出國報告（出國類別：進修）

赴美國參加國家運輸安全委員會
航空器失事調查基礎訓練報告書

服務機關：行政院飛航安全委員會
姓名職務：資深失事調查官／賓立亞
副工程師／郭嘉偉
派赴國家：美國華盛頓特區
出國期間：民國 100 年 9 月 12 日至 9 月 23 日
報告日期：民國 100 年 11 月 23 日

目次

壹、目的

航空器失事調查訓練係培育飛安會飛航事故調查員之重要基本訓練科目之一，歷年來本會皆編列預算安排新進技術同仁赴國外訓練機關（構）接受該訓練。本次訓練之目的爲學習先進國家調查機構之運作模式、法規背景、調查經驗，以及相關專業領域蒐集事故資料之方向及基本技能。

美國國家運輸安全委員會（National Transportation Safety Board，以下簡稱NTSB）之訓練中心爲國際知名之事故調查訓練機構，其每年皆辦理「基礎航空器失事調查（Basic Aircraft Accident Investigation Course）」訓練兩次，每次課程爲期兩週，並開放給其他國家之調查人員參加。

課程中除說明 NTSB 之組織架構與調查作業外，亦提供參訓學員航空器失事調查所需之基礎知識及技術，課程中並引用 NTSB 近年來調查之事故作爲印證，並利用過去事故之殘骸，以實際演練的方式，讓學員熟悉所學之知識及技術。

貳、訓練中心、學員與課程表

2.1 行程與 NTSB 訓練中心簡介

NTSB 訓練中心位於美國華盛頓特區郊區之雅許本（Ashburn）市，鄰近南方 10 英哩處即是華盛頓達拉斯（Dulles）國際機場（如圖 2-1），因此本次訓練的往返行程在安排上相對地直接便利。台灣與華盛頓間並無直飛航班，但國籍航空與美籍航空每日均有航班不中停前往美國西岸大城或東岸紐約市，可再轉接國內航班前往華盛頓達拉斯機場。

該訓練中心（如圖 2-2）因位於華盛頓特區之市區外，附近無便利的大眾運輸交通工具，因此建議自行租車代步；部分學員以鄰近旅館之接駁車或搭便車往返。訓練中心周遭亦無餐廳或商店，鄰近最近之商業區爲 Dulles town center，所幸訓練中心每日均提供午餐及茶點，讓學員們午休時不用舟車勞頓外出覓食。

訓練中心採無紙化環保政策，首日上課前提供每位學員一只包含所有課程資料之隨身碟，學員可以自行攜帶筆電使用課程資料，訓練中心亦提供網路，惟學員須自行攜帶網路線，無線網路僅供訓練中心職員使用。

圖 2-1　訓練中心位置圖

圖 2-2　NTSB 訓練中心外觀

2.2 學員介紹與名冊

本期學員共計 71 人，主要來自美國，包含 NTSB 新進人員、FAA 技術人員、軍方、航空公司等，除了本會兩位參訓人員外，其他有來自香港 HAECO、印尼 NTSC、加拿大龐巴迪、牙買加民航局、奈及利亞飛調會等外籍人員參訓，學員專長有航空器駕駛、維修、安全分析、工程師、飛航事故調查人員等。學員名冊如附錄一。

2.3 課程簡介

本次訓練爲期十天，課程表如下：

第一天 – 2011年9月12日 8:45 am – 5:00 pm

0845-0900 Welcome and Introduction to Academy - Dr. Paul F. Schuda
0900-1100 NTSB Mission, Operating Rules and Legal Authority – GC Robert Combs
1100-1200 Conducting an Accident Investigation: Preparation & Initiation - AS Debra Eckrote
1200-1300 LUNCH
1300-1700 Conducting an Accident Investigation: Documentation - AS Debra Eckrote

第二天 – 2011年9月13日 8:00 am – 5:00 pm

0800-1000 Conducting an Accident Investigation （Cont）: On-Scene Wrap-up, Follow-up Investigations & Preparing Reports - AS Debra Eckrote
1000-1200 Accident Site Management – AS Bob Swaim
1200-1300 LUNCH
1300-1500 Major Domestic Investigations - AS Robert Benzon
1500-1700 TWA800 Case Study／Tutorial - AS Robert Benzon

第三天 – 2011 年 9 月 14 日 8:00 am – 3:30 pm

0800-1100 Aircraft Systems & Party Perspective – Steve Miller
1100-1200 Safety Recommendations – SR Jeff Marcus
1200-1300 LUNCH
1300-1530 Turbine Engines （3.5 hrs） – AS James Hookey ／ J.P. Scarfo

第四天 – 2011 年 9 月 15 日 8:00 am – 5:30 pm

0800-1030 Survival Factors and Airports - AS Jason Fedok
1030-1230 Biomedical Issues in Accident Investigation – RE Kristin Poland
1230-1330 LUNCH
1330-1530 Weather-Related Accidents - AS Donald Eick
1530-1730 Flight Crew Operational Factors - AS David Lawrence

第五天 – 2011 年 9 月 16 日 8:00 am – 5:00 pm

0800-1000 Crash Dynamics - AS John Clark
1000-1200 Media Relations – PA Peter Knudson & AS Bill English

1200-1300 LUNCH
1300-1700 Investigative Reasoning – AS Dana Schulze & AS Dennis Hogenson

第六天 – 2011 年 9 月 19 日 8:00 am – 5:00 pm

0800-1200 Aircraft Performance – RE John O'Callaghan
1200-1300 LUNCH
1300-1500 Major Foreign Investigations- AS Frank Hilldrup
1500-1700 Recorders – RE James Cash

第七天 – 2011 年 9 月 20 日 8:00 am – 5:00 pm

0800-0930 Fracture Recognition – RE Don Kramer
0930-1200 Air Traffic Control – AS Scott Dunham
1200-1300 LUNCH
1300-1700 Cognitive Interviewing – Dr. Ron Fisher

第八天 – 2011 年 9 月 21 日 8:30 am – 5:30 pm

0830-1200 and 1300-1630

1. In -Flight Breakups and Mid-Air Collisions w／Exercise - Keith McGuire
2. Human Performance - AS Evan Byrne

1200-1300 LUNCH
1630-1730 Assisting Family Members – TDA Erik Grosof

第九天 – 2011 年 9 月 22 日 8:30 am – 3:30 pm

0830-1130 and 1230-1530

1. American Airlines Flight 587 Tutorial - AS Robert Benzon
2. Fire-Related Accidents w／Exercise – RE Nancy McAtee

1130-1230 LUNCH

第十天 – 2011 年 9 月 23 日 8:30 am – 10:30 am

0830-0930 Board Meetings & Public Hearings – AS Tom Haueter
0930-1030 Wrap-up and Presentation of Certificates

GC = Office of General Counsel
AS = Office of Aviation Safety
RE = Office of Research and Engineering
TDA = Office of Transportation Disaster Assistance
SR = Office of Safety Recommendations

參、課程重點摘要與心得

3.1 第一日課程重點與心得

- 美國 NTSB 由五位委員組成，任期五年；主任委員與副主任委員由總統提名，經國會同意任命，任期二年。現任主委爲 Ms. Deborah A. P. Hersman，現職委員如圖 3-1。 NTSB 組織架構圖如圖 3-2。

圖 3-1 NTSB 現職委員

- NTSB 前身爲民航委員會（Civil Aeronautics Board, CAB）於 1940 年依據民用航空法而成立。
- NTSB 於 1967 年由國會設立於交通部下，1975 年始轉成現行之獨立機關。
- NTSB 之法源依據爲 Chapter 11 of Title 49 of United States Code（U.S.C.）及 49 Code of Federal Regulations （C.F.R.） Part 800。
- 委員會的任務爲：透過事故調查程序，評定事故之事實及情境，判斷可能肇因，提出安全改善建議及運輸安全研究，以提升運輸安全。
- 調查對象包含：航空、鐵道、公路、油管及重大海事傷亡。
- NTSB 應調查民航及公務航空器事故，不包含軍機或國安單位之航空器。
- 當檢方或 NTSB 發現事故與犯罪行爲有關時，事故調查作業改由 FBI 負責，NTSB 轉爲輔助角色。
- 航空器事故通報及證物保存相關法規皆定義在 49 CFR 之第 830 條。

- 輔助調查團隊之權責定義於 49CFR 之第 831 條。
- 輔助調查團隊由主任調查官指定特定的單位或人員得以參加，但是僅限於能提供適當調查技術之合格人員、政府機構或民間公司爲限。
- 委員的職掌在於調查性質的報告書核准、可能肇因及做出飛航安全改善建議之決策；且可能伴隨重大事故之機動小組至現場，而成爲現場發言人。
- 工程研究部門、公關部門、家屬協助部門、飛航安全改善建議部門於調查案中扮演的角色。
- NTSB 爲事故中唯一得發布事故相關資訊之機構。

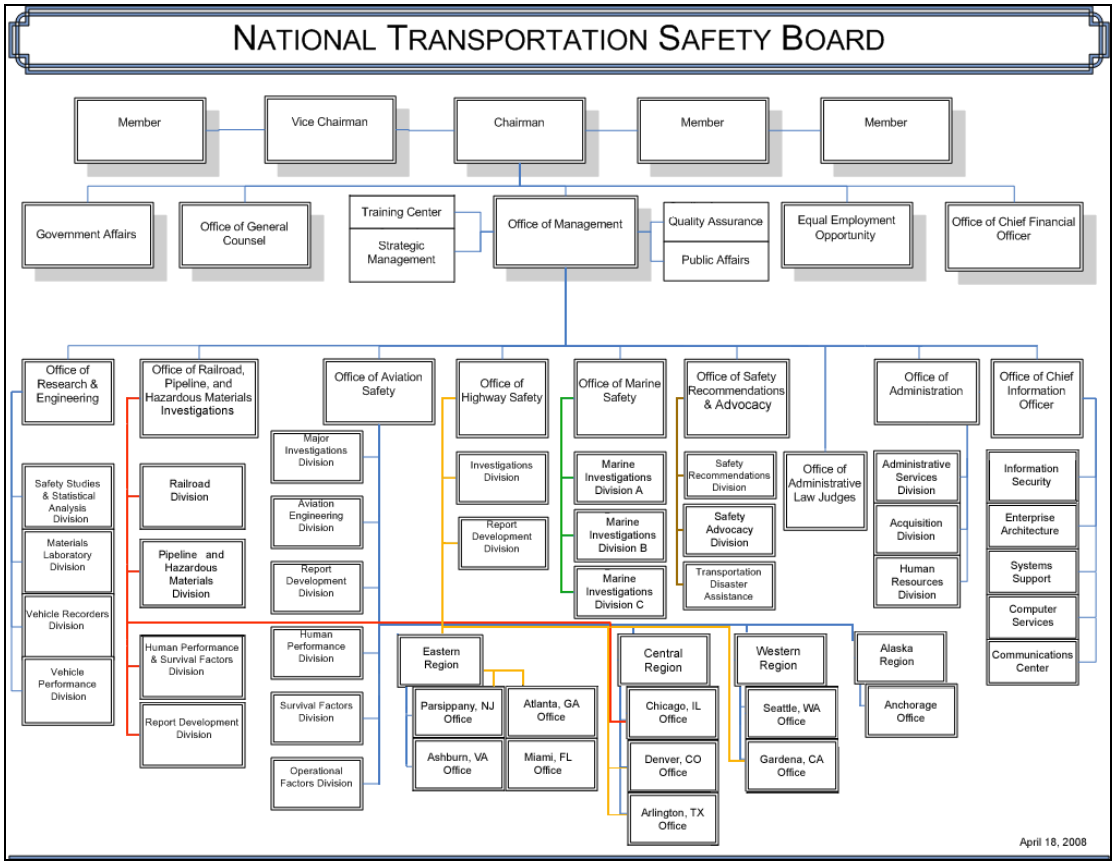

圖 3-2 NTSB 組織架構

- NTSB 訊息發布的方式。
- 事故調查程序之定義、以及了解參與失事調查的各單位之任務與責任。
- 調查團隊成員不得包含代表權利主張者或是保險公司之人員，成員均不得有法律職位。

- 國際民航組織（ICAO）簡介。
- ICAO 於 1944 年於芝加哥簽屬成立，目前共有 190 餘會員國。
- 目前我國尚無 ICAO 會籍。
- ICAO 每三年各締約國舉行一次會員會議，並推舉委員會成員。
- ICAO 秘書處其下有導航局（Navigation Bureau），航空運輸局（Air Transport Bureau），技術合作局（Technical Co-operation Bureau），法律局（Legal Bureau）和服務局（Service Bureau）。
- 國際民航組織第 13 號附約簡介，其內容乃作爲各國飛航事故調查之基本規範。
- ICAO 另外出版之調查人員所需文件：Manual of Aircraft Accident and Incident Investigation Doc. 9756，Reporting Accident Prevention Manual Doc. 9422，Accident and Incident Reporting ADREP Manual Doc. 9156。
- 瞭解主任調查官、分組召集人、調查員及授權代表與輔助調查團體人員的責任。
- 飛航事故發生時，如是超過 2,250 公斤以上之民用航空器，該締約國之事故調查機關於 30 天內須提出飛航事故初步報告（Preliminary Report）給 ICAO。
- 初步報告內容需含 ADREP 之年度統計及摘要報告（Annual Report and Summary Report）。
- 如爲 5,700 公斤以上之民用航空器事故，則在調查結束後另外需提出最終報告（Final Report）。
- 事故調查機構需建立意外事件強制報告系統及免責自願報告系統，將事故資料透過電腦化之資料庫建檔，以便統計與搜尋。
- 除以上資料之外，也需要人爲因素調查說明（Human Factor Circular）、飛航事故中家屬協助之相關文件、調查人員訓練手冊、事故調查流程與相關檢查表。
- 事故調查組織會議的組成。
- 飛航事故調查作業的進行。
- 國際重大飛航事故意外調查。
- 飛航紀錄器的取得與資訊保密。
- 飛航安全改善建議的撰寫、傳送與追蹤。

