行政院及所屬各機關出國報告

（出國類別：實習）

參加澳洲飛航服務學院
「飛航事件調查」課程出國報告書

服務機關：民用航空局飛航服務總
台飛航業務室
出國人　職　　稱：管制員、管制員
　　　　姓　　名：曾瓊慧、劉家棋
出國地區：澳洲墨爾本
出國期間：中華民國 91 年 11 月 23 日至 11
月 30 日
報告日期：中華民國 92 年 1 月 25 日

系統識別號:C09200886

公務出國報告提要

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報告名稱:

參加澳洲飛航服務學院「飛航事件調查」課程出國報告書

主辦機關:

交通部民用航空局

聯絡人／電話:

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出國人員:

曾瓊慧	交通部民用航空局飛航服務總臺	飛航業務室	管制員
劉家棋	交通部民用航空局飛航服務總臺	飛航業務室	管制員

出國類別: 實習

出國地區: 澳大利亞

出國期間: 民國 91 年 11 月 23 日 -民國 91 年 11 月 30 日

報告日期: 民國 92 年 02 月 27 日

分類號/目: H2／航空　H2／航空

關鍵詞:　飛航事件調查

內容摘要: 飛航事件調查爲飛航服務總台飛航業務室重要業務之一，此次赴澳洲飛航服務學院參加爲期五天之事件調查之課程，更清楚明白如何從事飛航事件之調查，學習如何進行飛航事件之調查、收集及整理資料最後如何撰寫調查報告，課程內容豐富又緊湊。包含事件調查的觀念、方法及技術、人爲因素之剖析，使參訓者能吸收他國之經驗，執行業務時能徹底找出事件肇因，進而研擬及提出建設性之改善措施。

本文電子檔已上傳至出國報告資訊網

參加澳洲飛航服務學院「飛航事件調查」課程報告書

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參加澳洲飛航服務學院「飛航事件調查」課程出國報告書

壹、 目的

此次赴澳洲飛航服務學院參加為期五天之飛航事件調查之課程，其主要目的為完訓後能夠更清楚明白如何從事飛航事件之調查，經由此次之訓練也可學習到如何進行飛航事件之調查、收集及整理資料最後如何撰寫調查報告。

貳、 行程

去程一中華民國九十一年十一月二十二日搭乘中華航空公司編號051班機，由桃園中正國際機場到澳洲雪梨，二十四日再由雪梨轉機至目的地墨爾本。

回程一中華民國九十一年十一月三十日由墨爾本搭機至雪梨然後轉乘中華航空公司編號052班機，由澳洲雪梨回到桃園中正國際機場。

參、 課程

本課程為期五日，自九十一年十一月二十五日至十一月二十九日，教授課目如下：

一. 第一日

(一). INTRODUCTION

(二). THE ROLE OF THE INCIDENT INVESTIGATOR

(三). INVESTIGATION EXERCISE

(四). HUMAN PERFORMANCE LIMITATIONS

(五). CONCEPTUAL MODELS IN INCIDENT INVESTIGATION

(六). HUMAN ERROR

(七). INTERVIEWING TECHNIQUES

(八). INVESTIGATION EXERCISE

二. 第二日

(一). SAFETY MANAGEMENT IN AIR SERVICES

(二). TAAATS AND ESIR

(三). INTRODUCTION TO HUMAN FACTORS

(四). CONCEPTUAL MODELS

(五). INVESTIGATION EXERCISE

三. 第三日

(一). INVESTIGATION EXERCISE

(二). THE LEGAL PERSPECTIVE

(三). CASE STUDY (DETROIT INCIDENT)

四. 第四日

(一). CASE STUDY (AMSTERDAM INCIDENT)

(二). INVESTIGATION EXERCISE

(三). REPORT WRITING (PLAIN ENGLISH)

(四). REPORT WRITING (REPORT STRUCTURE)

五. 第五日

(一). INVESTIGATION EXERCISE (INTERVIEW)

(二). INVESTIGATION EXERCISE (ANALYSES)

(三). INVESTIGATION EXERCISE (REPORT PREPARATION)

(四). INVESTIGATION EXERCISE (PRESENTATION)

(五). COURSE CRITIQUE

肆、 課程心得

這此課程共有 18 人參加，除了我們(劉家棋和曾瓊慧)來自台灣，其餘成員分佈全澳洲，在自我介紹過程中了解他們都有管制員背景，16 人中有 2 位來自軍方為軍方管制員、14 位來自民方（澳洲航管單位已民營化）其中 13 位為管制員及 1 位機務人員，大部分之資深管制員及機務人員是管理階層，五天的課程安排緊湊，上課期間大家都非常投入，整個課程安排非常生動活潑，主要的上課內容分：

一. 飛航事件調查員須具備：
  (一). 豐富之管制經驗及事件分析技巧。
  (二). 良好之溝通能力及團隊合作之精神。
  (三). 意外事件之調查人員將得到最大之協助，他可調閱所有資料(包括所有訓練資料及席位查核資料)、錄音抄件及訪談(包括航管單位主管、值班督導、訓練中心教官、機務單位主管、機務維修人員及機務督導等)。

二. 如何進行飛航事件調查及分析：
  (一). 進行飛航事件調查需考慮之因素：
    1. 當事人之身體狀況、對事件之警覺性及溝通方式。
    2. 班務輪值表(日班及夜班之時數)及是否給予當事人額外之工作。
    3. 工作環境(當時航情及工作環境)。
    4. 設備及裝備(裝備之適用性及維修紀錄)。
    5. 管理階層(組織文化、訓練課程、當時航管及機務輪值人員檢定及查核紀錄、對飛安之要求)。
    6. 包含航管及機務之各項隔離、作業標準及程序。
  (二). 進行飛航事件調查需思索：
    1. What has happened ? (發生了什麼事？)

2. What caused the event to happen? (為何發生？)

3. What must be done to prevent the event recurring ? (如何避免再度發生？)

三. 飛航事件之調查員須具備之面談技巧

(一). 進行訪談前：

1. 介紹當事人訪談成員。

2. 告知訪談規則。

3. 錄音且作記錄。

(二). 進行訪談時

1. 鼓勵當事人詳細將當時情境敘述出來。

2. 嘗試讓當事人自由發言。

3. 勿中斷當事人發言。

(三). 協助當事人

1. 模擬事件發生時之情境。

2. 協助當事人集中注意力。

(四). 訪談結束

1. 確認當事人已敘述完畢。

2. 謝謝她(他)們的努力。

3. 留下連絡方式以便告知遺漏之資料。

4. 追蹤(訪談結束一禮拜後)

有效收集資料，澄清並確認一禮拜前之訪談資料正確無誤。

四. 如何撰寫報告

每一飛航事件調查結束後都需寫報告其原則如下：

(一). 避免使用大寫字母。

(二). 陳述事實。

(三). 使用簡單易懂之文字敘述。

(四). 用語一致且勿寫錯字。

(五). 嚴謹的標題段落結構。

(六). 標點符號謹慎標示。

(七). 使用的文字需與事實相符。

(八). 出版前檢視文字及可讀性。

(九). 避免冗長句子。

(十). 標示項目符號及編號。

(十一). 報告封面。

(十二). 文件索引。

(十三). 文件目錄。

五. 案例研討

(一). THE DETROIT INCIDENT(略，詳見附件)

(二). THE AMSTERDAM INCIDENT (EL A1 1862) (略，詳見附件)

雖只有兩個案例，但由書面資料及錄音錄影可看出教官之用心，大家非常熱烈討論孰是孰非，看完其錄影、錄音還真教人怵目驚心，從事航空業能不小心嗎?

六. 分組討論及小組代表報告

整個課程最有趣就是在分組討論了，18 位學員被分成三組在課堂課進行期間同時進行模擬飛航事件之調查，即使是模擬狀況他們仍非常認真，不分資淺或資深(有些人已有案件調查之經驗)大家都參與討論，若不是置身小組討論無法想像他們的投入。

更有趣的是模擬飛航事件之發生有一整套之資料，教官設計兩架假想航空器因管制員沒適時修正高度？亦或是無線電維修機務未適時通知管制單位就進行關機維修、、、等因素造成兩航空器在 TERRACE HILL 接近，還好兩航空器按照

TCAS RA 之指示爬升、下降化解了一場危機。

由書面資料及錄音及錄影可看出教官之用心，我們進行模擬飛航事件之調查有非常完整之資料甚至還有地方報 之披露，除此之外，還可由下列資料一

(一). 信函：

1. 航管單位主管來函要求協助調查飛航事件之真相。
2. 雙方航空公司(EAGLE AIRLINERS AND PHOENIX AIRLINERS)來函陳述當時情境。

(二). 規定：

1. 作業規定。
2. 隔離標準。
3. 分區規定。

(三). 當事人訓練資料(包括筆試、實習測驗及席位查核資料、、、等)。

(四). 有效之執照資料。

(五). 錄音抄件。

(六). 管制記錄條。

(七). 公告(無線電將關機維修之公告)。

(八). 席位輪值表。

(九). 管制作業室當班管制員之席位配置(席位平面圖)。

每一人都有完整之資料可供參考，分組後每組 6 人，由小組長分別帶到三間房間利用所有資料反覆研討事件之始末，每一個人都做筆記亦從課堂課學習到之方法來進行整個假想狀況，思索發生了什們事、為何會發生、如何避免再次發生，亦運用 THE SHELL MODEL 及 THE REASON MODEL 之方式來討論事件發生之原因。

1. THE SHELL MODEL

各個英文字母代表：

(1). S＝SOFTWARE (有關個人與工作環境之間，例如：核對表、程序、地圖、航圖、相關規定等等。)

(2). H＝HARDWARE(有關個人與工作環境之間，例如：硬體使用之限制、裝備設計及陳設、裝備的色彩及可視性、視線參考點等等。)

(3). E=ENVIRONMENT(包括工作環境的舒適、室溫與溼度、採光、噪音干擾、空氣品質。)

(4). L＝LIVEWARE(人與人溝通的介面，例如：語音傳遞、術語、對話內容、通話速度、語言障礙、覆誦及聆聽覆誦、飛航組員簡報、座艙系統管理、飛航組員溝通、與乘客的互動、勞資關係、壓力等等。)

雖然所有因素並不一定處於同等的地位，但每一因素在飛航事件的調查若有任何誤導，都可能造成飛航事件的調查有所偏頗。

2. REASON MODEL

可由下列四個因素來界定：

(1). LATENT CONDITIONS(易被忽略的情況)

A. 錯誤的政策

B. 無效率的管理

C. 心理的指標

(2). ACTIVE FAILURES

第一線的執業人員若發生任何的錯誤，將立刻導致致命的後果，例如：飛航組員若在起飛前忽略襟翼的設定，將造成嚴重的事件；或者是維修人員未能更換引擎的小零件。

(3). PRECONDITIONS

這是赴著在組織內攸關生產的品質和問題。代表著正面及負面影響組織的因素，

正面的因素一良好的裝備、良好的職業道德、良好的職業訓練、高昂士氣的僱員。

負面的因素一生產效率不高的工作環境、沒有士氣的工作團隊、不良的程序等，這些容易被忽略的因素往後將會影響到組織安全。

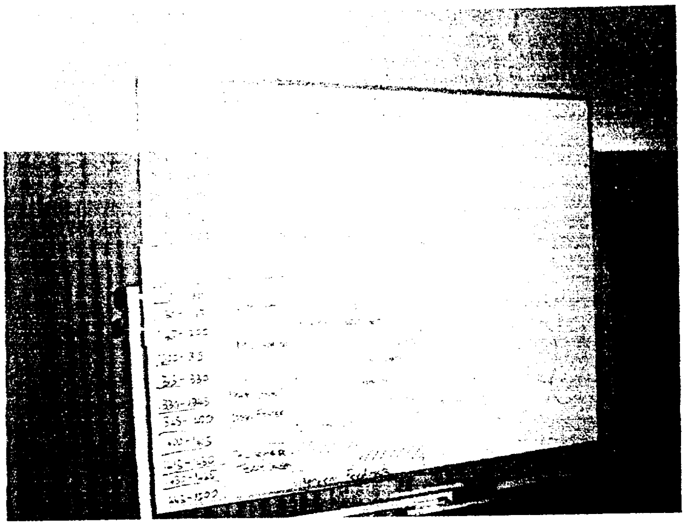
(4). DEFENSES

REASON MODEL 的最後一道防線，也是組織的安全防護網。無論飛航組員紀律、適切的訓練、查核表的使用、警告裝備、以及其他防止發生錯誤的技巧。假如不能建立這些安全防護網就極有可能發生意外事件。

我們這一組小組成員（如附圖一）依照授課教導方式方式（THE SHELL MODEL 及 THE REASON MODEL）反覆思考模擬飛航事件發生之可能原因，兩位 AIRSERVICES CILLEGE 之教官亦扮演各種被訪談之角色(角色扮演成功且有趣)供我們練習訪談技巧（如附圖二及附圖三），也經由此種方式讓我們清楚明白飛航事件的發生原因需多方推敲思考、收集資料及訪談相關人等，千萬不可掉以輕心，一個很重要的環節是在調查飛航事件發生的可能原因時，調查成員們互相討論（澳洲調查一件飛航事件之調查員有四人，且調查員需經訓練後取得證照）是非常重要的，大家熱烈的討論將可能造成之原因一件、一件條列式的寫在白板上大家將問題抽絲剝繭攤開來反覆思考（如附圖四），經由這一次上課得到之經驗真的是非常寶貴，最後每一組代表於課程最後一日分別上台提出該組之調查報告。唯一美中不足的是被約談角

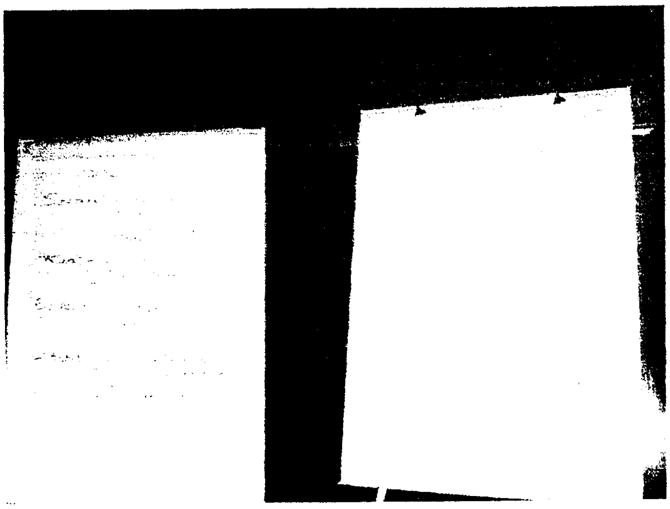
色扮演者只有二名教官，他們必須依照時間預約分配表至三小組變換扮演各種角色，如遇有需要第二次約談先前已約談過之被約談人時，角色扮演者會忘記或混淆先前之說辭，以致於模擬約談效果稍有折扣。


（附圖一：小組成員）



（附圖二：各小組訪談角色扮演預約分配表）

（附圖三：模擬飛航事件訪談角色扮演）



（附圖四：小組討論表列）

七. 專題演講

安排在每日晚餐後一小時。

陸、結論：

民航局之品質政策為「飛航安全，世界一流，飛航服務，顧客滿意」。但要達到該目標，飛航事件需儘量降低；國內、外的飛航事件資均顯示人為因素佔發生比率極高，一般對於人為疏失的調查與責任歸屬都直指值班當事人，而對於當事人大部分採取加強訓練來彌補其知識技能之不足和處罰當事人來減少疏失的再發生。可是，這些措施成效往往不彰；加強訓練只能對某些疏失有效，因為即使是熟練的作業或小心翼翼者也會有所疏失；至於對當事人的懲罰也僅能對那些有動機問題的違規事件有效，對於作業規劃的不當或執行的疏忽並無所助益，而且懲罰也常引起情緒反應，造成組織管理的問題。這次參加澳洲飛航服務學院飛航事件調查課程，印象最深刻的是他們對於事件之發生絕不會只針對值班當事人檢討及認為當事人為唯一負責者，他們更著重於工作團隊、組織、程序及作業查核等方面加強和改進。在作業者層面上改善系統與人機介面設計，增加人員與自動化間之相容性，避免人員負荷過輕或過量。施行訓練課程加強基本動作之要求，使之成為無需經過思考之良好反射動作，增進程序知識，讓管制員瞭解程序意義，以利於其記住；演練緊急應變程序，反覆進行技能練習以維持純熟度。審查及制定程序書，消除程序書上的錯誤、不清楚、難以瞭解之處。簡化程序並避免程序間的不一致性。

