of what is currently regarded as safer and better practice in this area.</u>	This statement is not supported by the factual evidence. See earlier comments.
Reference : 2.5.5 Before Take-Off Check, para 1, ASC Draft Final Report page 200	
The CVR indicated that none of the flight crew orally confirmed whether the runway they entered was Runway 05L. When an aircraft receives a clearance for takeoff, the flight crew' s confirmation that they are on the active runway provides an additional measure of safety. On runway line-up, the flight crew did not cross reference their outside picture with the information on the CKS Airport chart.	In normal operations, once a crew has navigated their aircraft to the runway holding position, by reference to their airport charts,, they refer to external visual cues to guide them onto the takeoff runway. The ' confirm active runway check' item was not a regulatory requirement, or an industry standard at the time of the accident.

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	The before takeoff check-list requires confirmation of the takeoff runway as cleared by ATC, and this was done by the crew of SQ 006, as shown by the CVR.
Reference : 2.5.6.2 Navigation Displays, para 1, ASC Draft Final Report page 201	
The navigation information necessary to fly the aircraft (such as track, waypoints and lateral and vertical navigation pointers, wind speed and direction, and other data) was shown on the Navigation Displays (ND) in front of both pilots. When a runway is selected, the ND displays a runway symbol, which appears as two parallel white lines. The position of the aircraft relative to the runway is shown by the aircraft symbol (white triangle) and identifier or label such as 05L. Runway 05L had been selected for departure. With the intended runway centerline being 214m (650ft.) to their left, the aircraft symbol appeared to the right edge of the runway symbol, indicating that the aircraft was possibly not aligned with Runway 05L. The Runway 05L label also remained unchanged.	There are no procedural or operational requirements for the flight crew to check these specific indications at the point of takeoff.
Reference : 2.5.6.3.1 Para-Visual Display (PVD) Information, para 2, ASC Draft Final Report page 202	
The procedure is not specified as related to Category III operations, rather, it is a general procedure for use of the PVD. The CAAS approved AFM supplement indicates that the PVD assists the flight crew in determining whether the aircraft is in the correct position for takeoff.	This statement is factually incorrect. The wording and intent of the CAAS approved AFM supplement has been misinterpreted in this analysis.

ASC Draft Final	MOT Comments
Reference : 2.5.6.3.1 Para-Visual Display (PVD) Information, para 5, ASC Draft Final Report page 202-203	
As part of the investigation, information was obtained from other Asia-Pacific B747-400 operators regarding the use of the PVD (they have been de-identified for commercial reasons). In particular, one operator’ s B747-400 Operations Manual stated that “Using the runway localizer tuned on the Navigation Radio page, the PVD provides guidance to runway centerline during ground operations.” Ground operations include taxiing, takeoff run, and landing roll. The operator’ s information was consistent with the CAAS approved B747-400 AFM supplement, which indicates that the PVD assists flight crew in determining if they are in the correct position for takeoff.	The PVD system is designed solely to provide steering guidance to the pilot under low visibility conditions. It is **not designed nor is it certified** to assist the crew in determining whether the aircraft is on the correct runway. The wording referred to is also that used in the SIA Operations Manual. The PVD is only designed and intended to be used to provide reversionary visual guidance to the runway centerline during the take off roll. It has no role in other ground operations. This should have been checked with airline operators who use the PVD.
Reference : 2.5.6.3.1 Para-Visual Display (PVD) Information, para 6, ASC Draft Final Report page 203	
SIA was not operating in accordance with the CAAS approved B747-400 AFM PVD supplement. The supplement information was not reflected in SIA procedures and training documentation.	This statement is wrong. The supplement information was reflected in SIA’ s procedures and training documentation.

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Reference : 2.5.6.3.2 Operational use of PVD, para 5, ASC Draft Final Report page 204	
The Safety Council was unable to determine how well the pilots of SQ006 understood the PVD system. The flight crew did not mention the CAAS approved supplement to the Boeing 747-400 AFM which indicated that the PVD will shutter dependent upon whether the “aircraft is in a position for takeoff or not”. In accordance with the CAAS approved Boeing 747-400 AFM PVD supplement information, the Safety Council concluded that the failure of the PVD to unshutter indicated to the flight crew that the aircraft was not at the correct location for takeoff. The routine operational context of PVD usage led the flight crew to discount the unshuttered indication further.	The sole purpose of the PVD is to assist the pilot to maintain centreline tracking during the takeoff run and **not** to identifiy the ‘correct location for takeoff’.
Reference : 2.5.6.3.3 PVD Procedures, para 11, ASC Draft Final Report page 205	
Therefore, when an aircraft positions and lines up and holds on the runway and the PVD has not unshuttered, if the ILS frequency is correctly selected and no message appears on the EICAS, the PVD information indicates to the flight crew that the aircraft is not in the correct position for takeoff.	The PVD system is designed solely to provide steering guidance to the pilot under low visibility conditions. It is **not designed nor is it certified** to assist the crew in determining whether the aircraft is on the correct runway.
Reference : 2.5.6.3.3 PVD Procedures, para 12, ASC Draft Final Report page 205	
In this occurrence, the PVD was still shuttered when the aircraft lined up on Runway 05R. The PVD did not unshutter because the PVD was not within the valid localizer region for Runway 05L. The PVD information was a cue indicated to the flight crew that the aircraft was	The PVD system is designed solely to provide steering guidance to the pilot under low visibility conditions. It is **not designed nor is it certified** to assist the crew in determining whether the aircraft is on the correct runway.

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not on the correct runway for takeoff. Although MCIT and CAAS made numerous submissions to the Safety Council investigation team to emphasize that the PVD was not intended to be used as a runway identifier. However, despite this very strong sentiment from Singapore, the language in the CAAS approved PVD supplement clearly stated that the PVD display will "shutter dependent upon whether the airplane is in a position for takeoff or not". The language in the CAAS approved PVD supplement did not reflect the sentiment that the PVD was not to be used as a runway identifier. Rather, the language in the CAAS approved PVD supplement indicated that the PVD will provide the crew with information as to whether the airplane is in a position to takeoff or not.	
Reference : 2.5.6.3.3 PVD Procedures, para 13, ASC Draft Final Report page 205	
Had the information in the CAAS approved PVD supplement been distributed in SIA training and operational documentation and reflected in operational practice, the crew of SQ006 probably would have considered the PVD indications further with a view that the airplane may not have been in a position to takeoff. The assessments and actions of the flight crew on the evening of the accident were indicative of their limited knowledge of what the PVD system was indicating, the operational context of PVD usage, the competing demands for their attention, the high task load, and degraded environmental conditions. A latter section of the analysis will discuss some of the factors that influenced the crew during the taxi from NP to Runway 05R.	Contrary to the report's assertion, the information in the CAAS approved supplement **is contained and explained** in SIA's training and operational documentation.

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Reference : 2.5.6.4 Heading Indicators, para 3, ASC Draft Final Report page 206	
Although CM-2 stated that the compass rose can help maintain orientation during taxi, he did not mention the use of the aircraft' s heading indicators and/or the compass to verify visual orientation during the critical phase of the taxi when SQ006 turned from Taxiway NP through Taxiway N1 directly onto Runway 05R. During interviews, CM-1 and CM-3 did not mention the use of the aircraft' s heading indicators and/or the compass to supplement visual orientation during taxi. The compass and heading indicators were useful aids available to the flight crew to enhance their orientation and navigational accuracy during taxi, especially in the low visibility conditions. It is standard industry practice to utilize the heading indicator and/or compass to assist surface navigation during complex taxi routing and/or degraded visibility.	It has to be noted that CM-2 was not specifically asked during the interview if he had referred to these instruments. It cannot therefore be inferred that his not mentioning these instruments means that he did not use them. Runways 05R and 05L are <u>parallel runways</u>. Thus, the heading indication is of no assistance as far as differentiating the two runways is concerned.
Reference : 2.5.7.1 Markings and Signage, para 2, ASC Draft Final Report page 206	
• A black/red sign marked " N1/5R-23L" was on the southwest side of Taxiway N1; located 54 meters from Runway 05R centerline and 20 meters from the left edge of Taxiway N1;	This sign was oriented obliquely away from the turn from Taxiway NP to Taxiway N1, and this significantly reduced its conspicuity and readability for a pilot making the turn.
Reference : 2.5.7.1 Markings and Signage, para 7, ASC Draft Final Report page 207	
The Boeing field of view study showed that the pilots' field of view outside the cockpit through the areas swept by the windscreen wipers was limited. However, the study found that the following items would	Boeing did not carry out any field-of-view study of the SQ 006 accident. The company has advised that it merely provided a series of diagrams showing possible field of view from the

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have been visible from the cockpit at intervals throughout the turn from Taxiway NP through Taxiway N1 onto Runway 05R: the Taxiway N1 sign and Taxiway N1 centerline lights leading to Runway 05L; the Runway 05R sign; the Runway 05R threshold markings and designation; and the Runway 05L signage. In particular, the study indicated that the "N1/5R-23L" signage was visible from CM-1's eye reference point through CM-1's windshield when the aircraft was turning from Taxiway NP onto Taxiway N1 (Figure 2.5-1). The clear areas in the diagram present the visible areas available to CM-1 during taxi. CM-1 stated that he had his eyes out of the cockpit during the turn from Taxiway NP onto the runway because he was taxiing the aircraft with reference to the taxiway lights during the turn.	cockpit of a B747. The ASC analysis fails to take into account all the factors involved at the time SQ 006 turned onto Runway 05R such as limited visibility and restricted field of view.
Reference : 2.5.7.1 Markings and Signage, para 10, ASC Draft Final Report page 208	
In addition, the "N1/5R-23L" signage was internally illuminated. The distance between the signage and the cockpit was about 60 meters when the aircraft was turning. With a RVR of 450 meters, the signage would have been visible from the cockpit when the aircraft was turning from Taxiway NP onto Taxiway N1.	The signage was located such that it only came into the pilot's view during the turn from Taxiway NP to N1. There could only have been a momentary exposure of the sign to the pilots, at the moment when the pilots were focusing their attention on safely executing the turn and keeping to the taxiway centreline.
Reference : 2.5.7.1 Markings and Signage, para 11, ASC Draft Final Report page 208	
When the aircraft taxied through Taxiway N1 and was just about to turn onto Runway 05R (Figure 2.5-2), the piano keys on Runway 05R and the Taxiway N1 centerline lights leading to Runway 05L were visible from CM-1's eye reference point through CM-1's windshield. The runway marking "05" and "R" were also visible from CM-1's eye	Given the heavy rain and wet pavement surfaces, it would be difficult to discern the runway designation markings on the pavement surface. In addition, the exposure of the runway designation markings to the pilots' field of view would also have been limited, as the aircraft was making a turn.

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reference point through CM-2' s windshield. The distance between the cockpit and the Runway 05R marking, Taxiway N1 centerline lights leading to Runway 05L, and the Runway 05R piano keys were all within 120 meters.	
Reference : 2.5.7.1 Markings and Signage, para 12, ASC Draft Final Report page 208	
Based on the above evidence, the Safety Council has concluded that if the flight crew had looked for the runway markings and signage to locate their position by scanning the outside scene, they would have been able to see that information and consequently navigate the aircraft to the correct runway.	This conclusion by the ASC is not based on any objective evidence, simulator tests or research.
Reference : 2.5.7.2.1 Taxiway Centerline Lights, para 2, ASC Draft Final Report page 210	
As discussed in Section 2.5.8.2, the attention focus of CM-2 and CM-3 was "inside" the cockpit for the checklist and crosswind component calculation during the turn onto Runway 05R. In addition, CM-1 was concentrating on maintaining the minimum taxi speed and following the green lights onto the runway. The use of the crew' s attention resources was not optimized to fully process cues and information that would have helped them maintain an awareness of their location during the taxi in challenging conditions. The flight crew' s limited attention resources were probably fully occupied by the high workload induced by: checklist and procedural requirements; taxiing accurately in slippery conditions; degraded visibility and fluctuating but poor weather conditions; concerns about the approaching typhoon; cross wind calculations and company requirements; and PVD indications	The CVR evidence indicates they coped well with their duties and worked well as a team. The evidence also shows that they had a heightened awareness of the additional hazards resulting from the prevailing weather conditions, and took extra care to taxi slowly and to keep with the lighted taxi route. See also MOT team' s comments on ASC' s ' findings related to probable causes' in Part 2 of the Singapore MOT Team' s Comments.

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during the turn onto and line up on the runway. Consequently, the flight crew did not comprehend the available information nor did they prioritize the information to ensure such that positive runway identification was achieved prior to takeoff.	
Reference : 2.5.7.2.2 Spacing of the Taxiway Centerline Lights, para 1, ASC Draft Final Report page 210-211	
The spacing difference between the taxiway centerline lights on Taxiway N1 that led to Runway 05L and those that turned right onto Runway 05R were a factor that influenced the flight crew to believe they were lining up on the correct runway. According to site survey data of CKS Airport, the only lighting system installed on Taxiway NP is the green taxiway centerline lights. As the taxiway turns right into Taxiway N1, the spacing of the taxiway centerline lights along the curved section to Runway 05R was 7.5m. However, the spacing of the taxiway centerline lights on Taxiway N1 between Runway 05R and Runway 05L was 4 times wider than the spacing of the taxiway centerline lights turning from Taxiway N1 onto Runway 05R. Therefore, the taxiway centerline lights that diverged onto Runway 05R were more salient than the lights that continued to Runway 05L because the spacing of the turning lights was smaller than the spacing of the lights that extended along Taxiway N1. The denser spacing of the taxiway lights illuminated a clear path to Runway 05R. Therefore, CM-1 followed the distinct path of green taxiway lights from Taxiway NP onto Runway 05R, as is often the case when aircraft taxi onto Runways. During interviews with CM-1, when he was asked how he had made a continuous turn onto Runway 05R when the airport chart showed a straight line on Taxiway N1 for Runway 05L, CM-1 replied that he had just followed the green taxiway centerline lights and made	At the point of tangency to the turn leading to Runway 05R, there was no clear alternative line of lights visible to the pilot leading across Runway 05R towards Runway 05L.

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a continuous turn from NP onto Runway 05R, believing it to be Runway 05L.	
Reference : 2.5.7.2.2 Spacing of the Taxiway Centerline Lights, para 3, ASC Draft Final Report page 211	
Research has indicated that human attention is attracted by salient cues in the environment and individuals will tend to neglect non-salient ones[3]. The Safety Council has concluded that during the turn from Taxiway NP onto Runway 05R, the green taxiway centerline lights leading into Runway 05R attracted CM-1' s attention. Therefore, he missed the centerline lights that led to Runway 05L and all the runway signage and designation marking in the vicinity of Runway 05R threshold.	When SQ 006 was turning from Taxiway NP onto Taxiway N1, the green taxiway centreline lights clearly indicated a continuous pathway ahead of the aircraft, and there were no other routes branching from this path.
Reference : 2.5.7.2.3 Color of the Centerline Lights, para 1, ASC Draft Final Report page 211	

[3] Wickens, C. D. 2001. Attention to Safety and the Psychology of Surprise. University of Illinois, Aviation Human Factors Division. Savoy, Illinois.

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The taxiway centerline lights were green, including the centerline lights on Runway 05R. However, the centerline lights for Runway 05L were white. Interview and CVR data indicated that the flight crew followed the green centerline lights and taxied the aircraft onto Runway 05R. All three pilots reported that they saw the centerline lights running down the runway when the aircraft positioned and held on Runway 05R. However, none of them recognized that the color of the runway centerline lights should have been white if the runway was 05L, rather than green. During the turn onto the runway CM-1 had sighted green taxiway centerline lights along the runway.	*The rain on the cockpit windscreen would have further downgraded the resolution of the image. Hence the presence of the centreline lights and not their colour would have been the dominant perception to the pilots.*
Reference : 2.5.7.2.3 Color of the Centerline Lights, para 3, ASC Draft Final Report page 212	
The eye is composed of two basic receptors, rods and cones, each of which has its own sensitivity function. At high levels of illumination, the rods and cones both function (photopic vision) and the eye is most sensitive to light wavelengths around 550 nanometers (nm[4]) (green). As illumination levels decrease, however, the cones cease to function, the rods takeover the role of seeing (scotopic vision), and the eye becomes most sensitive to wavelengths around 500 nm (blue-green). This shift in sensitivity from photopic to scotopic vision is called the Purkinje effect. The practical application of this effect is that targets can be made green or blue-green to increase the probability of detection at night[5]. That is one of the reasons why airfield guidance lighting such as taxiway centerline and/or edge lighting are often green or blue. Consequently, despite the glare of the aircraft' s landing lights and the reflected glare from the water droplets when the aircraft lined	*The rain on the cockpit windscreen would have further downgraded the resolution of the image. Hence the presence of the centreline lights and not their colour would have been the dominant perception to the pilots.*

[4] Nanometer =nm=10^{-7}cm.
[5] Saunders, M. S., & McCormick., E. J. (1992). *Human factors in engineering and design* (7^{th} Edition). Singapore: McGraw-Hill.

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up on Runway 05R, the green centerline lights of Runway 05R were clearly discernible along the runway. The "wash-out" type effect, where the color of the green centerline lights may have appeared less distinct to the crew within the immediate range of the aircraft landing lights was not an issue. CM-2 had identified the color of the centerline lights after the activation of the landing lights during the turn through Taxiway N1 prior to runway line up[6]. Moreover, the flight crew reported that the runway centerline lights were clearly visible.	
Reference : 2.5.7.2.3 Color of the Centerline Lights, para 4, ASC Draft Final Report page 212	
As discussed in Section 2.5.8.2, when the aircraft taxied onto and held on Runway 05R for takeoff, the focus of the flight crew were probably fully occupied by the high workload induced by concern about the degraded visibility and fluctuating but poor weather conditions; the approaching typhoon; cross wind takeoff; and PVD indications. Consequently, the flight crew did not comprehend the information that the centerline lights were green.	As mentioned above, the saliency of the runway centerline lights was the dominant attribute in the perception of the lights by the crew, and not their colour.
Reference : 2.5.7.4 Runway Difference Issues, para 2, ASC Draft Final Report page 213	
• Runway 05L is 15 meters wider than Runway 05R (60 meters vs. 45 meters respectively);	*There was nothing unusual about the width of the runway ahead of the SQ 006 crew on lining up as SIA operates to many airports with 45m-wide runways.*

[6] CVR 151540 CM-2 Strobes on, landing lights all on
……………………
CVR 151550 CM-2 OK green lights are here

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Reference : 2.5.7.4 Runway Difference Issues, para 4, ASC Draft Final Report page 214	
• The centerline lights of Runway 05L are white. There was no runway centerline lights for Runway 05R, however, there were taxiway centerline lights on Runway 05R for the purpose of using Runway 05R as a taxiway. The color of the taxiway centerline lights was green; and	See comments on colour above.
Reference : 2.5.7.4 Runway Difference Issues, para 5, ASC Draft Final Report page 214	
• Runway 05L is a CATII instrument approach runway. Runway 05R is a visual runway for takeoff only. The runway touch down zone (TDZ) marking stripes were also different.	Airline crews would be looking for the overall picture of an operational runway.
Reference : 2.5.7.6 Runway 05R Edge Lights, para 1, ASC Draft Final Report page 215-216	
As stated earlier in section 2.3, after reviewing all available information, the Safety Council was unable to positively determine the on/off status of the Runway 05R edge lights at the time of the accident. <u>However, regardless of the status of the Runway 05R edge lights, it was possible that the crew may have still taken off from Runway 05R.</u> Therefore, the Safety Council will discuss both possible situations in the following section.	This statement ' However, regardless… taken off from Runway 05R.' is not supported by evidence. This statement should be deleted.