- 簡介公聽會的舉行、轉播；發布事故報告。

3.2 第二日課程重點與心得

- 調查人員應具備的人格特質。
- 理想的失事調查員必須訓練有素、具有好奇心、奉獻、勤奮、耐心、謙遜、正直以及有毅力等特質。
- 事故調查作業之初始階段：備勤、接獲通報、與啓動調查程序。
- 調查員應保持警覺，輪值者應隨時必須趕赴現場的準備。
- 先遣小組成員的裝備（go-bag）應包括必要之保暖衣物、雨具、調查所需要之攝影蒐證工具。NTSB 之識別證或是具有法律效力之證明文件應攜帶著以備在現場執行調查工作用。
- 接獲通報後，應盡速通知飛機製造商、發動機製造商、FAA、航空公司、機場以及當地警察單位。
- 選擇交通工具上，除了使用汽車或是一般航班外，NTSB 人員得以使用商用航班之觀察員座（jump seat）以增加機動性。
- 當使用觀察員座時需填寫專用表格，並僅限於出發前往現場之單程行程。
- NTSB 在全美各地有四地區辦公室、近 50 名調查員可隨時趕赴事故現場。
- 事故調查作業之現場作業：先遣小組抵達現場、現場作業應收集之資料與完成工作、安全之注意事項。
- NTSB 調查員抵達現場後與當地警方合作，瞭解現場狀況。
- 與輔助調查團一同作業。如有國外代表則以 ICAO 規定以授權代表的身分參加調查作業。
- 事故現場調查階段，僅有委員會委員、指定發言人或主任調查官得以對外發言。
- 現場調查需注意飛機殘骸、環境危害、生物血源性病毒對人體的危害。
- 現場作業殘骸描繪作業介紹。
- 描繪殘骸時，可以利用方格圖，將其分布與環境的相對位置進行繪製。
- 由殘骸的完整與集中度判斷航機是否爲空中解體亦或結構失效。

- 藉由觀察火燒程度判斷起火時間。
- 以順時針方向對現場殘骸進行記錄，並逐一拍攝控制面、機身、起落架、發動機、駕駛艙儀表板、燃油系統、電力系統、液壓系統之損壞情形。
- 現場作業時需要完成的事項：
  - 移動並清理殘骸
  - 取得航機維修紀錄
  - 取得航機飛行紀錄
  - 對油體採樣
  - 取得載重平衡表
  - 訪談目擊者
  - 訪談飛航組員
  - 取得航管通聯紀錄
  - 取得航管雷達資料
- NTSB 得以對事故中喪生的駕駛員進行解剖。
- 依事故規模得召開每日進度會議。
- 事故調查作業之後續作業：分析工作與報告撰寫。
- 分析作業應包括：
  - 發動機拆解檢視
  - 航機系統功能分析
  - 飛航操作分析
  - 殘骸拆解檢驗，如材料金相試驗
  - 飛航紀錄器解讀
  - 人爲因素分析
  - 生還因素分析
  - 天氣與航管資料分析
  - 撰寫事故經過，並草擬調查報告與飛安改善建議

- NTSB 發布的報告格式有六種；其中重大意外事故 Major Accident 的調查報告爲藍色封面印刷，均遵照 ICAO 格式撰寫。
- 重大普通航空業事故調查報告爲 Brief Report，此類僅以 PDF 格式發行；內容含事實資料、分析、結論。
- 一般普通航空業之 GA Field Factual Report 僅含事實資料，在事故後半年內完成，格式並不遵照 ICAO annex 13。
- 無人傷亡之普通航空業事故，另有 Limited Report，僅有簡短的事實資料報告。
- 無人員受傷則另有一頁 C-form 報告，目的則是收集資料。
- 特別報告完成後不公布，僅供內部使用。
- NTSB 另有專門技術報告撰寫人，與主任調查官共同完成調查報告撰寫後送交委員會委員審核。
- 美國由於擁有龐大之普通航空業活動，在此類飛航事故發生時通常僅由駐地調查員單獨進行調查，因此這些調查員必須對飛機各系統均備有專業之瞭解。但由於每年發生之案件多達兩千餘件，因此多數之案件在人力有限情形下僅能進行有限程度的調查。
- 1996 年 TWA 800 航班意外事故調查介紹，重點如下：

  - 在經過 4 年調查之後，最終調查結果可能肇因乃爲油量探測器電線短路點燃空油箱中的油氣造成中央油箱爆炸。

  - 此一發現間接說明了飛機製造商的設計與適航認證問題，應使油箱中的氣體不可燃。NTSB 對此對 FAA 提出了安全改善建議。

  - 該次事故發生初始階段，曾有謠言傳出指稱飛機墜毀係因恐怖攻擊導致，造成事故調查上 NTSB 與 FBI 等政府單位多頭馬車各自爲政現象。

  - 對此，一個值得省思的課題是若將來發生重大刑事犯罪甚至與國家安全相關之飛航安全事故時，我國飛安會與刑事調查機關間的合作模式與權責管理，應有一套完整的作業程序及演練，以免混亂情況造成調查作業的拖延情況產生。

  - 本節課程後赴訓練中心之機棚檢視打撈工作撈起之殘骸並進行實際講解。

3.3 第三日課程重點與心得

- 渦輪發動機系統構件簡介，此部分課程重點如下：
  - 發動機失效的種類與定義
  - 當發動機內部機件失效，導致某一機件與其他機件脫離，並穿透發動機外殼，此類失效定義爲非承受性發動機失效（uncontained failure），反之則爲承受性發動機失效（contained failure）
  - 發動機外物吸入（Foreign Object Damage）
  - 常見的外物吸入有鳥擊、冰晶、輪胎碎片、橡膠物質等軟性物體，以及金屬碎片、道面水泥塊、石頭等硬性物體，此類易造成發動機葉片損傷
  - 引擎內部失火（Under-cowl engine fire）或尾管起火（tail pipe fire）。此類失火並不會影響飛航安全
  - 喪失引擎動力的發生通常是因爲壓縮機葉片或是渦輪葉片損壞或燃油系統失效。多發動機航機發生單一引擎喪失動力並不會影響飛航安全
  - 發動機蒐證時需攜帶的工具，如量角器、捲尺、原件識別號碼牌等
  - 由現場證據判斷發動機失火的類型
  - 藉由整流罩火燒的情形判斷發動機是否在空中即起火
  - 由進氣罩內部有無雜草或樹枝判斷發動機墜地後是否依然有運轉的動量
- 安全改善建議的提出與程序 – 安全改善建議辦公室負責撰寫送委員會核定。
- 安全改善建議的主要對象爲 FAA，因爲其有權力使製造商以及業者、機場或監理單位針對建議內容進行改善。
- 相關機構接獲安全改善建議後必須提出回覆意見，NTSB 委員會會針對其提出的改善建議措施進行評估，並表決是否繼續追蹤或結案。
- 被建議單位的回覆意見、建議的追蹤與結案。
- 持續追蹤之種類：
  - Open Acceptable Response
  - Open Acceptable Alternate Response
  - Open Unacceptable Response

- Open Response Received
- Open Await Response

- 結案可分爲以下種類：
  - Closed Exceed Recommended Action
  - Closed Acceptable Action
  - Closed Acceptable Alternate Action
  - Closed Unacceptable Action
  - Closed Unacceptable Action or No Response Received
  - Closed Reconsidered
  - Closed No Longer Applicable
  - Closed Superseded
- 改善建議的接受程度 – 均在八成以上。
- 安全改善建議之實例說明 – 直升機發動機意外案例。
- 此案例爲 NTSB 依據 1994 至 1997 年間數起 Allison 250 旋翼發動機事故所歸納出的建議。然而 FAA 卻始終未能有滿足 NTSB 提出之改善建議之行動，因此其中一項改善建議以不接受結案（Closed Unacceptable Action），另外兩項則在提出建議後七年始獲接受而結案（Closed Acceptable Action）。

3.4 第四日課程重點與心得

- 降低人員於事故的傷亡，亦能降低飛航事故的發生。
- 據統計，自 1983 年至 2000 年間，Part 121 之飛航事故中，共有 568 件飛航事故，約 93%之乘客生還；於重大事故中，約有 80%的乘客生還。
- 生還因素分組的主要調查工作如下：
  - 航機事故發生時乘客與組員的位置與受傷狀況
  - 逃生過程與生還情形
  - 救援時機與過程

- 蒐集目擊者證詞與其他有利調查工作的資料
- 航空公司的逃生手冊與程序
- 驗屍報告與毒物檢測
- 客艙組員訓練紀錄
- 航機內部受損狀況

- 小組成員不得對外透露調查工作情況，特別避免與家屬與保險業者產生不必要的互動。
- 傳統醫學上之病理學於飛航事故調查上的應用。
- 生醫工程模擬於生還因素調查上之範例展示。
- 可運用的資料來源包括：醫院病例、驗屍與毒品測試、事故現場照片、紀錄器資料、與訪談等等。
- 據統計，1994 年至 2003 年間在美國 Part 91 航機發生之飛航事故約有 21%與天氣因素有關，Part 135 航機發生之事故約有 30%與天氣因素有關，Part 121 航機發生之事故約有 29%與天氣因素有關。
- 最常見的天氣威脅爲風、能見度、與亂流。
- 天氣分組於事故現場的事實資料收集，如自動場面觀測系統 ASOS 資料、跑道能見度 RVR 資料、機場天氣報告 METAR、終端資料自動廣播服務 ATIS 資料、低空風切 LLWAS 資料、都普勒氣象雷達資料、以及與相關人員的訪談。
- 需注意駕駛員是否在執行任務時拿到最新的天氣資料，以協助其在飛航過程中能夠做出最正確的判斷或採取正確措施。
- 進行證人訪談時應詢問有關雲層特徵與是否有閃電，以及風向與風速的關鍵資訊。
- 簡介飛航操作分組於事故現場之工作內容。
- 主要內容有執行先遣任務、協助確認 CVR 抄件、撰寫報告與提出改善建議。
- 駕駛艙證據收集：與系統分組成員共同記錄駕艙各種開關的位置與控制面的最後設定位置，並對航機的損傷情形進行拍照。
- 收集駕駛員的使用藥物並記錄隨身行李。
- 駕駛員訪談、圖表與操作手冊收集。

- 調查分析階段工作簡介，如駕駛員的操作程序、訓練與複訓紀錄、組員資源管理與公司文化與管理等。
- 針對民航業者，應確保：
  - 有效之訓練及標準化
  - 程序製作、相關訓練、線上執行之驗證過程
  - 有效組員意見溝通與回饋
  - 組員資源管理
  - 安全政策之計畫執行與驗證
- 對於政府相關部門，應追蹤：
  - 過去對於航空公司監督的程序及報告
  - 於各種計劃、手冊及程序核可時擔任的角色及與業者的互動
  - 確保訓練、標準化及各種程序的有效執行
- 對於飛航組員，記錄並評估：
  - 事故發生前後的反應與操作
  - 操作程序
  - 訓練與標準化
  - 職責及監督
- 檢視飛航組員於下列的操作程序：
  - 載重平衡及飛機性能
  - 惡劣天候判斷與躲避
  - 海上迫降
  - 緊急逃生
- 檢視飛航組員的訓練：
  - 事故前後的應變訓練
  - 對飛航事故組員所獲得的指導原則及程序
  - 該原則或程序如何的提供給組員

- 承前項，該程序與線上執行時是否合於訓練的要求以及其執行上的連續性（手冊→模擬機→飛機→線上）。

3.5 第五日課程重點與心得

- 在美國由於多數事故均屬普通航空業，機上並不裝載飛航紀錄器，因此碰撞動力學成爲調查人員的主要工具以判斷事故發生原因。
- 碰撞動力學中主要參數的介紹與定義。
- 飛航軌跡夾角（flight path angle）：飛機移動的路徑與水平面的夾角。
- 俯仰角（pitch）：機身縱深軸線與水平線的夾角。
- 攻角（angle of attack）：flight 與 pitch 之間的夾角。

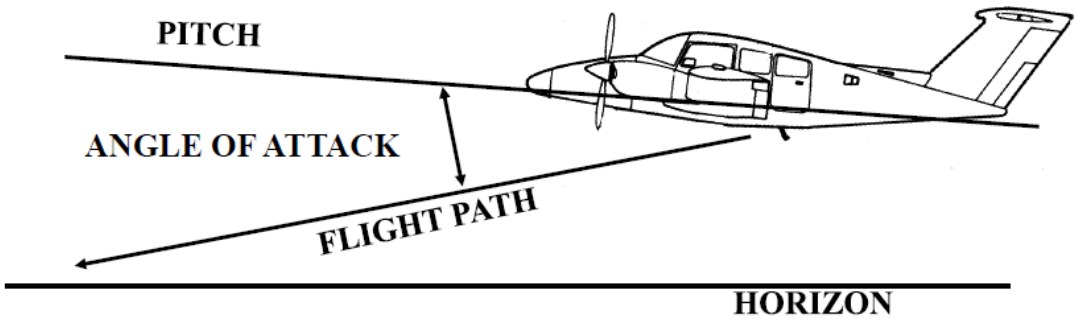

圖 3-3 俯仰角、攻角與飛航軌跡夾角的關係

- 空速：航機在飛航路徑上的移動速度。
- 地形角度（Terrain Angle）：地表與水平線的夾角。
- 撞擊角度（Impact Angle）：航機撞擊地面時航機路徑與地表的夾角。
- 墜毀角度（Crush Angle）：航機撞擊地面時，pitch 與地表之間的夾角。
- 從撞擊時的 G 力可以探討機上人員的生還因素，並藉由實際的傷亡情況得知機上設施如座椅及安全帶等是否符合規範。
- 飛航操作分組成員亦可由此資訊得知駕駛員的操作是否得當。