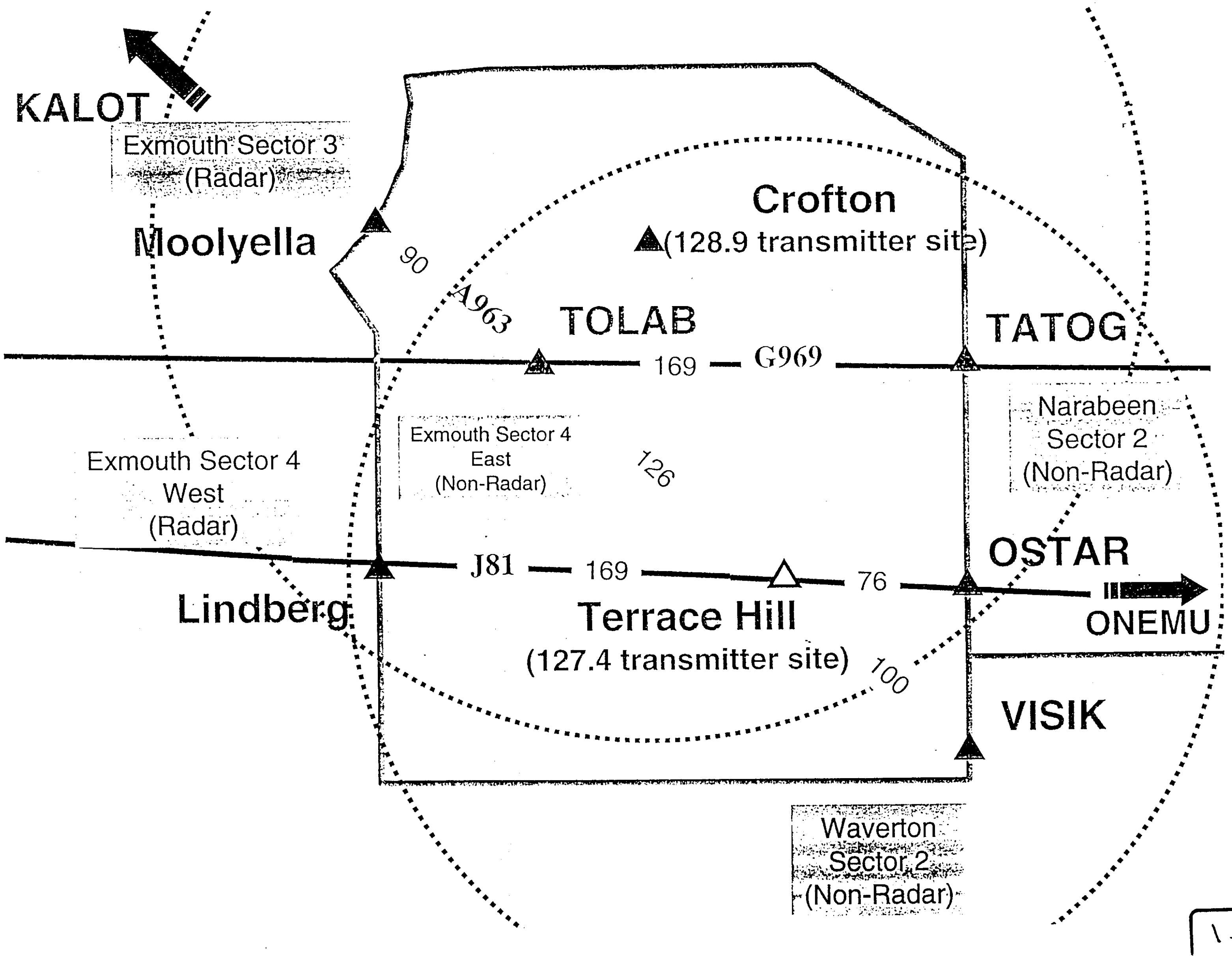
在工作團隊方面可以下列著手：一、狀況察覺：以監督、解釋及干預之方式維持警覺性以期待可能會觸發疏失的情境和有瑕疵的防禦設施。二、溝通及討論：在團隊作業時，知覺到互動過程中增加風險的因素。三、尋求協助。四、使用並遵守程序的習性：程序書是用以控制作業人員可以安全與可靠地執行規則性行為而達到高標準。建立團隊遵循程序書的價值觀與行為常模。而在組織方面：文化因素一直是飛航事件及案件中被忽略的，文化因素一般人認定

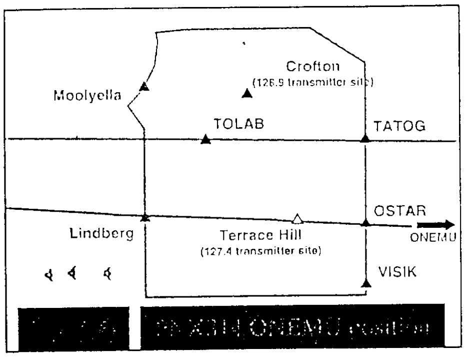
存在不同國籍人們的思考及行為模式不同，但不止於此，同一國家內同一公司內不同的單位都有可能發展出不同的文化。在本區航管單位即可以發覺，航路及終端有著不同的文化，而終端中因各近場台位處於不同地點而又各有差異，甚至於航路中值班分組因個人之差異及行為風氣不同而產生不同之文化。不論如何，應建立「持續改善」的文化；持續確認出組織內潛在的弱點。管理階層持續監督與控制所產生的改變，因此組織對安全議題會發展出正面效應。管理階層對於安全的承諾會透過決策的過程而發酵。並召集組織內所有層級的人員參與進行問題解決的活動，著重安全文化的提昇，建立共同的願景與目標，推動有效的溝通，以期達到「飛航安全，世界一流」的目標。

柒、 分組討論案例資料（如附件一）

捌、 課程資料精華（如附件二）

附件一


KALOT
Exmouth Sector 3 (Radar)
Moolyella
90
A963
Crofton
(128.9 transmitter site)
TOLAB
169
G969
TATOG
Narabeen Sector 2 (Non-Radar)
Exmouth Sector 4 East (Non-Radar)
126
Exmouth Sector 4 West (Radar)
J81
169
76
OSTAR
ONEMU
Lindberg
Terrace Hill
(127.4 transmitter site)
100
VISIK
Waverton Sector 2 (Non-Radar)


Crofton
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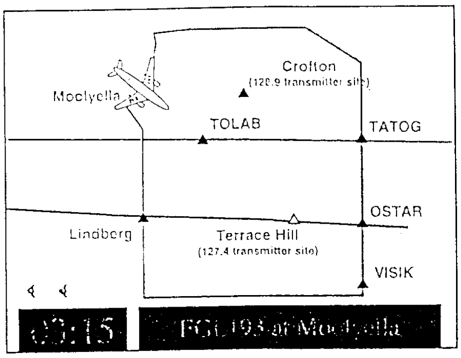
Moolyella
TOLAB
TATOG
OSTAR
ONEMU
Lindberg
Terrace Hill
(127.4 transmitter site)
VISIK
ONEMU position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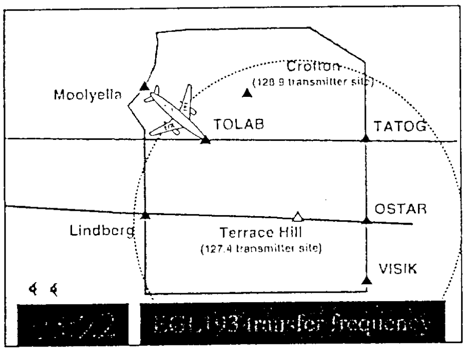
Moolyella
TOLAB
TATOG
OSTAR
Lindberg
Terrace Hill
(127.4 transmitter site)
VISIK
03:15
EGL193 at Moolyella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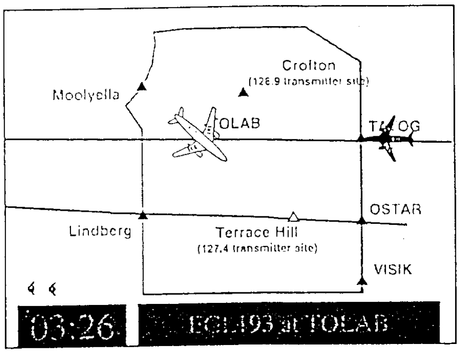
TOLAB
TATOG
OSTAR
Lindberg
Terrace Hill
(127.4 transmitter site)
VISIK
03:22
EGL193 transfer frequency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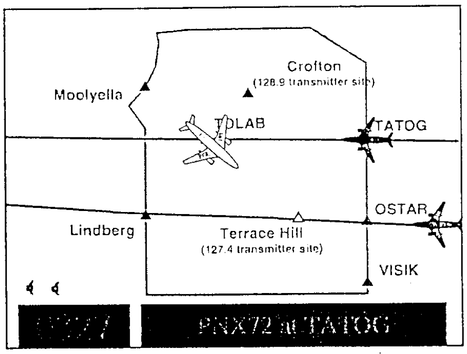
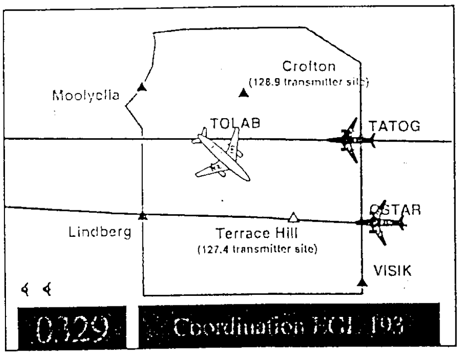
Moolyella
TOLAB
TATOG
OSTAR
Lindberg
Terrace Hill
(127.4 transmitter site)
VISIK
03:26
EGL193 at TOLAB


Crofton
(128.9 transmitter site)
Moolyella
TOLAB
TATOG
OSTAR
Lindberg
Terrace Hill
(127.4 transmitter site)
VISIK
03:27
PNX72 at TATOG


Crofton
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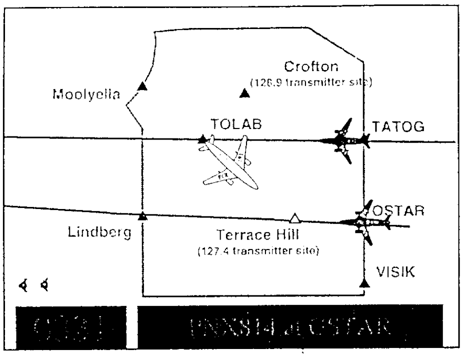
Moolyella
TOLAB
TATOG
OSTAR
Lindberg
Terrace Hill
(127.4 transmitter site)
VISIK
0329
Coordination EGL 193


Crofton
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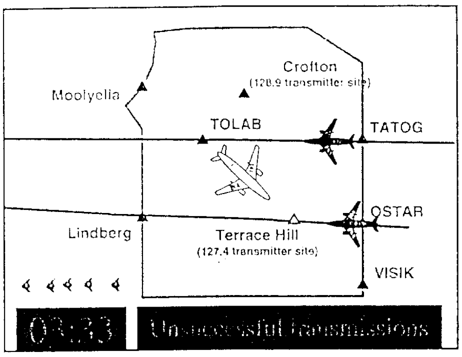
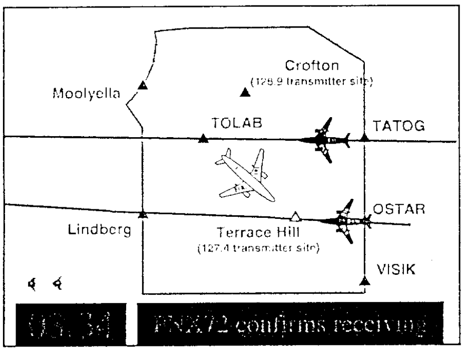
Moolyella
TOLAB
TATOG
OSTAR
Lindberg
Terrace Hill
(127.4 transmitter site)
VISIK
03:31
FNX814 at OSTAR


Crofton
(128.9 transmitter site)
Moolyella
TOLAB
TATOG
OSTAR
Lindberg
Terrace Hill
(127.4 transmitter site)
VISIK
03:33
Unsuccessful transmissions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TATOG
OSTAR
Lindberg
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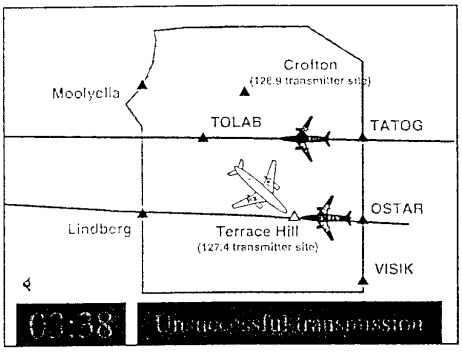
(127.4 transmitter site)
VISIK
03:34
FNX72 confirms receiving


Crofton
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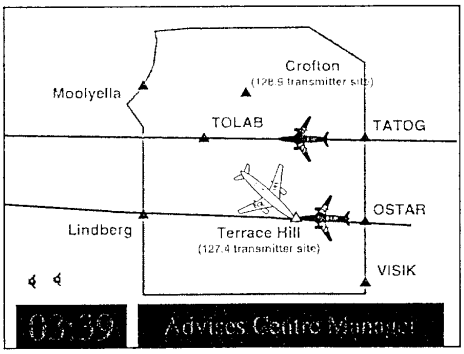
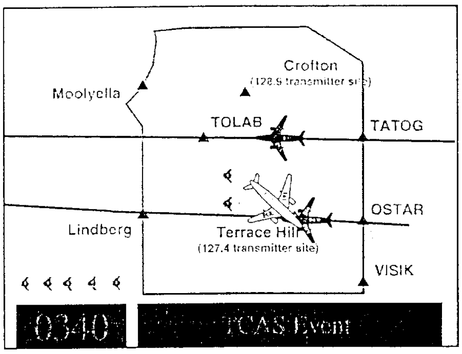
Moolyella
TOLAB
TATOG
OSTAR
Lindberg
Terrace Hill
(127.4 transmitter site)
VISIK
03:38
Unsuccessful transmission


Crofton
(128.9 transmitter site)
Moolyella
TOLAB
TATOG
OSTAR
Lindberg
Terrace Hill
(127.4 transmitter site)
VISIK
03:39
Advises Centre Manager


Crofton
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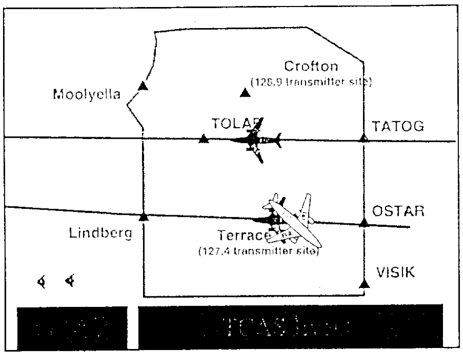
Moolyella
TOLAB
TATOG
OSTAR
Lindberg
Terrace Hill
(127.4 transmitter site)
VISIK
0340
TCAS Event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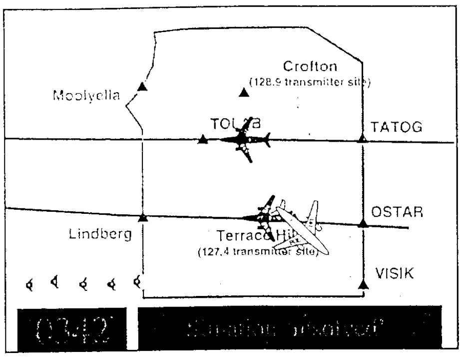
Moolyella
TOLAB
TATOG
OSTAR
Lindberg
Terrace
(127.4 transmitter site)
VISIK
TCAS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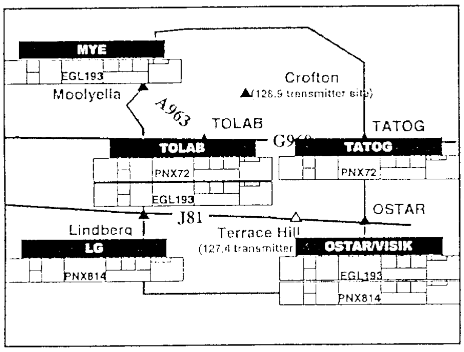
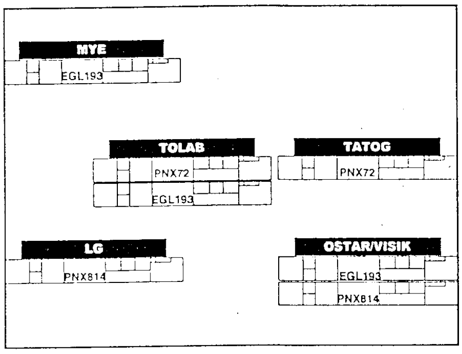
(128.9 transmitter site)
Moolyella
TOLAB
TATOG
OSTAR
Lindberg
Terrace Hill
(127.4 transmitter site)
VISIK
0342
Situation resolved?


MYE
EGL193
Moolyella
Crofton
(128.9 transmitter site)
A963
TOLAB
TATOG
G9
TOLAB
TATOG
PNX72
PNX72
EGL193
OSTAR
J81
Lindberg
Terrace Hill
(127.4 transmitter
LG
OSTAR/VISIK
PNX814
EGL193
PNX814


MYE
EGL193
TOLAB
TATOG
PNX72
PNX72
EGL193
LG
OSTAR/VISIK
PNX814
EGL193
PNX814

THE EXMOUTH CHRONICLE

25/11/2002

Jets in Near-Miss Drama

'Within metres of a collision!'- passenger

Sam Spade
Staff reporter

Two passenger jets came within seconds of colliding over Exmouth last week. Passengers on Phoenix Airlines Flight 814 from Riverstone said that the two aircraft 'were metres apart' before the pilot initiated a last minute maneuver to avoid colliding with an Airbus operated by rival Eagle Airlines.

A spokesperson from Exmouth ATC. Inc, speaking on condition of anonymity, said that a collision was avoided only through a combination of luck and emergency procedures.