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Reference : 2.5.7.6.1.1 If Runway 05R Edge Lights Were Off, para 4, ASC Draft Final Report page 216	
The Safety Council has concluded that the flight crew was convinced that they were on Runway 05L and there was no immediate or salient indication that the runway in front of them was closed for construction works. They saw what they expected to see - a "normal picture" of a runway. Furthermore, the pilots' attention was focused on the PVD information, the visibility along the runway, crosswind checklist completion, and how to conduct a visual takeoff in the strong crosswind. They probably did not perceive the absence of runway edge lights and process such information to realize that they were on the incorrect runway.	If they had perceived that the runway edge lights were off, it is unlikely that the crew would have commenced the take-off. The Captain stated that he was quite sure that the runway edge lights were on.
Reference : 2.5.7.6.1.2 If Runway 05R Edge Lights Were ON, para 1, ASC Draft Final Report page 217	

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Runway 05R was 45 meters wide. The width of Runway 05L, Runway 06 at CKS Airport, and also the two runways at Singapore Changi Airport were all 60 meters. If the Runway 05R edge lights were ON on the night of the accident, a comparison with the above runways, which were familiar to the flight crew, would have indicated that Runway 05R was too narrow[7]. This comparative cue may have alerted the flight crew that they were on the incorrect runway; however, determining such a width difference might have been difficult at night in low visibility conditions. Nonetheless, such a cue had reportedly been used on 23rd Oct 2000 at 2245 by a freighter captain who was conducting a routine flight from CKS Airport. The freighter had been given clearance to taxi for a takeoff on Runway 05L via Taxiway NP. The captain stated that the weather on that evening was rainy with some wind. The visibility was also degraded due to the moderate rain.	The critical issue was that Runway 05R looked exactly like an operational runway to the crew. The apparent widening of the pavement as the aircraft turned from Taxiway NP (30m width) into the 45m-wide Runway 05R may also have reinforced their belief that they were on Runway 05L. The ASC's footnote number 9 is not supported by factual or research evidence. Reference to basic aviation physiology and aviation psychology texts, together with accident investigation reports of mid-air collisions, would demonstrate that this belief by the Safety Council is misplaced.
Reference : 2.5.7.6.1.2 If Runway 05R Edge Lights Were ON, para 2, ASC Draft Final Report page 217	
The first runway that the aircraft captain encountered when he was on Taxiway N1 was Runway 05R. He recalled that he felt compelled to take Runway 05R as the active runway because Runway 05R was brightly lit with centerline and edge lights. He could not see the barriers nor the lights on the barriers further down Runway 05R. He stated that he was able to reject the compelling information because he had paused to think and became aware of the following conflicts: Runway 05R was too narrow; there were no touch down zone lights; and he realized that the centerline lights were green on the runway.	The statement by the freighter Captain reinforces the fact that at CKS Airport the Runway 05R taxiway centreline lights and runway edge lights had been switched on at the same time.

[7] The Safety Council believes that a line pilot should have a mental model of how a 60 meters wide runway should look like from the cockpit. This kind of mental model was built up from day to day flight experience. For example, pilots should be able to recognize an A320 or an A300 just by the size of the aircraft. It is not necessary to compare them side-by-side.

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Reference : 2.5.7.6.1.2 If Runway 05R Edge Lights Were ON, para 3, ASC Draft Final Report page 217	
The Safety Council has concluded that if the runway edge lights were ON at the time when SQ006 lined up on Runway 05R, the pilots would have seen the white runway edge lights and green centerline lights on the runway. They did not see any construction signs or equipment on the runway. Under the high workload of taking off in the severe weather conditions, and with the expectation that they were on Runway 05L, they might not have been able to perceive that the runway they were on was too narrow to be Runway 05L. In addition, there were no TDZ lights on the runway and the centerline lights of the runway were green, which is the color of the taxiway centerline lights. Nonetheless, the flight crew believed they were on the active Runway 05L and carried out the takeoff.	Touchdown zone lights are not required to be switched on for an aircraft taking-off.
Reference : 2.5.7.7 Expectation of Runway Picture, para 3, ASC Draft Final Report page 218	
According to CAA, there was no runway-closed indication in the vicinity of the Runway 05R threshold because this portion of the runway was still being used for taxi on the night of the accident. In addition, given the inbound typhoon, it was not safe to erect mobile runway closure signs, which may have been blown into taxiing aircraft. There were warning lights demarcating the construction area on Runway 05R but the distance from the 05R threshold to the construction area restricted the pilots from seeing those lights.	The use of the runway as a taxiway does not preclude the provision of appropriate closure markings to indicate that Runway 05R was closed as a runway. In this case, there were no visual warnings at all at the threshold of Runway 05R to indicate that it was closed. The section of Runway 05R between Taxiways N1 and N2 could have been closed and appropriately marked and lit

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construction area restricted the pilots from seeing those lights.	without any significant impact on taxiing operations at the airport. The painting of runway closure markings on Runway 05R would have addressed any concern about runway closure signs or marker boards being blown away. Alternatively, the runway threshold and designation markings could have been removed to prevent pilots from mistaking it for an operational runway.
Reference : 2.5.7.8 Summary, para 1, ASC Draft Final Report page 219	
Evidence indicated that when the aircraft approached the threshold of Runway 05R, the flight crew' s attention was focused on the crosswind component, visibility for takeoff, PVD information, and before takeoff checklist items. The crew did not recall seeing any runway signage and the runway designation marking. They saw the green taxiway centerline lights turning onto the runway but did not recall seeing any other signage or markings (except the piano keys that are not unique to a particular runway) in the vicinity of Runway 05R threshold. If runway guard lights or stop bars or a densely spaced centerline light along Taxiway N1 had been provided, they would have increased the conspicuity of the Runway 05L holding position and would likely have alerted CM-1 to the location of Runway 05L.	More importantly, had edge lights of the closed Runway 05R been disconnected, and the green taxiway center line lights leading from Taxiway N1 into the closed runway been disabled, and had Runway 05R been marked as a closed runway at the threshold, the pilots would not have taken off from the closed runway.

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Reference : 2.5.7.8 Summary, para 2, ASC Draft Final Report page 219-220	
The flight crew was also aware that the particular runway view should have included white centerline lights and that there should have been an area of bright TDZ lights on the runway. Thus, they should have recognized that their observations of Runway 05R did not match those of a CATII runway. In addition, given the flight crew' s experience in night flight operations, they were knowledgeable of taxiway and runway lighting and were aware that taxiway lights are typically green and runway lights are typically white. However, their lack of recent experience with Runway 05L and 05R configurations and high workload may have impeded the crews processing of runway configuration information. Furthermore, CM-1 elected to takeoff because he could see an adequate distance down Runway 05R to takeoff and the runway picture accorded with his mental model of an active runway. Finally, the conflicting instrument indications were not fully considered by the crew. The crew also believed the timing of the Air Traffic Control clearances for taxiing into position and holding and takeoff seemed to confirm that they were in the correct location for takeoff.	The word ' elected' should be changed to ' decided' . The ' instrument indications' mentioned in the second last sentence of this paragraph were not referred to by the crew during the take-off phase as it was not a requirement to do so under normal company operating procedures.
Reference : 2.5.8.1 Time Pressure to Take Off Before Typhoon Was Closing, para 1, ASC Draft Final Report page 220	

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At the time of the occurrence, typhoon "Xangsane" was approximately 360 kilometers south of CKS Airport and moving NNE at 12 knots. CKS Airport was experiencing heavy rain, low visibility, and strong wind. The conditions were expected to worsen when the typhoon got closer to the airport in several hours. CVR and interview data indicated that during taxi, the pilots were discussing the typhoon status[8] and they were aware that the weather conditions were going to deteriorate. Moreover, CM-1 stated that he was concerned that the typhoon was closing in and the weather would only deteriorate further if he delayed the flight. CM-3 had expressed similar concerns. The crews concerns about the typhoon and their desire to avoid it could enticed them to hasten their departure without appropriate attention checks to correctly identify and confirm the correct runway prior to takeoff. This could have occurred despite the CM-1's instructions for the crew to take their time and to be careful with checklists and other procedures.	This assertion that the SQ 006 crew were under time pressure to depart is not supported by the CVR evidence. This shows that the crew were not in a hurry, and had carried out their duties appropriate to the operational situation. Evidence from the DFDR also shows that the aircraft taxi speed was appropriate to the prevailing conditions.
Reference : 2.5.8.2 Attention Allocation, Workload, and Situation Awareness, para 3, ASC Draft Final Report page 221	
CM-2 was focused on the before takeoff checklist when the aircraft was turning onto Runway 05R. When CM-2 completed the checklist, the aircraft was half way through the turn and lining up on the runway. He had commented to CM-1 that the PVD had not unshuttered. CM-2	

[8] CVR 15:10:21, CM-3 said "Yah, it【typhoon】is coming in ah, the longer they delay the worse it is lah". CM-1 replied "Yah, worse if we are going to get out, if don't take off ah ….."

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stated that his attention was focused on the PVD. The focus of CM-2's attention inside the cockpit reduced CM-2's opportunity to scan outside the aircraft. Furthermore, he did not notice any runway marking or runway signs. However, he recalled seeing lights leading onto the runway and CM-1 following the lights onto the runway. CM-2 stated that he saw bright lights in the middle of the runway and that it was the "correct picture" for him.	The report is wrong in stating that CM-2 did not notice any runway marking. The factual evidence shows that CM-2 saw the runway piano keys and remembered that they appeared 'scratchy'.
Reference : 2.5.8.2 Attention Allocation, Workload, and Situation Awareness, para 5, ASC Draft Final Report page 221	
It is clear that all three pilots were not aware of the position of the aircraft when CM-1 turned onto Runway 05R. The attention focus of CM-2 and CM-3 was "inside" the cockpit for the checklist and crosswind component calculation. CM-1 was concentrating on maintaining the minimum taxi speed and following the green lights onto the runway. The crew essentially lost awareness of their location during the taxi. None of the three pilots had allocated their attention to the runway markings and signs during the turn.	The factual evidence shows that the crew believed that they were on the correct runway. There is no evidence that they were uncertain of their location. The taxiway marking and lights led the crew into Runway 05R, and the presence of the markings of an operational runway reinforced their perception that they were on Runway 05L.
Reference : 2.5.8.2 Attention Allocation, Workload, and Situation Awareness, para 6, ASC Draft Final Report page 221-221	
A loss of situation awareness can be due to a failure to attend to and perceive the information that is necessary for people to understand a given situation. The acquisition and maintenance of situation awareness is particularly important for individuals in complex, dynamic, socio-technical industries such as aviation. Research has	A loss of situational awareness could also result from misleading cues provided by deficient visual aids. In the case of SQ 006, the pilots navigated the aircraft during the final part of the taxi onto the take-off runway according to the cues provided by the runway and taxiway signage, markings and lighting. The

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indicated that humans have limited working memory and attention resources[9]. Therefore, increased attention to some elements (such as crosswind component, low visibility, slippery runway, following the green lights, checklist), the less attention to other elements (such as runway signs and markings, Taxiway N1 centerline lights leading to Runway 05L). Therefore, a loss of situation awareness occurs once the information-processing limit is reached or attention saturation occurs due to high concurrent task load and environmental stressors.	combination of these external visual cues guided them onto what they believed was the correct runway. The crew did not lose situational awareness in the sense that they became unsure or uncertain of their position. The CVR shows that at all times they believed that they knew the position of their aircraft, and this belief was correct until the very final stage of the taxi onto the take-off runway. It was only during this last segment of the taxi that the crew's situational awareness did not correspond to the actual situation of their aircraft.
Reference : 2.5.8.2 Attention Allocation, Workload, and Situation Awareness, para 10, ASC Draft Final Report page 223	
The Safety Council has concluded that under the high workloads experienced by the crew, the flight crews' attention had overly narrowed and focused on the weather information to the detriment of other critical operational information. Therefore, the crew could have missed the airport infrastructure information that may have been able to indicate their position on the airfield and that they were taxiing onto the incorrect runway for takeoff.	This proposition is based on the assumption that the crew were under high workload. However, there is no evidence that the crew of SQ 006 were under abnormally high workload. The B747-400 is designed to be operated by a two-pilot crew. In the case of SQ 006, the presence of the third pilot enabled the Captain to delegate some duties which would normally have been performed by the standard two-pilot crew prior to take-off. In the light of these facts, the 'high workload' argument is not

[9] Endsley, Mica. 1996. Situation awareness in aircraft. In Brent J. Hayward and Andrew R. Lowe (Eds.), Applied aviation psychology: achievement, change, and challenge: proceedings of the Third Australian Aviation Psychology Symposium. P403-417. Aldershot; Brookfield, Vt: Avebury.

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	valid.
Reference : 2.5.8.3 Pattern Matching, para 1, ASC Draft Final Report page 223	
Pattern matching problems are relatively common during high workloads. This is because the individual' s mental model accepts as a match for the required object something that looks similar, is in a similar location, or does a similar job[10]. In particular, the flight crew believed that Runway 05R was Runway 05L because their mental pictures lead them to believe that Runway 05R was a normal runway at night. CM-1 and other crewmembers may not have had the required attention resources to conduct a precise matching process because they were captured by: • CM-1 taxiing the aircraft in poor visibility and over relying upon the green taxiway lights for guidance onto the runway; • CM-2 completing the pre-takeoff checklist; and • CM-3 regularly re-calculating the crosswind component for takeoff to ensure it was within company limits.	See comments above. This analysis is predicated on the validity of the assumption that the SQ 006 crew were under high workload. However, as discussed above, the situation was that of a two-pilot aircraft being operated by a three-pilot crew. Consequently the workload was not abnormally high.
Reference : 2.5.8.4 Taxi Lighting Issues, para 2, ASC Draft Final Report page 224	
Changi Airport, the SIA home base, uses the " Airfield Lighting Control	The clause ' , or be less apparent than the taxiway centreline

[10] Reason, James. 1990. Human Error. Cambridge UK; Cambridge University Press.

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and Monitoring System (ALCMS)" to provide a safe and efficient operating environment in the airfield[11]. Its "Taxiway Lighting Control System (TLCS)" detects conflicts in multiple selected taxi routes and provides an inter-locking mechanism using taxiway centerline light segments and stop bars to resolve the conflicts at taxiway junctions. For aircraft arriving at or departing from Changi Airport, an air traffic controller will turn on the taxiway centerline lights along their assigned taxi route and tell pilots to "follow the green". The taxiway centerline lights on other taxi paths will either be turned off, blocked by stop bar lights or other mechanisms, <u>or be less apparent than the taxiway centerline lights of the assigned taxi path.</u> Therefore, pilots can easily taxi to their assigned gates or departure runways by following the green taxiway centerline lights selected by ATC. However, CKS Airport does not have this kind of taxiway lighting control system. When pilots taxi in to the gates or taxi out to the active runway at CKS Airport, they need to visually navigate to where they planned and were cleared to go using airport charts, cockpit instruments such as the compass and heading indicators, and taxiway lights, signage, and markings.	lights of the assigned taxi path.' should be deleted.
Reference : 2.5.8.4 Taxi Lighting Issues, para 4, ASC Draft Final Report page 225	
Up until the occurrence, all three pilots had worked for SIA and flown in and out of Singapore Changi Airport for at least five years. They	Most of the airports which SIA operates to do not have the 'follow the green' system. In fact, only the minority of these

[11] Koh Ming Sue, 2001. The New Airfield Lighting Control and Monitoring System at Singapore Changi Airport. 2001 International Symposium on Airport Infrastructure Development and Management, April 25-26, Singapore.

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were familiar with that airport's "follow the green" taxiway lighting control system[12]. During interviews, all three pilots stated that the green lights should take them to the takeoff runway. Under the time pressure to take off before the inbound typhoon closed in around CKS Airport, and the high workload of taking off in a strong crosswind, low visibility, and slippery runway conditions, it is possible that CM-1 inadvertently reverted to the most dominant previously formed mental model under high workload to follow the green taxiway centerline lights, which generally takes him to where he is supposed to go, and he reverted to this habit while turning from NP onto Runway 05R.	airports have such a system. Thus, the 'dominant mental model' hypothesis cannot be supported. With regard to the ASC footnote number 14, on 21 December 2001, the MOT team had provided to the ASC records of the airports the SQ 006 pilots had operated to in the 12 months preceding the accident. These records show that only about a small number of the airports they operated to were equipped with a 'follow the green' taxiway lighting system.
Reference : 2.5.8.5 Airport Layout, para 3, ASC Draft Final Report page 226	
Interview data indicated that during the preflight briefing, CM-1 briefed his intended taxi route to CM-2 and CM-3. Instead of taking the simple taxi route to Runway 05L - from Taxiway SS southbound to Taxiway WEST CROSS, to Taxiway NP, right turn on Taxiway N1 and onto Runway 05L, CM-1 originally anticipated to taxi to Runway 05L via eastwards on Taxiway SS to Taxiway EAST CROSS, proceed on Taxiway EAST CROSS until Runway 05R and backtrack on Runway 05R, exit left onto Taxiway N7, then onto Taxiway NP[13], pass Taxiway N2 and right turn Taxiway N1 to the threshold of intended departure Runway 05L. This planned taxi route matches the taxi route at Changi Airport when an aircraft taxies out from T1 East and T2 North Apron.	This hypothetical and speculative discussion is irrelevant to the investigation. The evidence shows that the crew of SQ 006 navigated their aircraft as briefed. The CVR shows that they made the appropriate decisions as to the route on their way to the take-off runway. They were well aware that they were at CKS Airport. In addition, the majority of take-offs and landings

[12] MCIT was unable to provide the flight crew's computer flight record for the past three years. However, according to CM-1 and CM-2's flight schedules from Aug. 28, 2000 to Oct. 31, 2000, 44% (19 of 43) of the airports that CM-1 operated into and 54% (29 of 54) of the airports that CM-2 operated into were equipped with the "follow the green" systems.

[13] Due to construction on north apron, aircraft was unable to left turn onto Taxiway NP from taxiway EAST CROSS.