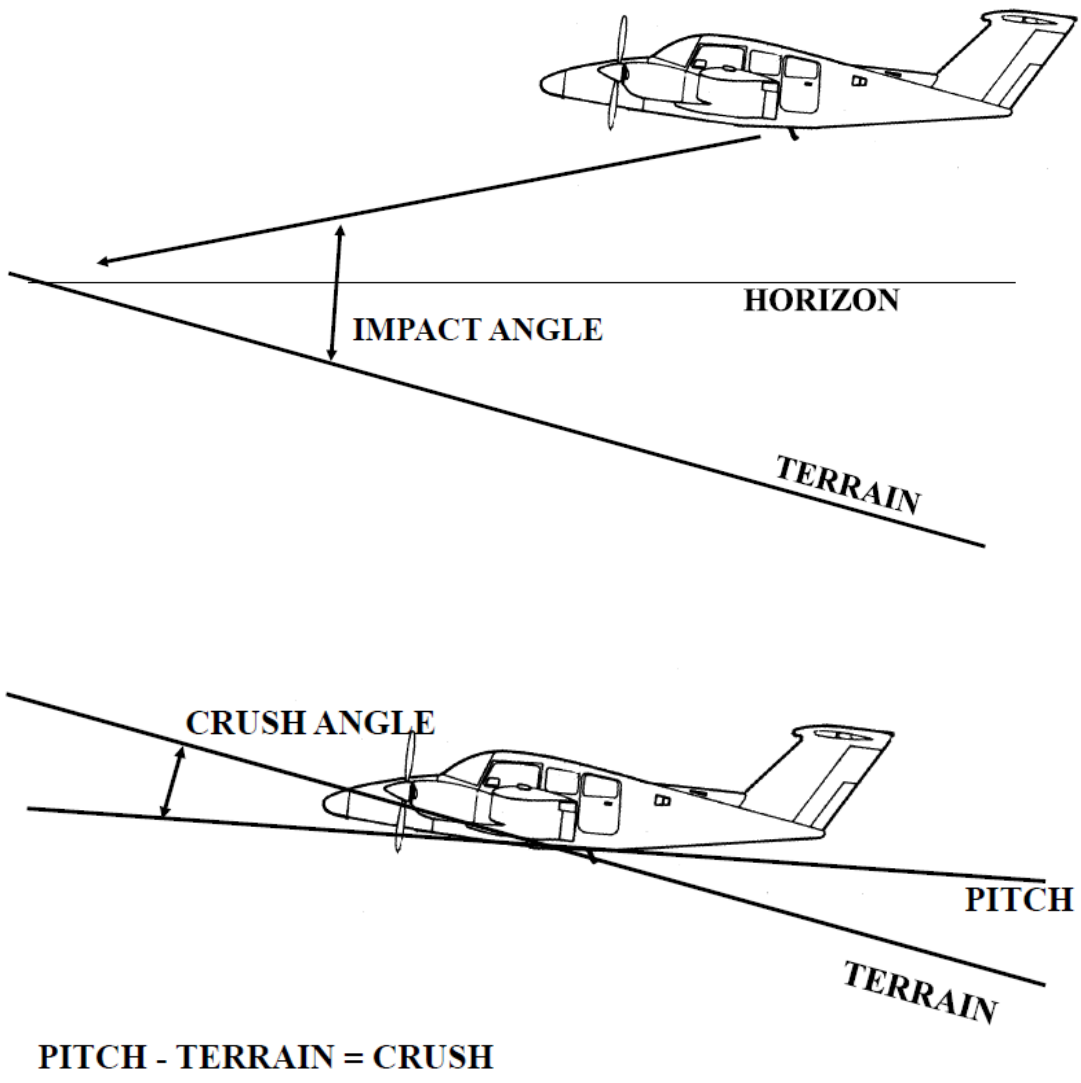

圖 3-4 地形角、撞擊角、墜毀角之間的關係

- 在事故現場對媒體有發言權之人士僅有委員會的委員、主任調查官與公共事務負責人。協助調查團體不得對外發言。
- 發言內容僅對事實資料爲主，絕不對事故之發生肇因做臆測。
- 對於事故相關人員之身分資料保護。
- 主任調查官與現場委員在認爲安全無疑慮的前提下，媒體方得以進入現場拍攝。

- 輔助調查團與授權代表不得對外發言，如有不當對外言論得以解除其在調查團隊中的身分。
- 媒體於事故現場的採訪原則。
- 航空公司於事故時發言之權限以乘客名單、同型機資料，以及家屬協助方式等爲主。
- NTSB 事故調查推論工具的發展，用以協助各專業領域調查官執行調查工作時推論事故發展過程，並依時序綜整後列出事實資料階段所發現之證據，透過此一調查推論工具，可將導致事故發生的重要事件依序列出，評估各分組所蒐集的事實資料是否爲一致，藉此說明事故爲何與如何發生 – 事件順序（Sequence of Events, SOE） 模型。
- 調查邏輯推理中的關鍵名詞：
  - 重要事件（Key Event）：在事故發生時因爲裝備失效、人爲失誤或外界因素導致可能發生事故之事件
  - 人爲失誤（Human Error）：人們從事的任務與期待的表現有落差之行爲。
  - 裝備失效（Equipment Failure）：裝備效能脫離正常應有之效能。
  - 初始事件（Initiating Event）：事故發生時用以區分人或裝備或外在因素，由正常表現或效能轉換成爲非在期待內之表現或效能時的事件。
  - 失效（Failure）：因爲系統或其元件之缺失造成其應有表現或功能的情形，並導致故障發生。
  - 故障（Fault）：系統或其元件出現的不正常狀況，然而故障時不一定會有失效情形發生。
- 以一重要事件來說，有可能由不同類型的錯誤而造成，此每一類型的疏失或失效稱之爲直接肇因（Direct Causes）。
- 根本肇因（Root Causes）爲造成直接肇因的潛在因子。

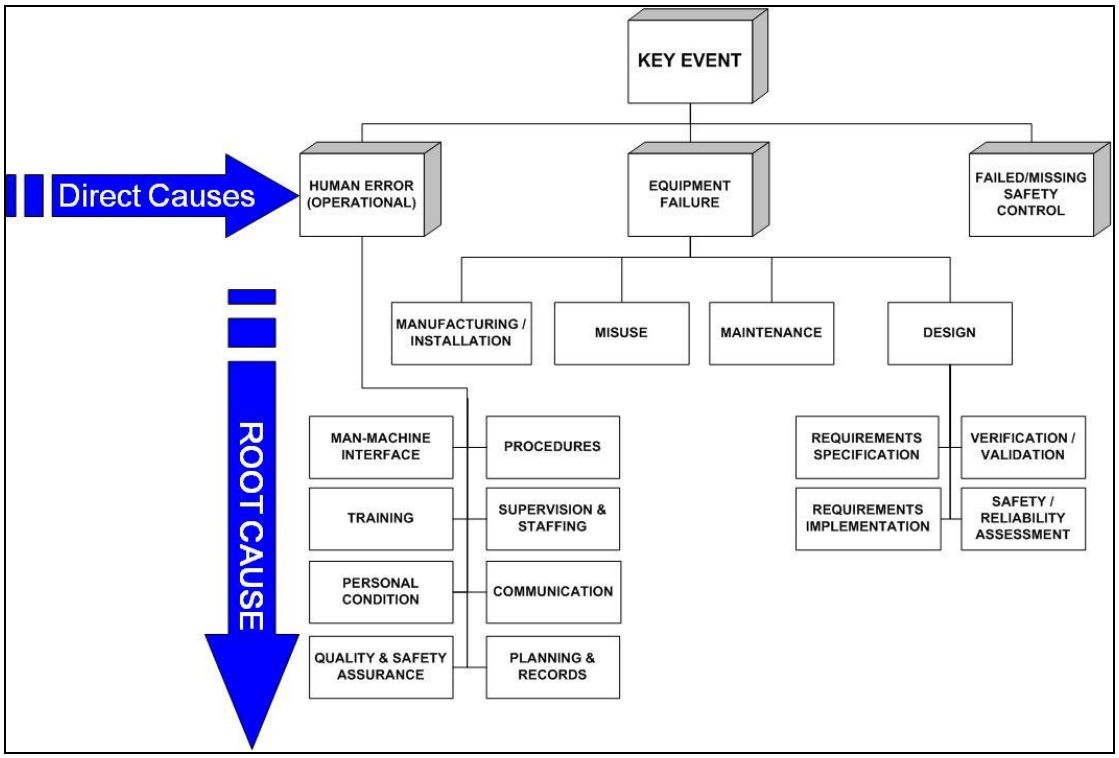

圖 3-5 直接肇因、根本肇因與重要事件之關係圖

- 課程中以一普通航空業的飛機，因升降舵上的俯仰配平發生問題而導致事故的案例加以說明調查邏輯推理的觀念。
- SOE 模型較過去 NTSB 使用的事件與成因模型（Events and Causal Factors Model）優越處在於可幫助調查人員有效的發展後續的飛安改善建議與加強調查報告的流暢度。
- SOE 模型中主要即包含了初始事件、人爲失誤、裝備失效、安全控制失效或遺失，以及飛航事故的發生。

3.6 第六日課程重點與心得

- NTSB 在事故調查上與飛機製造商對於航機性能分析的不同觀點。
- 航機性能分組於事故調查中的工作簡介。
- 事故現場測量、初級與次級雷達資料，以及與紀錄器分組的合作。
- 使用紀錄器資料時的注意事項、資料時間同步。

- 國外事故調查涉及 ICAO 第 13 號附約的兩個角色：授權代表（AR）與顧問（advisor）。
- 如 NTSB 接獲外國飛航事故通報時，會指定一名調查員爲授權代表，並依事故性質，授權代表得邀請相關專業人員如飛機製造商、發動機製造商、FAA 等擔任顧問。
- 飛航紀錄器之授課講師 James Cash 在國際飛航資料處理享有盛名，並爲 NTSB 中處理 CVR 與聲紋頻譜分析的首席專家。
- 飛航紀錄器 FDR 與 CVR 的介紹，重點如下：
  - 1958 年首次規範 2 名組員操作、載客量在 10 人以上之多發動機航機需搭載 FDR。
  - 早期 FDR 爲金屬錫箔式紀錄器。但其抗撞擊能力不佳，且無法紀錄聲音，因此後來被磁帶式紀錄器取代。
  - 1966 年規範 2 名組員操作、載客量在 6 人以上之多發動機航機需備有 CVR。至此 CVR 與 FDR 成爲航機中 MEL 之裝備。
  - 1992 年飛航紀錄器進展至第三代，以固態式記憶體（Solid State Memory）爲記錄媒體。
  - 飛航紀錄器之墜毀生存度要求（Crash Survivability Requirements）目前已進展到 TSO C123a 與 TSO C124a，規範紀錄器可置於高密度火焰中 60 分，低密度火焰達 10 小時。承受之瞬間撞擊加速度爲 6.5 微秒內承受 3,400G。
  - 1972 年 FDR 法規修定爲於 1969 年 9 月 30 日取得型別認證的飛機需能紀錄 17 項數位化之飛航參數，另外廣體客機如 747 需搭載數位式飛航資料紀錄器。
  - 1989 年 5 月 26 日全面更換爲數位 FDR。
  - 1991 年 10 月 11 日，規範搭載 20 名乘客以上的航機，其 FDR 需記錄 28 項以上之飛航參數。CVR 在氣壓高度 18,000 呎以下時需要有 hot microphone。
  - 1995 年 5 月 26 日通過將 1969 年適航之飛航紀錄器參數擴充到 11 項。
  - 1997 年於 FAR121 中修訂有關 FDR 之法規：
  - 原本紀錄 11 項參數的飛機，在 2001 年 8 月 18 日前改裝至 18 至 22 項參數

- 1991 年 10 月 11 日後製造的運輸用飛機，於 2001 年 8 月 18 日前改裝至可紀錄 34 項參數
- 2000 年 8 月 18 號後製造的運輸類飛機，規定 57 項飛航參數
- 2002 年 8 月 18 號後製造的運輸類飛機，規定 88 項飛航參數

- FDR 的參數確認。
- 動畫系統的評估：
  - 可重複、不同速度播放，增進對事故發生順序的瞭解。
  - 可將 CVR、ATC 抄件與 FDR 資料整合
  - 並不能當作事實資料，純屬分析工具
- CVR 係利用聲音去瞭解事故當時組員們與航管或彼此間的溝通，與他們當時的情緒狀態。
- NTSB 有 CVR Readout Handbook 作爲守則。
- 利用頻譜分析，可以協助調查人員找出如發動機的轉速狀態、駕艙操作甚至外界天氣狀況（如雷雨）。
- 飛機爆炸聲音透過結構及空氣傳播速度不同，找出其傳至駕駛艙區域麥克風的第一主波的時間差，可以推論可能爆炸點的位置。
- CVR 規定於引擎發動前必須開啓，持續記錄到發動機關俥爲止。
- FAR 法規規定 CVR 至少最後 30 分鐘的聲音資料必須被保存。
- CVR 同時記錄四軌聲音：
  - 正駕駛麥克風
  - 副駕駛麥克風
  - 駕駛艙區域麥克風
  - 廣播系統
- CVR 的聲音絕不對外公開，因此聲音與對話內容會製作成爲抄件供調查人員使用，抄件於公聽會時發布。
- 本會的 CVR 抄件可於事實資料發布時以附錄型式發布。
- 飛航紀錄器的保管與歸還。

- 本會於調查飛航事故時，飛航紀錄器可於事實資料發布後歸還於使用人。CVR 資料並於歸還時消除。
- CVR 聲音的頻譜分析簡介。
- 飛航紀錄器的未來發展：
  - 參數更新
  - CVR 至少紀錄時間爲 2 小時
  - CVR 備有 10 分鐘獨立電源（RIPS）
  - 影像紀錄器（Cockpit Image Recorder, CIR）的使用
  - 航機配備兩套飛航紀錄器（分別於機頭與機尾）
  - 停用磁帶式紀錄器
- 其他類型的飛航紀錄媒介：
  - Disk drives
  - Digital memory card
  - PAR recorders
  - HUMS recorders
  - Electronic engine recorders
  - GPS
  - EGPWS
  - System Computers
  - PFDs and MFDs