Both Phoenix and Eagle Airlines declined to comment, but Mr. Barry MacAvaney, a former pilot and ex-chairman of the Ultralight Aircraft Federation said that instances such as these were relatively rare. He said that Amnesia enjoyed an enviable safety record and that he had only witnessed a small number of similar incidents, mainly involving light aircraft. He warned however, that this incident could have resulted in hundreds of deaths, both of passengers and people on the ground.

INSIDE THIS ISSUE

Plan to 'medicate' beer

London
November 19 2002

Scientists are considering whether brewers should "medicate" their beer to reduce the risk of alcohol-related brain damage among Britain's heaviest drinkers.

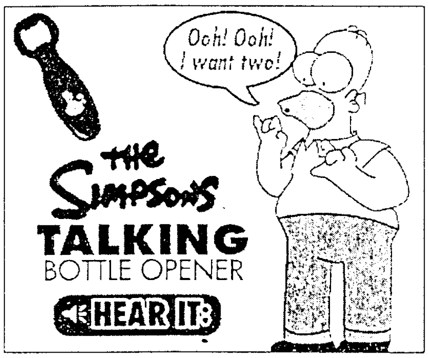
Ministers in Scotland are interested in the idea, which is likely to cause a political storm across the rest of Britain were they to decide such a scheme was practical, cost-effective and ethical.

Critics say adding thiamine, or vitamin B1, to alcohol would undermine health messages about the need for sensible drinking and reinforce complaints about the "nanny state".

The idea has been floated in Australia as a preventive measure against a disease called Wernicke's encephalopathy. The Scottish executive's health department has asked an advisory group on alcohol-related brain damage to ascertain just how widespread this is.

Alcoholics are at particular risk from the disease and from Korsakoff's psychosis, a condition that follows if the encephalopathy is not treated with an injection of thiamine.

Thiamine is found in foods such as cereals, lean meats - especially pork - soybeans, dairy products, fruit and eggs. Bakers have to add it to bread to make up for its loss during manufacture. A shortage can cause headaches, anorexia, tiredness, confusion and lack of balance.



>0

Exmouth ATC Inc.

555 Exmouth Street
Exmouth 9132
Western Amnesia

25/11/2002

Dear Sir or Madam:

An Air Safety Incident occurred in the airspace controlled by Exmouth ATC Inc. last week. I would like to invite you to investigate the incident and to report your findings to me.

Mr Ron Bellamy, Senior Air Traffic Controller, reported the details of the incident as follows:

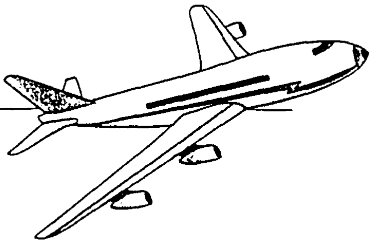
> **Date:** 20 Nov 2002
>
> **Time:** 0340 UTC (1140 AM Local time)
>
> **Aircraft Involved:** *EGL193* (Boeing 767-300, Eagle Airlines) and *PNX814* (Boeing 737-300, Phoenix Airlines)
>
> **Executive Summary:** ATC transmitter disconnected by technician. ATC unable to contact aircraft for a level change. Breakdown of lateral separation and subsequent TCAS manoeuvres by both aircraft.
>
> **Description of events and circumstances:** EGL193 and PNX814 were on crossing tracks at the same level (F370). The Sector 4 controller recognised the potential conflict and had intended to change the level of PNX814. Unknown to the controller or the Centre Manager, the duty technician disconnected the 127.4 MHz transmitter to perform routine maintenance. A NOTAM had been issued to cover this non-availability, but the Centre Manager's approval was not sought prior to disconnecting the transmitter.
>
> Shortly after PNX814 had reported at OSTAR, the controller attempted to issue the level change instruction but was unable to contact the aircraft. The controller determined that both primary and secondary transmitters were unserviceable.
>
> As the aircraft approached Terrace Hill, EGL193 experienced a TCAS RA climb. This was immediately followed by PNX814 experiencing a TCAS RA descent. Both aircraft transmitted the TCAS RA information but the controller was unable to respond.

In light of our commitment to air safety and the considerable public interest in this matter, I would appreciate your assistance in investigating this matter.

Sincerely,

Stan Foster
General Manager, Exmouth ATC Inc.

EAGLE AIRLINES



Dear Sir

I am writing in response to your request for information regarding an incident involving one of our aircraft on 21 Jun 2000.

Eagle Airlines is conducting a comprehensive internal investigation into the events leading up to the breakdown of separation.

The preliminary results of the investigation have revealed the following:

- The incident was the result of a failure in the air traffic control system.
- The aircrew involved followed all procedures correctly and reacted appropriately to the TCAS resolution advisory.
- The failure or non-availability of the VHF frequency was the result of a failure within the air traffic control system.
- The aircrew were aware of the planned outage but were led to believe that the frequency was available by the transfer instructions by the air traffic controller.

Eagle airlines does not envisage facilitating access to our crewmembers for interviews unless this is requested by the ATSB.

Yours Sincerely

Ben Hogan

Operations Manager

Phoenix Airlines

Dear Sir

I am writing in response to your request for information regarding an incident involving one of our aircraft on 20 Nov 2002.

The crewmembers involved have advised that they are unwilling to submit themselves to an interview unless required to do so by law.

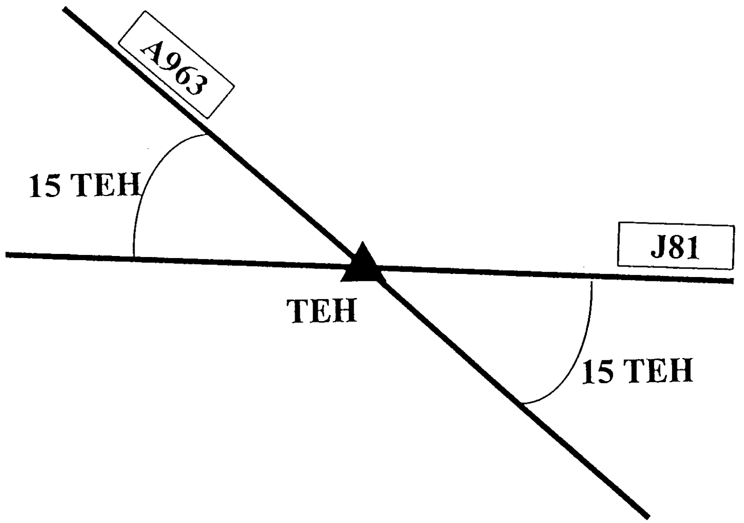
While Phoenix Airlines is keen to be of assistance in this and any other safety related matter, we are bound to respect the wishes of our staff members.

Yours Sincerely

Albert Rumpole

Senior Legal Adviser

Lateral Separation Diagram



Extract only A963 v J81

Exmouth
Air Traffic
Services Centre

Local Instructions

Exmouth ATSC Local Instructions : effective 19 June 1998

Authorised by : R Stillwell. 25

Local Instructions

Table of Contents

SECTION 1

EX ATSC Shared - Terms and Definitions

Standard Assignable Level	For arriving aircraft, the lowest level which an aircraft may be assigned without prior co-ordination. If this level is assigned in a radar environment, it need not be specified to the receiving controller. In a non radar environment, assigning of the lowest assignable level implies that the coordinating controller has no vertical restrictions on further descent unless specified.
Clean Hand-off	The controller handing off the aircraft has no vertical restrictions, and no lateral restrictions within ~~90° either side of track~~. 60° either side of track.

EX ATSC Shared - Airspace Management

EX TMA

Responsible for the provision of Control and Radar Advisory Services in and beneath all CTA/CTR within 30NM Exmouth at and below FL200.

EX Sector 1

Responsible for the provision of ATC services in all CTA and OCA within the lateral limits:

- 12S 117E - 12S 106 50E - 10 40S 105E - 20S 105E - 20S 102E - 25S 102E - 25S 113 30E - 22 12S 111 13E - thence 160Nm arc EX to 20 12S 115 56E - KINAG - 17 45S 121 30 E - 12S 117E

EX Sector 2

Responsible for the provision of Area Control Services in CTA within the lateral limits:

- 22 07S 115 31E thence via 80NM arc EX to 22 48S 115 25E - 22 44S 114 52E thence via 50NM arc EX to 22 55S 114 35E - 23 10S 114 45E -24 12S 114 45E - 25 00S 115 30E - 25 00S 113 35E - 22 12S 111 12E thence via 160NM arc Ex to 20 12S 115 56E - 21 00S 114 42E - 21 44S 114 08E thence 30NM arc to 22 12S 114 37E - 22 07S 115 31E

Excluding:

CTA within 30Nm EX at and below FL200.

EX Sector 3 Inner

Responsible for the provision of Area Control and Radar Advisory Services in and beneath CTA within the lateral limits:

- 20 12S 115 56E thence 160nm arc EX to 2124S 116 50E - 21 47S 116 20E - 21 57S 115 30E thence 80 NM arc EX to 22 07S 115 31E - 22 12S 114 37E thence 30 NM arc EX to 21 44S 114 08 E - 21 40S 114 08E 21S 114 42E - 20 12S 115 56E

above A050

Continued on next page

EX ATSC Shared - Airspace Management, Continued

EX Sector 3 - Outer

Responsible for the provision of Area Control services in CTA within the lateral limits:

- 20 12S 115 56E thence 160 NM arc EX to 21 24S 116 50 E - 21 12S 117 31E thence 80nm arc WF to 20 10S 120E - 20S 120 16E - 20S 120 38E BUDRA - SAPIX - 18 24S 120E - KINAG - 20 12S 115 56E

above A100.

EX Sector 4

Responsible for the provision of Area Control services in CTA within the lateral limits:

24 46S 118E - 25S 124E - AMTEC - 20S 123E - 20S 120 16E - 20 07S 120E - 80nm arc WF VOR - 21 13S 117 31E - 21 47S 116 20E - 21 57S 115 30E - 80nm arc EX VOR - 22 48S 115 25E - 23 54S 116 32E - 24 46S 118E"

and the vertical limits:

FL 125 to FL 600 excluding CTA FL200 and below within 90nm LG.

When radar is operational

Sector 4 **RADAR** will be responsible for the provision of area control services in that portion of the airspace defined above:
- West of a line south to north through Lindberg to 90 NM north of Lindberg, thence direct to Wedgefield.

Sector 4 **PROCEDURAL** will be responsible for the provision of area control services in that portion of the airspace defined above:
- East of a line south to north through Lindberg to 90 NM north of Lindberg, thence direct to Wedgefield.

Continued on next page

EX ATSC Shared - Airspace Management, Continued

Designated one-way routes in Exmouth Airspace

One Way Routes

One way routes in Exmouth airspace are:

- EX - AST
- W908
- W970
- A927
- WF - DOKET - LG

Navigation Aids

Location	*Ident*	*Navigation Aids*	*NDB Range (NM)*
Anderson	AND	LOC	30
Ashburton	AST	NDB	35
Burrow Island	BUI	VOR, ~~NDB~~ (NDB de-commissioned)	~~60 over land~~ ~~110 over water~~
Beaufort	BFT	VOR, NDB	100 over land 150 over water
Brill	BRI	NDB	35
Carnegie	CNG	NDB	60
Crofton	CFT	NDB	45
Cheltenham	CTE	NDB	70
Duck Creek	DUK	NDB	45
Eldorado	EDO	DME, NDB	60
Exmouth	EX	ILS, VOR, DME, NDB	60 over land 110 over water
Finlayson	FLS	NDB	35
Glenburgh	GBG	NDB	35
Hamersley	HSL	NDB	85
Kelly	KLY	NDB	40
Kumarina	KUM	NDB	35
Large Island	LRI	NDB	60
Lindberg	LG	VOR, DME, NDB	50
Melmak Island	MLM	NDB	80
Moolyella	MYE	VOR, DME	60
Mount Alexander	MXR	VOR, DME	60
Mount Genoa	MGA	NDB	45
Mount King	MKN	NDB	60
Nickol Bay	NKB	NDB	60
Northwest Cape	NC	NDB	50 over land 75 over water
Petre	PT	TACAN, NDB	80
Port Beadon	PON	NDB	45
Sandalwood	SAA	NDB	75
Shay Gap	SGP	NDB	110
Sherwood	SD	NDB	80
Terrace Hill	TEH	VOR	80
Wattle Downs	WDN	NDB	35
Wedgefield	WF	VOR, DME, NDB	75 over land 110 over water
Whim Creek	WHK	NDB	40

EX ATSC Shared - Separation Standards

MATS 4-7-1 6-9

Lateral Separation Diagrams

Lateral separation diagrams have been prepared for all Exmouth Sectors. These are useable subject to the following conditions:

- Where an on-track azimuth aid is located at the intersection of the tracks, this navigation aid must be serviceable.
- Where two or more azimuth aids are co-located at the intersection of the tracks, one of these navigation aids must be serviceable.

EX ATSC Shared - Radar Services

RADAR Sites

- **Exmouth:** MSSR, Range 160 NM
- **Mount Alexander Aerodrome** (MXR149010): MSSR, Range 250 NM
- **Goldsworthy:** MSSR, Range 160 NM - except that due to siting problems to the south and east, the radar is unreliable outside SEC 3 airspace.
- **Mount Genoa:** Military SSR, Range 160nm.

Radar Sectors

Radar Services are available from:

1. Exmouth Approach
2. Exmouth SEC 2
3. Exmouth SEC 3 (Inner and Outer)
4. Exmouth SEC 4 Radar
5. Petre Approach (Military)
   NOTE: The Petre radar system is incompatible with the Exmouth radar system.

Continued on next page

EX ATSC Shared - Flight Progress Strips

MATS 10-2-2

Diversions

In a full procedural environment, diversions left or right of track must be annotated in RED in Box 4.

MATS 10-2-2

Ticks

MATS 10-2-2 para 32 g add "A tick to the left of the item must be used to indicate an ATS unit response, and a tick to the right must be used to indicate an aircraft response."

Entering or leaving lateral conflict

ELC/LLC calculations shall be annotated as follows:

- (ELC or LLC)
- (Route of aircraft which is in conflict)
- (latsep point as a distance from an on track position)
- +- (ETI from the position to the latsep point based on current groundspeed)
- +- (half the longitudinal time standard) = time.

e.g. ELC A963 72NW VISIK 1032 + 8 - 5 = 1035

Restrictions from another unit

Shall be annotated as follows:

- (The unit name or standard abbreviation),
- NR, NLR, NVR as appropriate,
- ↓ as appropriate to indicate whether the restrictions apply to climb or descent.

e.g. LG NVR↓

Continued on next page

EX ATSC Shared - Communications

Radio Frequencies

Exmouth ATC

Unit	*Frequency*	*Location*
Exmouth Approach	125.7	Exmouth
Exmouth Sector 2	126.6	Exmouth
Exmouth Sector 3 Inner	118.9	Exmouth
Exmouth Sector 3 Outer	127.0	Wedgefield
Exmouth Sector 4	124.9	Cheltenham
	127.4	Kelly
	128.9	Crofton

EX ATSC Sector 4 - Communications

Inter-Unit Frequency Transfers (SEC 4)

Speed requirements	All time based transfers are applicable only to aircraft with a minimum groundspeed of ~~400 kts~~. 350 Kts
Boundary Positions	Aircraft shall be transferred to adjacent sectors at the airspace boundary except for the following cases:
J33 Northbound	Transfer from Waverton SEC2 to EX SEC 4 PROC at KUM
J33 Southbound	Transfer from EX SEC 4 PROC to Waverton SEC2 at KUM
G969	Transfer between SEC 4 RADAR and SEC 4 PROC 10 minutes east of MKN
Via MGA	Aircraft tracking on or east of the MGA DUK track shall be transferred at MGA when the radar is NOT operational.
AST	When radar is NOT available, aircraft entering SEC 4 airspace via AST shall be transferred at AST.

Internal Frequency Transfers

G969	MKN +- 10 minutes
A963	TOLAB
J33	TOLAB
J81	LG
T17/J81	LG

Exmouth ATC Inc.

Air Traffic Control Manual

(Extracts)

LATERAL SEPARATION

Standard

The lateral separation standard is 1NM between the possible positions of two aircraft.

Preparation of lateral separation diagrams

Lateral separation diagrams may only be prepared in accordance with methods approved by Exmouth ATC Inc. and shall indicate:

a. where lateral separation points rely on the serviceability of one or more navigation aid;

b. other lateral separation points using alternative aids if appropriate.

The appropriate Centre Manager shall approve all lateral separation diagrams.

Service Providers may develop and apply ready reference lateral separation tables between respective tracks for the assessment and resolution of lateral separation conflicts.

Preference for diagrams and tables

When applying separation, controllers should use approved lateral separation diagrams in preference to manually plotting the lateral separation requirements.

If the approved lateral separation diagrams cannot be used to resolve the conflict, controllers shall use the information contained in this section to calculate or plot the appropriate lateral separation requirements. Basic Lateral Separation Point (BLSP) calculations shall be rounded up or down on the "safe side" to the nearest whole NM.

Approved means of determining lateral separation

Approved means for the application of lateral separation are:

a. establishing an aircraft's position outside the BLSP; or

b. applying an appropriate radar separation standard; or

c. application of a 1 NM buffer to the track or position of an aircraft which is determined relative to a prominent topographical feature provided that:

1. the aircraft is tracking visually; and

2. the aircraft is not more than 10,000 FT above the topographical feature; and

3. this procedure is used by day only.