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According to the AIP published by CAAS (Figure 2.5-7), when an aircraft parks at T1 East and T2 North aprons and is going to use Runway 02L for takeoff, the normal taxi route will be to take Taxiway A6 northbound to Taxiway NORTH CROSS, left turn onto Taxiway NORTH CROSS to Taxiway WP, then left turn onto Taxiway WP taxi southbound, pass Taxiway W7, right turn onto Taxiway W8 and continues right onto Runway 02L.	by SIA pilots on SIA' s international routes are at airports other than Singapore Changi Airport.
Reference : 2.5.9 Water-affected Runway Issues, para1, ASC Draft Final Report page 229	
The ATC controller was not required to provide information to the crew regarding the condition of the runway. The determination of a contaminated runway by ATC is heavily dependent upon pilot reports. Although both pilots and controllers can assess the runway conditions, it is incumbent upon the pilots to be prudent and look for cues to aid them in making the final determination about the runway condition. The statement made by the SIA Chief Pilot indicating that the flight crews depend upon ATC to provide runway condition information demonstrated a normative understanding of water-affected runway operations.	This statement is not correct. ICAO Doc 4444, para 7.4.3 states that 'Essential information on aerodrome conditions shall be given to every aircraft, except when it is known that the aircraft already has received all or part of the information from other sources…' In para 7.4.2 of Doc 4444, essential information includes: a) construction or maintenance work on, or immediately adjacent to the movement area; b) rough or broken surfaces on a runway, a taxiway or an apron, whether marked or not marked; c) water on a runway, a taxiway or on apron …' It is extremely difficult for pilots to judge the depth of water on a runway from the cockpit. They depend on information from ATC. There is no means by which the pilot can determine the exact depth of water on a runway. The crew of SQ 006 were not

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	advised by ATC that Runway 05L was contaminated.
Reference : 2.5.9 Water-affected Runway Issues, para 9, ASC Draft Final Report page 231	
Had the crew of SQ006 assesses the intended departure runway as probably contaminated, they would have realized that the contaminated runway cross wind limit (15 knots) for takeoff in the Boeing 747-400 would have precluded a takeoff unless the wind had subsided long enough to attempt a takeoff. Given that the weather was worsening in accordance with the approaching typhoon, it was possible that the crosswind component would not have reduced to below 15 knots for sufficient duration to permit a contaminated runway takeoff. Alternatively, had the flight crew assessed the runway as contaminated, they may have had some additional time to assess the position of the aircraft as they waited on the runway threshold for the wind to subside for a contaminated runway takeoff as the flight 16 minutes before SQ006 had done.	This discussion is speculative and unnecessary. The accident to SQ 006 resulted from a take-off on the incorrect runway. The assessment of the runway surface as contaminated or wet had no bearing on the crew' s mistake in taxiing onto Runway 05R instead of Runway 05L.
Reference : 2.5.9.1 SIA Crosswind Limitation and Runway Condition Determination Procedure, para 3, ASC Draft Final Report page 231	
The SIA' s definition of a contaminated runway is much stricter than the	In the absence of notification by ATC, the SQ 006 crew

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European Joint Aviation Administration contaminated runway definition. This shows that SIA was using a higher safety standard for aircraft operating on a water-affected runway. In contrast, when determining if a water-affected runway is to be classified as a wet or a contaminated one, SIA pilots use a lower risk management standard; they assume the runway is wet if ATC does not provide standing water information. The Safety Council has concluded that SIA should provide procedures to assist pilots to assess the condition of the water-affected runway in heavy rain situation. It was not a risk averse practice to assume that the runway was wet if there was no information provided by ATC, particularly when there had been heavy rain fall (22.50 mm of rain fall) reported in the hour before 1500 UTC.	assessed the runway condition as ‘ wet’ . This was in accordance with normal operational practice. SIA’ s runway contamination procedures are similar to those of other airlines. It is an industry-wide issue that there is no objective means for ATC or flight crew to determine the level of water on a runway from the cockpit or the control tower. In any case, this discussion is irrelevant to the underlying contributory factors in the case of the SQ 006 accident.
Reference : 2.5.10 Crew coordination, para 1, ASC Draft Final Report page 232	
As discussed earlier in the report, the flight crew’ s dismissal of the PVD was the last line of defense in the sequence of events that led to the flight crew not correcting a situation that surfaced during the critical stage of lining up for takeoff. The CVR indicated that CM-2 questioned the PVD line-up while the aircraft was turning onto Runway 05R. CM-1 and CM-3 then engaged in the following discussion regarding the PVD: CM-1 stated: “ Yeah, we gotta line up first” . CM-3 stated: “ We need 45 degrees” . CM-1 continued, “ Not on yet PVD, never mind, we can see the runway, not so bad” . After SQ006 lined up on the runway, the 3 pilots did not resolve why the PVD did not unshutter. CM-2 did not continue to resolve the unshuttered PVD indication nor did CM-1 and CM-3 attempt to support or resolve this issue. This indicated the flight crew failed to apply basic CRM principles in resolving a critical operational problem. The opportunity was lost to discover that the	The PVD was designed as a defence against pilots deviating from the runway centerline during the take-off roll in low visibility conditions. It was not designed, and nor was it intended, to be a defence against incorrect runway selection by pilots. Contrary to the ASC statement, evidence from the CVR and the linguistic discourse analysis shows that the SQ 006 crew did practice good CRM principles. The reasons for the crew not ‘ trouble-shooting’ the unshuttered PVD have been fully explained elsewhere in the MOT comments.

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aircraft was not on the appropriate runway within the preset localizer.	
Reference : 2.5.10.1 SIA' s Crew Resource Management Training Program, para 3, ASC Draft Final Report page 232	
The SIA ARM courses are designed to cover concepts that the crews are expected to apply on the flight deck during line operations. During the interviews with various SIA Instructor Pilots, the Instructors reported that they informally examine the crewmember' s application of CRM principles during checks but the skills are not formally assessed in the same manner as technical skills. The Instructor Pilots reported that they sometimes discuss CRM principles and critique a crewmember' s CRM skills during a proficiency check debriefing. Apart from these observations by the Instructors, the company currently has no reliable and valid mechanisms to evaluate if the crew has acquired such skills. Furthermore, the ARM courses have not been updated to reflect the advances in CRM and Human Factors research. In summary, the SIA ARM programs did not contain all the elements of what is currently regarded as best practice in this area.	The SIA ARM training programme has been updated and enhanced since its original introduction in 1984. SIA crew are required to attend three ARM modules that cover CRM principles. A further update of the ARM programme, incorporating the latest CRM principles, was being considered before the accident. The new program was launched in 2001.

ASC Draft Final	MOT Comments
Reference : 2.5.10.1SQ006 Crew CRM Performance, para 1, ASC Draft Final Report page 233	
The flight crew reported that there were no difficulties in their relationship before or during the flight, and they considered, from their recollection and after listening to the CVR, that the CRM exhibited during taxi was good. A review of the CVR revealed that relationships between the crew appeared to be cordial. There was an instance where information was not volunteered. An example of sub-optimal CRM was when CM-3 elected not to inform CM-1 about the environmental conditions that he experienced when he conducted a pre-flight check of the aircraft. Although CM-3 mentioned his water-soaked shoes and removed them in the cockpit, no further discussions took place regarding the implications of that fact to the safety of the operation. Open communication is important between crewmembers under all circumstances.	There is ample evidence that the crew had practised good CRM principles. For example, the crew's decision to use Runway 05L was evidence that they were fully aware of the environmental conditions. The content of the CVR and the linguistic discourse analysis showed that the SQ 006 crew were operating well as a team and that the communication between the crew members was open and consultative. This analysis of the SQ 006 CRM does not reflect an understanding of the reality of modern airline operations. The discussion is not in keeping with the standard to be expected in a high quality accident investigation report.
Reference : 2.5.10.1SQ006 Crew CRM Performance, para 3, ASC Draft Final Report page 233-234	
Because all SQ006 crewmembers had not been given comprehensive PVD training that reflected the information contained in the CAAS approved B747-400 AFM PVD supplement, it would be difficult to assume that they would have known fully what the PVD indications were telling them. Nonetheless, there was adequate information available to the crew on the evening of the accident to tell them that they were not in the correct location for takeoff. With reference to navigation during taxi, communicating the severity of weather to all crewmembers, scanning the outside scene, cross-checking position,	See comments above.

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runway identification, the assessment of the runway conditions, the use of aircraft instruments to verify location during taxi, a higher standard of CRM was possible. CM-3 could have passed the information on the weather conditions experienced during his external aircraft check to the other crew and the crew could have considered the PVD unshuttering further. Such open communications may have enhanced the crew' s awareness of runway conditions and the location of the aircraft when it lined up on the runway.	
Reference : 2.5.10.3 The Role of Relief Crewmembers, para 1, ASC Draft Final Report page 234	
The SIA SOP did not assign specific duties to the third flight crewmember, although the captain of SQ006 requested the third pilot to verify crosswind limitations. Management pilots, instructor pilots, and line pilots commented that the level of involvement of relief crewmembers varied in accordance with an aircraft commander' s discretion. In general, there was a reluctance to interfere with the two-pilot operational philosophy, and therefore a reluctance to assign specific tasks or key operational duties to relief crewmembers during takeoff and landing. Like the other two pilots, CM-3 did not notice that the aircraft had lined up on the incorrect runway. Because SIA B747-400 operations involve variable crew compositions from two-pilot without relief crew up to two additional relief pilots who may be either captains and/or first officers or combinations thereof, it is difficult to assign specific duties to relief crewmembers during takeoff and landing. SIA relief crews are generally asked to be in the cockpit during takeoff and landing. Nonetheless, the role of relief crewmembers during these critical phases of flight, where transport category accidents occur most often, could be more clearly defined	The B747-400 is certified for two-pilot operations. Consequently, no duties are specifically assigned to a third pilot. For reasons of operational flexibility, the allocation of duties to a third pilot are left up to the Captain and vary in accordance with the operational requirements of a particular flight.

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and reinforced during check and training activities. Such initiatives would increase the level of effective involvement of relief crewmembers during these phases.	
Reference : 2.5.11 CAAS Safety Oversight, para 6, ASC Draft Final Report page 235	
The Safety Council has concluded that CAAS has not performed sufficient safety oversight of SIA' s low visibility taxi and PVD procedures and training, and the deficiencies in SIA procedures and training were not detected during routine CAAS safety oversight surveillance.	The investigation has found no evidence of systemic deficiencies in SIA' s low visibility taxi and PVD procedures and training. Consequently, there is no factual basis for this statement.
Reference : 2.6.1 SIA Crewmember's Emergency Evacuation Operations and Training , para 1, ASC Draft Final Report page 235	

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In this accident, the crewmember’ s emergency evacuation performance were affected by the following combined factors: severe impact and fuselage breakup, fuel tank explosion, post crash fire in the cabin and outside, smoke, falling foreign objects, unusual cabin attitude, abnormal slide inflation and extension after door opening, debris on the floor, incapacitation of some of the crew, no PA service, difficult for crew to communicate, emergency slides inflated in cabin, typhoon weather with heavy rain, dark environment, and panic reaction because of the accident.	From the interview report, there was no evidence to suggest panic reaction on the part of the crew.
Reference : 2.6.1 SIA Crewmember’s Emergency Evacuation Operations and Training , para 2, ASC Draft Final Report page 235	
The Safety Council believed that under the situation such as the SQ006 accident, where severe impact damage to the aircraft and fire spreading was obvious, currently existed emergency declaration method/ hardware/ procedure was ineffective. The Safety Council believes that under the circumstances of this type of accident, it would be very difficult to follow all of the procedures described in the ASEP. This was primarily because of the unexpected dynamics of the accident. However, the preparation to encounter an emergency situation during takeoff and landing was essential for the professional crew to avoid any incapacitation from shock. For instance, the crewmembers did not use any other proper method to declare emergency evacuation.	The current existing emergency declaration methods and procedures are effective. The procedures stated that where it is obvious that an evacuation is imperative and no contact with the cockpit crew is possible, the cabin crew should initiate the evacuation. In this instance the crew initiated and evacuated passengers from the cabin successfully. Cabin crew are trained to make a 30-second silent review of their emergency procedures prior to every takeoff and landing. Under the circumstances, the crew used words appropriate to the situation to instruct passengers to evacuate such as “Open seat belt”, “Come this way” and “Jump”.
Although the SIA emergency evacuation training and procedures were generally in line with existing industry standards, there is no training in a complex environment of simulated adverse weather with fire and	SIA’ s crew are trained to handle complex emergency situations in a cabin evacuation trainer with sound, motion and smoke effects. The trainer is capable of simulating adverse cabin

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smoke. The Safety Council believed more complex emergency situations may be necessary as part of the training syllabus in cabin safety training courses.	attitude and smoke scenario. SIA's training is consistent with industry best practice. There is no evidence from the investigation that the cabin crew's performance reflected deficiencies in their training. Consequently, there is no factual evidence upon which to base this statement.
Reference : 2.6.3.1 Smoke Protection Devices, para 2, ASC Draft Final Report page 237	
According to the interview of the survivors; the fuel-fed post crash fire in the main deck burned its way through to the upper deck in a very short period. In fact there was virtually no time delay as the chimney effect for the smoke to go to the upper deck. Since passengers could not evacuate all at once, a queuing situation arose and this delay in a life-threatening situation would require the smoke protection devices.	Provision of smoke hood for passenger evacuation is not legally required and no commercial airline provides them as acknowledged by Safety Council.
Reference : 2.6.3.1 Smoke Protection Devices, para 3, ASC Draft Final Report page 237	
The concept of smoke protection devices is not new and has been studied for many years. The carriage of safety devices, such as fire extinguishers and flashlights, by flight crew and cabin crew at each station is a standard practice. However, in this particular accident, none of the crew has smoke masks available for protection. The Safety Council noticed those cabin crews were trained to wear the smoke protection devices only during the fire fighting and the cockpit crew were trained to wear the smoke protection devices during cockpit smoke.	Smoke hoods are provided at crew stations for in-flight fire fighting purposes only as per TSO C116. Provision of smoke hood for crew evacuation is also not legally required and no commercial airline provides them, as acknowledged by Safety Council. The issue of smoke hoods has been debated in the aviation industry for many years and to-date no clear policy has been formulated with regard to their provision for passengers. The

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	debate is on-going and is kept under regular review by the industry.
Reference : 2.6.5 Coroner's Inquest, para 3, ASC Draft Final Report page 240	
Though there was no sufficient autopsy report for the cause of the death for occupants seated between Row 31 to 48, we suspect that the smoke was one of the main reasons of fatality.	Para 5.9 of ICAO Annex 13 provides for autopsies to be carried out on fatally injured crew and passengers after an accident. In the case of SQ006, only seven autopsies were carried out. This small number of autopsy reports prevented a comprehensive analysis of the survival factors of the accident.
Reference : 2.7.3 Weather Analysis, para 1, ASC Draft Final Report page 242	
The Safety Council checked the Runway 05L RVR sensor after the accident and the accuracy was found to be in conformance with ICAO SARPs. According to the weather observations and the data calculated by the manufacturer of the RVR, the visibilities at and before the accident were greater than the takeoff weather minimum (350m).	The take-off visibility minima for Runway 05L was promulgated as Runway Visual Range (RVR) of 200m at the time of the accident.
Reference : 2.7.4 SIA Typhoon Procedure, para 3, ASC Draft Final Report page 242-243	
In addition, the URGENT telexes pertaining to typhoon information were sent to the stations in off-duty time so it was not possible for personnel such as the Chief Pilot of SIA B747-400 to acknowledge the telex because he was not in the office at that time. Consequently, he	

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was not aware of the typhoon conditions at Taipei on the evening of the SQ006 occurrence. Moreover, the Chief Pilots reported that there was no requirement for him to talk to the aircraft commander under such conditions. The Chief Pilot stated that Fleet does not interfere with a commander' s decision-making. He defers operational decisions to the aircraft commander.	
Reference : 2.7.4 SIA Typhoon Procedure, para 4, ASC Draft Final Report page 243	
The Safety Council agrees that the aircraft commander should make the final decision and take full responsibility for the aircraft he operates. A well-trained and qualified commander should be able to make a sound decision based on his expertise and judgment when he has received all available information. However, to ensure relevant safety information is communicated, the Chief Pilot should inform the commander to improve his awareness but leave the decision to the commander. The Safety Council believes that if SIA had provided a structured decision making process and proactively provided more resources to the commander, it would have helped the commander with his decision making, thereby facilitating an increased probability of developing the best solution to operate the aircraft in typhoon conditions.	There is no need for the Chief Pilot himself to inform an aircraft commander of a typhoon condition, because the commander would have the latest weather update from the station concerned. The commander would base his decisions on the operational policy and the aircraft performance limits. SIA commanders undergo training and courses in structured decision making processes. For situations such as typhoon conditions, tactical day-to-day decisions are best left to the commander, as he would have the most current information and be in the best position to make operational decisions. It should be noted that the crew of SQ 006 were fully aware of the approaching typhoon. The SIA typhoon procedures were not a contributory factor in the accident. Once again, this ASC discussion does not reflect an understanding of modern airline operations.

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Reference : 2.7.4 SIA Typhoon Procedure, para 6, ASC Draft Final Report page 243	
Interview data indicated that EVA FCD is the ground-handling agent for SIA at CKS Airport to handle SIA flight operations including the flight dispatch operation. SIA Taipei Station is part of the SIA marketing division and is responsible for the non-technical aspects of the flight services. On the evening of the occurrence, the SIA Taipei Station manager believed that it was EVA’ s responsibility to inform the crew about the typhoon status. However, managers of EVA FCD stated that the responsibilities of EVA on handling SIA’ s flights are mainly on the flight dispatch and freighter load sheet preparations. They did not believe it was their responsibility to carry out the SIA typhoon procedures. Moreover, EVA believed that SIA did not require them to carry out any SIA typhoon procedures[14] and they were not aware that SIA has a typhoon procedure. Later, the SIA Senior Manager Flight Control Center clarified that the SIA typhoon procedure is an SIA internal procedure that does not apply to EVA. However, SIA FCC was unable to clarify who should be responsible for SIA’ s typhoon procedure in Taipei.	To clarify the statements by ASC, it should be noted that - SIA’ s handling agent at CKS Airport, EVA, was procedurally required to inform the SIA Flight Control Centre (FCC) of an approaching typhoon. EVA did this on the day of the SQ 006 accident. - SIA’ s FCC, through the SIA Taipei Station, would inform the commander of any SIA aircraft on the ground of the need to evacuate or tie down his aircraft should it be necessary.

[14] The contract between SIA and EVA on ground handling services at CKS Airport was followed IATA Ground Handling Agreements AHM810.

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Reference : 2.7.4 SIA Typhoon Procedure, para 7, ASC Draft Final Report page 244	
The Safety Council was unable to determine the influence of this situation on the outcome of the accident. It is unknown what the outcome might have been if the responsible agent in Taipei had been assigned and had carried out SIA' s typhoon procedures on the night of the accident. However, this communication break down between SIA FCC, SIA Taipei Station, and EVA FCD would certainly increase the risk of operating an aircraft under typhoon conditions.	It should be noted that Typhoon Procedures are applicable for flights to an affected station and not for a departing aircraft. As such, SIA' s Typhoon Procedures had no relevance to the departing SQ 006 flight.
Reference : 2.7.5 Out Station Dispatch, para 4, ASC Draft Final Report page 244-245	
The Safety Council was unable to determine the influence on the development of the accident if the flight crew had been fully briefed by a licensed dispatcher before departure on the night of the accident. However, the Safety Council has concluded that the inconvenience for the flight crew to discuss with a licensed dispatcher would have increasd the risk of operating a flight in adverse weather situations.	There is no basis to conclude that the ' inconvenience for the flight crew to discuss with a licensed dispatcher' increased the risk of operating a flight in adverse weather conditions. SIA crew are trained to self-brief, and its operations are not predicated on the need for a briefing by a licensed dispatcher. There is therefore no risk associated with the non-availability of a licensed dispatcher for briefing in adverse weather conditions. This is a common industry practice.

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7.5 交通部民用航空局之回覆意見

Singapore Airlines

Boeing 747 Accident, October 31, 2000

At

Chiang Kai-Shek Airport, taoyuan, Taiwan, Republic Of China

Representations on the draft final report By the Civil aeronautics administration Republic of china

Submitted March 2002

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Part 1

An Overview of the Representations from the CAA to the ASC on the Confidential Draft Final Investigation Report Concerning the SIA Boeing 747-400 Accident at CKS Airport, 31 October 2000

In addition to summarizing the CAA's submission, some liberty has again been taken to provide readers with a degree of explanation and comment on the content of the representations made by the CAA. This was done only to increase the clarity of the summary.

The ASC has declared that the aviation accident report on Singapore Airlines flight SQ006 is to be used solely in the prevention of accidents and incidents. The ASC further states that its investigation was not for the purpose of apportioning blame or liability. The CAA's representations on the draft final investigation report have been made only to increase the fairness, clarity and accuracy of the ASC's report. The CAA's representations are intended for the advancement of aviation safety, and are not to be used for any other purpose. They are particularly not intended for use in litigation that may be related to the accident. We have been unguarded and forthcoming in the interests of safety, which is quite different from being truthful but protecting our own interests as we would with comments intended to be used in disciplinary or court processes. This we believe is in line with your preface to the draft report.

The representations are much less numerous than on the preliminary draft. There are still a significant number of observations, but it is a modest number in light of the complexity and importance of the report.

In technically complex, well managed, and carefully operated systems, such as civil aviation, there are occasional safety failures. It is almost inevitable that in an objective analysis of one of those failures, such as is represented by this ASC investigation, all involved are able to learn that there are improvements that can be made to eliminate, or at least reduce, risks within the system. Generally, some of the risks are inherent, some were there but were simply not identified and removed when the system was developed, and others are introduced as components of the system develop and change. The draft final report prepared by the ASC has demonstrated that there were safety risks in the system and all involved have work to do to minimize those risks both on their own and in concert with others. The ASC was clearly open to the representations made on the preliminary draft and the report has been extensively revised, clarified and significantly strengthened.