3.7 第七日課程重點與心得

- 材料疲勞的定義：材料斷裂的過程，起始於裂痕，並在低於可承受應力的重覆應力作用下，產生斷裂的情況。
- 材料脆化斷裂的機制：過度的應力、應力集中於先前的裂痕。
- 材料的延展性與易脆性：如鋁合金材料受過大的應力時會出現的 45 度斷裂

面，如已有瑕疵或裂痕時則先從該處提早斷裂。易脆材料受過大應力時變形很小，斷裂與張力方向成 90 度。

- 找出材料斷裂面的鋸齒狀痕跡可以進一步推斷斷裂面的起始位置，在事故調查中可藉此確定機件斷裂的方式及方向，例如屬直接撞擊或大或小角度的撞擊而產生斷裂等。
- NTSB 材料實驗室於事故調查中的角色。
- 事故現場材料取樣與運送：
  - 材料表面應保持乾燥
  - 避免表面碰觸
  - 將斷裂材料的兩端結合
  - 做切割時避免關鍵區域
  - 避免損毀或腐蝕
- 報告撰寫時應具體描述材料失效的情況，避免使用單純描述性的字彙，如失效 （failure） 或分離 （separate） 等，應使用較爲具體的字彙，如斷裂（fracture） 、挫曲 （buckle） 、燒毀 （burned） 、腐蝕 （corroded） 、脫離（disbanded） 、彎曲 （bend deformed） 、扭轉並腐蝕 （twisted and corroded）等。
- 飛航管制分組於事故調查時的工作簡介。
- 飛航管制分組在事實資料蒐集階段的工作：
  - 雷達資料
  - 塔台錄音
  - 人員訪談
  - 天氣資料
  - NOTAM
- 雷達軌跡可以提供航機自起飛到發生事故過程之航跡，有助於飛航性能分析時使用。
- 一般雷達分爲以下種類：
  - 機場搜索雷達（Airport Surveillance Radar）

- 航路搜索雷達（Air Route Surveillance Radar）
- 場面搜索雷達（Airport Surface Detection Equipment）
- 多點定位系統（Multi-Lateration）
- 依照雷達是否接收應答機 Transponder 之 Mode-C 高度資料，而分爲初級與次級雷達

- 次級雷達爲接收 Mode-C 高度資料，若航管員於管制過程中發現 radar contact lost 訊息，表示航機運動已經超越該機於雷達系統預定之性能，故有可能發生空中解體或是下降率過大的問題。而此時雷達幕出現的則爲系統預測之航點，並非真實飛航軌跡。
- NTSB 亦可使用軍用雷達，優點爲資料有高度預測資訊，可彌補民用雷達的不足。
- 一般情況下航管資料僅保留 15 天，因此要留意即時申請的重要性。
- 塔台錄音資料視爲 NTSB 飛航事故時的證物，並可以與動畫結合。
- 飛航事故調查認知訪談簡介，重點如下：
  - 訪談時的提問注意事項。如何適當的作證人訪談。
  - 訪談時宜多採用開放式的問題，而不要用封閉式的問題。使用開放式問題的優點爲可藉此鼓勵目擊者提出較多的回應與有用資訊，而非單純回應式的是或不是的回答。
  - 訪談的結果會因場所的選擇或是提問的技巧而有不同，另外還要注意不得任意打斷訪談者的回答，打斷訪談者的談話容易造成其採取被動的回答方式而減少獲得有效資訊的機會。
- 瞭解會影響證人證詞的各種因素。
- 自目擊者或是事故的參與者取得相關資料。

3.8 第八日課程重點與心得

- 空中解體通常爲金屬疲勞、設計不良或是空氣動力負載所造成。
- 應了解事故之事故鏈 SOE 方能決定空中解體之肇因。
- Part 91 主翼與尾翼折斷之空中解體案例說明。

- 如在飛行中主機翼承受向上力而折斷時，在機翼根部的上表面會呈現壓力破壞的皺摺狀，下表面會出現張力破壞的光滑狀。
- 脫離的主機翼有可能在脫離機身時一併破壞尾翼的完整。
- 當飛行中尾翼先斷裂時，因航機失去平衡而會導致機頭下墜，進而使主機翼表面遭受向下的氣流施力。當此大於機翼結構可承受的最大強度時主機翼便會斷裂，進而造成上表面呈現張力破壞，下表面呈現壓力破壞。
- 調查空中相撞事故時，可利用以下資源進行調查，並藉此計算兩機接近率與撞擊角度：
  - 飛航紀錄器
  - GPS
  - TCAS
  - 物理證據如監視攝錄器等
  - 人員訪談
- 飛航紀錄器是最精確的調查資源，而人員訪談資料則較不可信，大部份的目擊者很難確切描述事故發生過程。
- 擦撞角（Convergence angle）與撞擊角（collision angle）的關係。

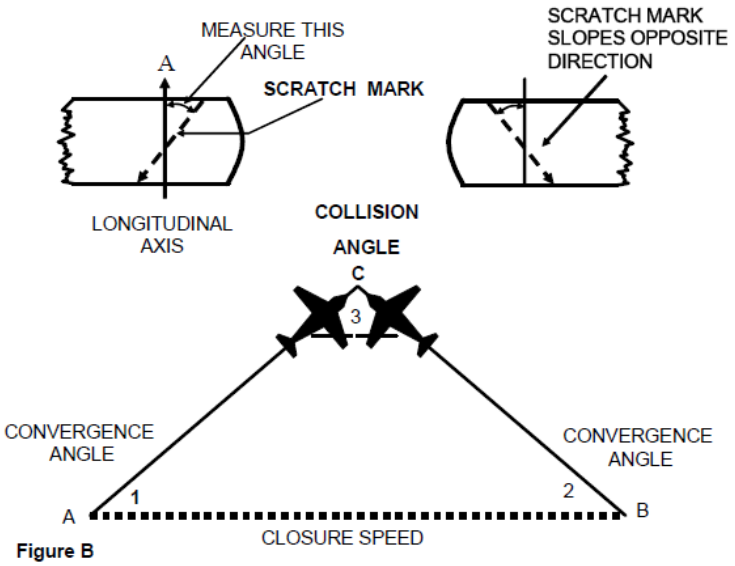

圖 3-6 擦撞角（1,2）與撞擊角（3）的關係

- 擦撞角的定義爲：兩機空中相撞後，在機體上所留的擦撞痕跡與航機縱向軸之間的角度。
- 課堂範例：兩機發生空中相撞，僅知甲乙機機型、甲機擦撞角，乙機擦撞角，但甲乙機速度均未知。假設甲機駕駛員存活且從面談可知甲機速度，乙機駕駛員死亡但可從乙機飛行手冊知道其飛行速度範圍，根據上述資訊而欲求兩機相撞之撞擊角方法如下：
  - 根據三角函數公式求得乙機擦撞角： V_a／sinA=V_b／sinB
  - 用不同乙機速度帶入上述公式求出在不同飛行速度時乙機的擦撞角
  - 在乙機飛行速度範圍內變動不同飛行速度，求得可能之乙機擦撞角範圍
  - 變動乙機擦撞角，可求出兩機空中相撞撞擊角範圍
- 可參考 ICAO Doc. 6920 取得進一步的參考資料。
- 調查空中相撞事故時，必須知道兩機之真空速及航向，以計算接近率與撞擊角度。
- 撞擊角度的計算（如下圖 3-5）：

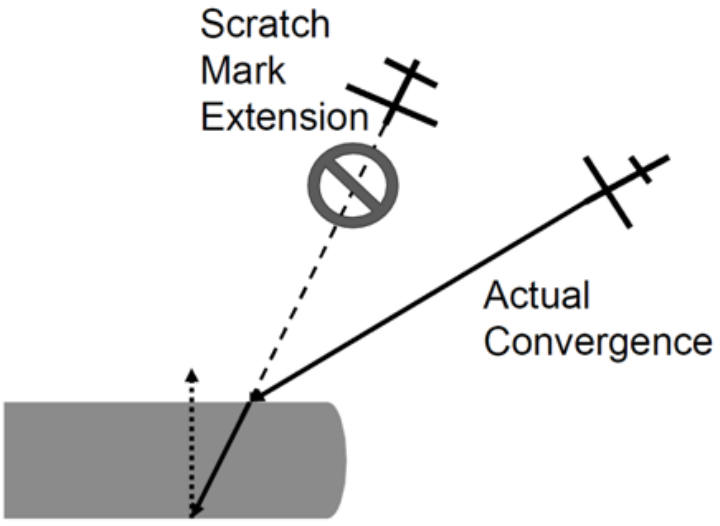

圖 3-7　撞擊痕跡與撞擊者的關係圖

- 撞擊角度計算公式爲 180° － 甲機之擦撞角 － 乙機之擦撞角。
- 瞭解在事故調查中人爲因素所佔的主要部份。
- 事故調查中人爲因素方面必須蒐集的資料。

- 如何運用蒐集到的人爲因素相關資料從事分析的工作：
  - 記錄事故中人員的每一行動
  - 蒐集事故中組員 72 小時內活動
  - 蒐集組員醫療背景資料
  - 藥物酒精檢測
  - 檢視並記錄工作環境
  - 取得工作上應有表現或性能上的資料，如前一航班中組員的 CVR 聲音，或是審核資料
  - 人爲因素證據或資料必須能夠量化並根據事實，調查人員的意見並不能當作資料
  - 由各類面向去廣泛審視人爲失誤的發生原因
  - 記錄人爲失誤發生的因果鏈進而發掘減低失誤的方法
  - 蒐集足夠資料進而排除人爲因素的可能性亦跟人爲因素分析的工作一樣重要
- Swiss Cheese Model 與 SHELL Model 在人爲因素調查上的應用。
- NTSB 設有運輸災難協助辦公室（Office of Transportation Disaster Assistance, TDA）參與事故中對於家屬的協助。
- 空難家屬協助法於 1996 年立法通過。
- 1997 年通過「國外空運家屬支援法」。
- 2008 年通過「鐵路乘客災難協助法」。法中規定美國國內有重大傷亡之空運及鐵道事故，TDA 必須參與提供協助。
- 家屬在事故第一時間時會有的反應乃因未預期之無法改變的事實產生對心理及生理產生的影響：
  - 生理上：呼吸急促、發抖、頭昏眼花、噁心、無食慾、失眠、胃痛、全身無力
  - 心理上：震驚、激動、失望、恐慌、內疚、產生敵意
- 調查人員必須認知以上反應並非家屬的本意。
- 對於家屬有效以及可以做的協助與溝通方式。

- 協助人員可以做的事：
  - 保持冷靜
  - 詢問如何協助
  - 表示同情
  - 重覆提供確認資訊
  - 專注傾聽
- 協助人員不可以做的事：
  - 爭執
  - 不切實際的空談
  - 假設性語氣
  - 插話或打斷家屬發言
  - 施捨
  - 以身體碰觸家屬
  - 無濟於事的慰問
- 面對家屬憤怒的情緒，務必掌控溝通時的氣氛。
- NTSB 另有提供家屬協助的專門課程。

3.9 第九日課程重點與心得

- 火災發生需要三樣元素：氧氣、熱源與燃油。
- 火災四個階段：初始點火階段（低溫）、火苗成長階段、完全發展階段、衰退階段。
- 初始階段：起火點之溫度高於外界環境，透過放熱反應、火花及自燃過程，發生點火，此時溫度最低。
- 火苗成長階段：取決於燃料、氧氣的供給。抑制型的燃燒，因燃料或氧氣的供應較不足，燃燒速度較慢。快速燃燒的型式爲起初燃燒部分的熱流足以點燃臨近的燃料表面，當有供應足夠氧氣便引起快速燃燒。

- 完全發展階段：釋放的熱能最大、燃燒最劇烈。整個過程控制主要端視氧氣量的供給。在這個階段中，未完全燃燒物質將在最上方，隨著空氣飄浮，當未燃燒物質接觸到易燃物表面時，將再度引起新的火苗。
- 衰退階段：當燃料或易燃物質已燒盡，整個燃燒能量開始逐漸衰退，最後熄滅。
- 飛航事故調查中事故現場受熱與燃燒後所留下痕跡的判斷。
- 五種可能的受熱燃燒狀況：
  - 底漆變色
  - 表面改變
  - 金屬表面變色
  - 穿孔
  - 掃帚化（Broomstrawing）