Entry and Exit Points shall be established by:

a. application to a BLSP of slant range and DME equipment error corrections;

b. application of RNAV tolerances;

c. passage over a visual fix located on the opposite side of a BLSP from the area of conflict;

d. passage over a positive radio fix (PRF) located on the opposite side of a BLSP from the area of conflict;

e. expiration of a time calculated using an estimate for a BLSP minus / plus:

1. 5 minutes, provided the estimate for the BLSP is within 30 minutes of an ATD, passage over a visual fix, PRF, way point or radar position; otherwise

2. half of the longitudinal time separation standard applicable to the aircraft.

Calculating DME based lateral separation entry and exit points

A DME based lateral separation entry / exit point shall be calculated by:

a. determining the ground distance from the DME site to the BLSP; then

b. if the area of conflict (or part of it) is between the BLSP and the DME site, the slant range correction shall be added to the ground distance; and

c. apply the correction for DME equipment error ensuring it is applied to a position outside the area of conflict.

Using GPS in lieu of DME

Where the navigation tolerance is determined with reference to ground based navigation aids, GPS distance may be used in lieu of a co–sited DME in the steps above.

Lateral separation between area of conflict and DME site

Where the lateral separation point is less than 60 NM from, and between the area of conflict and the reference DME site, an extra 1NM shall be subtracted from the DME–derived distance.

TIME SEPARATION (CROSSING TRACKS)

When the tracks of two or more aircraft cross at an angle of 45° to 135°, they may be separated according to the following method:

Provided That:

a. both aircraft have one of the following LRNS approvals:

(i) NAV/AUSEP;

(ii) NAV/GPSOCEANIC;

(iii) NAV/GPSRNAV; or

(iv) MNPS

b. groundspeeds are a minimum of 300 KTS;

c. separation exists when there is at least fifteen minutes between estimates at the intersection of the tracks.

Where fifteen minutes does not exist at the crossing point, another means of separation must be applied:

1. From 15 minutes prior to the estimate for the second aircraft at the intersection;
2. Until 15 minutes after the first aircraft has passed the intersection.

VERTICAL SEPARATION

The following vertical separation standards shall be used:

Standard	**Application**
1,000 FT	Below FL290
2,000 FT	Above FL290 or when turbulence or standing waves preclude the use of the 1,000 FT standard
3,000 FT	Whenever one or more of the aircraft are in supersonic flight

EMPHASIS ON PLANNING

In the provision of separation, controllers shall place greater emphasis on traffic <planning> and conflict avoidance than on individual conflict resolution being achieved. This shall be achieved by:

a. planning traffic to ensure separation;

b. executing the plan to achieve separation; and

c. monitoring the situation to ensure that the plan and execution are effective.

Nothing in this chapter precludes a controller from using discretion and initiative in any particular circumstance where these procedures appear to be in conflict with the requirement to promote the safe conduct of flight.

Separation shall be applied so that the spacing between the positions of aircraft is never less than the prescribed minimum.

If the type of separation or minimum used to separate aircraft cannot be maintained, controllers shall take action to ensure that another type of separation exists, or another minimum is established, before the previously used separation would be insufficient.

Safety is the priority

Expedition is secondary to the absolute requirement for safety.

Expeditious separation

The method of separation applied shall be based on operational advantage.

Increasing separation

Separation should be increased when significant factors may affect the application of separation standards. The increase should be sufficient to ensure separation is maintained.

DUTY STATEMENTS

General Manager

- Management of the corporate structure of Exmouth ATC Inc.
- Responsible for Policy
- Responsible for Safety
- Responsible for Financial Policy

Centre Manager

- Responsible for the provision of ATS within the Exmouth FIR
- Responsible for the provision SAR and IFER within the Exmouth FIR
- Responsible for Senior Controller duties when the Senior Controller is absent

Senior Controller

- Responsible for
  - Check Control
  - Rostering
  - Supervision

Safety Policy
Exmouth ATC Inc

1. Safety shall be the paramount consideration in all management decisions.

2. Line Managers shall introduce safety management practices to ensure safety in their area of responsibility.

3. All air safety incidents shall be reported to the General Manager within 24 hours of the occurrence.

4. The General Manager shall appoint an investigator or investigative team to determine the causal factors where there is any possibility that Exmouth ATC Inc may be liable or otherwise have a degree of responsibility.

5. Safety is the responsibility of every employee.

SEPARATION STANDARDS

SECTION 1

GENERAL

Introduction

1. The procedures contained in this chapter are intended to form the basis for traffic separation within Australian FIRs; nothing in them precludes a controller from using discretion and initiative in any particular circumstance where these procedures appear to be in conflict with the requirement to promote the safe conduct of flight.
2. It is paramount that air traffic controllers be in no doubt that expedition is secondary to the absolute requirement for safety.
3. Instructions issued by ATC to achieve a separation standard may include:
   requiring aircraft to change level and / or track;
   requiring aircraft to adjust speed to arrive at a nominated point at, before or after a specified time;
   requiring aircraft to hold at a positive radio fix, waypoint or visual fix;
   requiring aircraft to enter controlled airspace at a specified time, position or level;
   requiring an aircraft to depart or set course at, before or after a specified time;
   any other instruction considered necessary to ensure aircraft safety.
4. In the provision of separation controllers shall:
   Plan their traffic to ensure separation;
   Execute the plan so as to achieve separation;
   Monitor the situation to ensure that the plan and execution are effective.
5. If the type of separation or minimum being used to separate aircraft cannot be maintained, controllers shall take action to ensure that another type of separation exists, or another minimum is established, before the previously used separation would be insufficient.
6. It is important that controllers shall place greater emphasis on traffic planning and conflict avoidance, rather than conflict resolution. Separation shall be assured through planning, execution, and monitoring, rather than individual conflict resolution being achieved in each case.

Duty Priority

7. Air Traffic Controllers shall give first priority to separation in airspace classes A, B, C, D and E, safety alerts in all classes of airspace and traffic information to IFR and MLJ about IFR and MLJ in Class G airspace, as required in this manual. The action which is the most critical from a safety standpoint shall be performed first.
8. Additional services such as the provision of traffic information to IFR flight about VFR flights in Class E, or the provision of Radar Information Services (RIS) shall be provided to the extent possible, contingent only upon higher priority duties and other factors including equipment limitations, volume of traffic, frequency congestion and workload.

Aircraft Performance Variation

9. Controllers should be aware that operating performance characteristics of like type aircraft may vary between companies, or within the same company. Factors in the performance variations include the model or series of the aircraft, operational conditions, and in–flight or operator requirements.

10. Separation dependent on the performance of aircraft may be compromised by aircraft operating at different speeds. Whenever this possibility exists, controllers shall obtain speed confirmation from the aircraft concerned and, if required, adjust speed to ensure separation is maintained. If the pilot is unable to comply with the speed adjustment an alternative standard may be necessary.

Separation Calculations

11. When basing separation on mathematical calculations, controllers shall cross–check the results of the calculations for accuracy and reasonableness. The cross–check must provide an accurate result that can be reasonably assessed as being consistent with the traffic disposition.

Safety Alerts (Civil Controllers)

12. A safety alert shall be issued to an aircraft when a controller is aware the aircraft is at an altitude which, in his judgement, places it in an unsafe proximity to terrain, obstructions, or other aircraft. Once the pilot advises that action is being taken to resolve the situation, the issuance of further alerts may be discontinued. A controller shall not assume that because another controller has responsibility for an aircraft that an unsafe situation has been observed and a safety alert issued.

Note: The issuance of a safety alert is a first priority once the controller observes and recognises a situation of unsafe proximity to terrain, obstacles, or other aircraft. Conditions such as workload, traffic volume, the quality/limitations of the radar system, and the available lead time to react are factors in determining whether it is reasonable for the controller to observe and recognise such situations. While a controller cannot see immediately the development of every situation where a safety alert must be issued, the controller must remain vigilant for such situations and issue a safety alert when the situation is recognised.

Terrain / obstruction alert - a controller shall immediately issue / initiate an alert to an aircraft, which in his judgement, places it in unsafe proximity to terrain obstructions. Issue the alert as follows: ...(Callsign) LOW ALTITUDE ALERT, CHECK YOUR ALTITUDE IMMEDIATELY...(followed by advice on the minimum altitude appropriate to the aircraft's position).

Aircraft conflict alert - controllers shall immediately issue / initiate an alert to an aircraft if they are aware of another aircraft in unsafe proximity. If feasible the controller shall offer the pilot an alternative course of action.

Note: When an alternative course of action is given, end the transmission with the word "IMMEDIATELY".

...(Callsign) TRAFFIC ALERT (position of traffic if time permits), SUGGEST TURN LEFT / RIGHT (specific heading, if appropriate), and /or SUGGEST CLIMB / DESCEND (specific altitude if appropriate), IMMEDIATELY.

AIRBORNE COLLISION AVOIDANCE SYSTEM (ACAS)

13. Airborne Collision Avoidance System (ACAS) is an avionics system that uses aircraft transponder data to help reduce the risk of mid–air collisions between aircraft. ACAS is intended to serve as a safety enhancement, alerting pilots to the presence of transponding aircraft in their vicinity and providing assistance in the detection and resolution of potential conflicts. The equipment operates independently of ground–based systems used by air traffic control services for the provision of separation.
14. There are a number of ACAS available; the most common being TCAS II (Traffic Collision Avoidance System). A much more basic system, for use by general aviation aircraft, is known as TCAD (Traffic Collision Avoidance Device).
15. Aircraft carrying a serviceable ACAS, and with a crew trained in its use, are permitted to operate that system while in Australian airspace.

Traffic Alert and Collision Avoidance System (TCAS)

16. TCAS II reacts to the transponders of other aircraft in the vicinity to determine whether or not there is a potential collision. A warning, based on the time to the **closest point of approach** (CPA), enables the pilot to identify the conflicting traffic and if necessary, take avoiding action.
17. Warnings for aircraft with TCAS II are given in two steps:

CPA	TCAS Warning	Pilot Action	ATC Action
Approx. 45 seconds	TRAFFIC ADVISORY (TA)	Attempt to establish visual contact and change flight path only if a collision risk is confirmed.	Pilots may request traffic information.
Approx. 30 seconds	RESOLUTION ADVISORY (RA)	The pilot is required to respond to a vertical manoeuvre as indicated by the TCAS equipment.	Continue to advise traffic.

Note: TCAS II Resolution Advisories are in the vertical sense only. Horizontal manoeuvres are not prescribed.

18. RAs can only be prescribed if conflicting aircraft are operating with Mode C or Mode S. If a conflicting aircraft is not transmitting altitude, a TA will result; an RA will not be prescribed.
19. When both aircraft in an encounter are fitted with TCAS II, the transponders (Mode S) will "communicate" with each other to resolve the conflict.
20. TCAS II will not issue warnings against non–transponder equipped aircraft.

21. When operating in controlled airspace, the pilot is required to advise the ATS unit as soon as possible following the initiation of an RA manoeuvre.

    Note: RA manoeuvres are usually between 300 FT and 700 FT. They do not provide "ATC vertical separation". RAs provide a "minimum miss distance" only.

22. Following an RA a pilot will return to his cleared level unless advised otherwise by ATC.
23. "Nuisance Advisories" can occur even though standard separation exists. Controllers should therefore not immediately assume that separation has been lost, or they are at fault, when a pilot reports manoeuvring in response to a resolution advisory.
24. The following circumstances have been identified as the major causes of "Nuisance RAs":

    High vertical speed, particularly at low level and in congested airspace. Pilots are encouraged to, or can be instructed to climb/descend at standard rate when operating to cleared levels above/below other TCAS equipped aircraft.

    Parallel Runway Operations. Companies recommend TCAS equipment be operated to issue TAs only when operating on parallel runways. (A distance is to be prescribed for operations at Sydney KSA for TA Mode only.)

    Minimum Separation situations (vertical and radar). Opposite direction and crossing tracks.

    On departure near taxiing aircraft or helicopters.

    When close visual separation is being applied.

25. A controller shall not be subject to disciplinary action in the event of an accident or incident arising from an aircraft deviating from an ATC clearance or instruction as a result of a TCAS Advisory, provided that:

    such a deviation or departure was in response to an RA generated by an airborne collision avoidance system, and

    the occurrence was not the result of an incorrect clearance or instruction from the controller.

26. All TCAS RAs are classified as immediately notifiable incidents and as such must be the subject of an ESIR. A specific form is available for ACAS reporting in the ESIR file on the GCN.

LONG RANGE NAVIGATION SYSTEMS

General

27. Separation of aircraft is based on use of various navigation aids. In addition to the ground based navigation aids such as DME, VOR and NDB, Long Range Navigation Systems (LRNS) may be used. Regulatory authorities have developed operational approvals for the use of Inertial Navigation Systems, such INS or IRS/FMS, and Global Positioning System (GPS) in the enroute environment. These operational approvals specify minimum requirements for pilot and equipment. In many cases, these operational approvals form the basis of separation minima. Inflight advice of approval status, unless indicated in an initial flight notification submitted by radio, shall not be used in the application of separation.
28. Subject to conditions described in this chapter, a "Y" associated with I, N, or P on the flight progress strip indicates approval to use RNAV separation standards.
29. RNAV Route approval - AUSEP
30. RNAV Route approval, commonly referred to as **AUSEP**, is an Australian derived operational approval for self contained navigation systems (INS or IRS/FMS). AUSEP enables ATC to apply RNAV based separation minima, and is indicated by **NAV/AUSEP** in field 18 of the flight plan and "**IY**" in box 11 of the flight progress strip. This approval is issued by CASA.
31. GPS Approval - GPSRNAV
32. **GPSRNAV**, is an approval, primarily designed for low end RPT, charter and GA operations and applies to Australian registered aircraft. GPSRNAV enables ATC to apply RNAV based separation minima and use GPS as a substitute for DME in domestic CTA. Approval is indicated by **NAV/GPSRNAV** in field 18 of the flight plan and "**NY**" in box 11 of the flight progress strip.
33. Note: CASA have approved a limited number of Australian based, foreign registered aircraft to the GPSRNAV standard.

34. Pilots of GPSRNAV aircraft shall advise ATC when the GPS equipment operates in DR mode for one minute or more or whenever RAIM has not been available for more than ten minutes by use of the phrase "RAIM FAILURE". Additionally, where ATC request distance reports and RAIM is not available, but has been available in the last ten minutes, the distance report should be suffixed "NEGATIVE RAIM".

35. Whenever a pilot advises RAIM FAILURE, GPS is considered to be unreliable and ATC shall not use GPS as the basis for separation. Following re–establishment of RAIM, the pilot shall notify the condition by use of the phrase "RAIM RESTORED" and ATC may reassess the appropriate separation standard.

36. GPS Approval - GPSOCEANIC

37. **GPSOCEANIC**, as published by CASA, is based on the FAA approval of GPS as a primary means of navigation for oceanic/remote operations. The equipment standard for GPSOCEANIC is more stringent than for GPSRNAV and complies with the requirements of ICAO Annex 6. In addition to approval by the State of Registry, the requirements specified in AIP must also be met for an aircraft to be considered GPSOCEANIC.

38. GPSOCEANIC is indicated by NAV/GPSOCEANIC in field 18 of the flight plan and "PY" in box 11 of the flight progress strip. Aircraft meeting GPSOCEANIC may be considered as meeting AUSEP in all Australian airspaces. GPS distance reports may also be used as a substitute for DME in domestic CTA

39. ATC shall not continue to apply RNAV based separation after advice of GPS failure or operation outside prescribed limits.

40. Required Navigation Performance - RNP

41. Required Navigation Performance - **RNP**, is a published ICAO standard and defined as a statement of the navigation performance accuracy necessary for operation within a defined airspace. This is based on a navigation performance accuracy value which is expected to be achieved at least 95% of the time by the population of aircraft operating within the airspace. The navigation performance accuracy value is one of the elements used in the determination of separation minima in the RNP environment.

42. RNP10 has been selected by the Asia/Pacific states as the most appropriate for the majority of oceanic and remote area operations. Australia is incrementally implementing RNP10 in OCA. The approval is issued by the State of Registry or Operator.

43. Aircraft meeting the RNP specified for a particular route of airspace indicate with an "**R**" in field 10 of the flight plan and "**R**" in box 11 of the flight progress strip.

44. Within these instructions, reference to "RNP10 aircraft" indicates the aircraft is to operate on routes or within airspace requiring RNP10, and the aircraft continues to meet the RNP10 requirements.

45. Minimum Navigation Performance Specification - MNPS

46. Minimum Navigation Performance Specification - **MNPS**, is an approval designed for operations in the North Atlantic region. However, MNPS has been widely accepted as the basis for RNAV operations in oceanic and remote areas.

47. This approval is indicated by "**X**" in field 10 of the flight plan and "**X**" in box 11 of the flight progress strip. MNPS approval is issued by the State of Registry or Operator. Only limited application is available to Australian ATC.

48. Special Separation Standards Applicable in Military Controlled / Restricted Airspace

49. The Commander of a Military Base may have the Separation Standards detailed in this publication relaxed with the approval of DEFAIR (DOSIA–AF), or Headquarters Aviation Support Group (HQAVNSPGP) for Army operations. Approved variations to separation standards, which can only be applied in military controlled / restricted airspace, shall be promulgated in appropriate Orders.