On the night of the accident the weather was adverse with heavy rain, a low ceiling, and strong gusty crosswinds related to the approach of typhoon "Xangsane". However, during the entire time that the crew was in the aircraft the visibility was in the order of a half kilometer. The visibility was certainly not good but it was within the range where modern commercial aircraft can operate safely. During the latter part of the taxiing and the turn onto Runway 05R, the crew did not respond to the numerous indications that they had not reached the assigned takeoff runway. When the crew lined up the aircraft on partially closed Runway 05R instead of the intended Runway 05L they noticed an anomaly in the Para Visual Display but discounted it and elected to take off. With the cloud base at 200 feet the crew would have had to make a transition from visual to instrumental flight within a few seconds after lift-off. The key information necessary to fly the aircraft; such things as track, heading, altitude, rate of climb, airspeed and other vital data are shown on the Primary Flight Displays (PFD) in front of both pilots. With the intended runway centerline being 214m (650ft.) to their left, the Instrument Landing System azimuth (localizer) indication showed a left-turn command with the indicator fully deflected. Similarly, the runway symbol and the required track, instead of being in the center of their displays, were deflected to the left. Generally, there is a takeoff briefing by the captain shortly before the aircraft moves into position on the runway. Such a briefing confirms the departure procedure and actions in the event of an emergency such as an engine failure. This was not done. An experienced crew of three that was rated from average to above average, flying a modern aircraft, designed to be operated by a crew of two, with no noted unserviceable items, missed the last possible indication that they were not on the assigned runway. It was clear from the Primary Flight Display that they were not on the takeoff runway. The PFD was the display that they would have had to rely upon to fly the aircraft from a few seconds after lift-off, but apparently they did not look at it, or if they did, they did not appreciate what it was telling them. How this could have happened was clearly the object of the investigation. The investigation was comprehensive and looked at the accident and the circumstances surrounding it.

The draft final report follows the ICAO format with the three basic sections of factual information, analysis, and conclusions. The factual information covers a wide range of activities, systems, and data. It was carefully gathered but it is inevitable that there were some imperfections in communications, and there was new information that came to light after interviews were completed and documents were gathered. Often those supplying the information cannot see the gaps and errors until the preliminary confidential draft is prepared with all the information in context. The recognition of the need for change, where new or confirming information came to light following the confidential preliminary draft has resulted in a stronger and clearer draft final report.

In that light the CAA has reviewed the Factual section of the draft final report and has offered corrections to the information that it provided earlier, and corrections to the impressions that it left with those who were conducting the investigation

The review of the Analysis section brought forth comments on the information in the section and on the way it was treated. In the analyses of the draft final report, the CAA found there were more conjectural statements remaining than we believe is supportable in an excellent aviation accident investigation report. There were also still places where significant amounts of new factual information appeared in the analysis. The human factors analysis was detailed, as one might expect in this sort of accident. In a few places the CAA has noted disagreement with the views expressed in the ASC report on some of the human factors issues.

The total revision to the Conclusions section of the report has resulted in a major strengthening of the report. The number of findings and recommendations in the draft final report remains large. It is the view of the CAA that some very strong and important findings and recommendations lose some of their impact when set among some that are much less important. The CAA urges the ASC to review the findings and recommendations with a view to eliminating the less important among them in order to give greater impact to the more important ones. The individual recommendations, we believe, would be more compelling if they were supported by more rationale in the recommendations section. That approach was adopted and improved the acceptance of recommendations in accident investigation reports produced by United States and by Canada.

While there are some deficiencies in the CAA's organization and operations, both in the headquarters and at CKS airport, one must remember that in January 2000 the CAA Headquarters earned and received an ISO 9002 Warranty Certificate and the affiliated airport offices, Air Navigation & Weather Services and the Aviation Training Institute received the same award prior to April 2000. Also in January 2000 the CAA made public a civil aviation "White Paper" setting forth the direction of the ROC's civil aviation policy. Such central direction will encourage a new degree of coherence in civil aviation matters. Finally, in 2000 there was a review of air transport management to judge objectively how national air carriers were performing. The assessment included the review of the three major items of flight safety management, passenger service and policy adaptation.

In aviation safety the draft final report emphasizes that the ROC faces an inherent difficulty that is associated with being neither a member state of, nor an observer at, ICAO activities. Most ICAO documents can be obtained, although not directly, in a fairly timely manner but there is no opportunity to take part in the deliberations that result in new standards and recommended practices. Being excluded from ICAO, there is not the good notice of developing standards that permits the planning for their implementation and there is no forum for the ROC to bring its unique requirements to the international civil aviation community.

We noted there was still some information that was interesting but not really relevant to the accident or to safety deficiencies uncovered in the investigation. This tends to make a long report a little longer than necessary and a little more difficult to understand than is necessary.

To the extent practicable, we have noted our differences with the draft report, given reasons for the differences and suggested changes to the wording that can be 'pasted' into the report.

The CAA understands that the ASC will advise on the degree to which it accepts the representations made on the final draft report. The CAA will then decide whether to ask to have its representations appended to the public report.

Part 2

Representations on Section 1, Factual Information

✈ Section 1.1 History of Flight

Ref: Second to last Paragraph of the section, ending with "end of the recording."

CAA Issues and Discussion

To enhance the factual information, it is important to include the fact that the jersey barriers were equipped with lights at the time SQ006 collided with them.

CAA Proposed Changes

The CAA proposes that the word "lighted" be inserted in the following paragraph:

"Approximately 33 seconds after the takeoff roll commenced, the aircraft collided with several lighted concrete "jersey" barriers, 2 excavators, 2 vibrating rollers, a bulldozer, an air compressor cart, and a pile of metal reinforcing bars on Runway 05R, between Taxiways N4 and N5. The FDR recorded airspeed about 158 knots and ground speed about 131 knots at the end of the recording."

✈ Section 1.3 Damage to Aircraft

Ref: General to the one Para section, which ends with "vertical drip patterns."

CAA Issues and Discussion

Section 1.3 Damage to Aircraft, is a general description of the aircraft damage, and it would benefit from a brief discussion of the overall damage to the aircraft and the monetary amount of the hull loss. (i.e. The airplane was destroyed by impact and fire damage. According to the insurance company the airplane was valued at $??? million dollars (U.S.). The information currently presented is better suited for discussion in Section 1.12.

CAA Proposed Changes

The airplane was destroyed by impact forces and by a post-accident fire. According to insurance company records the airplane was valued at $??? million dollars (U.S.).

✈ Section 1.4 Other Damage

Ref: Last portion of section ending with the words "in the various pits."

CAA Issues and Discussion

Other Damage is a general description of the overall damage to the construction equipment and any other airport property that was damaged or destroyed in the accident. This description should include a monetary value estimated to be in the thousands or million of dollars for both equipment and cleanup.

CAA Proposed Changes

Airplane wreckage and the post-crash fire either destroyed or significantly damaged two excavators (Figures 1.4-1), two vibrating rollers (Figures 1.4-2), one small bulldozer (Figure 1.4-3) and one air compressor. The total equipment damage (not including airplane) and clean up of construction site were estimated at $740,000 dollars (U.S.).

✈ Section 1.5.1 The Captain (CM-1)

Ref: Paragraph 3, ending with "initial and recurrent training."

CAA Issues and Discussion

The report states that the CM-1 was qualified for CAT III operations and that he had received both initial and recurrent PVD training. The report does not state when he received his CAT III qualification, or the initial and recurrent PVD training.

Also, in Section 2.5.4.5, SIA Low Visibility Taxi Training, the ASC report states "…CM-1 stated that he did not receive low visibility taxi training." It is apparent that this statement could be contradictory to the information for CAT III qualifications because a portion of this training (Crew Training Manual (CTM)) addresses "Taxiing in Poor Visibility," and the SIA Flight Instructor Manual requests instructors to teach pilots about, "taxi routing and situational and environmental awareness." Further, although the video portion of this training does not address low visibility taxi operations, and the written materials and instructor training may not have been complete or as detailed as necessary to provide a good foundation, the SIA training program did provide some information and recommended practices in the CTM.

CAA Proposed Changes

The CAA suggests that the dates of CM-1 CAT III qualification and the PVD be included to complete the factual record.

✈ Section 1.5.2 The First Officer (CM-2)

Ref: Paragraph 2, which ends with “in February 2000.”

CAA Issues and Discussion

The report states that the CM-2 was qualified for CAT III operations and that he had received both initial and recurrent PVD training. The report does not state when he received his CAT III qualification.

Also, based on the discussion that occurred with the CM-2 and the other crewmembers about the PVD and its operation (CM-3 explaining the 45 degree alignment), it is important to know why the CM-2 may not have known this fact about its operation since he had just completed PVD recurrent training on September 24, 2000, one month prior to the accident.

CAA Proposed Changes

The CAA suggests that the date(s) of CM-2 CAT III qualification be included to complete the factual record.

✈ Section 1.5.3 The Relief Pilot (CM-3)

Ref: Paragraph 3, which ends with “initial and recurrent training.”

CAA Issues and Discussion

The report states that the CM-3 was qualified for CAT III operations and that he had received both initial and recurrent PVD training. The report does not state when he received his CAT III qualification or his initial and recurrent PVD training.

CAA Proposed Changes

The CAA suggests that the date(s) of CM-3 CAT III qualification and initial and recurrent PVD training be included to complete the factual record.

✈ Section 1.7.2 Surface Weather Observations [2 issues]

Issue 1:
Ref. table 1.7-1

CAA Issues and Discussion

This wind direction and magnitude in this table are currently presented in meters per second although the column headings indicate “degrees/knots.” The numbers presented in bold font are the corrected “knots” values. Also, the table contains information derived from both the automated weather observation system for CKS Airport called Airport Weather Advisor (AWA) and the runway crosswind magnitude calculated by the

ASC. As currently presented, the chart could be misunderstood because there is no explanation of the source of the values used.

Additionally, the text that is currently presented after the chart should be revised and placed ahead of the chart to provide the reader with an explanation of where the automated system records the wind values. Also, the calculated crosswind magnitudes need to be explained so that the reader will understand the method used in their determination.

CAA Proposed Changes

Table 1.7-1 Weather Condition of CKS Runway should be re-titled to reflect accurately that the values in the Table are not weather conditions but recorded AWA wind and visibility readings. The chart should be edited so that the Crosswind magnitude is removed and discussed separately, or a footnote should be added to tell the reader that these values do not come from the AWA but were calculated by the ASC using some specific method (airline table, National Weather Service program, etc.)

Also, the description of the AWA (see example) should include information that there are three sensors along runway 5L (approach-end, mid-field and departure-end) and the values presented in the chart are from the 05L approach end sensor. Also it needs to be noted that the wind magnitude and direction recorded by the AWA for the time periods listed in the chart are the "average" of the wind reading recorded over a one minute period and not the actual wind value at the beginning of that minute. These values also incorporate any peak gusts during that period.

Example text: "The automated weather observation system for CKS Airport is called Airport Weather Advisor (AWA). The AWA is comprised of anemometers, forward scatter sensors (RVR sensors), ceilometers, barometers and temperature/dew point sensors. The anemometers are located at the approach-end, mid-point and departure-ends of runways 05, 23, 06, 24; and the RVR sensors are located in the vicinity of each anemometer with the exception of the mid-point of Runway 06/24. The AWA records the "average" wind direction and magnitude over a rolling "1-minute" period. Thus, the values presented in the Table 1.7-1 for the one-minute periods beginning at 2312 through 2317 are averages and not the actual wind condition at the particular time.

Additionally, the wind value provided by the air traffic controller to the flight crews is based on a 2 minute rolling average recorded by the AWA at the runway 5L threshold."

Issue 2

CAA Issues and Discussion

The information presented in Finding No. 1 (Findings Related To Probable Cause) can be confusing because it states the wind condition at the time of the accident was from 020 degrees with a magnitude of 36 knots, gusting to 56 knots, and the values are not attributed to a specific location on the airport. However, Table 1.7-1 indicates the wind condition at 2317 for Runway 05 was 360 degrees at 41 knots with a crosswind magnitude of 31 knots. Further, the Table does not represent the instantaneous wind gusts that occurred during that period that would have had to be factored into the flight crew's determination of headwind and crosswind limitations for the "wet" runway.

The variance in these values is significant because the reduced steady-state wind conditions are "more acceptable" and within the SIA operating limits. However, as CM-3 has stated in his interview, he was concerned the wind condition (by his calculation 28.5 knots) was at a value close to the SIA maximum limit when they began their takeoff.

CAA Proposed Changes

Table 1.7-1 Recorded AWA Wind and Visibility Readings

Time	Runway 05 Wind Direction and Magnitude (degree/knots)	Runway 05 Cross Wind Magnitude from Left Hand Side (knots)	Runway 05 Visibility[1] (meters)	Mid-Point 05/23 Visibility (meters)
2312	358/**29**	**23**	518	475
2313	023/**86**	**38**	504	604
2314	018/**56**	**29**	923	420
2315	029/**59**	**20**	450	236
2316	013/**59**	**34**	360	168
2317	360/**41**	**31**	444	192

✈ Section 1.10.1 General

Ref: Paragraphs 1 & 2, which end with "CKS Airport was commissioned."

CAA Issues and Discussion

The Ralph M. Parsons Company designed the CKS Airport in 1973 according to FAA specifications.

The main purpose of Runway 05R/23L was always for taxiing.

CAA Proposed Changes

The following corrected text will enhance the clarity of this section:

[1] The visibilities were calculated by the manufacturer.

The Ralph M. Parsons Company of the United States designed the CKS Airport in 1973, according to FAA specifications; and construction was completed in February 1979. CKS Airport diagram is shown in Figure 1.10-1.

The original design of the airport did not include Runway 05R/23L, but rather included a parallel taxiway (identified as Taxiway A). It was determined during construction that an additional runway was necessary in the event that the primary runway, 05L/23R, was closed. Hence, Taxiway A was re-engineered and designated Runway 05R/23L when CKS Airport was commissioned. However, the intended purpose of Runway 05R/23L was always for taxi operations.

In 1987 the CAA created its own airport construction specifications, incorporating information from both the FAA Airport Specifications and ICAO Standards and Recommended Practices (SARPs).

In November 1971 the ICAO ceased to recognize the Republic of China (ROC) as a member State. Although the CKS Airport had been constructed in accordance with FAA Specifications and ICAO SARP's, the CAA of the ROC was no longer able either to receive directly the ICAO SARP's information or participate in working groups.

✈ Section 1.10.2.1 Runway Configuration and Specifications

Ref: Paragraph 3, which ends "or 17 knots "wet runway.""

CAA Issues and Discussion

The information presented is complete. Minor editorial change and the addition of a key word would make the factual record complete.

CAA Proposed Changes

The following words are suggested for inclusion in the ASC paragraph:

"Runway 05R/23L was 45 meters wide and 2752 meters long and was designated as a "non-instrument" runway. It was equipped with green centerline lights for taxi operations and white edge lights for takeoff operations. The runway was not available for landing but pilots were able to request its use for takeoff. Pilots were required to obtain prior approval from both the CKS Airport and the Air Traffic Controller for the use of the runway. Typically, approval would not be granted when there were large aircraft on Apron 501-515 because of the lack of sufficient safety zone clearance. Further, the simultaneous use of Runway 05R/23L and the parallel Taxiway "NP" was prohibited if the crosswind component exceeded 22 knots (dry runway) or 17 knots (wet runway)."

Issue 2:

CAA Issues and Discussion

Figure 1.10-6, identified as the Taxiway centerline markings near the threshold areas of runway 05R is " missing."

CAA Proposed Changes

Include Figure 1.10-6

✈ Section 1.10.3.2.2 Runway Guard Lights

Ref: End of section, which ends with "guard lights installed."

CAA Issues and Discussion

This section should reflect the statement found in Section 1.10.3.2.3 regard the SMGCS program to provide continuity.

CAA Proposed Changes

The CAA suggests the inclusion of the following sentence at the end of this section:

"At the time of the accident, CKS Airport did not have a SMGCS program and the runways were not equipped with guard lights."

✈ Section 1.10.3.2.3 Stop Bar Lights

Ref: 2nd paragraph beginning with, "The stop bar lights are also one component…."

CAA Issues and Discussion

The stop bar lights don't necessarily enhance taxiing capability in low visibility conditions. In fact, the stop bar identifies the intersection of a runway and a taxiway and provides an indication of proximity to a runway in low visibility conditions.

CAA Proposed Changes

It is suggested that the paragraph be modified as follows:

The stop bar lights are also one component of the SMGCS that is used to identify the intersection of a runway and taxiway in low visibility conditions. The stop bar lights, in conjunction with the other components of the SMGCS are also intended to enhance the pilot's awareness of his proximity to a runway.

✈ Section 1.10.3.2.4 Taxiway Centerline Lights

Ref: Paragraph titled "ICAO Annex 14, Volume 1, Paragraph 5.3.15.7 (Standard):"

CAA Issues and Discussion

The section would benefit and be more complete with information from ICAO Annex 14, Volume 1, Paragraph 5.3.15.10

CAA Proposed changes

Insert: According to ICAO Annex 14, Volume 1, Paragraph 5.3.15.10,

> *"Recommendation – Taxiway center line lights should normally be located on the taxiway center line marking, except that they may be offset by not more than 30 cm where it is not practicable to locate them on the marking."*

✈ Section 1.10.5.1.2 Circuit Monitoring

Ref: Last paragraph which ends with, "selected at intensity level 3."

CAA Issues and Discussion

In the spirit of addressing those issues that are either causal or contributing to the accident, the information provided in Section 1.10.5.1.2, Circuit Monitoring, is not pertinent to the accident because, 1) SQ006 was assigned runway 05L for takeoff not 05R, 2) the appropriate taxiway centerline lights were operational on runway 05R the night of the accident and 3) the crew of SQ006 was aware of the operational status of this runway by NOTAM. Therefore it is recommended that this section be deleted.

CAA Proposed Changes

If the ASC believes the information should remain in the report, the CAA suggests the following text change for the third paragraph to complete the factual record and provide clarity:

"The airfield lighting system is monitored both electronically and by personnel from the Air Navigation and Weather Services (ANWS) section at CKS Airport. This unit is comprised of ten persons, six supervisors and four artisans; and they are scheduled on shifts round the clock. ANWS maintenance staffers inspect the airfield lights twice a day, once in the morning (0900 – 1100 hours) and once in the afternoon (1300 – 1500 hours). They coordinate this activity with the Control Tower for an available time slot to enter the taxiway/runway and conduct necessary repairs. Typically, any faults recorded in the morning are rectified in the afternoon on the same day. In addition to the daily checks, ANWS has weekly and monthly checks for airfield lights that require greater attention."

✈ Section 1.13 Medical and Pathological Information

CAA Issues and Discussion

The information presented in this section regarding the "Alcohol and Drug Test on the Flightcrew" needs to be expanded to provide an explanation of the regulations governing these tests and why they were not conducted. Article 6 of the ASC regulations explains the authority of the ASC regarding toxicological tests for deceased crew members – but there is ambiguity for surviving crew.

CAA Proposed Changes

Provide additional information regarding the authority of the ASC, the CAA and "Prosecutor" regarding the ordering of these tests.

✈ Section 1.16.6 Cockpit Field of View Study

Ref: End of section, which reads "range of the human eye."

CAA Issues and Discussion

The conclusions that can be drawn from this study are extremely limited. The study was based on the assumption that pilots only look straight ahead. The study does not take into account [continuous] head and shoulder movements of the pilots. Therefore, figure 1.16-8 provides an extremely conservative and misleading depiction of the pilots' field of view. CM-1 even stated in his interview (1.18.1.1.1) that the "wiper cleaned most of the windscreen and he could see through almost the whole windscreen." CM-1 also reported that he "felt that his visibility was not impaired by the rain, even in the areas not swept by the wipers." Because of the limited nature of this study, it also produces results that are inconsistent with the Taxi Route Simulation (1.16.1) that showed that most signs, markings, and lights were visible from the cockpit. To be performed correctly, this field of view study should have calculated the field of view for different degrees of head rotation from both the left and right of pilots' forward views. These overlapping fields should then have been plotted in figure 1.16-8 to illustrate a more realistic range of ground visibility. Simply stating in the text that "the actual field of view will be slightly better when the pilot moves his head" (p. 118), is inappropriate.