圖 3-8　五種受熱燃燒情況

- 其中掃帚化是指金屬受熱部分融化後受力而造成掃帚般呈現細絲纖維化的現象。

- 航機火災可能的發生點：電線、燃油外洩、發動機、貨艙
- 航空器火災溫度對照如下：

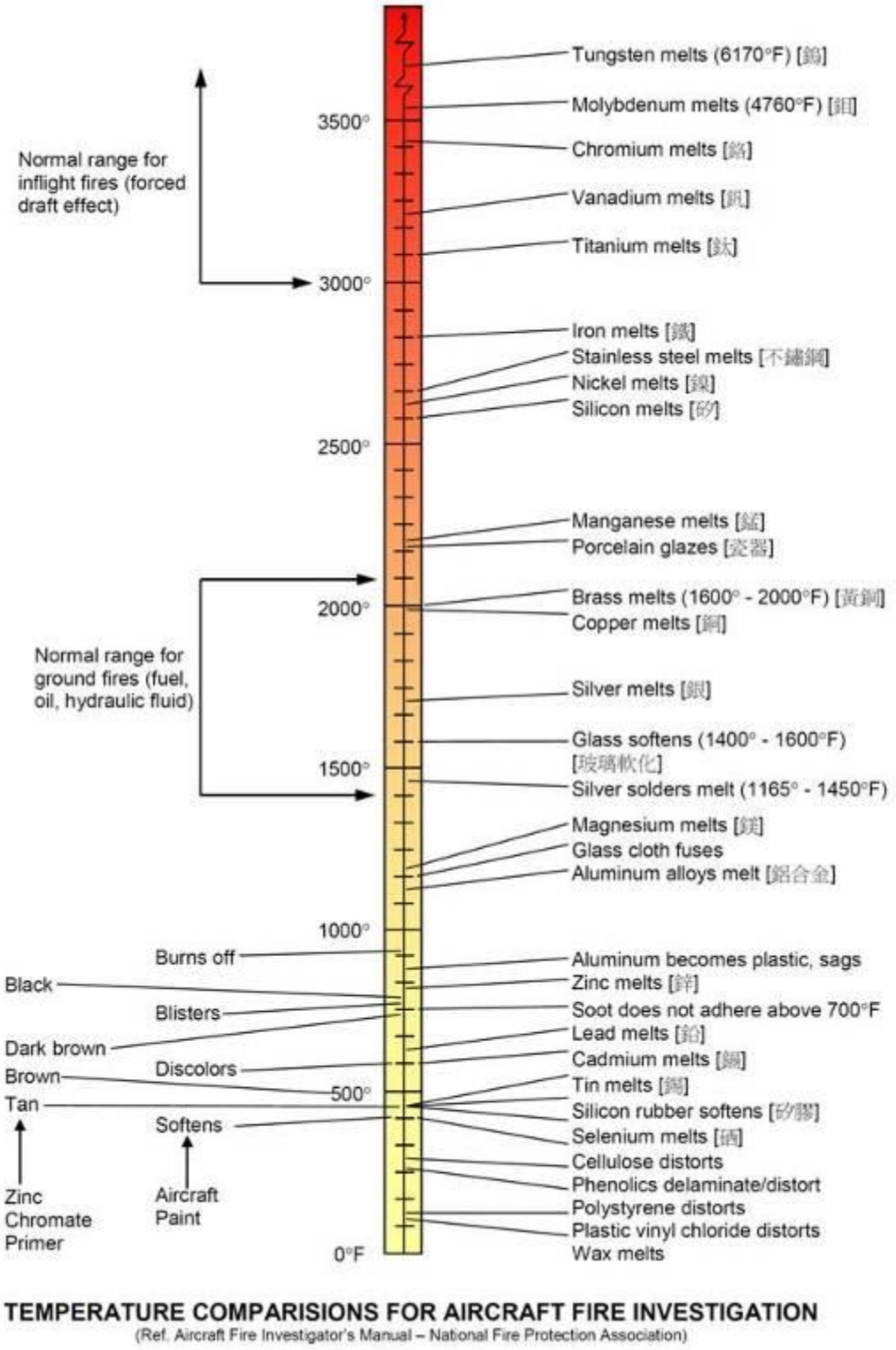

圖 3-9 航空器火災溫度對照表

- 電線起火的原因：
  - 受力彎曲
  - 電線裸露處彼此碰觸
  - 電線破皮與機體接觸
- 電線起火的特徵：
  - 燒穿絕緣體
  - 將絕緣體燒成球狀
  - 波及局部並與起火點的材料有關
- 發生爆炸時，因爲是由小空間內的氣體快速燃燒所致，因此當結構無法承受時，發生快速外翻，常常伴隨碎裂。
- 爆炸發生時，外表結構因受力不均而會有皺摺存在。
- 事故調查中之應用：證據保存、人身安全、裝備等。
- 調查火災的飛航事故時，個人防護裝備 PPE 與適當穿著絕不可忽略。
- 現場事故調查分組練習。原本 AA587 事故調查簡介臨時中止，讓學員體會事故現場的調查作業。
- 講師在說明簡要的事故經過後，將學員分爲適航、發動機、飛航操作、生還因素等四組，並指派一名主任調查官及從各組中推派出一名分組召集人。在 1.5 小時中讓學員到棚廠收集事實資料後，由分組召集人與主任調查官討論現場作業的結果，最後由主任調查官上台報告。

3.10 第十日課程重點與心得

- 公聽會召開的時機與目的。
- 由部門執行長提議經委員會同意後召開，目的在透過專家或是證人證詞取得進一步事實資料。
- 公聽會可公布已蒐集的資料讓各方確認。
- 公聽會前的會前會，在公聽會前一周進行。
- 會前會由調查團隊與輔助調查團隊組成，目的在確認公聽會資料，證人名

單，以及公聽會的沙盤推演。

- 公聽會的參與成員組成、程序。
- 由委員會成員擔任主席、資深調查員列席，參加人員有調查員、輔助調查團成員、專家證人等。
- 媒體、家屬、律師等僅能列席。
- 公聽會的程序通常是由調查員對證人提問，接著由輔助調查員提問，最後是委員提問。
- 公聽會均爲對外公開。
- 公聽會結束後，分組的事實資料報告都將成爲 public docket ，供外界參考取閱。
- 調查團隊會在技術審查會議（TRM）中針對所有獲得的資訊進行確認無誤。
- 技術審查會議後的分析、調查發現與報告、改善建議提出的作業將由 NTSB 獨自接手完成。
- 委員會：NTSB 於委員會中討論事故調查報告，並由委員投票決定報告中的結論、可能肇因、安全改善建議及是否採納報告。由主任調查官向委員做事故調查的經過與結果。
- 委員根據調查報告內容提問，並討論表決是否接受，與提出意見。
- 待委員們接受報告後，主任調查官會與技術報告撰寫人共同依據委員們的意見修改報告。
- 調查報告的發布程序。
- 陽光法案（Government in the Sunshine Act）的精神，委員會議採公開進行，大眾與媒體均可參加，惟獨涉及組員部份之法律相關討論不開放。過程並可在網路下載。
- 我國飛安會的委員會議每月召開一次，得召開臨時會議。

肆、結語

我國飛安會所調查的飛航安全事故爲民用航空運輸業，僅有少數屬於普通航空業、公務航空器及超輕事故；但就比例上，美國 NTSB 所調查的普通航空業飛航事故比例上佔了每年調查事故的九成以上，而與我國大爲不同。這種差異也反

映在課程與內容的安排上，如果能夠在課程題材中納入更多的民航重大事故調查經驗，則相信能夠使此行收穫更加豐富。此次奉派赴美受訓，發現已成立四十餘年的 NTSB 來說，無論是人力、物力、財力、設備等皆較我國飛安會充沛及豐富甚多，而且其經驗豐富的調查人員在事故現場表現出的專業態度、對殘骸做出的觀察、量測、對事實資料的收集分析，其專業及審慎細膩的態度值得效法。我國飛安會每一名成員應抱持謙遜與不斷學習的心態，方爲不斷進步的準則。

此行除吸收新知與調查技術外，課堂之餘與各國飛安相關人員建立聯繫管道，亦分享彼此工作經驗，促進調查技術的交流，相信對未來調查工作涉外事務上絕對有所助益。

伍、建議

調查人員的養成實屬不易，NTSB 舉辦之航空器失事調查基礎訓練中的課堂資料皆是該委員會多年累積下的經驗，並包含了多起重大意外事故調查的成果，可使本會調查人員除吸收更新的調查技術外，並能與國際接軌，使在回國後對本會的事故調查程序及技術提出更精進的貢獻。茲提出以下建議：

1. 持續派員參加該中心舉辦之課程，厚植本會人員之調查實力。
2. 參考並建立類似 NTSB 之作業程序及勾選單（詳附錄二）。
3. 檢視本會法規及作業程序與 ICAO Annex 13 之差異性並修訂標準作業程序。
4. 逐年編列紀錄器解讀硬體更新的預算，以維持應有之解讀能量。

附錄一　學員名冊

Participant Information

AS101-091211 / Aircraft Accident Investigation

NTSB Training Center　　*Date* 9/12/2011 9/23/2011　　*Time* 8:45:00 AM 1:30:00 PM

Full Name	*title*	*Organization / Address*	*Email*
Mr James P Abarno	Director Of Transition Aircraft	Jet Aviation Flight Services Inc. 112 Charles Lindbergh Drive Teterboro, NJ 07608 / United States	jim_abarno@jetaviation.com
Ifeolu Akinjayeju, N.F.	Air Safety Investigator	Accident Investigation Bureau P.M.B. 016, Murtala Muhammed International Airport Ikeja Lagos 100272 / NIGERIA	akinjayejuifeolu@aib.gov.ng; ifeakinjayeju@yahoo.com
Oluponmile Joseph Alao	Air Safety Investigator	Accident Investigation Bureau of Nigeria P.M.B. 016, Murtala Muhammed International Airport Ikeja Lagos 100272 / NIGERIA	ponlealao@yahoo.com; alaojoseph@aib.gov.ng
Maryam Allahyar	Investigator	NTSB AS-60	maryam.allahyar@ntsb.gov
Ms JAMI L ANZALONE	REGIONAL AVIATION SAFETY MANAGER	USDA FOREST SERVICE 333 BROADWAY SE FAM ALBUQUERQUE, NM 87102 / United States	jamianzalone@fs.fed.us
Janez Arzensek	Investigator	Republic of Slovenia-Ministry of Defense Sluzba Za PREISKOVANDE LETALSKIH NESREC IN INCIDENTOV VZ RS CERKLJE OB KRKI 4A 8263 / SLOVENIA	janez.arzensek@mors.si
Juan Jose Balonga	Investigator Coordinator (Investigation Coordinator)	Spanish Air Accident Investigation Board Calle Fruela, No. 6 Madrid 28011 / SPAIN	jjbalonga@fomento.es
Arturo Bernardi	Military Pilot	Presidencia de la Republica Hangar Presidencial, Puerta No.9, Aeropuerto Int. de Mexico Mexico 15620 / MEXICO D.F.	abernardimx@yahoo.com.mx
Mr Thomas Wayne Bishop	VP Texas Turbines/Conversions	www.texasturbines.com / United States	tom@twbishop.com

Thomas E Carlson	Staff Officer	Department of the Army 400 Army Pentagon, HQDA, Att: G-3 SOD Washington D.C. 20310-0400	thomas.carlson@us.army.mil
Gary Carr	Senior Flight Safety Inspector (Airworthiness)	Jamaica Civil Aviation Authority 4 Winchester Road Kingston / JAMAICA	gcarr@jcaa.gov.jm
Mr Eugenio Alejandro Charlin	Air safety manager	LAN AIRLINES cesar lavin toro 2198 Santiago, OF / Chile	eugenio.charlin@lan.com
Mr Victor Siu Kei Chiu	Supervisor	HAECO Flat H, 41/F, Block 9, Royal Ascot, Shatin Hong Kong, OF / Hong Kong	victor_chiu@hotmail.com
Jeffrey S Ciesla	Lt. Col.	US Air Force Joint Combat Assessment Team ASC/END (JCAT) 1970 Monohan Way Bldg 11A, Rm 001 WPAFB, OH 45433	jeffrey.ciesla@us.af.mil
Mr Joel Stephen Cole	Project Engineer	Fedex Express AC Systems Engr - MS 5413 3131 Democrat Rd Memphis / USA, TN 38017 / United States	jscole@fedex.com
Mr Raul Schlie Cuadra	Captain	LAN Airlines Americo Vespucio 902, Renca Santiago, OF / Chile	raul.cuadra@lan.com
Scott Edward Davis	Aviation Safety Officer	2nd Battalian, 1st Aviation Regiment, 1st CAB Bldg 805 Fort Riley, KS 66442 / USA	scott.edward.davis@conus.army.mil
Harris Dian	Investigator	KNKT/Indonesian NTSC JL Angkasa Blok B15 KAV 2-3 Jakarta DKI 10720 / Indonesia	harrisdian@merpati.co.id
Esmeralda Dominguez	Tecnico Investigador (Technical Investigator)	Spanish Air Accidents Investigation Board Calle Fruela No. 6 Madrid 28011 / SPAIN	edsanchez@fomento.es
Charles Irikefe Erhueh	Air Safety Investigator	Accident Investigation Bureau P.M.B. 016, Murtala Muhammed International Airport Ikeja Lagos 100272 / NIGERIA	erhuehcharles@aib.gov.ng; irikefecharles@yahoo.co.uk
Armando Fermin	Civil Aviation Authority of Panama Airworthiness Inspector	AAC Panama	afermin@aeronautica.gob.pa; fermin.armando@gmail.com
Mr Angelo Christian Ferrari	Airline Pilot	Alitalia Via Pietro Campana 4 Frascati / Rome, OF 00044 / Italy	ferrari.ac@gmail.com

Mr Gary Stephen Goodpaster	Chief of Maintenance	The Kroger Co. 640 Wilmer Ave. Cincinnati, OH 45226 / United States	gary.goodpaster@kroger.com
Barbara S. Gordon	Aviation Safety Officer	U.S. Naval Test Pilot School 22783 Cedar Point Road Patuxent River, MD 20670-1918 / USA	barbara.gordon@navy.mil
Armando Guerrero	Military Pilot	Presidencia de la Republica Hangar Presidencial, Puerta No.9, Aeropuerto Int. de Mexico Mexico 15620 / MEXICO D.F.	warriorwall@hotmail.com
John Kent Hamilton	Regional Aviation Safety Manager	U.S. Forest Service 740 Simms St Golden, CO 80401 / USA	johnkhamilton@fs.fed.us
Robert M Heltemes	Staff Officer	Department of the Army 400 Army Pentagon, Att: G-3 SOD Washington D.C. 20310-0400	robert.m.heltemes@conus.army.mil
Francisco Javier Hernandez	Tecnico Investigador (Technical Investigator)	Spanish Air Accident Investigation Board Calle Fruela No. 6 Madrid 28011 / SPAIN	fjhsanz@fomento.es
Michael B Iweka	Air Safety Investigator	Accident Investigation Bureau P.M.B. 016, Murtala Muhammed International Airport Ikeja Lagos 100272 / NIGERIA	iwekamichael@aib.gov.ng; mike.iweka@yahoo.com
Sanda Jakopic	Investigator	Republic of Slovenia-Ministry of Defense Cerklje OB KRKI 4A 8263 Cerklje OB KRKI, P.P. 15 / SLOVENIA	sanda.xx@gmail.com
Daniel Putut Kuncoro Adi	Director of Safety	Lion Mentari Airlines R. Gajahmada No. 7 Jakarta 10130 / Indonesia	daniel_putut@lionair.co.id
Dr Brian Chiawei Kuo	Engineer	Aviation Safety Council Taiwan 11F No.200 Sec.3 Beiyin Rd. Xindian Dist. New Taipei City 231 / Taiwan, Republic of China	hsnu84053@gmail.com
Yusuf A Lawal	Air Safety Investigator	Accident Investigation Bureau P.M.B. 016, Murtala Muhammed International Airport Ikeja Lagos 100272 / NIGERIA	lawalyusuf@aib.gov.ng;yalawal@yahoo.com
Flavio Leon	Military	Presidencia de la Republica Hangar Presidencial, Puerta No.9, Aeropuerto Int. de Mexico Mexico 15620 / MEXICO D.F.	ops-hangarpresidencial@yahoo.com.mx