50. The Commander of a Military Base may vary separation standards for those areas for which the Base is responsible for specific operation of visiting military aircraft. Any variation to separation standards may only be to the extent approved at the home base of the visiting aircraft.

51. Variations to separation standards shall not apply to VIP aircraft, civil IFR aircraft, transiting military IFR aircraft and visiting aircraft departing via SID or SRD procedures.

52. When a radar service is not available and separation is required, it should be provided within military controlled / restricted airspace as follows:

53. Lateral Separation. Apply Lateral Separation by dividing airspace into Sectors. Design the Sectors to accommodate the aircraft type expected to operate therein and ensure that lateral separation exists with adjacent sectors and air routes. Lowest safe altitudes shall be published.

54. Vertical Separation. Apply vertical separation by dividing airspace / sectors into Height blocks. Design the Height blocks to accommodate the aircraft type expected to operate therein and ensure that vertical separation exists with adjacent Height Blocks. Lowest safe altitudes shall be published.

55. When a radar service is not available separation is not normally applied in VMC within military controlled / restricted airspace between:

56. military aircraft, and

57. military and civil VFR aircraft.

58. Aircraft not separated within military restricted / controlled airspace shall, workload permitting, be given traffic information. Separation may be applied whenever the volume of traffic or other circumstances create a risk of collision.

59. WAKE TURBULENCE

60. Wake Turbulence Categorisation of Aircraft

61. Wake Turbulence separation shall be based on the three categories, according to the maximum certified take–off mass of the aircraft, as listed in Chapter 6 (Aerodrome Control).

62. Application of Wake Turbulence Separation

63. Wake turbulence separation shall be applied when an aircraft is operating within ½ NM laterally, or crossing behind, another aircraft's flight path at the same level or less than 1,000 FT below.

64. Wake Turbulence Separation Minima

65. The following wake turbulence radar separation minima shall be applied:

66. HEAVY behind a HEAVY - 4 NM
MEDIUM behind a HEAVY - 5 NM
LIGHT behind a HEAVY - 6 NM
LIGHT behind a MEDIUM - 5 NM

67. In the application of standard D6, the DME separation minimum of 5 NM shall be increased to 6 NM where a LIGHT aircraft is following a HEAVY aircraft.

68. Exceptions

69. Wake turbulence separation standards do not apply where a LIGHT aircraft will follow a MEDIUM fixed wing aircraft of less than 25,000 KG maximum certified take–off mass (includes F27, F50, SF34 and A748).

70. Due to the wake turbulence characteristics of the B757, for the purpose of wake turbulence separation, B757 are to be classified as a HEAVY aircraft if the leading aircraft and as a MEDIUM aircraft if a following aircraft.

71. When a following HEAVY aircraft is in excess of 200,000KG MTOW a wake turbulence separation minimum of 3NM or 1.5 minutes shall be applied (includes B74A / B, L101, DC10). This reduction shall not apply when the following HEAVY aircraft commences take–off from an intermediate point.

72. SEPARATION

73. Separation within and from Formation Flights

74. Separation between aircraft within a formation or in–company flight shall be the responsibility of the flight leader and pilots of the other aircraft within the formation, or the individual pilots when operating in–company. This shall also include periods of transition, when aircraft are manoeuvring to attain their own separation within the formation or in–company flight and during join up and break away.

75. A CLOSE FORMATION is considered to be one aircraft and separation between the formation and other airspace users shall be based on the lead aircraft.

76. A STANDARD FORMATION differs from a close formation in that aircraft in the formation may be spread up to 1NM either side of the lead, co–altitude, and up to 1 NM behind. Separation with other traffic is to be based on the outer edges of this envelope.

77. MILITARY TACTICAL FORMATIONS or IN–COMPANY FLIGHTS are formations which occupy an airspace block of defined dimensions. When planning flights of this nature, the horizontal and vertical dimensions of the block are to be included in the flight plan. Separation with other airspace users is predicated on the limits of the block.

78. In controlled airspace, the minimum vertical separation between formation or in–company flights and other airspace users is 1,000 FT at or below FL290 and 2,000 FT above FL290.

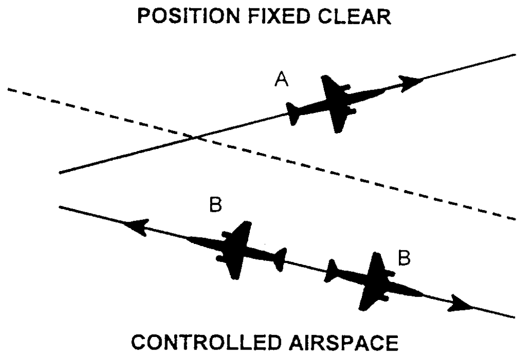
79. Formation leaders will specify the formation type on first contact with approach / departures when outbound, or the first ATC element encountered when inbound. If the formation type is not specified, or if doubt exists as to the exact nature of the formation being flown, controllers are to seek immediate clarification. In addition, formation leaders will obtain clearance before transitioning from one formation type to another and inform ATC when the transition is complete. Controllers may withhold approval for a formation change if that change would compromise separation with other airspace users.

80. When coordinating hand–offs of formation flights to other control agencies, the type of formation being flown is to be included in the hand–off. In the case of tactical or in–company flights, the hand–off will include the disposition of formation members.

81. Unless operational considerations dictate otherwise, individual formation aircraft should be instructed to squawk normal if proceeding in–trail and the distance between aircraft exceeds 2 NM. This does not preclude controller discretion in assigning separate codes at lesser distances, when radar performance permits.

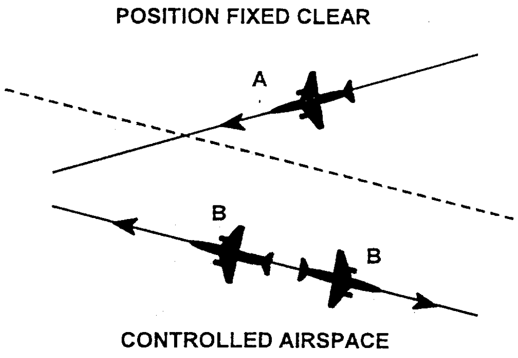
82. Controllers should also be aware, when checking formations through levels on climb or descent, that all aircraft may not be at the same level as the lead. This particularly applies to in–trail formations, where other formation members may be significantly higher or lower than the lead aircraft. Where a level check is being made for the purposes of applying vertical separation with other airspace users, and doubt exists as to the level of any aircraft in the formation, then the level check is to be extended to those formation aircraft.

83. A group of civil aircraft conducting the same flight, (eg an Air Safari), which require to operate at separation distances greater than those specified above, shall be considered to be separate aircraft in the application of separation.
84. Application of Separation at the Boundaries of Controlled Airspace
85. The position of an aircraft can be determined to be fixed clear of Control Areas or Civil / Military Control Zones by:
86. a military controller if A is proceeding from, into, or is in the vicinity of, military controlled airspace;
87. a civil controller using radar;
88. the pilot in all other circumstances.
89. When an aircraft is:
90. **Leaving Controlled Airspace**, separation is required until aircraft A is positively clear.



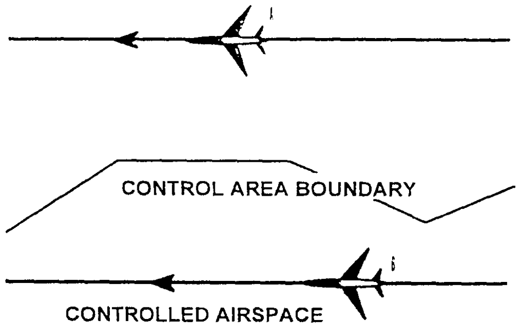
91.

92. **Entering Controlled Airspace**, separation is required when aircraft A enters controlled airspace.



93.

94. **In Close Proximity**, separation is not required between aircraft A and aircraft B while aircraft A remains outside the lateral boundaries of controlled airspace.



95.

96. INTENTIONALLY BLANK

Simulator Exam Results (Procedural Simulator) **SUPPLEMENTARY EXAM**				PASS
Trainee	Phil Ironside	Instructor	Michael Doherty	Date 13/03/2002

CONFLICT RECOGNITION	
Number of recognised conflicts	21
Total number of conflicts	22
Number of conflicts not recognised	Nil
SEPARATION ASSURANCE	
Number of resolved conflicts	19
Total number of conflicts	21
Number of separation scenarios not assured	Nil
CO-ORDINATION	
Number of co-ord completed	27
Total number of co-ord required	27
Number of co-ordination errors	Nil

Workload and Traffic Management	1	2	③	4	5
Traffic Planning	1	2	③	4	5
In Flight Emergency Response	1	2	3	④	5
Stripwork	1	2	3	④	5
Phraseology and Communication	1	2	3	④	5
Equipment Handling	1	2	③	4	5
Documents, Procedures and Airspace Knowledge	1	2	③	4	5
Handover/Takeover	1	2	③	4	5

General Instructor Comment

Despite the fact that Phil passed this exam, he still needs to concentrate on achieving separation in the most expeditious and timely manner. The two separation assurance errors (see above) involved situations where the aircraft were eventually separated, but only at the last minute.

		Signature	Michael Doherty

EXAMINATION DEBRIEF FORM (ATC) - SUPPLEMENTARY

Trainee	Phil Ironside	Instructor	Michael Doherty	Date 13/03/2002

This form and trainee signature below constitute documentary evidence of completion of the examination debrief. Additional instructor comment and trainee comment may be annotated overleaf. Original to be held by ATS Training College, photocopy to be given to the trainee. The trainee signature and comment overleaf (if any) is an indication that the trainee accepts the debrief as complete, comprehensive, and to his/her satisfaction.

CONFLICT RECOGNITION

All conflicts recognised, but you are occasionally not seeing them until the last minute. You must continually assess information as you receive it.

SEPARATION ASSURANCE

On two occasions, separation was only achieved at the last minute. Better planning will achieve a more orderly assurance of separation.

WORKLOAD & TRAFFIC MANAGEMENT

Handled the work-rate well, but more attention is needed to prioritise tasks

CO-ORDINATION

All coordination completed correctly and on time. Try not to keep the other unit waiting for too long while you consider your own traffic.

TRAFFIC PLANNING

More attention is needed to planning your traffic to avoid conflictions rather than merely resolving them.

RADAR TECHNIQUE (if applicable)

Not applicable

IFER

All SARtimes monitored

STRIPWORK

Neat, accurate and up to date

PHRASEOLOGY & COMMUNICATION

Clear, concise and standard phraseology used.

EQUIPMENT HANDLING

No apparent problems

DOCUMENTS, PROCEDURES & AIRSPACE KNOWLEDGE

Documents known

HANDOVER/TAKEOVER

Comprehensive handover

TEAMWORK

Satisfactory

GENERAL COMMENT (*Trainee comment on back if required*)

See comments on Exam Results form.

Trainee Signature	PRIronside	Instructor Signature	M Doherty

SENIOR CONTROLLER CHECK REPORT

Name	Ron Bellamy
Checking Officer	Bob Stilwell
Date	06 Jan 2002

The officer named above has been checked and rated proficient in the position of Senior Controller, Exmouth Eastern Group. The officer has undergone examination and practical assessment in the following areas:

Assessment area	**Rating**	**Comments**
Staff supervision	3	*Needs to be more 'hands on' with staff. Don't be hesitant to provide the benefit of your experience.*
Local procedures	4	*Good knowledge of local procedures*
SAR & IFER	4	*Good*
Administration	3	*Make sure you keep an eye on staff leave requirements.*

Other Comments

Overall, a very good performance. Your experience shows through. Make sure that you keep an eye on your staff as they may not all share your level of experience. Your skills in managing people are very good and you should use these to the team's advantage.

Let people make their own decisions when possible This is the only way to let them learn.

Assessor's Signature	**Staff member's signature**
Bob Stillwell	Ron Bellamy

ATC Ab Initio Course 23: Trainee Counselling Report

Trainee: **Philip Rhys IRONSIDE**

Designation: Air Traffic Controller In Training

Employee Number: 9999

Date Commenced Duty: 8/05/2001

Confirmation Due: Upon achieving final field rating.

Disciplinary Action: No disciplinary action required.

Theory: Philip passed all of his theory examinations except Aircraft Performance. He passed the supplementary examination well.

Subject	Examination Result	Supplemetary Examination Result (if applicable)
Enroute Control	82%	n/a
Separation Standards	78%	n/a
Aircraft Performance	56%	88%
Airspace & Procedures	89%	n/a
Radar Control	98%	n/a
Air Legislation	73%	n/a
AIS	94%	n/a
IFER	93%	n/a
Tower & TMA	87%	n/a
Flight Information Service	81%	n/a

Simulator: Philip failed his final simulator examination and subsequently passed the supplementary examination.

Philip will need to work at his separation assurance skills in his field training. He has all of the skills required to separate traffic in even a busy environment. He must concentrate on planning his workload in order to ensure that tasks are carried out in a timely manner.

Philip's skills in communication and conflict recognition have served him well, despite his poor performance in the final examination.

Overall Performance: Phil has demonstrated a mature and dedicated attitude towards his training. His lack of aviation experience was apparent at the beginning of the course, but he overcame this through hard work and dedication. He has applied himself well to the task at hand. He has managed to recover from a few stumbles, but will need to maintain consistency in his final field training.

Recommendation: Philip is recommended for final field training.

Trainee Comment:

Ed Toohey PR

Ironside

Shaun McRae	Ed Toohey	Philip Ironside
Senior Instructor	*Course Co-ordinator*	*Trainee*

EXAMINATION COMPETENCY GRADING CRITERIA

Conflict Recognition

No more than two missed conflicts.

Separation Assurance

No more than two separation scenarios not assured.

Coordination

No more than two errors in co-ordination.

Workload & Traffic Management

1 The trainee was unable to process information in such a way so as to manage workload or avoid delays. The work method was haphazard leading to significant difficulties in decision making or prioritising. Work rate was too slow and little ability to adjust to increasing work was evident.
3 The trainee demonstrated an ability to process information correctly, prioritise tasks and implement a plan to minimise workload and delays. Any difficulties were due to problems in adequately adjusting work rate or methods to cope with increasing workload or complexity.
5 The trainee was, at all times, able to adjust methodology and workrate to cope with workload demands and avoid any delays. Prioritisation, decision implementation and task completion were carried out so as to maximise planning time.

Traffic Planning

1 Unprepared for simple and probable changes in traffic patterns. No methodical approach to planning is demonstrated.
3 Planned ahead and adopted a methodical approach to various situations presented, however failure to consider all options resulted in a higher than necessary workload.
5 All situations were planned in advance and alternatives considered. Traffic predictions and strategies were continuously reviewed and amended as necessary, in adequate time for efficient implementation.

Radar Technique

1 Poor identification/verification and/or vectoring techniques. Did not use the radar to improve traffic flow and resolve problems.
3 No errors in identification and verification procedures. Little use of radar was made to actually facilitate and expedite traffic.
5 Radar used to maximum potential to facilitate and enhance traffic flow. Potential problems were anticipated early and dealt with efficiently.

IFER

1 Failed to respond to abnormal situations. Failed to monitor SARtimes and communication checks were not performed in the required time.
3 SARtimes were continuously monitored to ensure that communication checks were carried out on time. A correct initial response to SAR/abnormal situations, however there was insufficient investigation of the events.
5 Correct priority was given to SAR/abnormal situations, reacting quickly and analysing all aspects of the situation with consequent correct responses. SARtimes were at all times maintained with 100% accuracy.

Stripwork

1 Did not maintain a functional and effective display.
3 Display was accurate, clear and generally up to date, with only minor errors. Did not base instructions to aircraft on incorrectly displayed information.
5 At ALL times the display was accurate, updated promptly, and performed in a reactive and expeditious manner.

Phraseology and Communication

1 Poor or incorrect use of standard phraseology, resulting in indistinct and hesitant delivery.
3 Standard phraseology used effectively with only minor errors. A basic ability was demonstrated with non-standard phraseology, however exaggerated transmissions resulted. Delivery was usually clear and concise.
5 Use of standard phraseology was automatic, and non-standard phraseology was effectively used, resulting in clear, unambiguous delivery at all times.

Equipment Handling

1 Unable to use equipment effectively.
3 Demonstrated rudimentary use of the equipment.
5 Sound understanding and optimum use of equipment at all times.

Documents, Procedures and Airspace Knowledge

1 Lack of knowledge of documents, procedures, airspace or facilities affected performance. Constant referral to maps/documents, for basic detail.
3 Sufficient knowledge to perform satisfactorily. Intimate detail was lacking, hampering performance during complex and busier situations.
5 A thorough knowledge of all procedures relevant to, and facilities within, the airspace demonstrated.