CAA Proposed Changes

Either the study should be expanded to identify the overlapping fields of views from different rotation angles of the pilots' heads, or the above paragraph should be inserted in the text to notify the reader of the extreme limitations of the study and subsequent conclusion that can be drawn from it.

✈ Section 1.17.3.2 Training Department

Ref: Sub-section on Low Visibility Training, which ends with "approved level 2 simulator."

CAA Issues and Discussion

The issue of training discussed in Section 1.17.3.2, especially the low visibility training, should be explored with more depth. The CM-1 made a statement that he did not receive low visibility taxi training yet he is CAT III and PVD qualified. Furthermore, both the CM-2 and CM-3 were CAT III and PVD qualified. If the CM-1 did not receive "any" training regarding low visibility taxiing operations, then it is likely that CM-2 and CM-3 were also at a disadvantage. However, neither the CM-2 nor CM-3 indicated this training deficiency in their interview statements. Further, the CAT II & III training video that crewmembers are required to view does not address low visibility taxi operations. Consequently, it is apparent that the low visibility training focuses only on the takeoff and approach portions of flight operation, as has been implied by the CM-1. Based on the lack of training and detailed training materials available to educate the crew members as to the hazards associated with this type of operation, it can be concluded that this flight crew was not fully trained by SIA and was at a disadvantage on the evening of the accident.

In addition, the deficiency in the training extend beyond a lack of information in SIA B-747-400 Operations Manual and "no formal training" for low visibility taxi as stated in Findings No. 6 and No. 13 under Findings Related to Risk. SIA, in not providing such training, resulted in the flight crew not being equipped with the knowledge and tools necessary to conduct such an operation. Thus, Finding No. 6 and No. 13 could be combined to reflect the seriousness of SIA's deficiency and the implications it had on the accident flight crew.

<u>CAA Proposed Changes</u>

It is suggested that the description of the Low Visibility training conducted for both CAT III operations and the PVD be expanded to include the exact information that is provided to crewmembers in the flight and training manuals, the classroom, the simulator and in the videotape. This would provide a clear picture to the extent of the low visibility training especially on taxiing operations. Also, it would serve to demonstrate exactly where the deficiencies are in the training program and provide the basis for a more definitive Safety Recommendation.

✈ Section 1.17.4.4 Aircraft Documentation

Ref: The entire section which ends with, "of Runway 05R and 05L."

<u>CAA Issues and Discussion</u>

The information provided in Section 1.17.4.4 is interesting information but it is not relevant to the accident nor is it referenced in the analysis.

<u>CAA Proposed Changes</u>

It is proposed that section 1.17.4.4 be deleted from the report. However, if the ASC believes it should remain in the report, it could be moved to Section 1.17.3.4 since it relates to a function of the SIA FCC.

✈ **Section 1.17.4.5 SIA Taxi Procedures**

Ref: End of section which reads "B747-400 Operations Manual."

CAA Issues and Discussion

There are several sections of this report that should be rearranged to improve its clarity. One such section is 1.17.4.5 because it is training related. Thus, for report continuity, the information should be moved in sequence with Section 1.17.3.2.

CAA Proposed Changes

It is suggested that 1.17.4.5 be moved in sequence with Section 1.17.3.2.

✈ **Section 1.17.4.6 Out-Station Audits**

Ref: Entire section, which ends with "audit on May 31, 2000."

CAA Issues and Discussion

Section 1.17.4.6 is related to the FCC and out station services. For report continuity, the information should be moved in sequence with Section 1.17.3.4.

CAA Proposed Changes

It is suggested that 1.17.4.6 be moved in sequence with Section 1.17.3.4.

✈ **Section 1.17.5 EVA Airways Flight Control Department**

Ref: Entire section, which ends with "typhoon condition II at 2155."

CAA Issues and Discussion

Section 1.17.5 is related to the FCC and out station services. For report continuity, the information should be moved in sequence with Section 1.17.3.4.

CAA Proposed Changes

It is suggested that 1.17.5 be moved in sequence with Section 1.17.3.4.

✈ Section 1.17.6 SIA Taipei Station

Ref: Entire section, which ends with "crew of the typhoon status."

CAA Issues and Discussion

Section 1.17.5 is related to the FCC and out station services. For report continuity, the information should be moved in sequence with Section 1.17.3.4.

CAA Proposed Changes

It is suggested that 1.17.5 be moved in sequence with Section 1.17.3.4.

✈ Section 1.17.8 Voyage Record

Ref: Entire section, which ends with "satisfactory reasons are provided."

CAA Issues and Discussion

Section 1.17.8 is interesting factual information but its relationship to the accident is unclear and is not referenced in the analysis nor used to support a Safety Recommendation.

CAA Proposed Changes

It is suggested that 1.17.8 be deleted from the report.

✈ Section 1.17.9 Organization of CAA

Ref: Organization chart.

CAA Issues and Discussion

The CAA has a new organizational chart that should be included in the report to provide the most accurate data. Also, the current positioning of the chart in the report is confusing because there is no introduction.

CAA Proposed Changes

Insert most current Organizational Chart and move the chart to the end of the 1st paragraph.

✈ Section 1.17.11 The Aerodrome Engineering Division

Ref. Entire section, which ends with " the airport master plan."

CAA Issues and Discussion

The correct name of the division is the ' Aerodrome Division (AD).'

CAA Proposed Changes

Change all references in this section and other sections (e.g. 1.17.13) to eliminate the word ' engineering' and the related abbreviation ' E' wherever it is used.

✈ Section 1.18.1.1 The Captain CM-1 [2 issues]

Issue 1:

Ref: Points to note by CM-1, first paragraph of the subsection, which ends with "and this was the trap."

CAA Issues and Discussion

Under the subsection of "Points to note by CM-1," the statement, "and this was the trap" should be in quotation marks if this is what the captain actually said. If it is not what he actually said, then the statement is biased and should be removed from the document.

CAA Proposed Changes

Remove the statement if it is not what the pilot actually said or enclose the statement in quotation marks if it does reflect the exact words of the pilot.

Issue 2:

Ref. Final paragraph of section, which ends "in low visibility conditions."

CAA Issues and Discussion

Unlike CM-2 and CM-3, CM-1 was apparently never asked what his mental picture of a closed runway would look like. However, in the analysis section 2.5.7.7, it is implied that he was asked this question. Also, none of the flight crew was asked to describe a mental picture of what a CAT II runway should look like. This seems like a very important oversight, since a great deal of the analysis is based on the idea of "confirmation bias" or that the pilots "saw" what they expected to see.

CAA Proposed Changes

Some of the analyses of flight crew comments should be re-evaluated in light of these apparent oversights during the interview process. These issues have been addressed within relevant sections of the document.

✈ Section 1.18.1.3.4 Interviews with Controller D

Ref: Entire section, which ends with "there was no arrival traffic."

CAA Issues and Discussion

Sections 1.18.1.3 is related to Section 1.18.2. Thus, for report continuity, either section should be moved as appropriate to be in sequence with each other.

CAA Proposed Changes

It is suggested that 1.18.1.3 be moved in sequence with Section 1.18.2.

✈ Section 1.18.1.5 Other Interviews

Ref: 5th paragraph, which ends with "broken clouds at 30,000 feet, no rain."

CAA Issues and Discussion

The inclusion of the interview with the freighter captain of the MD-11 is questionable. The captain did not contact Singapore MCIT until two months after the accident and the first interview did not take place until 4 months after the accident. It also appears that the first interview was not done with all parties to the investigation being present. The second "official" interview took place almost 9 months after the accident. The freighter captain had obviously been exposed to reports of the accident and possible runway issues. His recollection could also have been biased by questions asked during the first interview. Furthermore, the statements in the document do not indicate from which interview they came (1^{st} or 2^{nd}).

CAA Proposed Changes

The statements derived from the interview are dubious and unsubstantiated, and should be deleted from the report.

✈ Section 1.18.2.3 ATC Procedures [2 Issues]

Issue 1:

Ref: Following point 3 there is a line that reads, "The progressive taxi instruction was not issued to SQ006."

CAA Issues and Discussion

Insert an additional sentence in place of the referenced sentence.

CAA Proposed Changes

The replacement sentence should read:

"SQ006 was the only traffic in the maneuvering area. The controller provided precise taxi instructions to the crew of SQ006 which they accepted without a request for progressive taxi instructions."

Issue 2:
Ref: Paragraph beginning with, "During interviews with the Chief of the Tower…"

CAA Issues and Discussion

The following sentences are not factually correct:

1st sentence: "In particular, ATC tries to ensure that the aircraft are expedited from the active runway after landing and that taxiing aircraft do not enter the active runway until cleared" is not factually correct because of the context in which the words "expedite" and cleared are used.

2nd sentence "If there are no other aircraft on the airfield during taxi, ATC does not have specific procedures or practices to assist flight crew's navigating." This is not factually correct because ATC does have specific procedures and practices to assist flightcrew taxiing around the airport. The controller provided the crew of SQ006 with a detailed taxi plan. It was accepted by the crew. If the crew believed they would not be able to safely navigate to the runway it would have been incumbent upon the pilot to request progressive taxi instructions. Further, it is evident that the need for progressive taxi instructions was not necessary since the crew was able to taxi from the terminal apron to runway 5R

CAA Proposed Changes

To enhance the factual record, the following replacement sentences are suggested where appropriate:

1st sentence: "In particular, ATC must ensure that the aircraft are clear of the active runway after landing and that taxiing aircraft do not enter an active runway until authorized by ATC."

2nd sentence: "ATC does have specific procedures and practices to assist flightcrew taxiing around the airport but they are not normally exercised unless requested by the pilot."

✈ Section 1.18.2.4 Airport Surface Detection Equipment [3 issues]

Issue 1:
Ref. Opening sentence, which ends "duties at any time."

CAA Issues and Discussion

The first part of the opening sentence is inaccurate. The controller is not 'required to use ASDE' but has the discretion to use it or not use it to augment visual observations of aircraft or vehicles.

CAA Proposed Changes

The opening words of the sentence should read: "ATP-88 states that the controller can use Airport Surface Detection . . ."

Issue 2:
Ref: 2nd paragraph, first sentence, which ends with "control instructions by aircraft and vehicles."

CAA Issues and Discussion

First sentence is redundant (see previous paragraph) and should be deleted.

CAA Proposed Changes

Delete the first sentence of the paragraph.

Issue 3:
Ref: 3rd paragraph beginning with, "During interviews, the duty controller stated that…"

CAA Issues and Discussion

The statement is an opinion and does not represent the CAA's position.

CAA Proposed Changes

It is suggested that the statement be deleted. However, if the ASC believes the statement should remain, there should be a clarifying statement that this is a personal opinion and does not represent the CAA's position.

Part 3

Representations on Section 2, Analysis

Changes Proposed to the ‘ANALYSIS’ section of the ASC Draft Final Investigation Report.

✈ Part 2 Analysis

Ref: The final paragraph that ends “utility of air safety investigation data.”

CAA Issues and Discussion

The classification of the findings as ‘cause related’, ‘risk related’ and ‘other’ is very progressive and serves safety purposes better than the more traditional and slightly different classifications often seen in accident investigation reports. The addition of ‘safety deficiencies’ identified in the course of the investigation, whether related to cause or not is also very constructive.

CAA Proposed Changes

The clarity and the strength of the report could be further improved by consolidating some of the findings and by eliminating those of less importance.

✈ Section 2.2 Structural Failure Sequence

Ref: Entire Section

CAA Issues and Discussion

This information is factual with no conclusions being drawn and is not the basis for Safety Recommendation support.

CAA Proposed Changes

The information could be edited and moved to the Section 1.12 Wreckage Information to enhance the description of the accident site and damage to the airplane.

✈ Section 2.3 CKS Airport at the time of SQ006 Accident

Ref: Entire section

CAA Issues and Discussion

The information presented in this section is factual information and is discussed in Section 1.10, Airport Information.

CAA Proposed Changes

To eliminate redundancy, it is suggested that this Section be deleted.

✈ Section 2.3.1.1 Design of Taxiway N1 Centerline Marking [2 issues]

Issue 1:
Ref: Paragraph 2 – which ends with "from Runway 05R toward Runway 05L."

CAA Issues and Discussion

The CAA civil engineering specifications (ATP-AE 1000301: 3.8.5.1) did not state how to calculate the distance between the south edge of the Runway 05R and the tip of the curvature where N1 centerline made a turn into Runway 05R, and the distance between the north edge of the Runway 05R and the tip of the curvature where taxiway centerline marking turned away from Runway 05R to join Taxiway N1.

CAA Proposed Changes

CAA recommends that this reference be deleted.

Issue 2:
Ref: Paragraph 5 [final paragraph], which ends with "safety oversight mechanism by the CAA."

CAA Issues and Discussion

There is no question that there were deficiencies in the marking of Taxiway N1. The significance of those deficiencies appears to be very slight in light of the extensive time that they went unnoticed by the airport operator, the carriers and the States that conducted inspections prior to authorizing their carriers to operate out of CKS airport. While the ASC believes that the lack of a safety specialist and the lack of a safety supervision mechanism were responsible for the oversight there are additional plausible considerations. Even with a specialist and an oversight organization, there is no guarantee that their observations would be acted upon. There could be an assessment that the standard was not important, there could be an absolute shortage of money to implement the changes and there could be other more important safety items that used the available funding year after year.

CAA Proposed Changes

It is suggested that the final sentence be revised to read:

"The Safety Council was not able to determine the reason for the discrepancy. Certainly the absences of a safety specialist and a safety oversight mechanism increased the probability of the discrepancy remaining unnoticed. However, air carriers operating at CKS and ICAO member States that conducted inspections of the CKS Airport did not identify these discrepancies. Further, the Safety Council is concerned that other factors such as the availability of funding and other safety priorities may have also played a role."

✈ Section 2.3.1.2.1 Taxiway Lighting System Interlock with Runway 05R Lighting Systems

Ref. Para 2 – which ends with "to update the local regulations."

CAA Issues and Discussion

According to ICAO Annex 14, Volume 1, Paragraph 5.2.1.3 and the FAA Advisory Circular 150/5340-1H, Taxiway N1 centerline marking of CKS Airport meet ICAO standard and FAA AC**.**

CAA Proposed Changes

CAA recommends that this paragraph be deleted.

✈ Section 2.3.1.2.2 Spacing of Taxiway Centerline Lighting [2 issues]

Issue 1:
Ref: Paragraph 2, which begins with "The curved radius from Taxiway NP…"

CAA Issues and Discussion

The CAA offers clearer wording**.**

CAA Proposed Changes

It is suggested that the following text be inserted beginning at the second sentence:

"Therefore, in order to meet the most recent ICAO recommendation (issued in 1999), there should be 16 centerline lights spaced 7.5 meters apart along the straight segment of taxiway N1 where the curved portion of taxiway NP intersects with taxiway N1, up to the runway 05L holding position. . ."

Issue 2:
Ref: Paragraph 3, which begins with "The distance of Taxiway N1 centerline lights . . ." and ends with, "… did not meet ICAO SARPs."

CAA issues and Discussion

It has been recognized that the 200 meter RVR that was in print at the time of the accident was the result of the misinterpretation of the ICAO standard. Although this is factual information and should be addressed along with the change that was made after the accident to 350 meters, the analysis of this issue, as it relates to the SQ006 accident, should be based on the fact that the RVR at the time of the accident was in excess of 350 meters. Further, although the standards call for a certain number of centerline lights to be installed for use during "low visibility" operations, on the night of the accident the RVR was well in excess of both the 200 meter and 350 meter RVR minimums. Therefore, to focus the issue, the discussion should address the fact that there was a misinterpretation of standards resulting in the wrong RVR minimum

CAA Proposed Changes

The text should discuss the requirements for 350 meter RVR, which was the intent and was the practice at CKS until the error was introduced. Further, the 350 meter limit was restored when the error was realized.

In addition it is suggested that the following sentence be inserted as the conclusion to this section:

"The Safety Council considers that a reduced spacing of the centerline lights on the curves should assist crews to maintain awareness of their position and would reduce the likelihood of taxiing errors."

✈ Section 2.3.1.2. Unserviceable Taxiway Centerline Lights

Ref: 2nd paragraph which ends "of the November 4 inspection."

CAA Issues and Discussion

The information in the section moves the balance of probabilities toward the lights being normal at the time of the accident.

__CAA Proposed Changes__

In the last full line of the second paragraph change "might or might not . . ." to "were unlikely to . . ."

✈ **Section 2.3.2 The Installation of Runway Guard Lights**

Ref: Paragraph 2 which begins, "If CKS Airport had installed RGL…"

__CAA Issues and Discussion__

The text, as written, draws a conclusion that can not be supported by fact. The installation of runway guard lights would have increased the conspicuity of the taxiway and runway intersection, however, it is not known what effect the RGL would have had since the flightcrew believed they were on the correct runway. Further, the flight crew did not identify other visual cues that would have alerted them to fact they were not on the assigned runway

__CAA Proposed Changes__

It is suggested that the concluding paragraph be revised to summarize the fact that the RGL, in combination with the stop bars and other taxiway/runway markings typically used for low visibility operation were not installed. Further, the installation of this equipment would reduce the probability of such an event.

✈ **Section 2.3.3 Safety Considerations for Temporarily and Partially Closed Runway**

Ref: Paragraph 1 – which ends with "exclusive use as a main taxiway."

__CAA Issues and Discussion__

The problem is greater than noted. Instead of the normal situation of having traffic separated by direction, there would be the need to handle opposing traffic on a single taxiway.

__CAA Proposed Changes__

Add the sentence:

"The closure would put the combined traffic of Runway (Taxiway) 05R and Taxiway NP onto Taxiway NP. There would be the loss of the ability to provide directional separation and an increase in the risk of ground collisions."

✈ **Section 2.3.5.2.1 Making Revising and Updating of Civil Aviation Regulations**

Ref: Paragraph 1, which ends with " rules and regulations in time."

CAA Issues and Discussion

It is not clear why the specialist division staff should have any legal background. One often finds those with the technical background state the operational requirement and legal experts draft the language for the regulations.

CAA Proposed Changes

Restate the first paragraph as follows:

"Each individual division of the CAA was responsible for making the regulations within its jurisdiction; however, most of the staff members of the divisions had no legal background. That resulted in delays occasioned by a requirement to coordinate the operational requirements with the process of legalization. In addition, CAA's access to certain civil aviation resources is impaired by its absence from participation in major international organizations, including ICAO. This also causes some timeliness problems in the modifications of some rules and regulations."

✈ **Section 2.3.6 Summary of Organization and Management Related Airfield Deficiencies [2 issues]**

Issue 1:
Ref: Item 1,2 & 3 in paragraph 1

CAA Issues and Discussion

There are inaccuracies in each of the items.

CAA Proposed Changes

1. Relevant facilities met the ICAO standards at the time of design but did not correspond to subsequent revisions:

- Runway and taxiway lighting systems interlock mechanism;
- Installation of stop bar lights;
- Installation of runway guard light.

2. Relevant facilities did not meet ICAO SARPs at the time of design and were not identified during the construction specification review, acceptance at work completion or in routine maintenance and operations.
   - Mandatory Instruction Signs;
   - Taxiway centerline marking and lighting.

3. Inadequate administrative management:
   - Safety measures during airfield work in progress;
   - Process of converting Runway 05R into Taxiway NC;
   - Fail to revise CAA regulations to reflect updated ICAO SARPs.

Issue 2:
Ref: Paragraph 2 that ends with "caused those deficiencies to exist."

CAA Issues and Discussion

It is difficult to see how the above conclusion can be the only one. Regardless of the organizational structure, the denial of participation in ICAO working groups is an impediment to learning about developing standards and an impediment to inserting ROC requirements into those standards. Similarly, the availability of funding and other safety priorities would have to be considered and could easily affect the scheduling of dealing with any deficiencies.