Jose Luis Lopez	Tecnico Investigador (Technical Investigator)	Spanish Air Accident Investigation Board Calle Fruela, No. 6 Madrid 28011 / SPAIN	jldelafuente@fomento.es
Mr Joseph John Maxin	ESQUIRE/Pilot/Safety Officer	EATON FLIGHT DEPARTMENT 945 WINDHAM CT #3 YOUNGSTOWN, OH / United States	JOSEPHJMAXIN@EATON.COM
Mr Charles M. McHugh	Instructor Pilot / Safety Officer	80 FTW 835 20th Ave Sheppard AFB, TX 76311 / United States	charles.mchugh@sheppard.af.mil
Jefferson McMillan	Transportation Research Analyst	NTSB RE-10 Room 5431	jefferson.mcmillan@ntsb.gov
Ms Rosabel Melendez	Esq./Student Pilot/Civil Air Patrol Member	Melendez Law Offices (also member Air Civil Patrol Via 7 2QL-210 Villa Fontana Carolina / Puerto Rico, PR 00983 / United States	roselaw7@yahoo.com
Mr Luis Michalski	accident investigator	DINACIA Av.Ferreira Aldunate 5519 Montevideo, OF / Uruguay	oipaia@hotmail.com
Mr Italo Leonel Montes de Oca	Aircraft Accident Investigator	DINACIA OIPAIA Av. Wilson Ferreira Aldunate 5519 - Aeropuerto Carrasco / Canelones 14002 / Uruguay	oipaia@hotmail.com
Eric S Morefield	Supervisory Special Agent/Explosives Examiner	FBI 2501 Investigation Parkway Quantico, VA 22135	eric.morefield@ic.fbi.gov
Henry Aniagolu Nwanyanwu	Air Safety Investigator	Accident Investigation Bureau P.M.B. 016, Murtala Muhammed International Airport Ikeja Lagos 100272 / NIGERIA	nwanyanwuhenry@aib.gov.ng;henryanih@yahoo.com
Shehu Oyebanji Olayanju	Air Safety Investigator	Accident Investigation Bureau Murtala Muhammed International Airport Ikeja Lagos 100272 / NIGERIA	olayanjushehu@aib.gov.ng;soyeolayanju@yahoo.com
Jose Flores Oliva	Mechanic	Presidencia de la Republica - Mexico Hangar Presidencial, Puerta No.9, Aeropuerto Int. de Mexico Mexico City / Mexico	ingenieriacgtap@yahoo.com.mx

Mr Steven Adrian Olmos	10 AF Chief of Flight Safety	10th Air Force 1700 Tuskegee Airman Drive NASJRB Fort Worth, TX 76127 / United States	steven.olmos@us.af.mil
Charles Olvis	Transportation Safety Specialist (ATC)	NTSB AS-30 Room 5316	charles.olvis@ntsb.gov
Lt.Col. Blaz Pavlin	Assistant to Force Commander for Air and Air Defense	Force Command of SAF Ivan Cankar Barracs, ZG. Raskovec 50 VRHNIKA 13601 / SLOVENIA	blaz.pavlin@mors.si
Alfredo Perilla	CP B-767/Instructor	Lan Ecuador Orellana Av. E11-28 and Coruna St - OF.303 Quito / Pichincha / Ecuador	alfredo.perilla@lan.com
Mr L. Todd Phillips	Accident Investigation Committee	US Airline Pilots Association 200 E. Woodlwan Road Suite 250 Charlotte, NC 28217 / United States	Tphillips@usairlinepilots.org
Mr Bernard Pichette	Capt, F.S.O.	Bombardier Aerospace 13100 Henri-Fabre Blvd Mirabel / Quebec J7N3C6 / Canada	bernard.pichette@aero.bombardier.com
Li Ya Pin	Capt/Investigator	Aviation Safety Council Taiwan IIF No 200 Sec 3 Beixin Rd Xindian Dist New Taipei City / Taiwan, Republic of China	liyapin@ms28.hinet.net
Michael A Polk	Combat Aviation Brigade Safety Officer	U.S. Army / USA	bigmikeniraq@hotmail.com
G. Kyle Price	Air Interdiction Agent/Safety Officer	U.S. Customs and Border Protection, Office of Air and Marine 8092 Hangar Road San Angelo, TX 76904	gordon.k.price@cbp.dhs.gov
Mr Tony Raila	Safety Officer	DODFRA 7905 Royal Mint Place Green Haven, MD 21122 / United States	my2pks@yahoo.com
Renato Duarte Rodrigues	Investigator Officer (Brasillian Air Force)	CENIPA Av. Para, S/N. Val-De-Cans Belem, Para 66115-565 / BRAZIL	renatoduarte05@uol.com.br
James Rodriguez	Attorney-Advisor	NTSB GC-1	james.rodriguez@ntsb.gov

Jacqueline Rutter	Aviation Safety Inspector (Cabin Safety)	Jamaica Civil Aviation Authority 4 Winchester Road Kingston 10 / JAMAICA	jrutter@jcaa.gov.jm
Angel Said	Miliary Pilot	Presidencia de la Republica Hangar Presidencial, Puerta No.9, Aeropuerto Int. de Mexico Mexico City 15620 / MEXICO D.F.	asaidv@hotmail.com.
Ms Yolanda Rebecca Saldana	Aviation Safety Manager	US FOREST SERVICE 3237 PEACEKEEPER WAY, STE 101 McCLELLAN, CA 95652 / United States	ysaldana@fs.fed.us
Nicholas J Santoro (Donald Slother)	Technology Officer, Transportation Security Specialist - Explosive	TSA HQ 601 S. 12th St. Arlington, VA 20598	nicholas.santoro@dhs.gov
Mr Felipe Alexandre N. Santos	Engineer	Embraer Asia Pacific Pte. Ltd. 38/53 Darrambal Street Chevron Island Gold Coast / Queensland QLD 4217 / Australia	felipe.santos@embraer.com.br
Robert Schick	Safety Officer	DODFRA 654 Spring Meadow Dr Westminster, MD 21158 / United States	rschick103@gmail.com
Alexander Coelho Simao	Investigator	CENIPA QRI 38 Casa 16, Residencial Santos Dumont Santa Maria DF 72594-238 / BRAZIL	alexandersimao@gmail.com
Mr Basuki Suprianto	Captain/SM Incident Management	Garuda Indonesia Airlines Kemanggisan Ilir I / 77 JAKARTA 11480, INDONESIA 2nd Floor, Garuda Operation Center, Soekarno-Hatta Tangerang/Banten Cengkareng 19120 / Indonesia	baszuki@garuda-indonesia.com
Muhtar Shuaibu Usman	Air Safety Investigator/Director of Operations	Accident Investigation Bureau P.M.B. 016 Murtala Muhammed International Airport Ikeja Lagos 100272 / NIGERIA	usmanmuhtar@aib.gov.ng;msusman@hotmail.co.uk
Terry G. Weber	1-1 ARB Battalion Safety Officer	U.S. Army Fort Riley, KS 66442 / USA	terry.g.weber@us.army.mil
W. Mark Whitworth	SUPERVISORY SPECIAL AGENT/Explosives Examiner	FBI 2501 Investigation Parkway Quantico, VA 22135	w.whitworth@ic.fbi.gov

Katherine Wilson	Psychologist	NTSB AS-60 Room 5325	katherine.wilson@ntsb.gov
Ngamwinijsagul Wiwat	Aviation Safety Inspector	Department of Civil Aviation 71 Soi Ngarmduplee, Rama IV Rd Bangkok / THAILAND	wiwat.n@aviation.go.th;teyue@hotmail.com
Christopher Michael Zidek	Chief of Safety	413th Flight Test Group 257 Southfield Ct Bonaire, GA 31005 / USA	chriszidek@aol.com

附錄二　Group Chairmen Checklists （Selected）

- ATC Group
- Human Performance Group
- Maintenance Group
- Operations Group
- Survival Factors Group
- Meteorological Group

DETAILED ATC INVESTIGATIONS

Should the situation appear to warrant specific attention to ATC issues or performance, AS-30 will normally assign an investigator to identify and provide whatever assistance is needed by the field investigator. This section addresses the basic steps involved in a specialist ATC investigation.

Setting Up the Investigation

Once the decision has been made to proceed with an in-depth examination of ATC issues, coordination is required with Air Traffic Investigations (AAT-20) at FAA headquarters. They will arrange interviews at the facility and make any other FAA contacts required to accommodate the needs of the investigation. AAT-20 will also normally send an FAA investigator to the facility to serve as data collection liaison and brief the involved employees before their Safety Board interviews. The FAA's Office of Accident Investigation (AAI-100) may also send someone to participate as the FAA's party representative/group member. It is a good idea to obtain as much information as possible (briefing from AAT/AAI, tape review, radar replay, etc) before leaving Washington in order to have a basis for identifying possible parties and ensuring that all necessary resources are available to you at the facility.

Selecting Group Members – party member selection is a joint decision between the ATC investigator and the IIC

1. Persons with ATC experience, preferably in the same facility or at least the same type of facility
2. Facility Quality Assurance or Training specialist (no management)

B. Conducting the Investigation

1. Receive an initial briefing from ATC facility staff/manager. Try to control the size of the crowd, limiting attendees to those necessary to assist in the investigation. The briefing is for you and those you choose to assist you; feel free to account for all those present and ask that unnecessary persons leave.
2. Listen to the original ATC recording (may be tape or digital off a hard disk drive.)
    a. Facilities generally record the line to/from the control position headset jack. If there are any questions about what actually got transmitted or received from the radio system, it may be necessary to consult with the airway facilities technicians to discover whether other recording points exist and were being recorded at the time of the accident or incident. You may find that comparing the two recordings shows discrepancies, although this is unusual.
    b. Watch the time clock to ensure there are no breaks.
    c. Read the draft transcript along with the recording to ensure you have an accurate working copy.

d. If the time is off more than 1 or 2 seconds, point it out to the facility person responsible for creating the recording. If the times are not corrected in the certified transcript, make a footnote in your report that this is what you found.
e. Previously furnished cassette working copies are good to take with you, but you should listen to the original ATC tape. Certified re-recordings will be stereo, with time on one channel and voice on the other, whereas working copies normally include only the voice channel.

3. Additional data should be obtained via written request to the FAA air traffic coordinator. Retain a signed and dated copy for yourself. For major incidents with many items requested, try to maintain a consolidated list with the status of each item; it is easier on you and the coordinator to manage one request list instead of several partial lists.

Items to Request

18.15. Certified voice recording (in stereo) time channel re-recorded at 5db or less. List each position you are requesting a recording for, typically 5 minutes before initial contact to 5 minutes after the last contact with the subject aircraft. Include the Automatic Terminal Information Service (ATIS), as necessary. Most facilities record incoming and outgoing telephone conversations; request these recordings if pertinent calls were made or received.

18.16. Certified transcripts. A partial transcript is normally sufficient for frequencies the aircraft was working with before the accident or incident. A full transcript should be requested for the frequency the aircraft was on at the time of the accident/incident.[2]

18.17. A copy of controller statements for any person who had direct responsibility for controlling or communicating with the flight or preparing or handling data related to the flight; witnessed any portion of the flight operation; was involved in emergency action as a result of the accident; or provided a weather briefing to the flight crew within 24 hours of the accident. Obtain a statement from the supervisor on duty at the time of the accident/incident.

18.18. Copies of all notes, flight progress strips, pads, forms, and memoranda used by the controller at the time of the accident/incident, as well as copies of pertinent chapters of facility orders and position binders.

[2] A partial transcript contains only the communications between ATC and the accident or incident aircraft and any pertinent interphone conversations. A full transcript contains all communications on the recording.

18.19. If OJT was being conducted, a copy of the facility training order and verification that the instructor is properly certified, and a copy of the training evaluation for the session that included the incident/accident

18.20. Diagram of facility layout

18.21. Applicable letters of agreement between the air traffic facility and other facilities or operators

18.22. Pilot bulletins

18.23. A copy of the authorized and on-duty staffing on the day and the shift at the time of the accident/incident.

18.24. Logs, Reports, Forms – as applicable:

a. FAA Form 7230-10, Position Log for all involved positions of operation
b. FAA Form 7230-4, Personnel Log and Daily Record of Facility Operation
c. FAA Form 8020-6 and 8020-6-1, Report of Accident and Continuation Sheet
d. FAA Form 8020-9, Aircraft Accident/Incident Preliminary Notice
e. FAA Form 8020-3, Facility Accident Notification Record
f. Traffic Management Logs
g. FAA Form 8020-21, Preliminary Near Midair Collision Report
h. FAA Form 8020-17, Preliminary Pilot Deviation Report
i. FAA Form 8020-11, Incident Report
j. FAA Form 7233-1, Copy of Flight Plan Record
k. FAA Form 7233-2, Copy of Preflight Briefing Log
l. FAA Form 7233-5, In-Flight Contact Record

12. Recorded radar data (NTAP, CDR, F20, RS3, COMDIG as appropriate)

13. LLWAS, RVR, TDWR (LLWAS kept 15 days, digital RVR 15 days, TDWR)

14. Copy of all NOTAMs pertaining to airport operational and equipment status on the day of the accident/incident.

15. Copy of all SIGMETs, AIRMETs, CWA, Meteorological Impact Statements, terminal forecasts, and current weather observations for the time and day of the accident/incident.