Handover/Takeover

1 Incomplete, important information omitted or incorrect.
3 Satisfactory although more detail required for comprehensive Handover/Takeover.
5 Comprehensive Handover/Takeover effected as per AOI Vol 1 Admin 7.1

STAFF-IN-CONFIDENCE WHEN COMPLETED

ENROUTE/TMA AIR TRAFFIC CONTROLLER
PERFORMANCE ASSESSMENT REPORT

	PLEASE PRINT NAME:	LATTICE NUMBER:
This assessment is for........................	*Philip IRONSIDE*	*9999*
Parts 1, 3 and 4 Assessed by..................	*Ron Bellamy*	*8888*
(IF DIFFERENT) Part 2 Assessed		

RATING TYPE: Indicate the ratings under which the endorsement(s) is(are) being assessed (more than one may be appropriate)

○ Approach Radar Control (TMA - Radar) ○ Area Radar Control (Enroute - Radar) [✓ ○ Area Control (Enroute - Procedural)]

ENDORSEMENT: Indicate those included in this assessment (more than one may be appropriate)

Exmouth sector 4 procedural

TYPE OF ASSESSMENT: TYPICAL ○ CHECK [✓ ○]

eg over a period of up to 6 months (including MINIMUM, TYPICAL and MAXIMUM scores)

ie an over-the-shoulder assessment

Overall Comments by Assessor/s:

Mr Ironside displayed a level of confidence commensurate with his ability to quickly resolve any potential conflictions. He displayed an ability to defer decision making in a mature and professional manner in order to maximise use of the airspace and satisfy pilot requests.

Assessee Comments:

Sighted and agreed

The signatures below indicate that:

- the assessor/s has/have performed the type of assessment indicated; and
- the assessee has reviewed the assessment and made comments above as considered necessary.

Parts 1, 3 and 4 Assessor *Ron Bellamy*	SIGNATURE R.Bellamy	DATE *20/07/2002*
Part 2 Assessor (IF DIFFERENT)	SIGNATURE	DATE
Assessee *Phil Ironside*	SIGNATURE PRIronside	DATE *20/07/2002*

OFFICE USE ONLY

Mr Ironside deemed suitable for solo operation as at 20/07/2002

PART 1 - PRACTICAL PERFORMANCE

Not Competent — Competent

1.0 MAINTAIN SITUATION AWARENESS

1.1 Updating Traffic Picture

1.1.1 Scanning ① ② ③ ④ [✓ ⑤] ⑥ ⑦

1.2 Interpreting and Evaluating Traffic Events

1.2.1 Monitoring separation standards and/or traffic requirements ① ② ③ ④ [✓ ⑤] ⑥ ⑦
1.2.2 Recognising conflicts ① ② ③ ④ ⑤ [✓ ⑥] ⑦
1.2.3 Evaluating sequencing ① ② ③ [✓ ④] ⑤ ⑥ ⑦
1.2.4 Evaluating traffic configurations ① ② ③ ④ [✓ ⑤] ⑥ ⑦

1.3 Prioritising, Projecting and Planning

1.3.1 Prioritising ① ② ③ [✓ ④] ⑤ ⑥ ⑦
1.3.2 Projecting and planning ① ② ③ ④ [✓ ⑤] ⑥ ⑦

Comments:

Displayed an ability to predict future needs and plan an implementation such that maximum use of airspace allowed with minimum disruption to pilots

2.0 EXECUTING CONTROL ACTIONS

2.1 Maintaining Separation

2.1.1 Applying Separation Standards ① ② ③ ④ [✓ ⑤] ⑥ ⑦
2.1.2 Providing Traffic Information ① ② ③ ④ ⑤ ⑥ ⑦

2.2 Managing Traffic

2.2.1 Conducting traffic sequencing ① ② ③ [✓ ④] ⑤ ⑥ ⑦
2.2.2 Regulating traffic flow ① ② ③ ④ [✓ ⑤] ⑥ ⑦
2.2.3 Regulating workload ① ② ③ ④ [✓ ⑤] ⑥ ⑦
2.2.4 Responding to changing conditions ① ② ③ ④ ⑤ [✓ ⑥] ⑦

2.3 Providing Airspace-Specific Services

2.3.1 Providing ancillary air traffic services ① ② ③ [✓ ④] ⑤ ⑥ ⑦
2.3.2 Implementing local procedures ① ② ③ [✓ ④] ⑤ ⑥ ⑦

Comments:

Aware of changes in situation and reacted quickly to same. Regulated workload effectively to apply appropriate separation standards in timely manner.
Traffic information rarely required this sector.

3.0 COMMUNICATION

3.1 Telephony

3.1.1 Using standard phraseology ① ② ③ [✓ ④] ⑤ ⑥ ⑦
3.1.2 Using non-standard phraseology ① ② ③ [✓ ④] ⑤ ⑥ ⑦
3.1.3 Delivery ① ② ③ [✓ ④] ⑤ ⑥ ⑦

3.2 Using Communication Procedures

3.2.1 Passing on operational information ① ② ③ [✓ ④] ⑤ ⑥ ⑦
3.2.2 Issuing instructions ① ② ③ [✓ ④] ⑤ ⑥ ⑦
3.2.3 Coordinating traffic ① ② ③ [✓ ④] ⑤ ⑥ ⑦
3.2.4 Performing handover/takeover ① ② ③ [✓ ④] ⑤ ⑥ ⑦
3.2.5 Responding to requests ① ② ③ [✓ ④] ⑤ ⑥ ⑦
3.2.6 Responding to SAR alerting, IFER and/or facility failure ① ② ③ [✓ ④] ⑤ ⑥ ⑦

Comments:

Communication skills adequate. Appropriate response to questioning on IFER situations.

PART 1 - PRACTICAL PERFORMANCE CONT'D

Not Competent Competent

4.0 OPERATING FACILITIES

4.1 Operating Workstation

4.1.1	Managing FDF	~~①~~	~~②~~	~~③~~	~~④~~	~~⑤~~	~~⑥~~	~~⑦~~
4.1.2	Managing Flight Plan Database (or Flight Progress Strips)	①	②	③	④	[✓ ⑤]	⑥	⑦
4.1.3	Managing AIF	~~①~~	~~②~~	~~③~~	~~④~~	~~⑤~~	~~⑥~~	~~⑦~~
4.1.4	Using graphic facilities for route	①	②	③	④	⑤	⑥	⑦
4.1.5	Using graphic facilities for display	①	②	③	④	⑤	⑥	⑦
4.1.6	Using operational facilities	①	②	③	④	⑤	⑥	⑦
4.1.7	Using CPDLC	①	②	③	④	⑤	⑥	⑦
4.1.8	Using ADS	①	②	③	④	⑤	⑥	⑦
4.1.9	Responding to facility failure and/or degraded modes	①	②	③	④	⑤	⑥	⑦
4.1.10	Managing alarms	~~①~~	~~②~~	~~③~~	~~④~~	~~⑤~~	~~⑥~~	~~⑦~~
4.1.11	Using mandated memory prompts	①	②	③	④	[✓ ⑤]	⑥	⑦

4.2 Using Displays

4.2.1	Managing displays	①	②	③	④	[✓ ⑤]	⑥	⑦

4.3 Managing Ancillary Data

4.3.1	Record ancillary written (scratch pad) information	①	②	③	④	[✓ ⑤]	⑥	⑦

Comments:

Accurate and effective record kept on flight progress strips. Flight progress board used to advantage and potential conflicts displayed in appropriate manner until resolved.
Items crossed out above not applicable to a procedural non TAAATS sector.

PART 2 - CONTEXTUAL PERFORMANCE

Poor Adequate Desirable
Improvement Req'd

5.0 CONTEXTUAL BEHAVIOUR

5.1 Working in a Team

5.1.1	Providing assistance to team members	①	②	③	[✓ ④]	⑤	⑥	⑦
5.1.2	Providing feedback within the team	①	②	③	[✓ ④]	⑤	⑥	⑦
5.1.3	Cooperating with team members and contributing to a positive team climate	①	②	③	④	[✓ ⑤]	⑥	⑦

5.2 Working Professionally

5.2.1	Providing high quality customer service	①	②	③	④	[✓ ⑤]	⑥	⑦
5.2.2	Demonstrating initiative	①	②	③	④	[✓ ⑤]	⑥	⑦
5.2.3	Conforming to staff code of conduct	①	②	③	④	[✓ ⑤]	⑥	⑦

5.3 Supporting Organisational Objectives

5.3.1	Advocating improvements	①	②	③	[✓ ④]	⑤	⑥	⑦
5.3.2	Adapting to changing technology	①	②	③	[✓ ④]	⑤	⑥	⑦
5.3.3	Adapting to changing work conditions	①	②	③	[✓ ④]	⑤	⑥	⑦

Comments:

A positive team member whose personality displays a confidence inspiring to others.
Should develop into a useful member of the team.

PART 3 - SITUATIONAL FACTORS

Please rate the severity of the following Situational Factors during the period of assessment...

	Severity of Situational Factor Low Moderate High
Traffic Volume........................	① ② ③ [✓ ④] ⑤ ⑥ ⑦
Traffic Complexity..................	① ② [✓ ③] ④ ⑤ ⑥ ⑦
Weather................................	[✓ ①] ② ③ ④ ⑤ ⑥ ⑦
Abnormal Situations..................	[✓ ①] ② ③ ④ ⑤ ⑥ ⑦
Pilot Actions...........................	① [✓ ②] ③ ④ ⑤ ⑥ ⑦

PART 4 - OUTCOMES

	Observed Outcome Not at All Moderately Totally Poor Outcome Average Outcome Outstanding Outcome	ATC's Control of the Outcome
ORDERLINESS		
Was the flow of traffic orderly?	① ② ③ ④ [✓ ⑤] ⑥ ⑦	Low [✓ Moderate] Significant
Did the aircraft fly on expected routes and/or arrive to expected runways?..	① ② ③ ④ ⑤ [✓ ⑥] ⑦	Low [✓ Moderate] Significant
Did the configuration of aircraft tracks and levels allow for controllers or pilots to respond to unanticipated events without disrupting traffic?......................................	① ② ③ [✓ ④] ⑤ ⑥ ⑦	Low [✓ Moderate] Significant
EFFICIENCY		
Did the configuration of aircraft tracks and levels maximise the use of airspace and/or landing facilities?......	① ② ③ ④ [✓ ⑤] ⑥ ⑦	Low [✓ Moderate] Significant
Did the configuration of aircraft tracks and levels maximise efficiency and minimise flight time for aircraft?..	① ② ③ ④ ⑤ ⑥ ⑦	Low Moderate Significant
Did aircraft fly on their routes without disruption?...........	① ② ③ ④ [✓ ⑤] ⑥ ⑦	Low [✓ Moderate] Significant
Was coordination and radio communication minimised?...	① ② ③ ④ ⑤ [✓ ⑥] ⑦	Low [✓ Moderate] Significant

OUTCOMES ACHIEVED IN VARIOUS SITUATIONS - COMPLETE THIS SECTION FOR TYPICAL ASSESSMENTS ONLY

	In Low Difficulty Situations Not at All Moderately Totally	In Moderately Difficult Situations Not at All Moderately Totally	In Highly Difficult Situations Not at All Moderately Totally
To what extent did the ATC achieve an orderly flow of traffic?	① ② ③ ④ ⑤ ⑥ ⑦	① ② ③ ④ ⑤ ⑥ ⑦	① ② ③ ④ ⑤ ⑥ ⑦
To what extent did the ATC achieve an efficient flow of traffic?	① ② ③ ④ ⑤ ⑥ ⑦	① ② ③ ④ ⑤ ⑥ ⑦	① ② ③ ④ ⑤ ⑥ ⑦

Simulator Exam Results (Procedural Simulator)				FAIL
Trainee	Phil Ironside	Instructor	Steven Smith	Date 6/03/2002
CONFLICT RECOGNITION				
Number of recognised conflicts				21
Total number of conflicts				23
Number of conflicts not recognised				Two
SEPARATION ASSURANCE				
Number of resolved conflicts				19
Total number of conflicts				23
Number of separation scenarios not assured				Four
CO-ORDINATION				
Number of co-ord completed				22
Total number of co-ord required				22
Number of co-ordination errors				Nil

Workload and Traffic Management	1	②	3	4	5
Traffic Planning	1	②	3	4	5
In Flight Emergency Response	1	2	3	④	5
Stripwork	1	2	③	4	5
Phraseology and Communication	1	2	3	④	5
Equipment Handling	1	2	③	4	5
Documents, Procedures and Airspace Knowledge	1	2	③	4	5
Handover/Takeover	1	2	③	4	5

General Instructor Comment

Four conflicts' were not separated. The two missed recognitions were of particular concern as they were opposite direction aircraft, which could have been easily recognised with appropriate assessment techniques. The other conflicts were recognised, but separation assurance was left too late to effect separation.

		Signature	Stephen Smith

EXAMINATION DEBRIEF FORM (ATC)

Trainee	Phil Ironside	Instructor	Steven Smith	Date 6/03/2002

This form and trainee signature below constitute documentary evidence of completion of the examination debrief. Additional instructor comment and trainee comment may be annotated overleaf. Original to be held by ATS Training College, photocopy to be given to the trainee. The trainee signature and comment overleaf (if any) is an indication that the trainee accepts the debrief as complete, comprehensive, and to his/her satisfaction.

CONFLICT RECOGNITION

Two opposite direction conflicts were not seen, despite the fact that there were strips in common bays which should have highlighted the conflicts.

SEPARATION ASSURANCE

Apart the two conflicts mentioned above, two lateral conflicts were not resolved. Requirements were correctly issued, but this was not done until very close to the area of conflict.

WORKLOAD & TRAFFIC MANAGEMENT

Fell behind in the work load relatively early and did not recover sufficiently to complete tasks in a timely manner. More attention to prioritisation of tasks will facilitate the ability to complete more tasks on time

CO-ORDINATION

All coordination completed correctly and on time.

TRAFFIC PLANNING

Planning would have helped to avoid the missed conflicts in today’s exercise. Keep looking at pending strips and at the current traffic picture.

RADAR TECHNIQUE (if applicable

Not applicable

IFER

All SARtimes monitored

STRIPWORK

Neat, accurate and up to date

PHRASEOLOGY & COMMUNICATION

Standard - except when under pressure. Practise ‘ad lib” phrases.

EQUIPMENT HANDLING

No apparent problems

DOCUMENTS, PROCEDURES & AIRSPACE KNOWLEDGE

Good knowledge

HANDOVER/TAKEOVER

Full and complete

TEAMWORK

Satisfactory

GENERAL COMMENT (*Trainee comment on back if required*)

See comments on Exam Results form.			
Trainee Signature	PRIronside	Instructor Signature	S Smith

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Issued to **PHILIP IRONSIDE**

Date of issue: **20/07/2002**
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Medical Valid to: **04 Dec 2002**

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ATS LICENSING REQUIREMENTS

Delegation issued by the Civil Regulator of Aviation Procedures.

Exmouth ATC Inc., an approved provider of Air Traffic Services is hereby authorised to act as the issuer of Air Traffic Control Licences and ratings under the applicable legislative instruments.

Conditions

1. Exmouth ATC Inc shall establish a check, training and licensing organisation.
2. Prior to the issue of an ATC Licence, Exmouth ATC Inc shall require the applicant to undergo such checks as deemed appropriate to the position for which an endorsement or rating is to be issued.
3. ATC Licence holders shall hold their ratings subject to the following conditions:

- The endorsement shall lapse if its privileges are not exercised for at least seven hours in the last twenty-one days.
- Licence holders shall undergo a proficiency check by a holder of the required rating at least once every six months, except that, upon initial issue of a licence, a proficiency check shall be conducted within three months of the issue date. This three-month interval may be extended at the discretion of the General Manager or delegate to a maximum of six months. The six-month period between routine proficiency checks may be extended at the discretion of the General Manager or delegate to a maximum of nine months.

Signed for and on behalf of the Minister for Transport, Racing and Gaming.

16 Sep 2000

TERRACE HILL INCIDENT - TAPE TRANSCRIPT

Time	From	To	Medium/ Frequency	Recorded Data
0356	Centre Manager	Keith Jones	Telephone	"Maintenance. Jones here"
				Keith, it's Bob mate. What the **** is your bloke doing at Terrace Hill? We've ******** lost everything."
				"What do you mean, lost everything?"
				"The ***** has pulled our frequency. We just had two jets have a ***** close look at each other. Get the ***** to ***** turn the thing back on. Now!"
				"Yeah, OK, Jeez you're getting cranky in your old age."
				"I haven't got time now, mate, just get me my frequency back."
				"OK, I'll see what....." (PHONE DISCONNECTED)
0404	Keith Jones	Terry Green		"Hello."
				"Terry, it's Keith here mate. Uh, listen, did you ring the Centre before you pulled that transmitter."
				"What do you mean?"
				"You know you're meant to ring the Centre before you take it off line. They reckon you didn't ring."
				"I didn't ring anybody. Am I meant to?"
				"Yeah, look, they're pretty worked up about it. How long to get it back."
				"About ten, fifteen minutes."
				"Ok get it back as quick as you can."
				"OK"

TERRACE HILL INCIDENT - TAPE TRANSCRIPT

Abbreviations

Sec4	Exmouth sector four	(Non Radar Sector)
EX3	Exmouth sector three	(Radar Sector)
NB2	Narabeen sector 2	(Non Radar Sector)
WV2	Waverton sector two	(Non Radar Sector)
EGL193	Eagle flight 193	Eagle Airways B767 – 300
PNX72	Phoenix flight 72	Phoenix Airways B737-300
PNX814	Phoenix flight 814	Phoenix Airways B737-300

Time	From	To	Medium/ Frequency	Recorded Data
0252	**EX3**	**Sec4**	**Intercom**	**"Position. Eagle one nine three was KALOT five one, flight level three seven zero, Moolyella one four."**
				"Eagle one ninety three, flight level three seven zero."
0256	**NB2**	**Sec4**	**Intercom**	**"Position, Phoenix eight fourteen, ONEMU five five, non standard flight level three seven zero, OSTAR three zero."**
				" Uh, stand by.... I'll have to... uh....Okay, flight level three seven zero Phoenix eight fourteen, but have you got any restrictions if I have to change him?"
				" "No level restrictions Phoenix eight fourteen."
0315	**EGL193**	**Sec4**	**128.9**	**"Exmouth Centre, Eagle one ninety three, at Moolyella one four, flight level three seven zero, estimating TOLAB two five.**
				"Eagle one ninety three, Exmouth Centre good afternoon."
0322	**Sec4**	**EGL193**	**128.9**	**"Eagle one ninety three, at TOLAB contact centre on one two seven decimal four."**
				"One two seven decimal four, Eagle one ninety three.
0326	**EGL193**	**Sec4**	**127.4**	**"Exmouth Centre, Eagle one ninety three was TOLAB two five, flight level three seven zero, VISIK five four.**
				"Eagle one ninety three, Exmouth centre."
0327	PNX72	Sec4	128.9	"Exmouth Centre, Phoenix seventy two, TATOG two seven, flight level three one zero, TOLAB five two."
				"Phoenix seventy two, Exmouth Centre"
0329	**Sec4**	**WV2**	**Intercom**	**"Position Eagle one ninety three TOLAB two five, three seven zero, VISIK five four."**
	WV2	**Sec4**		**"Uh, flight level three seven zero Eagle one nine three"**
0331	**PNX814**	**Sec4**	**127.4**	**"Exmouth Centre, G'Day, Phoenix eight fourteen, position OSTAR three zero, flight level three seven zero, estimating Lindberg at zero five next hour."**
				"Phoenix eight fourteen, good afternoon, Exmouth centre."