CAA Proposed Changes

It is suggested that the final sentence be revised to read:

"The Safety Council concludes that the inadequacy of the CAA organizational structure and the exclusion of the ROC from ICAO increased the probability of the deficiencies remaining unattended. It was not determined how the availability of funding and the existence of other safety priorities affected the scheduling of dealing with the deficiencies."

✈ Section 2.4.1 Low Visibility Taxiing and Ground Movement Instruction [2 issues]

Issue 1:
Ref: Paragraph 1, which begins, "Air Traffic Control Procedures (ATP-88)…."

CAA Issues and Discussion

The primary purpose of the ATC system is to prevent a collision between aircraft. In accordance with ATP-88, during periods of reduced visibility, or when the taxi route is not visible from the tower, the controller is not required to issue progressive taxi instructions, but has the option, based on his or her judgment, to issue such instructions. SQ006 was the only aircraft operating on the airport at the time the taxi clearance was issued. The controller provided a precise taxi route, which was accepted by the pilot of SQ006 without a request for progressive taxi instructions.

Further, it is evident that the crew was able to navigate to the runway environment without difficulty using the taxi clearance they received.

CAA Proposed Changes

It is suggested that the last sentence be revised as follows:

The primary purpose of the ATC system is to prevent a collision between aircraft, both on the ground and in-flight. The controller provided the flightcrew of SQ006 with a precise taxi route from the terminal apron to runway 05L. Although the visibility was reduced due to weather and SQ006 was the only aircraft moving on the airport, the guidance provided in ATP-88 only requires the controller to issue progressive taxi instruction if requested by the pilot. ATP-88 also indicates that if the pilot does not request progressive taxi instruction, the controller, at his or her option may issue progressive taxi instructions

Issue 2:

Ref: Paragraph 4 – which ends with "been more alert about the aircraft location."

CAA Issues and Discussion

It would have taken very little alertness on the part of CM-1 to realize that the tower controller could not see 2,000 meters in about 600 meters visibility. The CM-2 noted that he did not expect the tower to see the aircraft as it approached the departure runway. Information from the tower controller about not seeing the aircraft may have increased the probability of pilot remaining alert to his position, however, it must be noted that the CM-1 was not alerted by much more compelling information.

CAA Proposed Changes

Replace the last two sentences with:

"However, the Safety Council believes that if the CKS ground controller had told the pilots that they were not be able to see the aircraft from the tower, there is an increased likelihood that CM-1 may have been more alert to his position."

Issue 3:

Ref: Paragraph 5, beginning with, “It is apparent that the controller did not issue…”

CAA Issues and Discussion

There is nothing in the factual or analysis to support the assertion “ . . . it is likely that this would have significantly enhanced the flight crew’s situational awareness.” Refer to discussion in Issue 1 of this section.

CAA Proposed Changes

It is suggested that the last sentence be replaced with the following:

“The effects of issuing progressive taxi instructions to the accident aircraft are not known. However, if the controller had issued progressive taxi instructions to the SQ006 crew, there would have been one more indication to the crew of their position and there is a possibility that the crew may have remained conscious of their position beyond Taxiway NP.”

✈ Section 2.4.2 Airport Surface Detection Equipment (ASDE) [2 issues]

Ref: Paragraph 3, which ends with “traffic and occasional poor visibility.”

CAA Issues and Discussion

The Safety Council proposal appears to be advocating ASDE without ensuring that it is considered in the light of all other safety priorities at airports with high traffic volume.

CAA Proposed Changes

It is suggested that the last two sentences be replaced with:

“Therefore, the Safety Council concludes that the CAA should conduct a risk analysis of its safety related requirements to ensure that expenditures are matched with the highest risks. The Safety Council also recommends that ASDE or an equivalent be considered among the safety requirements assessed, on the basis of a risk analysis, at civil airports.”

Issue 2:
Ref: Paragraph 4, which ends with “CAA’s safety enhancement project”

CAA Issues and Discussion

There is nothing in the factual section to support the assertion that the MOTC did not understand the significance of such an installation, or that there was a lack of professional knowledge or motivation. The discussion in Section 1.18.2.4 indicates that in 1996, the ANWS and CAA agreed on the need for ASDE and began the procurement process. The process did continue from 1996 with final approval from the MOTC in August 2001**.**

<u>CAA Proposed Changes</u>

The paragraph should be rewritten as:

"At the end of February, four months after the SQ006 accident, the CAA asked the MOTC to approve the ASDE procurement process in the first part of that year and the request was approved six months later. It is not known what factors affected the timing but in light of the high cost and limited effectiveness of the ASDE in adverse weather, the time to conduct the appropriate assessment and weigh the project against other safety priorities appears reasonable."

✈ Section 2.5.2.1 NOTAMS and INTAMS

Ref: Paragraph 2, which ends with "works in progress on Runway 05R."

<u>CAA Issues and Discussion</u>

The discussion is mostly speculative and provides an unfounded basis for the crew not taking in the kind of information they receive and must understand before every flight involving adverse weather.

<u>CAA Proposed Changes</u>

The paragraph should be edited and reconstructed to read: The flight crew was provided with information contained in the various flight documents prepared by the EVA dispatchers. Further, the flight crew stated after the accident that they were fully aware that sections of Runway 05R were only available for taxi and there were construction works in progress on Runway 05R.

✈ Section 2.5.4.1 Taxiing

Ref: Paragraph 2, which ends with "will be discussed in Section 2.5.7.1 of the report."

<u>CAA Issues and Discussion</u>

The comments about the distraction of the crew are without specific support. Since they were operating within the range of expected performance and there were three crewmembers to do the work designed for two, specific reasons would be required to justify any finding of distraction or mental overload.

CAA Proposed Changes

From the beginning of the third sentence the paragraph should read:

"The flight crew was operating toward the busy end of the range of normally expected activity. However, there were three crewmembers to handle the work expected of two. The flight crew indicated that they did not monitor the final phase of the taxi (the turn from Taxiway NP onto Runway 05R via N1) in accordance with the airport chart and the associated aircraft-heading indications. Further, the crew did not check the taxiway and runway signage and markings to verify their position when the aircraft turned from Taxiway NP onto Runway 05R via Taxiway N1. Nor did they react to the green centerline lights, the absence of bright TDZ lights and the PAPI, the narrow maneuvering surface, the PVD anomaly or the primary flight display indications. The pilot's field of view during the critical turn from NP onto Runway 05R will be discussed in Section 2.5.7.1 if this report.

✈ Section 2.5.4.2 Flight Crew Awareness

Ref: Paragraph 4, which ends with "the final phase of the taxi".

CAA Issues and Discussion

It seems that the presumption is that because the crew did not get onto the assigned runway, they must have been distracted. While the winds were near the crosswind limit and worse weather was expected in the coming hours, there was nothing that should have distracted the crew. The normal oral briefing on what to do in the event of a take-off emergency (e.g. engine failure) was omitted which suggests less than full attention to takeoff procedures. The "Before Take-off" procedures are required on every flight and are part of normal routine, thus, they cannot be considered distracting in themselves. Also, there is no evaluation of the reliability of the flightcrews' after accident recollections.

CAA Proposed Changes

It is suggested that the last sentence of Section 2.5.4.2 be deleted.

✈ Section 2.5.4.3 Intra-flight Deck/Cockpit Verbal Coordination

Ref: Paragraph 2, which ends with "was not used effectively."

CAA Issues and Discussion

This section implies that the flightcrew complied with the FAA Advisory Circular that states, in part, "before entering a runway for takeoff, the flight crew should verbally coordinate to ensure correct identification of the runway." Although the ASC report states that "They had verbally coordinated to ensure that they all knew that Runway 05L was the takeoff runway..," this is NOT the same thing as "verbally coordinating to ensure correct runway identification before turning onto it."

CAA Proposed Changes

The paragraph should be revised to read as follows:

"Although the crew had verbally coordinated to ensure they all knew that Runway 05L was the takeoff runway, and they had received ATC clearance to use it, the crew did not confirm that they were actually on 05L. Further, as the CM-1 taxied into position for takeoff, the crew accepted that they were on Runway 05L without verifying their position using the aircraft instrument indications, taxiway/runway signage, the runway environment or the anomalous PVD indication."

✈ Section 2.5.4.5 SIA Low Visibility Taxi Training

Ref: Paragraph 1, which ends with "did not receive low visibility taxi training."

CAA Issues and Discussion

Additional information could be added to the paragraph to enhance the discussion.

CAA Proposed Changes

CM-1 stated that he did not receive low visibility taxi training. However, he was qualified for CAT III operations, which infers operating at visibilities considerably below those at CKS on the night of the accident.

✈ Section 2.5.5 Before Take-Off Check

Ref: Paragraph 2, which ends "practice for low visibility conditions."

CAA Issues and Discussion

There is no mention of other common practices that are usually included under the heading of good airmanship. In limited visibility conditions pilots routinely count the runway edge lights, which are a nominal 200 (60 meters) feet apart to cross check the RVR reading. In addition it is common to ask to have the runway lights turned up to strength 5 in adverse weather. Such a request would have quickly shown the crew that there were no edge lights on, or in the unlikely event that they were on they would not be the ones that increased in strength.

CAA Proposed Changes

It is suggested that the following text be added to the end of the paragraph:

"The crew did not employ the 'rule-of-thumb' check to verify the RVR by counting the visible (60 meter spaced) edge lights and they did not ask for brighter lighting for the reduced visibility takeoff."

✈ Section 2.5.6.1 Primary Flight Displays

Ref: Paragraph 3, which ends "these indications before take-off."

CAA Issues and Discussion

Pilots routinely use the ILS localizer and other information on the PFD before takeoff to verify the runway, and to set up the return to the departure airport in the event of a takeoff emergency.

CAA Proposed Changes

It is suggested that the last paragraph be revised as follows:

"Pilots routinely use the ILS localizer indicator and the runway symbol on the PFD as a runway alignment reference for landing. However, there were no SIA procedural requirements for the flight crew to utilize the localizer alignment to validate assigned runway alignment before takeoff."

✈ Section 2.5.6.3.3 Operational Use of PVD

Ref: Bullet point list

CAA Issues and Discussion

Bullet 2 – "the aircraft is not within the valid localizer region." For clarity additional information should be added to expand on "valid localizer region.

CAA Proposed Changes

Add the following text after the "region" (i.e. not on the assigned runway); or…

✈ Section 2.5.7.1 Markings and Signage [2 issues]

Issue 1:
Ref: Opening paragraph, which begins "During the airport site survey…"

CAA Issues and Discussion

An introductory sentence, before the present beginning, that cites the information reported by the pilots would enhance this section.

CAA Proposed changes

It is suggested the following text be added as the 1st paragraph:

"During interviews with the pilots of SQ006 after the accident, they stated they did not recall seeing any markings and signage except the piano keys when the aircraft was turning from Taxiway NP onto Runway 05R."

Then delete the last sentence in the paragraph which begins, "However, during interviews, the pilots…"

Issue 2:
Ref. Figure 2.5-1

CAA Issues and Discussion

A note indicating that the diagram is based on the pilot not moving his head would be informative. (Unless the related section is revised)

CAA Proposed Changes

Add: The diagram is based on the pilot looking forward and not moving his head. (Unless the related section is revised)

✈ Section 2.5.7.2.1 Taxiway Centerline Lights

Ref: Paragraph 2, which ends with "was achieved prior to take-off."

CAA Issues and Discussion

In light of the limited reliability of post accident memory, the representations of the flight crew should be qualified. Also, the conjecture about the crew's attention resources should be eliminated.

CAA Proposed Changes

It is suggested the text of paragraph 2 be modified as follows for accuracy:

"The crew indicated that the attention focus of CM-2 and CM-3 was "inside" the cockpit for the checklist and crosswind component calculation during the turn onto the runway. In addition, CM-1 indicated that he was concentrating on maintaining minimum taxi speed and following the green lights onto the runway. The aircraft is designed for operations in all conditions within its flight envelope with two pilots. The operational envelope includes the handling of emergencies, such as the failure of two engines on the same side of the aircraft in the most critical stages of flight. The preparation for takeoff at night in adverse weather could be considered a high workload situation but it is not extreme. Further, the flightcrew of SQ006 was in a favorable situation because there were three pilots to conduct the work typically expected of two. Additionally, the flight crew did not seek or make use of all the pertinent information available nor did they prioritize the information to ensure they were on the assigned runway."

✈ Section 2.5.7.2.2 Spacing of the Taxiway Centerline Lights [2 issues]

Issue 1:
Ref: Paragraph 1, which ends with "believing it to be Runway 05L."

CAA Issues and Discussion

The assertion in the first sentence is too strong to be supported by the facts. Taxiway centerline lights are not used for lining up on the runway, but in fact are only guidance to the runway. Thus, the assertion that the spacing of the taxiway light influenced the crew to "believe they were lining up on the correct runway" cannot be supported.

Further, the report includes the statement that the "Safety Council has concluded that during the turn from Taxiway NP onto Runway 05R, the green taxiway centerline lights leading into Runway 05R attracted CM-1's attention." This statement and others leading up to it imply that the green lights were responsible for, or controlled, the CM-1's attention allocation processes. In the human factors literature, this reflects a stimulus-driven or bottom-up process. However, given that the PIC of the Asia-Pacific 747-400 was able to follow the green taxi lights from NP to 05L, suggests the green lights leading to 05R were driven, at least in part, by more top-down or mental processes rather than driven solely by environmental factors such as the saliency of the lights.

CAA Proposed Changes

It is suggested that the beginning text of the 1st paragraph be revised as follows for clarity and accuracy:

"The spacing difference between the taxiway centerline lights on Taxiway N1 that let to Runway 05L and those that turned right on to Runway 05R might appear ambiguous and may have been a factor that influenced the flightcrew to believe that they were taxiing into position on the "correct" runway."

Issue 2:

CAA issues and Discussion

Revise the ASC conclusion.

CAA Proposed Changes

The conclusion statement should be rephrased to state:

"The Safety Council has concluded that the captain's expectation that he was approaching the departure runway coupled with the saliency of the lights leading onto runway 05R resulted in the captain allocating most of his attention to these centerline lights. He missed the centerline lights that led to Runway 05L…"

✈ Section 2.5.7.2.3 Color of the Centerline Lights [2 issues]

Issue 1:
Ref: Last Paragraph, which ends with "centerline lights were green."

CAA Issues and Discussion

The last paragraph in this section states, "the flight crew were probably fully occupied by the high workload induced by concern about the degrading weather…" The term "high workload" is used throughout the report to imply that this flight crew experienced an exorbitant workload that was above that experienced by any other flight crew that departed CKS around the time of the accident. However, there are no facts offered to support this claim. Furthermore, one must question whether three pilots operating under conditions for which they have been trained to typically operate with only two pilots, were really experiencing the effects from a high workload. In any case, the term is certainly not used appropriately here. "Workload," in the human factors literature, is not induced by "concern." The term preoccupation might be a better term.

In addition, a review of the CVR transcript revealed that the flightcrew had approximately 56 seconds between the times the "Before Take-off" checklist was completed and the takeoff commenced. Additionally, of those 56 seconds, the last 30 seconds was with the aircraft holding in the takeoff position on runway 05R.

Furthermore, the CVR transcript indicates that the majority of the discussion occurring among the flight crew during this period was regarding the anomalous PVD indication.

CAA Proposed Changes

It is suggested that the last paragraph be revised for clarity and accuracy to the following:

"When the aircraft taxied into takeoff position and held on runway 05R for approximately 33 seconds, the focus of the flightcrew's attention was apparently the PVD and the reason it had not un-shuttered. During that period there were no further discussions about the degraded visibility, fluctuating weather conditions, approaching typhoon or crosswind limitations. Consequently, despite the fact that they had a brief period of time, prior to commencing the takeoff, to look out the windscreen at the runway environment, the reason for the flight crew's incorrect perception that the centerline lights were white rather than green, and the significance of this fact, could not be determined."

✈ Section 2.5.7.4 Runway Difference Issues [2 issues]

Issue 1:
Ref: First Paragraph, second bullet

CAA Issues and Discussion

The second bullet, there is no mention of the PAPI on Runway 05L.

CAA Proposed Changes

Following TDZ, add: and a four-light PAPI to the left of the runway.

Issue 2:
Ref: Last paragraph of the section, which ends "runway configuration information."

CAA Issues and Discussion

Based on previous discussions about the flight crew's actions during the final moments of taxiing to the runway and the misuse of the term "high workload," the last sentence is speculative and should be deleted.

CAA Proposed Changes

Delete the final sentence of the paragraph, which deals with experience and workload.

✈ **Section 2.5.7.5 Runway 05L Guard Lights**

Ref. Second Paragraph, which ends "location of Runway 05L."

CAA Issues and Discussion

The second part of the concluding sentence is speculative and cannot be supported by the facts.

CAA Proposed Changes

It is suggested that the last sentence be revised to end after the words "holding position." The remainder of the sentence should be deleted.

It is suggested that a new paragraph 3 be inserted as follows: The lack of stop bar or guard light is unrelated to flight crew's judgment in this event, because if flight crew should have expected the existence of stop bar or guard light before Runway 05L, they would not have taken off on Runway 05R in the absence of them. On the other hand, the AIP already indicated the lack of stop bar and guard light and flight crew should not have expected to rely on them to identify the correct runway.

✈ **Section 2.5.7.6.1 Runway 05R Edge Lights**

Ref: 1st sentence, which ends "time of the accident."

CAA Issues and Discussion

Additional text should be inserted after the first sentence to bring the paragraph fully in line with the factual information in the report. Also amend the final sentence.

CAA Proposed Changes

Insert the following text after the words, "…time of the accident:"

"Based on the facts, the Safety Council believes that there is a high probability that the edge lights were out during the SQ006 takeoff."

Amend the last sentence to read:

"Regardless of the status of the Runway 05R edge lights, the crew took off from Runway 05R."

✈ Section 2.5.7.6.1.1 If Runway 05R Edge Lights Were Off

Ref: End of section, which reads "on the incorrect runway."

CAA Issues and Discussion

The report includes the statement, “They saw what they expected to see – a normal picture of a runway.” However, all three pilots were aware that they would be taking off on a CAT II runway and they discussed the use of the runway as a landing alternate in case they had to divert the flight, because it was a CAT II runway. The report now also states that all three pilots were qualified for CAT III operations. Therefore, given the pilots’ training and experience, and the recency in which they discussed the runway information, the flight crew should have expected to see a “normal picture” of a CAT II runway (typically illuminated with touchdown zone lights). During the interview process, however, they were never asked about what a normal CAT II runway should look like. Therefore, it is unknown what their actual knowledge was at the time of the accident. Nonetheless, the fact that they interpreted 05R as the CAT II Runway 05L, suggests that their expectation of what a CAT II runway should look like was inaccurate.

CAA Proposed Changes

It is suggested that the concluding paragraph be revised to include the following text beginning with the second sentence:

“Based on the fact that the pilots’ were CAT III qualified and experienced, in addition to the recency in which they discussed the runway information, they should have expected to see a “normal picture” of a CAT II runway. During the interview process, however, they were never asked about their perception of what a normal CAT II runway should look like. Therefore, it is unknown what their actual knowledge was at the time of the accident. Nonetheless, the fact they interpreted 05R as the CAT II Runway 05L, suggest that they had an inadequate mental model of what a normal CAT II runway should look like.”

✈ Section 2.5.7.6.1.2 If Runway 05R Edge Lights Were On [2 issues]

Issue 1:
Ref: End of section which reads “and carried out the take-off.”

CAA Issues and Discussion

The first paragraph in this section refers to statements made during the interview of the freighter captain.

CAA Proposed Changes

In light of the concerns previously expressed about the dubious nature of this testimony, the discussion of this captain’s statements should be deleted.