16. Facility equipment status documentation

a. FAA Form 6030.1, Facility Maintenance Log
b. Previous flight checks of NAVAIDs, as appropriate
c. Postaccident flight check reports

17. Copy of instrument approach procedure, including the chart on file at the air traffic facility if an instrument approach procedure is involved.

18. Facility evaluations and facility replies

19. Unsatisfactory Condition Reports related to procedures or equipment pertinent to the incident.

20. Any other pertinent documentation that may come to your attention as a result of your investigation.

21. Review controllers training records for the following information:

a. Date entered the current facility
b. Date became fully certified
c. If in training, the positions the individual is certified on
d. The number of hours the individual has accumulated on the position involved
e. Date certified on the position involved
f. Any applicable training briefing items and the date received
g. Any history of operational errors. Any in past 2 ½ years should be shown in training records, and the full facility investigative package can be requested if needed. Date entered on duty FAA
h.
i. Technical training discussion records – supervisory evaluations of controller performance

Conducting interviews

a. Introduce yourself and the other members of the group, if any.
b. Explain how the interview will be conducted. Normally, tape recorders are not allowed in the interview.
c. Interviewee has the right to one representative of his/her choice. Their role is not to either tell the interviewee what to answer or tell you what you can't ask.
d. You are in charge of the interview. Ensure that questions are fair and are not phrased in a leading manner. (i.e., "would you agree that….")
e. Although NTSB operates on a party system, the only requirement is that the NTSB and interviewee attend the interview. Group members can be given your notes in lieu of actual attendance if you believe that having others present during the interview will reduce the interviewees willingness to talk. Interviewees may also request that one or more members of the group be excused, but you should advise the interviewee that the interview notes will still be available to all group members.

22. Observe conditions in the facility

a. Determine the location and accessibility of maps, charts, approach plates, ready reference files
b. Noise levels
c. Lighting
d. Locations of alarms, bells, doors, various sectors, traffic management staff, supervisory positions.

HUMAN PERFORMANCE STANDARD CHECKLIST

A. Activities in last 72 hours

1. When was the last time you (the pilot, the controller, etc.) worked before the accident?

2. When did you work during the previous 3 days? What were your other activities during this period?

3. When did you go to sleep the previous night (or previous 3 nights)? When did you wake up? Did you feel well rested?

4. What is your normal work schedule? When are days off? When was your last vacation?

5. Describe your activities on the day of the accident up to the accident. When/what did you eat? Any rest breaks?

6. Was this an unusual schedule?

B. Accident History

1. Have you been involved in any previous accidents? Have you been disciplined for your performance? Have you received commendations for your performance?

C. Life Changes

1. In the past year:

   a. Have you had major changes in your health (good or bad)?

   b. Have there been major changes in your financial situation (good or bad)?

   c. Have there been major changes in your personal life (e.g., separation, divorce, birth, death, changes in the health of immediate family/close friends)?

D. Medical/Drugs

1. How is your health?

2. What is the name/address of your personal doctor?

3. How is your vision? Do you wear corrective lenses? Name of eye doctor? Prescription?

4. How is your hearing? Do you wear a hearing aid? Name of doctor?

5. Do you take prescription medicine? What? How often? When was the last time you took it before the accident?

6. Do you drink alcohol? When/what was your last drink before the accident?

7. Do you smoke tobacco? Last use before the accident?

8. Do you use illicit drugs?

9. In the 72 hours before the accident, did you take any drugs, prescription or non-prescription that might have affected your performance?

E. Workload

1. How was workload on the day of the accident?

2. How was workload affected by the weather?

F. Environmental

1. Any problems with the aircraft?

2. Any problem with noise, vibration, temperature?

3. Any problems with visibility (instruments, signals, etc.)?

G. Mood

1. What was the mood of the other crewmembers before the accident? During the accident? After the accident?

2. Had the crewmembers flown together before?

3. Did the crewmembers get along personally? Did they see each other socially?

4. What did they talk about?

5. How did the pilots get along with passengers/flight attendants?

H. Background

1. What was the pilot like personally?

2. Was he married? Any children? What were his living arrangements?

3. What level of education did he complete?

4. How did the pilot get interested in aviation? Where did the pilot get training? What were previous jobs?

5. What did the pilot like about flying? About this job? About the aircraft?

6. How familiar was the pilot with the accident route? With the accident airport?

7. What was the deadline for completing the trip?

8. What were the pilot's greatest strengths as a pilot? Were there areas in which the pilot could have improved?

9. Did anyone ever complain about flying with this pilot?

10. Did the pilot ever complain about the company or equipment?

11. Did the pilot experience any emergency/incident/problem during a previous flight? What happened?

12. Did the pilot receive training in cockpit resource management?

Immediate action items

While the operator is preparing the briefing and collecting the requested documents, the following actions should be taken:

1. Perform a cursory review of the accident aircraft's maintenance log entries and maintenance history printout for the last 30 days. This review should focus on maintenance discrepancies that appear to relate to systems that are tentatively suspect based on the limited accident sequence information already available.

2. Determine if either the operator or a contract maintenance provider performed maintenance actions on the accident aircraft in the last few days. If they have, now is the time to determine if drug testing of the individuals who performed the work will be requested.

3. Have the operator complete the Aircraft and Engine History Data Sheet.

In-depth review of items specific to the accident aircraft

Review the following items for the accident aircraft:

1. Aircraft maintenance logs for the last 90 days. Make sure to record the station identifier, mechanic's identification number, and ATA chapter code for any suspicious writeup or corrective action.

2. Aircraft maintenance history data printout for the last 120 days. The operator should be able to print out this history by an ATA code and for any time period that you feel is important.

3. All non-routine work cards for the last periodic check and for the last "D" or "C" level Heavy Check. For a transport-category aircraft, there will probably be hundreds of cards from a "C" or "D" check.

4. All overhaul records for the aircraft's engines, propellers, and primary system components.

5. Routine work cards. If there is a suspect system or component, the routine work cards signed off during the last applicable inspection should be requested. Each action box on the relevant card should be reviewed for inspection findings and corrective actions taken.

6. Conditional inspection history for life of aircraft. Because these inspections are only performed if the aircraft has experienced a special or unusual condition, it is important to search the work cards for evidence of damage and repairs.

7. Contract maintenance before final flight. Talk directly to the contract shop supervisor to determine if maintenance was performed. The operator may not yet be aware of all contract maintenance actions taken before the aircraft's last flight.

8. Aircraft damage report. This might be the only place that will say if the aircraft was damaged while out of service (e.g., service truck colliding with engine pylon while aircraft is parked at gate overnight).

9. List of major repairs and alterations. In one case in which the aircraft experienced an inflight loss of control, reviewing this list helped to determine that the accident aircraft was the only one in the operator's entire fleet with the newest thrust reverser modification.

10. A list of all STC work that has been accomplished on the accident aircraft.

11. Engine condition monitoring data for the last 30 days. There may be a formal or informal program or just untracked data recorded on the daily aircraft maintenance log. If you are provided raw data only, ask the operator if it can display the data in a graphic format. Provide this data to the Powerplants Group.

12. Engine change log. This log will show you which aircraft within the operator's fleet the engines on the accident aircraft have been on in the past. If there is a suspect engine, you can review its maintenance history (by engine ATA code) for the period it was on the previous aircraft.

13. Engine and airframe vibration monitoring data. Collect and provide to Powerplants and Structures groups.

14. List of MEL/CDL items currently being carried on the accident aircraft. Determine from the master MEL the category (A, B, C, or D) of any carried items, and whether any B or C category items are on an extension.

15. List of all ADs for the accident aircraft. Confirm compliance date and methods. If there is a suspected problem with a component or system that has any ADs written against it, review a copy of the EO or EA that was written by the operator to carry out the applicable portions of the AD.

16. Service difficulty reports (SDR) or maintenance defect reports (MRD) for any suspect component. Data may be obtained through the local FSDO or by calling (405) 954-6509. Be very specific and narrow the request as much as possible (there may be thousands of MRDs for a specific model of aircraft.)

17. List of service bulletins/letters, by title, that apply to the accident aircraft and its components.

18. Operator's list of cancellations/diversions/deviations for the accident aircraft (and all others of the same model) for the last 6 months. If possible, have data listed separately for each maintenance base.

19. Weight and balance sheet. If weight or cg might an issue, check the compliance date, location, and method used for the last weight and balance check. If electronic scales were used, check the method and date of calibration and certification.

20. Import and return-to-service documentation. If the accident aircraft or its engines were imported from a foreign country in the recent past, review all import process documentation and the actions taken qualifying the aircraft to be returned to service. You may have to contact and possibly interview the involved designated airworthiness representative (DAR) who handled this process. You may also need to contact the FAA office that provided oversight of the DAR.

In-depth review of operator's programs, policies, and work conditions

In addition to the group's review of the accident aircraft's maintenance history, the following programs, policies, and conditions should be considered for review:

1. Maintenance training program. Look at the in-house training program for engine, airframe and systems, to include curriculum, instructor qualification/training, participation percentage, recurrent training, training on special systems, and record-keeping. Determine percentage of participation in manufacturer's resident training courses. Interview workers to get their opinion of initial and recurrent training. Also look at the in-house training of maintenance inspectors.

2. Environmental conditions/human factors. Evaluate the work conditions for line and hangar maintenance personnel (day and night shifts). Take a look at lighting, temperature, ventilation, dryness, noise, hazards (e.g., weak or unstable work scaffolds), size and roominess of work area, hazardous waste collection and disposal. Review assigned shift consistency, amount of overtime, and rest break adequacy. Interview workers to get their opinion about relationships with supervisors, management, parent company, and unions. Get the workers' opinions on the clarity of manuals, work cards, and oral instructions. Coordinate with AS-50 for support and guidance in this effort.

3. Shift-change program. Determine how workers on the oncoming shift know where the previous shift left off in the performance of any uncompleted maintenance tasks. Ensure the program is really being used and that it identifies any components or hardware disconnected or removed simply to gain access to the component being worked on.

4. Reliability program. How does the operator identify and track repeat writeups, line and hangar maintenance rejects (completed maintenance tasks that were determined to be unacceptably performed at inspection sign-off), and part infant mortality (i.e., parts determined to be unairworthy when received new from the manufacturer). Get a copy of the operator's FAA-approved program.

5. Tool control program. Determine how personal and company-owned tools are accounted for after each shift change. Determine how a tool is tracked when temporarily at another base. Review procedures followed when a tool appears to be missing. Find out what type of inspection the operator performs to make sure personal tool boxes do not contain loose, excess, or unapproved hardware.

6. Supplemental Structural Inspection Program (SSIP). Review the operator's corrosion prevention control program. Make sure the required reports are being sent to the Aircraft Certification Office (ACO) and manufacturer for findings of level 2 and 3 corrosion. Review the aging aircraft inspection status sheet for the fleet.

7. Repetitive inspection program. Acquire a copy of the component repetitive inspection list for the model of aircraft involved in the accident. Review the program to ensure that all components for the accident aircraft are being inspected at required intervals.

8. Parts receiving program. If a specific off-the-shelf part is suspect, review the program by which the operator receives, inspects, and incorporates parts into its system. Review the documentation to make sure that the suspect part was "approved" and "airworthy" when installed on the aircraft.

9. Functional check flight (FCF) program. Determine what type of maintenance actions require an FCF. Review the operator's program for FCF pilot qualification, maintenance technician participation and qualification, flowchart/checklist usage, and documentation of data and final airworthiness determinations.

10. Foreign object damage (FOD) program. Review program for hangar and line maintenance. Determine if the program is actually being used.

OPERATIONS GROUP

During the initial organizational meeting, the operations group chairmen should instruct the participants to pick up any papers, documents, or manuals from the accident site and forward them to the operations group, which will review this material for its relevance to the investigation. This group's chairman should also coordinate with the appropriate group (usually, the structures group) in documenting the identification, location, and weight of the cargo and passenger baggage on board the aircraft. To the extent possible, the material should be returned to its pre-accident condition before weighing.

The operations group chairman should also coordinate with the appropriate group (usually, the systems group) in documenting the cockpit environment and should confirm that the cockpit area will not be moved or violated pending its full documentation. If the cockpit area is being documented, the assistance of those who are qualified and proficient in the design and operation of the aircraft (e.g., representatives from the airline, the aircraft manufacturer, and the FAA) should be enlisted . In documenting the cockpit, the group should:

1. Take copious notes of the observations and have the participants sign the notes in agreement

2. Take photographs, if possible

3. Obtain the aircraft flight manual for reference

4. Obtain and document the contents of the flight crew's flight cases and personal/overnight luggage. Have a representative of the airline, union (if applicable), and the FAA present during this activity.

5. Retrieve any and all copies form police/port authority/FBI interviews that may have been conducted prior to NTSB involvement.

History of Flight

The following information should be collected to document the history of the flight:

1. Name(s), address, and telephone number of owner and operator of the aircraft

2. Type of aircraft

3. Registration number and serial number

4. Flight number(s)

5. Type of operation (i.e., 14 CFR Part 121, 125, 129, or 135)

6. Date, time, and location of accident site (latitude, longitude, and elevation). Distance from departure or destination

7. Last point of departure. Obtain block in/out and takeoff time.

8. Intermediate stops. Obtain block in/out and takeoff time.

9. Point of intended landing

10. Diversionary landing site, if applicable

11. Dispatch release. Review the original and obtain a certified copy.

12. Weather information provided to the crew. Review the original and obtain a certified copy. Request a statement of the weather briefing that was given, if applicable.

13. Flight plan filed with the FAA. Review original and obtain a certified copy.

14. Clearance received. Obtain certified transcript. Listen to original recording if no ATC group assigned.

15. Route and altitude actually flown and normally flown/assigned. Crew familiarity with each route.

16. En route company and ATC radio contacts (facility and frequency). Obtain certified transcripts and recordings.

17. Flight plan log. Review the original, if available, and obtain a certified copy.

18. Aircraft maintenance log. Review the original and obtain certified copies, as required, of writeups entered during the previous 72-hour period, checking for conditions that could affect the performance of the aircraft and/or the ability of the flight crew to perform their duties. Maintenance records groups will view more extensively.