0333	Sec4	PNX814	TAPE ONLY[1]	**"Phoenix eight fourteen, due to crossing traffic, descend to flight level three five zero, and reach flight level three Five zero by one five miles east of Terrace Hill.**

	Sec4	PNX814	TAPE ONLY	"Phoenix eight fourteen, Exmouth centre?'

	Sec4	EGL193	TAPE ONLY	"Eagle one ninety three, centre?"

	Sec4	PNX814	TAPE ONLY	"Phoenix eight fourteen, Exmouth centre on secondary, how do you read?"

	Sec4	EGL193	TAPE ONLY	"Eagle one ninety three Exmouth centre, secondary, do you read?"

0334	PNX72	Sec4	128.9	"Centre, Phoenix seventy two has got you fives."
				"Roger thanks Phoenix seventy two, it looks like my other frequency has gone, stand by"

0338	Sec4	PNX814	TAPE ONLY	**"Phoenix eight fourteen, If you're reading this, er, descend to flight level three five zero, crossing traffic is an Eagle seven six seven at Terrace Hill."**

0339	Sec4	FIRM	Intercom	**"Mate, I've lost my one two seven four, and I've got two at the same level at Terrace Hill that I can't get hold of.**
				"I'm on my way"

0340	EGL193	Sec4	127.4 (TCAS)[2]	"Eagle one ninety three TCAS climb"
				"Eagle one ninety three, Exmouth centre do you read?"

0340	PNX814	Sec4	127.4 (TCAS)	"Phoenix eight fourteen, TCAS descent"

0342	PNX814	EGL193	127.4	"Uh Eagle, you at Terrace Hill?"
	EGL193	PNX814	127.4	"Er Eagle one ninety three, affirm, uh we're climbing now, TCAS, ah out of three seven six."
	PNX814	EGL193	127.4	"Phoenix eight fourteen, er roger, no sighting, but we're on the drop, and out of three six five, got you on the TCAS, looks er looks like, uh stand by, ah looks like you've gone past and behind us now.
	EGL193	PNX814	127.4	"Yeah, ah were you at three seven also, cause uh we were level at three seven zero.
	PNX814	EGL193	127.4	"Yeah we're cleared to er three seven zero by Narabeen"'
	EGL193	PNX814	127.4	"Okay, I er think we're Okay now, we're gonna get back to three seven."
	PNX814	EGL193	127.4	"Okay eight one four"
	EGL193	Sec4	127.4	"Exmouth Centre, Eagle one ninety three."
	Sec4	EGL193	TAPE ONLY	"Eagle one ninety three, Exmouth centre, how do you read?"
	EGL193		127.4	"All stations, Eagle one ninety three is returning to flight level three seven zero."
End of transcript				

---

[1] TAPE ONLY: This indicates that the transmission was recorded, but was not transmitted on the appropriate frequency. (It was transmitted on 128.9 due to re-transmission capability)

[2] TCAS: Indicates that TCAS warning audible during transmission.

MYE 14 23 ~~15~~ **03**	14 14		370 ~~M~~ →	C/B763/H I **EGL193**	KALOT 0252	51 370		WSSS A963 JV	C	D F O I Y L
TOLAB 25 12 ~~27~~ **03** 26	~~25~~ ~~27.4~~ 25		370 ~~M~~ →	C/B763/H I **EGL193**				WSSS A963 JV	C	D F O I Y L
VISIK 54 30 ~~57~~ **03** 55		√	370 ~~M~~ →	C/B763/H I **EGL193**	TEH (17) 0342			WSSS A963 JV	C WV2 √ 119.3	D F O I Y L

OSTAR 30 34 **30** **03**	30 30	R 350 X 15 TEH	370 ~~M~~ → 350	C/B733/M I **PNX814**	ONEMU 0256	55 370	TEH (11) 0341	RV J81 EX	C	D F O I Y L
LG 05 34 ~~04~~ **04** 04			370 ~~M~~ →	C/B733/M I **PNX814**				RV J81 EX	C 124.9 4R	D F O I Y L

TATOG 27 37 ~~27~~ **03**	27 27		310 ~~M~~ →	C/B733/M I **PNX72**	TEMPA 0250	50 310		MT G969 EX	C	D Y F O I W L
TOLAB 52 22 ~~52~~ **03** 52			310 ~~M~~ →	C/B733/M I **PNX72**				MT G969 EX	C 124.9 4R	D Y F O I W L

C0087/99 NOTAMN
A) EXMOUTH FIR C0087/00 (COM) 200211180604
B) 200211200330 C) 200211200500
C) A/G FAC EXMOUTH 127.4 (TERRACE HILL AREA) NOT AVBL

C0087/99 NOTAMN
D) EXMOUTH FIR C0087/00 (COM) 200211180604
E) 200211200330 C) 200211200500
F) A/G FAC EXMOUTH 127.4 (TERRACE HILL AREA) NOT AVBL

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W) 200211200330 C) 200211200500
X) A/G FAC EXMOUTH 127.4 (TERRACE HILL AREA) NOT AVBL

AIRWAYS SERVICES WORKS PLAN

Reference Number : **WMD** : 00 : 025 issue : 1
(Mtce centre : year : number)

APPROVED WORKS PLAN: tick if YES (YES)
ADVICE WORKS PLAN: tick if YES ( )

SERVICES AFFECTED : Terrace Hill 127.4

EQUIPMENT : PRIM + SEC VHF

SYSTEM AVAILABILITY : NOT AVAILABLE DURING WIP.

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COMPLETION OF WORK: -DEFINITE (date/time UTC)	200211200500 yyyymmddhhmm
-ESTIMATE (date/time UTC)	yyyymmddhhmm
RECALL TIME:	NO RECALL AVAILABLE
PRE-DEPARTURE APPROVAL DATE:	200211200100
NEGOTIATED RELEASE APPROVAL:	EX CENCO

ON SITE CONTACT DETAILS: TECHS 02 4961 6136
(name, phone no or other means of contact)

REMARKS: FACILITY NOT AVAILABLE DURING WORKS PLAN.

EXMOUTH SECTOR FOUR PROCEDURAL ROSTER

PM2 = 1300 - 2000
PM1 = 1200 - 1900
AM = 0600 - 1300

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11 Nov 2002	PM1	AM	AM	RDO (ED PM2)	RDO	PM2 (sick)
12 Nov 2002	AM	AM	RDO	PM1	AM	AM
13 Nov 2002	AM	RDO	RDO	AM (sick)	AM	RDO (ED AM)
14 Nov 2002	RDO	RDO	PM2	AM	RDO	RDO
15 Nov 2002	RDO	PM2	PM1	RDO	RDO	PM2
16 Nov 2002	PM2	PM1	RDO	RDO	PM2	PM1
17 Nov 2002	PM1	RDO	RDO	PM2	PM1	AM
18 Nov 2002	RDO	RDO	PM2	PM1	AM	AM
19 Nov 2002	RDO	PM2	PM1	AM	AM	RDO
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23 Nov 2002	AM	RDO	RDO	PM2 (Check)	PM1	AM
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30 Nov 2002	RDO	RDO	PM2	PM1	AM	AM
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02 Dec 2002	PM2	PM1	AM	AM	RDO	RDO
03 Dec 2002	PM1	AM	AM	RDO	RDO	PM2
04 Dec 2002	AM	AM	RDO	RDO	PM2	PM1
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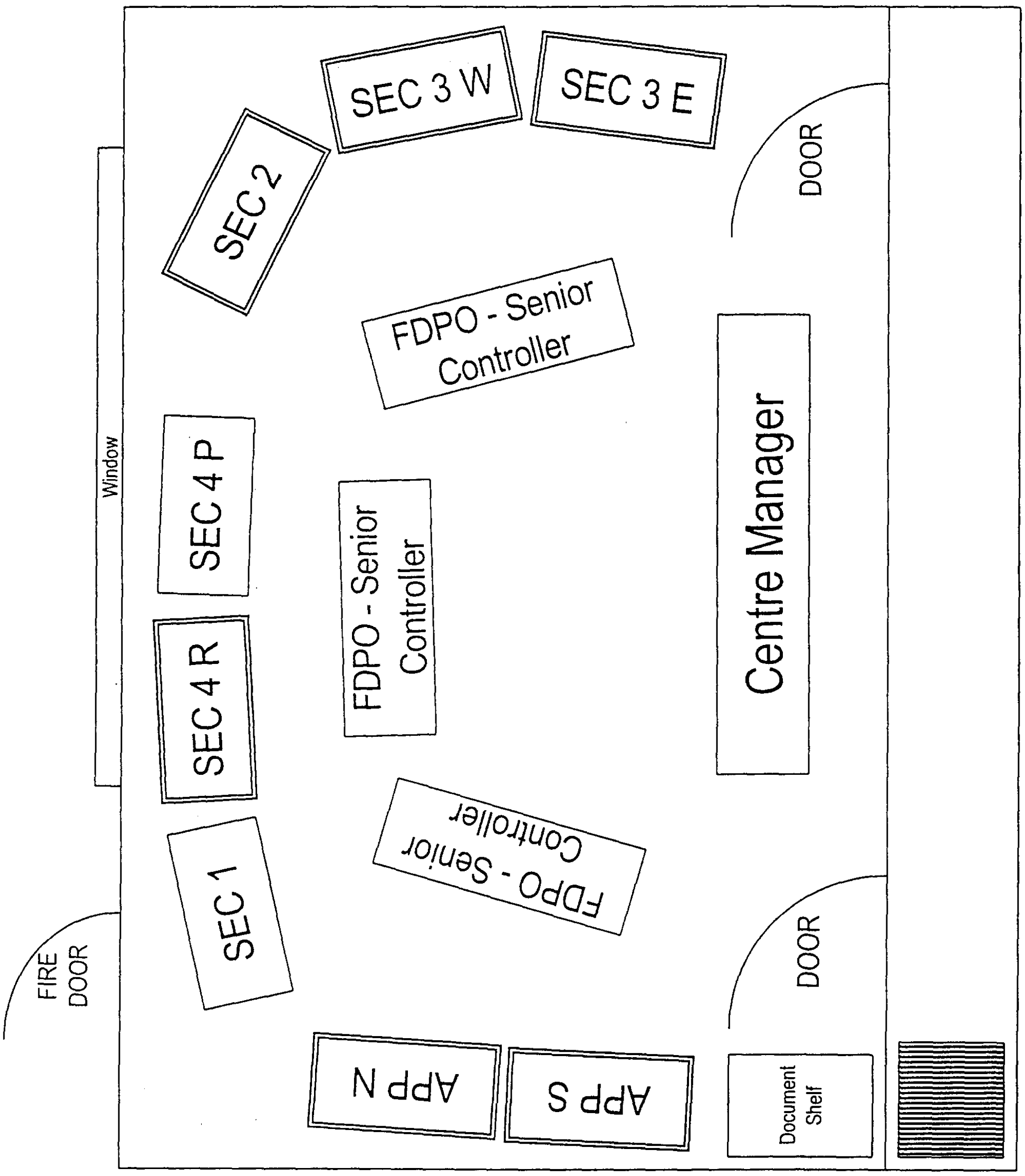
07 Dec 2002	RDO	PM2	PM1	AM	AM	RDO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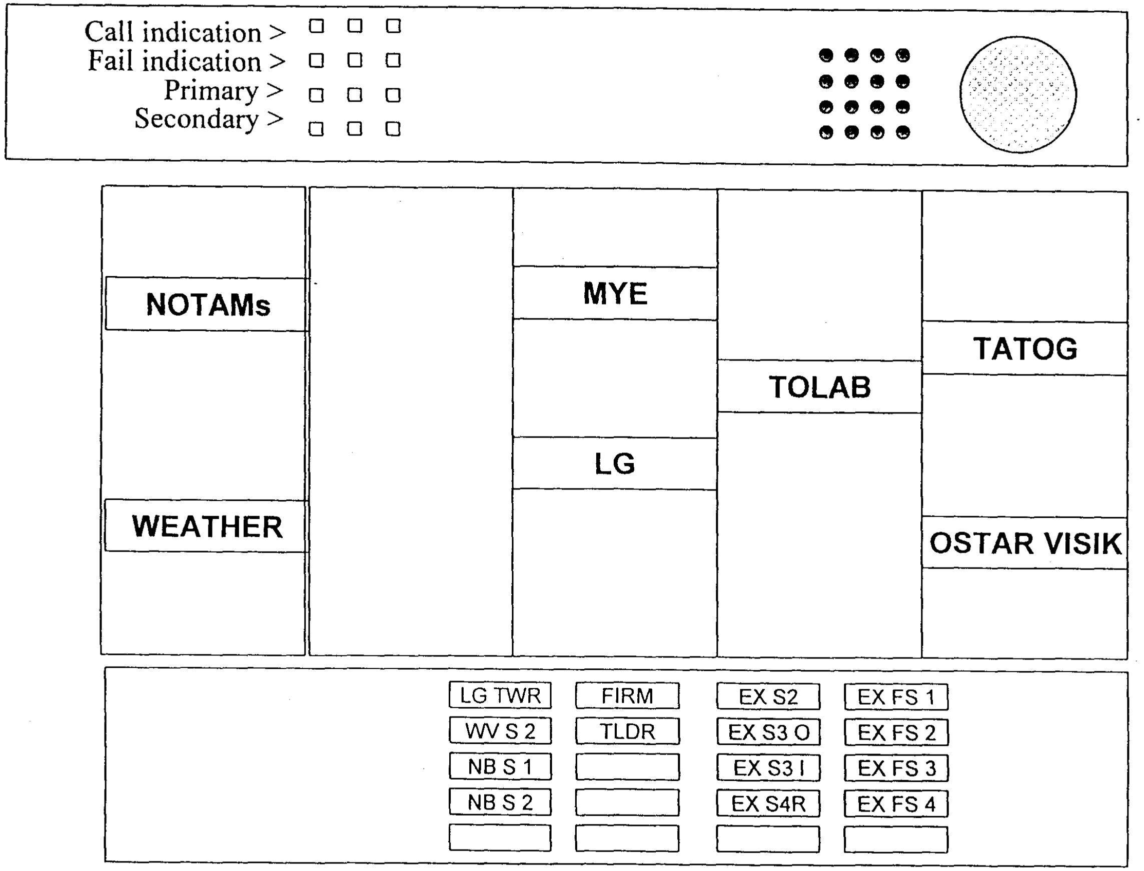
SEC 3 E
SEC 2
DOOR
FDPO - Senior Controller
Window
SEC 4 P
FDPO - Senior Controller
Centre Manager
SEC 4 R
SEC 1
FDPO - Senior Controller
FIRE DOOR
DOOR
APP N
APP S
Document Shelf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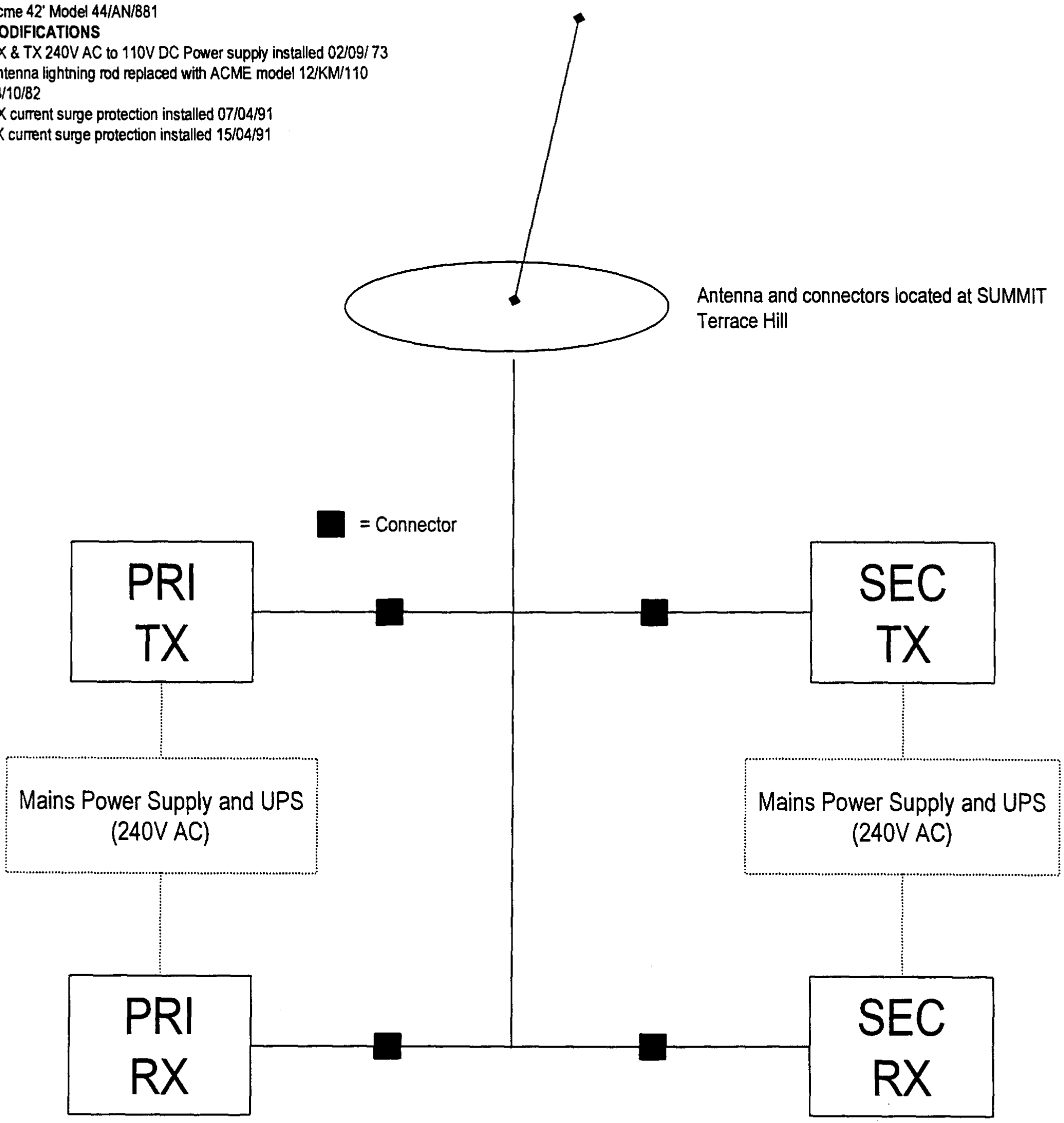
Fail indication >
Primary >
Secondary >
NOTAMs
WEATHER
MYE
LG
TOLAB
TATOG
OSTAR VISIK
LG TWR
WV S 2
NB S 1
NB S 2
FIRM
TLDR
EX S2
EX S3 O
EX S3 I
EX S4R
EX FS 1
EX FS 2
EX FS 3
EX FS 4