Issue 2:

CAA Issues and Discussion

The third paragraph in this section states, "Under high workload of taking off in severe weather conditions…" Again, the term "high workload" appears throughout this document without any consistent meaning. In this context, it appears that workload is not being used to refer to task characteristics at all, but to the internal emotional state of the pilots', such as stress or anxiety. The liberal use of this term makes it a "catch-all," and often negates the true meaning in favor of a meaningless explanation of pilot performance.

CAA Proposed Changes

The use of the term "workload" in general, and "heavy workload" in particular, should be clearly defined and its use carefully re-examined throughout the entire report. If the term workload is being used in this section of the report to refer to an internal emotional state of the crew, then the sentence should be restated to read "Under the stress and anxiety of taking off in severe weather conditions…"

✈ Section 2.5.7.7 Expectation of Runway Picture [2 issues]

Issue 1:
Ref: End of section, which reads "from seeing those lights"

CAA Issues and Discussion

The first paragraph ends with the statement "Furthermore, CM-1 stated that the timing of the take-off clearance gave him an impression that CKS Tower could see him." This is contrary to the fact that he told the CM-2 at 23:14:58, "tell them [the controller] we are ready." Based on this request, the controller would issue the clearance based on the pilot's verbal statement not visual identification of the aircraft.

CAA Proposed Changes

It is suggested that the following statement be included at the end of the 1st paragraph:

"However, neither CM-2 nor CM-3 was under the impression that CKS Tower could see them. Therefore, although the perceived timing of the takeoff clearance received from ATC (CM-1 had instructed CM-2 to tell the controller that they were, "…ready") may have confused the CM-1, it did not have an impact on the situation awareness of CM-2 and CM-3."

Issue 2:

CAA Issues and Discussion

The 2nd paragraph indicates that when the flightcrew was asked about their mental picture of what a normal CAT II runway should be, they responded that a closed runway should be black and the runway should not be illuminated. In addition, the crew commented that there should be obstruction lights and barricades for the work-in-progress area, and lighted no-entry signs at the beginning of the runway." These are not entirely correct statements. According to the flight crew interviews, only CM-2 and CM-3 were asked this question but not CM-1. Furthermore, CM-2 and CM-3 did not give entirely the same answers. For example, CM-2 did not mention barricades or illuminated no-entry lights. Therefore, implying that the flight crew all shared this same impression or mental model of a closed runway is incorrect and unfounded. Also, it was noted earlier that none of the flight crew was asked what a CAT II runway should look like. Therefore, it is unknown what their actual "expectation of the runway picture" was at the time of the accident.

CAA Proposed Changes

It is suggested that this paragraph be revised and the following text inserted as follows after the words, "were still available for taxi.":

"When queried about their mental picture of a closed Runway 05R, CM-2 and CM-3 stated that a closed runway should not be illuminated and should have warning lights. In addition, CM-3 commented that there should be barricades for the work-in-progress area and lighted no-entry signs. This question was not asked of the CM-1, and it could not be determined whether he too had the same impression of a closed runway. Regardless, all three flight crew members were aware of the NOTAM indicating that Runway 05R was available for taxi operations only on the night of the occurrence."

✈ Section 2.5.7.7.1 Confirmation Bias [2 issues]

Issue 1:
Ref: As noted.

CAA Issues and Discussion

The first paragraph in this section ends with the statement that, "Essentially, the crew may only seek information that confirms their present interpretation of the runway." Consequently, this is the reason why formal procedures and checklist are used in complex systems such as aviation. They are utilized to overcome nuances and idiosyncrasies of human behavior. The FAA stated in its Advisory Circular (AC) that "before entering a runway for takeoff, the flight crew should verbally coordinate to ensure correct identification of the runway." This was intended as tool to provide a safety barrier against confirmation biases, hasty decisions, and loss of situational awareness. However, as noted in section 2.5.4.4, SIA did not have such procedures in place.

CAA Proposed Changes

It is suggested that the following text be added to the end of the first paragraph:

"Procedures and checklist are often used in complex systems such as aviation to overcome these nuances and idiosyncrasies of human behavior. Consequently, the FAA stated in its Advisory Circular (AC) that "before entering a runway for takeoff, the flight crew should verbally coordinate to ensure correct identification of the runway" in order to provide a safety barrier against confirmation biases, hasty decisions, and loss of SA. However, as noted in section 2.5.4.4, SIA did not have such procedures in place."

Issue 2:

CAA Issues and Discussion

The second paragraph in this section includes a statement that "The crew also believed the timing of the Air Traffic Control clearances for taxiing into position and hold and takeoff seemed to confirm that they were in the correct location for takeoff." This statement is inaccurate. Only CM-1 made this statement. CM-2 understood the timing of this statement, because he is the one who asked for the clearance. CM-3 stated in his interviews that he was not under the impression that ATC tower could see them.

CAA Proposed Changes

The statements should be modified to read "CM-1 stated that the timing of the Air Traffic Control clearances for taxiing into position and hold and takeoff seemed to confirm that the aircraft was in the correct location for takeoff." However, CM-2 likely understood the timing of the ATC clearances, because he was the one who made the requests. CM-3 also stated in his interviews that he was not under the impression that ATC tower could see them."

✈ Section 2.5.7.8 Summary [2 issues]

Issue 1:
Ref: Final sentence of first paragraph.

CAA Issues and Discussion

The last part of the final sentence is too conjectural to be considered analysis. Recast the sentence to remove the conjecture.

CAA Proposed Changes

The final sentence should read:

"If runway guard lights or stop bars or densely spaced centerline lighting along Taxiway N1 had been provided, they would have increased the conspicuity of the Runway 05L holding position and would have increased the probability that the crew would have been alerted to the location of Runway 05L."

Issue 2:
Ref: Last paragraph of the section.

CAA Issues and Discussion

The paragraph could be restructured to increase accuracy and eliminate conjecture.

CAA Proposed Changes

Beginning with the third sentence:

"The crew was experienced in night operations and was familiar with runway and taxiway lighting. They were aware that taxiway centerline lighting is green and runway lights are white or near white. There was nothing in the workload that should have impeded the crew's processing of runway configuration information. When CM-1 elected to takeoff, he could see an adequate distance down the runway, and none of the visual cues prompted him to realize his error. Finally, the contrary cockpit instrument indications (PFD &PVD) were not resolved by the crew.

Additionally, the CM-1 stated that the timing of the Air Traffic Control clearance for taxiing into position and holding and takeoff seemed to confirm that they were in the assigned position for takeoff. However, this perception should be balanced against the known difficulties in recounting events accurately following an accident."

✈ Section 2.5.8 Additional Human Factors issues – An Elaboration of Factors Influencing the Flight Crew during Taxi from NP to Runway 05R

CAA Issues and Discussion

This section appears to include more exploration and conjecture than it does the analysis of facts that are known to have played a role in this accident. Furthermore, the series of sections from 2.5.8.2 through 2.5.8.5 are almost entirely speculation.

COMMENT ONLY, FOR CONSIDERATION BY THE AUTHORS

✈ Section 2.5.8.1 Time Pressure to Take-Off Before Typhoon Was Closing

Ref: Second to last sentence.

CAA Issues and Discussion

Accuracy could be increased and conjecture could be removed from the last part of the paragraph.

CAA Proposed Changes

The second to last sentence should read:

"It could not be determined whether the crew's concerns about the approaching typhoon enticed them to hasten their departure to the point where they did not make appropriate checks to identify and confirm that they were on the assigned runway."

The last sentence should be deleted.

✈ Section 2.5.8.2 Attention Allocation, Workload, and Situation Awareness [2 issues]

Issue 1:
Ref: General to section.

CAA Issues and Discussion

In this section, the report states that "Under high workloads,…individuals may load shed to the point that important information is not given priority or not fully examined. Furthermore, scanning of information may be scattered and poorly organized." While this statement may be true, the report should also point out to the reader that this is why the aviation industry requires more than one pilot to fly the airplane, so that the pilots can share the workload and monitor each other's actions and maneuvers. Given that there were three crew members on this particular flight rather than the normal two, should have helped reduce the workload in the cockpit on the night of the accident.

CAA Proposed Changes

Since the report attempts to educate the reader on situation awareness and workload, it should also educate the reader on what the industry has done to place barriers in place to prevent the occurrence of such performance decrements. The report should include the following text to provide clarity and enhance the discussion:

"The aviation industry is aware of the possible problems that can arise from high workload in the cockpit. This is the reason why more than one pilot is often required to fly an airplane, so that the pilots can share the workload and monitor each other's actions and maneuvers. Given that SQ006 had three flight crew members in the cockpit, rather than the required two, should have helped reduce the workload in the cockpit on the night of the accident."

Issue 2:

CAA Issues and Discussion

This section also contains the statement "Interview and CVR data showed that the pilots experienced high workload induced by taxiing in the severe weather conditions, cockpit tasking and planning." Again, the term "high workload" is used to imply that this flight crew experienced an exorbitant amount of workload that was above the workload experienced by any other flight crew that departed CKS around the time of the accident. However, there are no facts offered to support this assertion. Furthermore, the CVR data does not "show" that pilots experienced high workload. Rather, it reveals that pilots were having difficulty managing the workload that they were experiencing. Given SQ006 was operating with three flight crew members, rather than the required two flight crew members, severely undermines the validity of this analysis.

CAA Proposed Changes

It is suggested that the discussion be modified to read:

"Interview and CVR data indicated that the pilots had difficulty managing the workload induced by taxiing in the severe weather conditions, cockpit tasking and planning."

Additionally, we also recommend that the term "workload" be clearly defined and its use carefully re-examined throughout the entire report.

Following the third sentence, insert:

"The PVD is a simplified form of head-up display and is designed to be captured by peripheral vision while the pilot's attention is on the runway ahead of the aircraft. CM-2 did not notice any runway marking or runway signs. However, he recalled seeing lights leading onto the runway and CM-1 following the lights onto the runway. CM-2 stated that he saw bright lights in the middle of the runway."

✈ Section 2.5.8.3 Pattern Matching

Ref: General to section

CAA Issues and Discussion

The report states that "the flight crew believed that Runway 05R was Runway 05L because their mental pictures lead them to believe that Runway 05R was a normal runway at night." However, as stated previously, given the pilots' CAT III training and experience, and the recency in which they discussed the runway information, the flight crew should have expected to see a "normal picture" of a CAT II runway. However, they were never asked about what such a normal CAT II runway should look like during the interview process. Therefore, it is unknown what their actual knowledge was at the time of the accident. Nonetheless, the fact they interpreted 05R as the CAT II Runway 05L, suggest that their mental picture of a normal CAT II runway was inaccurate.

The last sentence in this section also states, that "…it is normally not necessary to devote a large component of the residual attention resources to the matching process to see if the runway is in fact the correct runway for takeoff." However, the report fails to add that in keeping with the best practices in the industry, it is customary for flight crews to verify that they are on the correct runway prior to takeoff in order to avoid any problems that might arise from the pattern matching process.

CAA Proposed Changes

This whole section is entirely speculative and conjectural and should be deleted from the report. If the ASC believes that it should remain, a sentence at the end of the section should be added that reads:

"However, in keeping with the best practices in the industry, it is customary for flight crews to verify that they are on the correct runway prior to takeoff in order to avoid any problems that might arise from the pattern matching process."

✈ Section 2.5.8.4 Taxiway Lighting Issues

Ref: Paragraph 4 which ends with "from NP onto Runway 05R."

CAA Issues and Discussion

This section of the report states that "…it is possible that CM-1 inadvertently reverted to the most dominant previously formed mental model under high workload to follow the green taxiway centerline lights, which generally takes him to where he is supposed to go, and he reverted to this habit while turning from NP onto Runway 05R." Again, this statement is highly speculative and there are an unlimited number of "possible" human factors issues that could be discussed. Furthermore, there is no evidence that what is describe here is CM-1's "most dominant previously formed mental model." As indicated in footnote 58, the majority (56%) of the airports that CM-1 operated into during the two months prior to the accident were NOT equipped with "follow the green systems."

CAA Proposed Changes

This section should be deleted from the report. However, if the ASC believes it should remain, the following text should be added:

"Although the Safety Council considered possible pattern matching issues, there was no way of knowing what the most dominant previously formed mental model would have been for the flight crew and therefore, no conclusions could be made."

Such a statement is already included in section 2.5.8.5 on airport layout.

✈ Section 2.5.9 Water-affected Runway Issues

Ref: Paragraph 4, which ends with "all runways are the same"

CAA Issues and Discussion

SIA could have given its pilots a practical means of using the rainfall rate to assess whether a runway is contaminated. By the practices adopted by some other carriers, the runway would have been determined contaminated.

CAA Proposed Changes

Add at the end of the paragraph the following text:

"While SIA had established a conservative measure for determining when a runway was contaminated, they did not convey a practical means to their pilots to make the determination, which largely defeated the effect of the company standard."

✈ Section 2.5.9.1 SIA Crosswind Limitation and Runway Condition Determination Procedure

Ref: General to the section.

CAA Issues and Discussion

Based on the wind information presented in Table 1.7-1, the wind condition recorded by the AWA at 23:14, 23:15, 23:16 and 23:17 were, 018 degrees at 56 knots, 029 degrees at 59 knots, 013 degrees at 59 knots and 360 at 41 knots. The crosswind magnitude (also cited in Table 1.7-1) as calculated by the ASC for the same time period were from the left side of runway at 29 knots, 20 knots, 34 knots and 31 knots respectively.

The flightcrew received several wind updates from the controller prior to commencing the takeoff. The controller issued SQ006 a takeoff clearance at 23:15:22, and reported the wind to be 020 degrees at 28 knots, gusting to 50 knots. There was no discussion among the crewmembers regarding the crosswind limitations based on the latest wind conditions. Further, the CM-1 did not commence the takeoff until 23:16:44, or 1 minute and 22 seconds after the last wind report.

Based on the wind conditions reported by the controller at 23:15:22, the recorded AWA wind condition at 2316 (013 degrees at 59 knots) and the crosswind magnitude of 34 knots calculated by the ASC, it is highly probable that the flightcrew departed in conditions that exceeded the SIA crosswind limitation of 30 knots. Additionally, the wind conditions may have also precluded the flightcrew from using CKS Airport as their "alternate" because the conditions would have exceeded the landing limitations.

CAA Proposed Changes

Based on the factual information presented, it is suggested that the crosswind values be re-validated and that the wind direction and magnitudes, as recorded from both the AWA and the provided to crew by the controller at 23:15:22 be used to determine if the flightcrew attempted to operate in wind conditions that exceeded the limitation imposed by the aircraft manufacture and SIA.

If the crosswind limitation was exceeded, then the report should be modified with a brief analysis of the information and an appropriate 'Finding' included.

✈ Section 2.5.10 Crew Coordination

Ref: One paragraph section.

CAA Issues and Discussion

The paragraph can be made more accurate and comprehensive.

CAA Proposed Changes

The flight crew's dismissal of the PVD in concert with not referring to the Primary Flight Display eliminated two of the last lines of defense to ensure during the final stage before takeoff that the aircraft was in position on the assigned runway. The CVR transcript indicated that CM-2 questioned the lack of a PVD indication while the aircraft was turning onto Runway 05R. CM-1 and CM-3 then engaged in the following discussion regarding the PVD: CM-1 stated: "Yeah, we gotta line up first," followed by CM-3 stating, "We need 45 degrees." The CM-1 continued, "Not on yet PVD, never mind, we can see the runway, not so bad."

After SQ006 lined up on the runway, the 3 pilots did not resolve why the PVD did not unshutter. CM-2 did not continue to resolve the unshuttered PVD indication nor did CM-1 and CM-3 attempt to support or resolve this issue. This indicated the flight crew did not apply basic CRM principles in resolving a critical operational problem. In addition, they did not employ 'rule of thumb' cross checks on visibility by counting edge lights or asking for strength five lighting. The opportunity was lost to discover that the aircraft was not on the appropriate runway and was not within the usable signal of the preset ILS.

✈ Section 2.6.1 SIA Crewmember's Emergency Evacuation Operations and Training

Ref: Paragraph 2, which ends "declare emergency evacuation."

CAA Issues and Discussion

A little more credit could be given to the crew for initiative during the evacuation.

CAA Proposed Changes

Add to the end of the paragraph, the following text:

"Some did use what was immediately available such as flashlight beams to direct survivors to exits and they made some use of deflated slides as a form of exit ladder."

✈ Section 2.6.4.3 Work Designation and Human Resources in Rescue Operations of Fire Fighters

Ref: General to section.

CAA Issues and Discussion

The CKS firefighting capability should be seen in light of the total resources available. The surrounding communities provide significant supplementary vehicles and personnel, which is not the case at numerous other airports.

CAA Proposed Changes

Add the following text to the second to the last paragraph:

"Several communities around the CKS airport provide supplementary firefighting equipment and personnel as required. These readily available resources should be factored in when assessing the operational firefighting capability of the airport. The on airport fire fighter numbers may be low, but the airport appears to be well covered when nearby available resources are added."

✈ Section 2.7.2 Airport Incident Reporting and Tracking

Ref: Last paragraph of the section.

CAA Issues and Discussion

There is a very important point to be made here that is different from the ASC recommendation.

CAA Proposed Changes

It is well known in countries that have fairly long experience with independent accident investigation bodies that flight and ground crews together with ATC personnel are much more likely to report on incidents if the report can be made to someone other than the regulator and preferably to the independent accident/incident investigation authority. The fear of prosecution associated with reporting incidents to the regulator leads to significant underreporting. The ASC will seek authority to develop an incident reporting system.

Part 4

Representations on Section 3, Conclusions

<u>Section 3 Conclusions</u>

Ref: Second paragraph, which ends "leading to the accident."

<u>CAA Issues and Discussion</u>

There is a logic problem with the highlighted title, 3.1 Findings Related to Probable Causes. When a group of things happened or almost certainly happened the word 'probable' is not necessary or even desirable. Those elements that are shown to have operated are beyond the concept of being probable. The term 'probable' could be applied to those that almost certainly operated. However, the definition of the term, as developed by the ASC and shown in Para 2 of the 'Conclusions' section includes both certain and highly probable events, and it would be much preferable to drop the word 'probable' and make the title "Cause Related Findings".

<u>CAA Proposed Changes</u>

Make the heading: Cause Related Findings in both section 3 and section 3.1

✈ <u>Section 3.1 Finding Related To Probable Causes</u>

<u>Finding 1</u>

<u>CAA Issues and Discussion</u>

The information presented in Finding No. 1 is confusing because it states the wind condition at the time of the accident was from 020 degrees with a magnitude of 36 knots, gusting to 56 knots, and the values are not attributed to a specific location on the airport. However, Table 1.7-1 indicates the wind condition at 2317 for "runway 05" was " 360 degrees at 41 knots with a crosswind magnitude of 31 knots. The Table does not state whether these values are for runway 05L or 05R. Further, the Table does not represent the wind gusts that also occurred during that period and that would have had to be factored into the flight crew's determination of headwind and crosswind limitations for the "wet" runway.

The variance in these values is significant because the reduced steady-state wind conditions are "more acceptable" and well within the SIA operating limits. However, as the CM-3 has stated in his interview, he was concerned the wind conditions were at values that were close to the SIA maximum limit when they began their takeoff.

Additionally, refer to CAA discussion addressing Section 2.5.9.1, SIA Crosswind Limitation and Runway Condition Determination Procedure for additional information about the wind values.

CAA Proposed Changes

The CAA proposes that the factual text in Section 1.7 be accurately reflected in Finding No. 1. Additionally, expand as necessary to discuss whether the flightcrew attempted to depart in crosswind conditions that exceeded both the manufacturer and SIA limitations.

✈ Section 3.1 Finding 4

CAA Issues and Discussion

Finding No. 4 is correct, but contains a very long sentence that could be re-written for clarity.