Weight and Balance

The operations group should complete the following items to verify the aircraft's weight and balance:

1. Weight and Balance Form. Review the original document and obtain a certified copy. Perform manual weight and balance and compare with automated results. Validate the authorization for actual vs. standard weights. Weigh the cargo and passenger baggage, if applicable.

(3) Cargo manifest. Review for type, labeling, placement, and means of securing cargo, especially hazardous cargo, as applicable to the situation. Review original documents and obtain certified copies.

(4) Passenger manifest.

(5) Fuel and oil record. Review original documents, if available, and obtain a certified copy. Compare data with quantities verified or stated to be on board the aircraft. Check with airport authorities for previous problems with fuel and/or the fueling facility. Verify the security of fuel samples for future analysis. (See Airport section).

(6) Method of mean aerodynamic chord (MAC) or center of gravity (cg) computation. Verify by manual and automated method, if applicable.

(7) Weight and balance manual used by airline. Compare with manufacturer and FAA approved data.

(8) Aircraft limitations. Compare airline, manufacturer, and FAA approved data.

Aircraft Performance

Per evidence and company standard operating procedures (SOP), the operations group should determine the following:

1. For Takeoff and Landing

    a. Flap and trim settings
    b. Reference V speeds. (atmospheric adjustments)
    c. Takeoff and go-around engine pressure ration (EPR)

2. En route

    a. Engine power schedules for climb, cruise, and descent
    b. Airspeed (indicated) schedules for climb, cruise, and descent

Air Carrier Information

The operations group should collect the following information regarding the air carrier:

1. Size and scope of operation

    a. Number of personnel, aircraft and size of route structure
    b. Standardization of aircraft fleet

2. Copy of operations certification

3. Copy of operations specifications. Waivers and amendments to the operations specifications.

4. Operations manual. Compare with operating procedures of the airline with the procedures recommended by the manufacturer and the FAA.

5. Aircraft flight manual. Compare the checklist in the company flight manual with the checklist actually used by the flight crew and the one published by the manufacturer.

6. En route, Standard Terminal Area Arrival Route (STAR), Standard Instrument Departure (SID), terminal, and approach charts used by flight crew. Determine if each crewmember was provided with his/her own.

7. Training program. Obtain training program and syllabus. Confirm FAA approval of training program. Indicators that assist in determining the quality and effectiveness of the program include the establishment of a training directorate within the airline, programs incorporating stabilized approach criteria, and cockpit resource management (CRM). Compare the policy and procedures of the operations manual with the training manual/program for continuity. Document the background and qualifications of company training personnel.

8. The airline's safety office/directorate (if applicable). Determine its authority and ability to impart safety enhancements to the flight operations. In the absence of such an entity, determine which person and/or department is delegated this responsibility and conduct interviews.

9. Company pilot bulletins or reading file. Review for data that may be relevant to the circumstances surrounding the accident/incident.

10. Dispatch and/or flight following. Determine size and scope of the dispatch or flight following function. Compare the duties and responsibilities of this function as stated in company documents with the FARs. Compare the background and qualifications of dispatch/flight following personnel with the FARs. Determine dispatch/flight following procedures.

    a. Weather briefings

        1. Review original data provided and obtain certified copies
        2. Determine source of data and method provided

    b. Flight planning forms

    c. Computer flight plan

d. Fueling record

e. Method of flight following. Advisories issued.

Flight Crew Information

1. Confirm the extent of the pre-employment checks that were performed on the flight crewmembers

2. Request and obtain FAA "blue ribbon" certification and medical packages and violation data. Confirm that the human performance group or specialist has requested the flight crew's state driving records.

3. Review company personnel files and employment history for trends (both positive and negative) that may be relevant to the investigation. This includes violations and commendations, absenteeism, and any extended periods between employment. Obtain names, addresses and telephone numbers of previous employers and physician(s) who were used for the FAA medical. Also look for possibly non-flight related events. Obtain certified copies.

4. Obtain copies of FAA pilot certificates and ratings held from company files

5. Obtain copies of medical certificates and related information from company files and compare to FAA data.

6. Training records. Review the training records to determine the quality and quantity of training given and remarks noted by the instructor. If possible, request that the instructor and pilot sign and date the forms attesting to the training given. On occasion, it may be prudent to compare the signatures of the pilot and instructor and the training documents with other sources such as payroll records and driver's licenses.

    a. Review the training records for initial, line (en route), 6 months proficiency, and annual/recurrent including ditching and emergency. Obtain certified copies.

    b. Initial focus should be on specific areas of training that on the surface may appear to be relevant to the investigation.

    c. Information that should be available and obtained from the personal, training, and flight records of each cockpit crew member includes:

        i. Date employed
        ii. Date upgraded to present position
        iii. Date upgraded to present position in particular equipment
        iv. Total pilot time

v. Total pilot time (flight and duty) last 24 hours, 72 hours, 30 days, 60 days, and 90 days
vi. Total instrument time, if available
vii. Total instrument time in type, if available
viii. Total night time, if available

7. Recency of experience with airport and approach procedure

8. Previous experience of flight crew in flying with one another

Airport Information

1. Obtain latest copy of airport master record (Form 5010) and airport planning chart

2. Latest report of FAA annual inspection

3. NOTAMs (class D, L, and FDC)

4. Construction on airport property and surrounding area

5. Inspection results on the condition of airport surface(s)

6. Local obstructions

7. Waiver of Part 77

8. Condition of airport lights and radio aids

9. Aerial photos, topographic charts

10. ATC information if no group assigned

11. Weather information, if no group assigned

12. Obtain fuel specimens for analysis

In the absence of a survival factors group, the operations group will address the following crash and rescue activities in addition to those listed above:

1. Time and method notified

2. Response time

3. Number and types of units responding

4. Fire fighting time
5. Rescue activities
6. Pictures of accident scene and cabin
7. Problems with terrain/visibility/route to accident
8. Problems with access to wreckage/passengers and crew
9. Type and quantity of fire fighting compounds used
10. How, when, and by whom security was established
11. Crowd control problems
12. Facility station log
13. Last disaster drill
14. Accident report from fire station(s) and security.

Survival Factors Checklist

Survival Factors Investigation

The Survival Factors Group is responsible for developing and documenting information related to: (1) injuries and crash survivability, (2) flight attendant procedures and training, (3) seats and restraints, (4) aircraft rescue and firefighting, (5) airport operations, (6) evacuation systems and post-evacuation survival, (6) passenger interviews, (7) search and rescue, (8) aircraft interior configuration and damage, and (8) post-mortem examinations and toxicological analyses of fatalities.

As a member of the Survival Factors Group, the Safety Board expects that you will comply with the following guidelines so that the group can function as effectively as possible:

(1) Group members should refrain from discussing the accident in public and, in particular, the work of the Survival Factors Group. We will be working at times in extremely sensitive areas of the investigation (body recovery and identification, personal effects, injuries sustained by survivors and fatalities, etc.). Conversations, if overheard by the press, insurance representatives, or relatives of passengers and crew, could cause unnecessary grief and could be misinterpreted or misquoted.

(2) If, at any time, the work of the Survival Factors Group is of such a nature that a group member would prefer to be assigned to another task within the group or to another group, the Group Chairman is to be notified. Group members will remain until the completion of the on-scene investigation; however, in the event that a group member must leave before the field investigation is completed, the Group Chairman is to be notified immediately so that a replacement can be assigned to the group.

(3) Group members will be required to take notes during their group duties. Original notes and photographs taken by group members are to be turned in to the Group Chairman at the conclusion of the field investigation. The group, under the direction of the Group Chairman, will consolidate the notes into one set of group notes. Each group member will then initial the group notes signifying that they agree that the notes represent accurately the findings of the group.

(4) Group members may be issued badges that will permit access to designated control areas during the investigation. These badges must be returned to the Group Chairman before group members can be released from the group and before they receive copies of group notes.

(5) Because of the amount of work that the group must accomplish within relatively short period of time, it will be necessary for group members to confine all of their investigative activity exclusively to this group. Each

person will be assigned specific duties to complete before their participation in the investigation can be considered complete. When a group member's participation is no longer required, the Group Chairman will personally release that member from the group and notify the IIC of his action.

(6) The Group Chairman relies on group members to keep him/her informed and up-to-date on the member's progress and findings. The Group Chairman, in turn, must keep the IIC continually informed of the group's progress. Consequently, you are to inform the Group Chairman of your findings first and then your coordinators.

(7) Progress meetings will be convened by the IIC to disseminate information and findings of each group to all the parties to the investigation. During these meetings, the Group Chairman may call upon group members to present certain detailed findings, which they were responsible for developing or documenting.

(8) The Survival Factors Group Chairman will convene group meetings to review the group's progress. These meetings will afford the Group Chairman the opportunity to learn of any difficulties the members may be having in developing certain information. Finally, based on the group's progress, the Group Chairman will reassign group members to the other tasks.

(9) The attached Investigative Outline and Checklist details the scope of the group's work. Obviously, some of the items are not relevant to every accident, and they will be left blank.

(10) Each group member will be assigned specific checklist items to accomplish individually or, in some cases, with one or more persons for the more complex items. The Group Chairman will maintain an up-to-date master copy of the checklist, which will provide an indication of progress in gathering the required information.

(11) Upon completion of assigned tasks, the group Chairman may reassign members to other tasks as required in order to complete the investigation in a timely manner.

(12) The final group activity will be the writing of the group notes of the on-scene investigation. Group members may be assigned to write portions of the report. Each group member will initial the notes to show their agreement and will receive a copy of the initiated notes before being released from the group. After leaving the accident scene, the Group Chairman will use the notes to develop the Survival Factors Group Chairman's Factual Report which will be entered into the public record. If no public hearing is held, the report will be placed in the public docket along with other reports in our Washington Headquarters.

Meteorological Investigation Checklist

Defining The Environment

Data Sources

- NOAA/National Weather Service
- Federal Aviation Administration
- Private Weather Companies
- TV and Radio Stations
- Utility Companies
- State and Local Weather Networks
- Universities
- Department of Defense
- Air Quality Monitoring Networks
- Witnesses - Ground and Airborne
- Meteorological Operational Tests
- Meteorological Research Programs
- Computer Graphics and Weather Analysis System (McIDAS)
- Internet Sites
- Sunrise/Sunset/Sun Azimuth/Angle Software
- Video Cameras

Data

NOAA/National Weather Service

- Surface Weather Observations
- Forecasts and Advisories
- Weather Radar Data (WSR-88D)
- Upper Air Data
- Satellite Data
- Lightning Data
- Transmissometer (visibility) Data
- Rainfall Records
- Severe Weather Reports
- Location of Meteorological Sensors
- Cooperative Weather Observers
- Time Source and Time Accuracy
- High Resolution Data from Automated Weather Observing Systems (ASOS and AWOS)

Federal Aviation Administration

- Surface Weather Observations
- Transmissometer (visibility) Records
- Low Level Windshear Alert System (LLWAS) Data
- Pilot Reports

- Data From Flight Service Station
- Weather Radar Data (WSR-88D/TDWR)
- High Resolution Data from Automated Weather Observing Systems (ASOS and AWOS)

Private Weather Companies
- Weather Radar Data
- Locally Produced Data
- Lightning Data

TV and Radio Stations
- Videotape
- Locally Produced Data
- Weather Radar Data
- Lightning Data

Utility Companies
- Lightning Data
- Weather Observation Data

Universities
- Lightning Data
- Weather Radar Data
- Weather Observation Data

Department of Defense
- Surface Weather Observations and Data
- Weather Radar Data
- Upper Air Data
- Lightning Data
- Transmissometer (visibility) Data
- Satellite Data
- Pilot Reports

Air Quality Monitoring Networks
- Surface Weather Data
- Upper Air Data
- Radar Data (Acoustic Doppler, LIDAR)

Ground Witnesses
- Wind Information
- Cloud Height Information
- Rainfall Information
- Pressure Information
- Lightning Information

- Information on the Type of Clouds
- Visibility Information
- Videotape Records (Personal, From Outdoor Security Systems, etc)
- Temperature Information
- Type of Precipitation (Frozen or Freezing)

Meteorological Operational Tests

- Weather Radar Data (Doppler)
- Lightning Data
- High Resolution Surface Data
- Upper Air Data (Profiler)

Meteorological Research Programs

- Aviation Impact Variables
- Numerical Atmospheric Modeling

Evaluating Weather Products and Services

Products

National Weather Service

- AIRMET
- SIGMET
- Center Weather Advisory
- Meteorological Impact Statement
- Area Forecast
- Terminal Forecast
- Aviation Weather Watch
- Convective SIGMET
- Local Airport Advisory
- Forecast Upper Winds
- Special Weather Statements
- Public Forecasts and Warnings
- Verbal Issuances
- Written Issuances (Transmissions NWS to Operator, computer)
- Post Accident Checks of Equipment
- Visibility Reference Charts
- Upper Air Charts and Surface Charts
- Icing, Turbulence, and Convective Graphic Products

Private Weather Companies

- Locally Produced Forecasts, Advisories and Warnings
- Verbal Issuances

Department of Defense
- Locally Produced Forecasts, Advisories and Warnings
- Verbal Issuances

Services (Provided By)
- National Weather Service
- Local NWS Office (Aviation Forecaster, Public Forecaster, Meteorological Technician)
- National Office (Aviation Weather Center)
- Center Weather Service Unit

Federal Aviation Administration
- Weather Coordinator (Center)
- Air Traffic Control Specialist (Flight Service Station)
- Controllers
- Supervisors

Private Weather Companies
- Meteorologist

Airline Meteorological Office
- Meteorologist

Airline Dispatch Office
- Dispatcher

Department of Defense
- Forecaster
- Observer
- Air Traffic Control Personnel