CAA Proposed Changes

It is suggested that following revision be made:

The flight crew had CKS Airport charts available and the CM-2 and CM-3 initially monitored the progress of the flight immediately after departing the parking bay. However, as the flight approached Taxiway N1 from NP, both crewmembers diverted their attention to other tasks and CM-1 made a continuous turn from N1 on Runway 05R. The flight crew did not verify their taxi route in accordance with the airport chart, which would have shown the need to make a 90 degree turn from Taxiway NP and then taxi straight ahead for a distance of 210 meters on Taxiway N1, rather than to make a continuous 180 degree turn onto Runway 05R. Further, none of the flight crewmembers confirmed orally whether the runway they entered was Runway 05L. (1.18.1.1; 2.5.2.2; 2.5.4.3).

✈ Section 3.1 Finding 5

CAA Issues and Discussion

The report states that "The flight crew did not build a mental picture of the taxi route to Runway 05L that included the need for the aircraft to pass Runway 05R before taxiing onto Runway 05L." However, this statement should be made in behavioral terms that allow interventions to be developed.

CAA Proposed Changes

The finding should be restated as "The flight crew did not review the taxi route in a manner that was sufficient to ensure that they all understood that the route to Runway 05L, including the need for the aircraft to pass Runway 05R, before taxiing onto Runway 05L."

✈ Section 3.1 Finding 6

CAA Issues and Discussion

The report states, that "…runway conditions subtly influenced the flight crew's decision making and ability to maintain situation awareness." The use of such human factors terms as "situation awareness" should be avoided in finding statements, since most readers will not be familiar with the true meaning of the term.

CAA Proposed Changes

The statement should be reworded to read: "The moderate pressure to depart before the inbound typhoon closed in around CKS Airport, and the fairly high workload of taking-off in low visibility and slippery runway conditions, subtly degraded the flight crew's decision-making and their ability to monitor and maintain awareness of their location along the taxi route."

Section 3.1 Finding 7 [2 issues]

Issue 1:
Ref: List of bullets.

CAA Issues and Discussion

The seventh bullet is qualified by the words "if the runway edge lights were on." This is unnecessary, as the aircraft landing lights would have illuminated the surface well enough to make the width difference apparent. The eighth bullet should be introduced by the word "Significant." The introductory word following the ninth bullet should be corrected from "Parallel" to 'Para.' Wording associated with the tenth bullet should be supplemented to show what the PFD did show.

CAA Proposed Changes

End the wording following the seventh bullet at the coma between the words "05R" and "if". Start the wording after the eighth bullet with the word 'Significant." For the ninth bullet the introductory word should be "Para". Add to the end of the wording associated with the tenth bullet "which showed the aircraft to the right of the assigned runway."

Issue 2:

Ref: Final two sentences of the finding.

CAA Issues and Discussion

The last two sentences state, "The flight crew did not comprehend the available information. They lost situation awareness and commenced takeoff from the wrong runway." Again, the use of the term "situation awareness" is not informative in this context.

CAA Proposed Changes

The statement should read "The flight crew did not comprehend the available information and were therefore unaware that they were actually on Runway 05R. Since they did not utilize the many visual cues available to verify which runway they were actually on, they commenced takeoff from the wrong runway."

✈ **Section 3.2 Findings 1 & 2 [2 issues]**

Issue 1:

CAA Issues and Discussion

Finding 1 should be moved to "Other Finding." According to CAA guidelines for the control of air traffic, the primary purpose of the air traffic control system is to prevent a collision between aircraft operating in the system. On the evening of the accident, the only aircraft operating at CKS Airport was SQ006, and the flight crew taxi normally within ground controller' s responsible area. Therefore, in the professional judgment of the air traffic controller, there was no possibility of a collision between SQ006 and any other aircraft operation. Additionally, this finding has no direct relation to the accident or cause of the accident. Furthermore, Finding 1 is considered an element that has the potential to enhance aviation safety rather than considered a safety deficiency or an unsafe condition or act. The weather related findings lead off the findings in 3.1, so for consistency, finding 2 could be moved to 6.

CAA Proposed Changes

Move finding 1 to "Other Finding" & finding 2 to have it become finding 6.

Issue 2:

CAA Issues and Discussion

As discussed in the Factual and Analysis, the ATP-88 requires the controller to issue progressive taxi instructions if requested by the pilot. Further, the ATP-88 makes it optional for the controller to issue progressive taxi instruction if a request is not received from a pilot. Therefore Finding No.1 should reflect this information.

CAA Proposed Changes

It is suggested that Finding No. 1 be revised as follows:

The local controller provided the flightcrew of SQ006 with a precise taxi routing and was not required to provided progressive taxi instructions unless requested by the pilot. Although, the ATP-88 permitted the controller to exercise judgment in providing progressive taxi instructions if he did not receive a request from the flightcrew, the controller did not use the required low visibility taxi phraseology to inform the flightcrew to slow down during taxi.

✈ Section 3.2 Finding 4 (original number)

CAA Issues and Discussion

The finding should be amended to increase its accuracy and to note that other carriers have effective procedures. NOTE: This finding may need to modified if it is determined that the CM-1 attempted the takeoff in crosswind conditions that exceed the manufacture and SIA limitations.

CAA Proposed Changes

Revise the finding to read:

"The SIA crosswind limitation for a "wet" runway was 30 knots and for a "contaminated" runway was 15 knots. CM-1 assessed that the runway condition was "wet" and determined that the crosswind was within company limitations. The lack of equipment and procedures for quantitatively determining a "wet" versus "contaminated" runway creates ambiguity for flight crews when evaluating takeoff crosswind limitations. (1.18.4; 2.5.9) By the practices adopted by some other carriers, the runway would have been assessed as contaminated."

✈ Section 3.2 Finding 5 (original number)

CAA Issue and Discussion

Finding No. 5 may need to be revised based on the discussion in Section 1.17.3.2.

CAA Proposed Changes

The CAA proposes that Finding No. 4 be revised to reflect any changes to the discussion found in 1.17.3.2.

✈ Section 3.2 Finding 8 (original number)

CAA Issue and Discussion

Finding No. 8 states "It is possible that CM-1 inadvertently reverted to the most dominant mental model…"

CAA Proposed Changes

As stated previously in the Analysis, this conclusion is entirely speculative and not supported, and therefore should be deleted from the findings.

✈ Section 3.2 Finding 9 (original number)

CAA Issues and Discussion

For accuracy add a reference to the PFD.

CAA Proposed Changes

Reword finding to read: "SIA did not have a procedure for the pilots to use the PVD or the PFD…"

✈ Section 3.2 Finding 11 (original number)

CAA Issues and Discussion

For accuracy add a reference to the PFD.

CAA Proposed Changes

Reword finding to read: "SIA procedures and training documentation did not ensure that the approved B747-400 AFM supplement regarding use of the PVD and the PFD . . ."

✈ Section 3.2 Finding 13 (original number) [2 issues]

Issue 1:
Ref: Accuracy wording in finding.

CAA Issues and Discussion

Reword the finding to increase its accuracy.

CAA Proposed Changes

Reword finding to read: "The deficiencies in SIA training and procedures for low visibility taxi operations did not ensure that . . ."

Issue 2:
Ref: Possible revision consequent on review of factual records in Taiwan.

CAA Issues and Discussion

Finding No. 13 may need to be revised based on the discussion in Section 1.17.3.2.

CAA Proposed Changes

The CAA proposes that Finding No. 13 be revised to reflect any changes to the discussion found in 1.17.3.2.

✈ **Section 3.2 Finding 14 (original number)**

CAA Issues and Discussion

There is a logic problem in that the second sentence does not necessarily follow from the first.

CAA Proposed Changes

If the 'Therefore' is replaced by an 'and' it will be OK**.**

✈ **Section 3.2 Finding 16 (original number)**

CAA Issues and Discussion

Several adjustments are required to increase the accuracy of the finding.

CAA Proposed Changes

Revise the first sentence " there were a number of items …" change to "there were several items …".

Revise the second sentence of the introductory paragraph to read: A standardized environment could have contributed to the situation awareness of the SQ006 flight crew while taxiing to Runway 05L for takeoff.

The second paragraph is too speculative for a finding and should be deleted.

The following changes are proposed for the list of bullets:

The first bullet item should be revised to read: The green centerline lights leading from Taxiway NP onto Runway 05R were more visible than the Taxiway N1 centerline lights leading toward Runway 05L because they were more densely spaced. In order to meet the most recent (1999) ICAO recommendation, there should have been 16 centerline lights spaced 7.5m apart along the straight segment of Taxiway N1 where the curved Taxiway centerline markings from Taxiway NP meet Taxiway N1 up to the Runway 05L holding position. (1.10.3.2.4; 2.3.1.2.2)

The second bullet item should be revised to read: Taxiway N1 centerline marking of CKS Airport met the latest version of ICAO and FAA specifications. (1.10.3.1.3; 2.3.1.1)

The fourth bullet item should be moved to "Other Finding." The lack of stop bar or guard light is unrelated to flight crew's judgment in this event, because if flight crew should have expected the existence of stop bar or guard light before Runway 05L, they would not have taken off on Runway 05R in the absence of them. On the other hand, the AIP already indicated the lack of stop bar and guard light and flight crew should not have expected to rely on them to identify the correct runway.

The seventh bullet item should be revised to read: Although the flight crew was aware that Runway 05R was closed, there were no runway-closed markings in the area where SQ006 entered Runway 05R, nor would it have been practical to have put them there. (1.10.4.2)

The ninth bullet item should be revised to read: In accordance with CKS ATC procedures, simultaneous use of the Runway 05R edge lights and the taxiway centerline lights were not permitted, and the ATC Ground controller and the tower controller coordinate and manually select the appropriate lights for the specific operation being conducted on the runway. However, there was no interlocking system installed at CKS Airport to preclude the possibility of simultaneous operation of the runway lighting and the taxiway centerline lighting. (1.10.5.1.1; 2.3.1.2.1)

The tenth bullet item should be revised to read: The serviceability monitoring mechanism of the CKS airfield lighting system was accomplished both electronically and manually. However, there was a lack of a continuous monitoring feature of individual lights, or percentage of unserviceable lamps, for any circuit for CKS Airport lighting. (1.10.5.1.2)

The eleventh bullet item should be revised to read: ASDE is designed to enhance airport ground operations in low visibility. There is no requirement for installation of Airport Surface Detection Equipment (ASDE) at CKS Airport. The Safety Council was not able to determine whether ASDE would have provided information to the ATC controllers about SQ006 taxiing onto the incorrect runway because of the attenuation of the signal from heavy precipitation that diminishes the effectiveness of the radar presentation. (1.18.2.4; 2.4.2)

Section 3.2 Finding 18 (original number)

CAA Issues and Discussion

The finding would benefit from rewording to align it better with the facts and analysis.

CAA Proposed Changes

There was a lack of a specified safety regulation monitoring organization and mechanism within CAA that resulted in the absence of a mechanism to highlight conditions at CKS Airport for taxiways and runways lighting markings, and signage that did not meet internationally accepted safety standards and recommended practices. (1.17.9; 2.3.6)

✈ Section 3.2 Finding 23

CAA Issues and Discussion

The finding would benefit from minor rewording to increase its accuracy.

CAA Proposed Changes

The main deck mid cabin from row 31 to 48 was not survivable during this accident due to fuel tank fire and explosion. Sixty-four out of 76 passengers died in this area. All passengers in tail section survived where there was much less fire damage. (1.2)

✈ Section 3.2 Finding 25

CAA Issues and Discussion

Minor word change is justified to recognize the efforts of the cabin crew in difficult circumstances.

CAA Proposed Changes

The crewmembers did some improvising to assist with the emergency evacuation when the Public Announcement (PA) system was found inoperative. (1.15.1.2; 2.6.1)

✈ Section 3.2 Finding 31

CAA Issues and Discussion

1. The CKS Airport have had an Emergency Medical Treatment Procedures with CAA medical center in charge of all the emergency medical services since its opening to service in 1979.
2. After the withdrawal of CAA medical center from the airport in 1995, various supporting contracts with Chan Gan Memorial Hospital in Lin Kou , Branch of Ming Shen Hospital in Da Yuan and some other major hospitals in the neighborhood were signed for emergency operations and also with the Ming Shen Hospital setting up airport medical clinic to pick up the services left over.
3. With all the related medical treatment commissioned to the contracted airport clinic and also being accepted as one of the local emergency medical network, the said plan and procedures developed at this airport was not only well extended, but also marked in a form of appendix in our emergency plan.
4. In hope of mobilizing all the available sources effectively for the potential heavy casualties, Min Shen Hospital established its own Emergency Medical Treatment Measures for major massive casualties.
5. According to our Airport Civil Aircraft Accident Handling Procedures and Regulations, once the medical team of the airport clinic gets informed on the accident at the airport, it should act and report immediately to the accident site, setting up interim triage in the neighborhood and beginning operations as required in the plan. As said in the contract it should also coordinate and help those from the local hospitals and medical network to carry out the earliest medical treatment and rescue.

6. As specified in our Medical Treatment Procedures, the command job resides first with the airport clinic doctor, then it will be passed over to the arriving doctor from the Da Yuan Branch, then in sequence to the Chan Gan , and finally falls with the Chief of the County Health Bureau or his agent.

CAA Proposed Changes

In light of these observations, it is proposed that the findings be deleted.

✈ Section 3.2 Finding 32

CAA Issues and Discussion

1. In response to adverse weather conditions, we have formulated our own specific plan against the most threatening typhoon namely the CKS Airport Typhoon Precaution and Handling Measures, which expresses well all the duty and equipment assigned for the individual team of the interim taskforce.

2. When the moment comes, all the members of the taskforce will be called upon to stand by as required to meet the potential situations and thus help lower the risk to the minimum effectively.

CAA Proposed Changes

In light of these observations, it is proposed that the findings be deleted.

✈ Section 3.2 Finding 33

CAA Issues and Discussion

1. We have collected in hand the medical rescue capacity in the neighboring Taoyuan area and affixed it in no.4 to our civil aircraft accident handling procedures as an important reference material.

2. The policy taken in the early stage was to move the injured to the hospitals for better care, then the commander center of the local medical network will take over to monitor all the injured get best treated according to the status of each patient and the facilities and specialty provided of various hospitals.

CAA Proposed Changes

In light of these observations, we propose deleting the item.

✈ <u>Section 3.2 Finding 36</u>

CAA Issues and Discussion

The finding should be reviewed in the light of supplementary firefighting resources in the area.

<u>CAA Proposed Changes</u>

The fire-fighting department was understaffed in handling a major accident (1.14.1.2;1.15.3.2; 2.6.4.3). While technically correct, this should be reviewed in light of the large amount of close-by support, which is not available at many other airports.

✈ <u>Section 3.3 Other Findings Finding 12</u>

<u>CAA Issues and Discussion</u>

There is a minor departure from the ICAO standard in expressing injuries to persons.

<u>CAA Proposed Changes</u>

Combine the totals for minor and none.

✈ <u>Section 3.3 Finding 18</u>

CAA Issues and Discussion

1. Under the effect of severe weather, the medical rescue couldn't be conducted as usual in accordance with CKS Airport (not CAA regulations) procedures. In the early stages after the accident, some of the injured were given first aid while on the way to the hospitals, for those seriously injured we provided EMT members as escorts. As for those slightly injured, we sent our transport to carry them to hospitals for further care.

2. Later on we set up the interim medical center at A9 the flight operation office. All the doctors and nurses from both the contracted hospitals and local medical network checked in one after another and came into service immediately.

<u>CAA Proposed Changes</u>

CAA proposes that the ASC revise the Finding to reflect CKS Airport procedures and delete "CAA Regulations". Furthermore the Finding should be amended in light of the additional information.

✈ <u>**Section 3.3 General**</u>

CAA Issues and Discussion

The Findings in the three different sections are very complete and provide a significant amount of detail regarding the accident. There are several areas where findings could be combined without disrupting the meaning or intent, yet would serve to reduce the overall length of the findings section. An example of this would be to combine both the flight and cabin crew statement regarding the fact that they were both qualified in accordance with SIA standards, etc.

<u>***CAA Proposed Changes***</u>

It is suggested that the findings be reviewed to determine those findings that could be combined to reduce the overall number of findings without losing the intent of the ASC's assertions.

Part 5

Representations on Section 4, Safety Recommendations

✈ Section 4 To CAA Recommendation 2

CAA Issues and Discussion

Suggest the ASC qualify the priority in the light of other priorities

CAA Proposed Changes

Amend the finding as follows: Place appropriate priority on budgetary processes and expedite, if justified, the procurement and installation of ASDE at airports with high traffic volume.

✈ Section 4.1 To CAA Recommendation 7

CAA Issues and Discussion

Aviation safety would be better served by broadening the recommendation.

CAA Proposed Changes

Delete the words ". . . for enhancing air traffic controller's abilities . . . "

✈ Section 4.1 To CAA Recommendation 11

CAA Issues and Discussion

The responsibility for post accident/incident testing is currently the responsibility of the "Prosecutor" and the ASC, in accordance with the regulator Articles. Unless a change is made to the regulation, the CAA has no authority to require these tests.

CAA Proposed Changes

Delete the Recommendation

✈ Section 4.1 To ICAO Recommendation 1

CAA Issues and Discussion

The recommendation would benefit from further definition.

CAA Proposed Changes

Add to the end of the recommendation the words: "and significant periods of adverse weather."

✈ Section 4.2 Safety Actions Taken ROC (CAA)

CAA Issues and Discussion

Please add to safety action taken under item 4.

CAA Proposed Changes

As of June 2001, the fire staff will conduct, during their respective shifts, three different missions: fire fighting, rescue and medical services respectively.

The Airport Emergency Medical Treatment Procedures are being redrafted with the recently contracted Lee Shin Hospital who will take over the remaining duties. These procedures are anticipated to be implemented by April 30, 2002.

Redefining the Emergency Radio Communication Channels as follows: CH1 for on-site command, CH2 for medical rescue Services, CH3 for executive and logistical support, CH5 for emergency rescue operations, and CH6 for firefighting. This will take effect in April 2002.

✈ Section 4.2 3. CKS Airport Facility Improvement

CAA Issues and Discussion

The following information updates the information in the ASC draft report

CAA Proposed Changes

The information is current as of March 2002 and the text, as written, could be inserted:

Bullet 1 - Painting:	-North Section construction was completed on November 27, 2001. -Taxiway centerline marking was completed January 31, 2002, in accordance with the ICAO Standards.
Bullet 2 Airport Lighting:	-Taxiway centerline lighting installation from N1 was completed January31, 2002. -Renew sign boards for runway 05/23 were completed January 31, 2002; and the sign boards for 06/24 were completed March 1, 2002. -Installation of Runway Guard Lights for runway 05/23 was completed January 31, 2002.

-Installation of yellow-green taxiway centerline lights in Runway 05/23 was completed on January 31, 2002.

Bullet 3 Airport Pavement: -Taxiway S1-S2 indicating boards base adjustment was completed July 31, 2001.

-Appropriate sections of Runway 06/24 and related taxiway resurfacing was completed July 31, 2001.

-Appropriate sections of Runway 05/23 and related taxiway resurfacing was completed January 31, 2002.

{NEW} – completed repainting and repositioning of "hold" lines on N1 through N11 taxiways with pattern "A" on January 31, 2002.

✈ Section 4.2 5. Improvement to Air Traffic Control System

CAA Issues and Discussion

The CAA established new "Low Visibility procedures, AIP A002C003/02, effective February 1, 2002, for operations at the Taipei/CKS international Airport.

CAA Proposed Changes

Add new bullet: The CAA established new "Low Visibility procedures, AIP A002C003/02, effective February 1, 2002, for operations at the Taipei/CKS international Airport.

✈ Section 4.2 Safety Action Taken - New Item 6

CAA Issues and Discussion

Add actions taken subsequent to the previous draft.

CAA Proposed Changes

Improvements to CKS Emergency Communications
To respond to the potential emergency situations, CKS Airport has redefined the use for radio communication channels as thus:

- CH1 for on-site command operations (459.2MHZ).
- CH3 for executive and logistical supports. (467.15MHZ)
- CH6 for fire fighting and rescue operations. (462.75MHZ).

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航空器失事調查報告

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