VHF TX/RX SPECIFICATIONS
TERRACE HILL 127.4 MHz

RECEIVER TYPE:
Acme Model 47/GB/341 (Installed
TRANSMITTER TYPE:
Acme Model 47/GM/772
ANTENNA TYPE:
Acme 42' Model 44/AN/881
MODIFICATIONS
RX & TX 240V AC to 110V DC Power supply installed 02/09/ 73
Antenna lightning rod replaced with ACME model 12/KM/110
23/10/82
RX current surge protection installed 07/04/91
TX current surge protection installed 15/04/91



Antenna and connectors located at SUMMIT
Terrace Hill

Transmitter and Receiver equipment located
at BASE of Terrace Hill

Technical Proficiency Report	
Name	**Terry Green**
Date	**18 February 1999**
Equipment	**VOR, NDB, VHF Comm, LLZ**
Next assessment required	**18 February 2001**
The person named above has been assessed as competent to perform repair and maintenance work on the equipment listed.	

Technical Proficiency Report	
Name	**Terry Green**
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Next assessment required	**18 February 2001**
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INTEROFFICE MEMORANDUM

Date: 9 Sep 2002 15:50
From: Robert Stilwell
Dept: ATS
Tel No: (01) 5555 4879

To: Keith Jones

Subject: Facility Downtime Notice

Keith

Confirming the procedures agreed to at our meeting yesterday:

1. SCHEDULED MAINTENANCE OF FACILITIES

All scheduled maintenance of ATS facilities shall be the subject of a NOTAM. It shall be the responsibility of the unit carrying out the maintenance to request that the NOF raise a NOTAM. A minimum of 48 hours notice shall be given of any scheduled maintenance.

2. UNSCHEDULED FACILITY OUTAGES

Immediately on becoming aware of a facility failure, the duty technician shall advise the Centre Coordinator. This is to occur regardless of whether monitoring equipment is present in the ATSC.

3. REMOVAL OF FACILITIES FOR WORKS OR REPAIRS

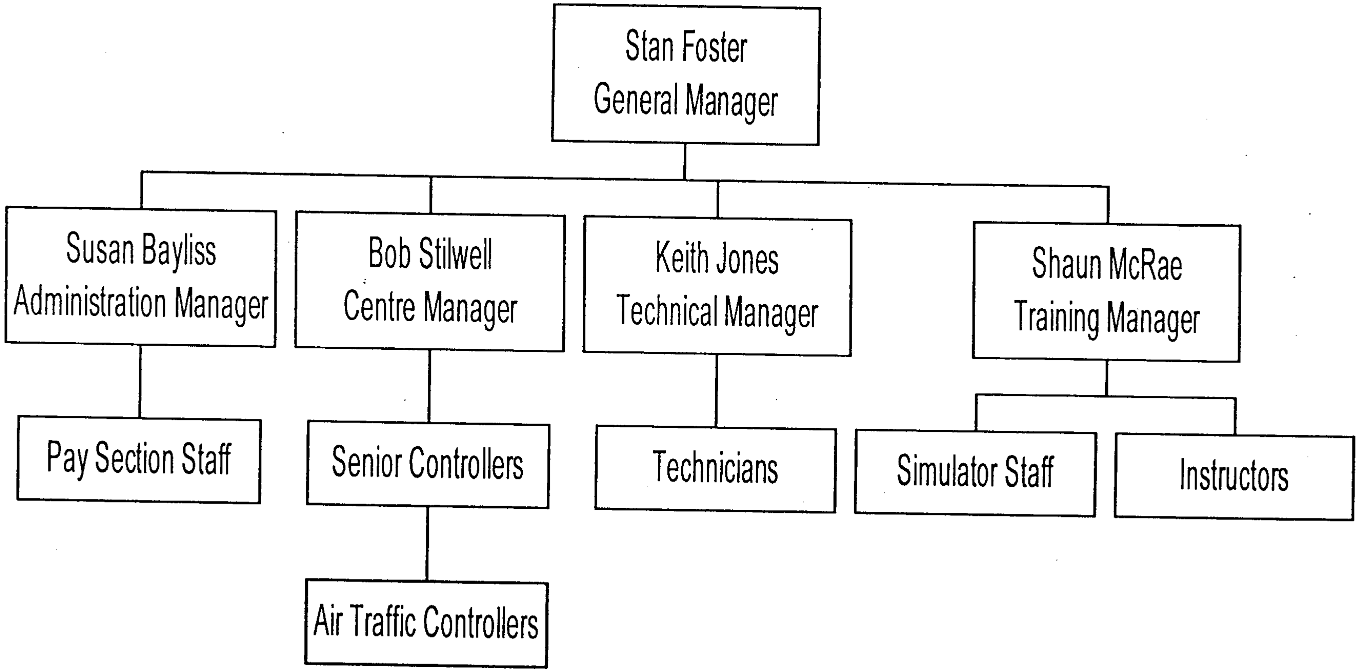
Prior to removing any facility for works, the duty technician or technical supervisor shall obtain the concurrence of the Centre Manager. The facility shall not be removed from service without the concurrence of the Centre Manager. It shall be the responsibility of the Centre Manager to liaise with affected ATS units, including any ATS units outside the Exmouth ATSC.

Please advise your staff of these procedures, and amend any documentation as necessary.

Thank you.

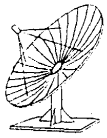
Bob Stilwell
Centre Manager
Exmouth ATSC

Exmouth ATC Inc – Organisational Structure



Exmouth ATC Inc.

555 Exmouth Street
Exmouth 9132
Western Amnesia



25/11/2002

Dear Sir or Madam:

I am responding to your requests for materials in your incident investigation. Most materials have been provided, however the following materials can not be provided:

1. Airline incident reports: Both Phoenix and Eagle Airlines have been contacted and have declined to provide access to their records.

2. Handover/Takeover sheets: These are not used in the Exmouth ATSC. Handovers are conducted at the console and are done using information displayed at the console.

3. IFER Training Program: IFER Training is a part of the overall training program. As such no specific training packages are available. Senior Controllers provide the majority of IFER Training on an as required basis. IFER forms part of the semi-annual check procedure.

4. Safety Case (Use of non-standard levels): No safety case has been prepared as no safety deficiency has been identified. Standard levels are encouraged but non-standard levels are at controller discretion.

Sincerely,

Stan Foster
General Manager, Exmouth ATC Inc.

附件二

Air Safety Incident Investigation Course

Participant Manual

Presented by the

Airservices College
10 International Square
Tullamarine VIC 3043
Australia
Telephone: + 61 (0) 3 9335 8350
Facsimile: + 61 (0) 3 9335 8355

TABLE OF CONTENTS

TABLE OF FIGURES AND ATTACHMENTS

INTRODUCTION

Course Aim

The purpose of this course is to prepare air traffic services and other staff to undertake the duties of air safety incident investigator.

Learning Outcomes

At the conclusion of this course and with appropriate supervised workplace application, participants will be able to:

- Manage an incident investigation.
- Conduct an incident investigation.
- Gather and manage incident investigation material.
- Report the outcomes of an incident investigation.
- Contribute to the refinement of ATS incident investigation procedures.

Qualification

Upon successful completion of this course, participants who hold an ATS licence issued by Airservices Australia will receive the Incident Investigator (INCINV) qualification. Holders of other certificates or authorities should check with their managers.

The Purpose of this Manual

This manual contains notes for some sessions that will be covered during the course. The notes are **additional** to the content of the session, and do not merely paraphrase what may be covered during the course. It is therefore recommended that participants read this manual after completing the course.

THE ROLE OF THE INCIDENT INVESTIGATOR

Introduction

THE INVESTIGATOR:

Any investigator selection process seeks to deliver individuals that possess a healthy balance of experience and analytical skills. Theory without practice can be ineffective and uneconomical. Good communication skills and a team spirit are also vital assets to any investigator.

HUMAN FACTORS:

Introduction: Any ATS investigator will need to consider in detail the following aspects:

The principles of human error:

- Physiology
- Physical well being of the operator
- Communication processes utilised through the incident
- Situational awareness
- The personalities of all parties to the incident.

Rosters:

- Shift cycles.
- Rest periods provided and utilised.
- Length of day and night shifts.
- Additional tasks imposed on the operator.

Environment:

- Operational
- Domestic

Equipment and Facilities:

- Fitness for purpose
- Service history Maintenance

Management Aspects:

- Organisational culture
- Training program
- Safety programs and awareness
- Visible support
- Operational feedback processes.

Standards and Procedures:

- Standard Operating
- Procedures documented and available to all operators
- Defence mechanisms utilised:
- Separation assurance techniques
- Quality management and control systems

ANALYSIS OF THE DATA:

In the vast majority of air traffic service related air safety occurrence investigations, the *who, what, when and where* is known and generally well documented and recorded.

The primary purpose of the analysis is to provide a seamless link from the factual information, through a rationalisation of that information, to conclusions and findings that provide the answers to the whys.

The range of methods available to analyse any ATS incident or related accident is endless. The more experienced investigators will call upon their previous encounters and determine a suitable method.

It is important to remember that there is no specific right or wrong way to practice analytical investigation. However, the following steps may assist in reaching a timely result.

Establish links.

- In any sequence of events, attempt to fill those gaps that exist between the facts. Extrapolate them where logically possible based on both theory and your practical knowledge.

Avoid repetition.

- Repetition of factual data will be a source of distraction for all participants at any level of analysis.

Evaluate the situation.

- Remember that these evaluations must always be based on factual evidence.

Develop a progressive analysis.

- Attempt to always resolve any elements of controversy or contradictions in evidence at an early stage of the analysis.

Apply accepted analytical models to support the analysis.

- The Reason Model or the SHELL Model can usually be applied to great effect. Why not try them at an early stage.

Include all relevant facts.

- This is most important for completeness of the details.

Exclude all irrelevant facts.

- They will add nothing but a source of further distraction to the analysis.

Support realistic possibilities.

- Any relevant theme may be considered. Do not rule out the value of the hypothesis until it can no longer be supported.
- Reject possibilities, when they are no longer valid.

Test the analysis with argument.

- If the analysis will stand scrutiny against the factual information then the validity is most likely to be logical and credible.
- Clearly indicate instances of opinion or fact.

Conclude with a clear analysis.

- State that the analysis is clear. If it is not clear, then state that the analysis is undetermined
- Cautiously explain unsupported conclusions. If the conclusion cannot be fully and positively supported by weight of evidence, state that it is so. It aids the credibility process.
- Relate any uncovered issues. This is vital especially when relating those that did not directly contribute to the event.
- Identify ambiguities. If you don't then the reader will with a negative impact.

Conduct a final review.

- Reaffirm your conviction as to the "who, what, when and where" of the investigation.
- Commit to the analysis.

CONCLUDING THE ATS INVESTIGATION:

Not only must air traffic services investigators possess the skills and training to initiate an investigation, they must also be aware of when the investigation is complete. The following guidance is provided:

- Review all documentation to ensure that it will support recommendations and debunk any issues that are not relevant to the investigation.
- Determine if additional information or documentation is required. Review with other investigators the findings and conclusions and proposed recommendations. Have answers to any issues they may present.
- Review interview summaries to ensure that any issues have been addressed
- Ensure that those individuals who have been interviewed are able to provide answers to any outstanding issues to which information has not been provided.
- Determine if the recommendations can be made informally through a briefing or require a formal submission (report)
- Remember that proposed corrective actions should be, feasible, realistic and will clearly remedy the deficiency.
- Determine if there are any items that require follow-up, such as corrective action that management may have taken that will preclude formal recommendations.
- Determine if identified deficiencies are isolated to that specific facility or part of a national trend

- Develop a draft report of investigation and disseminate, for comment, to other parties to the investigation

INVESTIGATION CONCLUSIONS:

There should be no new material introduced in this section of the report. Every finding must be clearly stated, identified and supported within the body of the report itself. This section of the report should follow the sequence of the occurrence as closely as possible by presenting all findings and significant factors without being a complete synopsis of what happened. These investigation conclusions should permit the reader to arrive at, and agree with, the logical processes and results of the investigation.

SIGNIFICANT FACTORS:

The significant factors are those factors (failures, errors or omissions) that, if removed from the sequence, would have prevented the occurrence. They must be:

- Tested for logic, relevance and importance before inclusion.
- Listed in a chronological sequence.
- Clear and provide a brief explanation whenever conclusions cannot be recorded.

AUTHORITY AND TERMS OF REFERENCE

From the Manual of Air Traffic Services (MATS)

Investigation of Incidents

Airservices has an obligation to investigate all reported incidents that indicate a degree of responsibility rests with Airservices.

Line managers are responsible for ensuring that investigations are carried out and that any recommendations made by the investigator are reviewed and implemented as appropriate.

Terms of Reference for ATS Investigations

The following generic terms of reference shall apply to investigations carried out by Airservices Investigators. Line Managers may specify additional areas to be covered:

a. any officer assigned the task of investigating an air safety incident or related event will have the full support of the manager responsible for the investigation. This manager will retain overall responsibility for all facets of the investigation;

b. the investigator, through the manager responsible, will have full access to all records including recorded data and file records;

c. the investigator, through the manager responsible, is entitled to seek advice from any relevant source;

d. the investigator is obliged to regularly communicate progress to the manager responsible. The information obtained is confidential and must not be divulged to any person or organisation without the approval of the manager responsible;

e. any potential items of conflict are to be referred to the manager responsible for advice or resolution;

f. in conducting the investigation, an investigator must consider three primary issues:

1. **What has happened?** This will often be a simple statement of the facts in a chronological order;
2. **What caused the event to happen?** The cause or causes determined through the investigation will be obtained through a combination of fact, personal interview, reference to documentation and subsequent specialist analysis;
3. **What must be done to prevent the event recurring?** These will essentially be recommendations for the manager authorising the investigation to consider.

The investigator is required to report on any other significant issues that may appear to be peripheral to the initial investigation.

HUMAN FACTORS

Mishaps and Human Factors

By Captain Robert L. Sumwalt, III (F03396)

Human factors (HF) must be fully integrated into accident and incident investigations to ensure identification of all relevant factors leading to the mishap.

> *(This article was adapted with the author's permission from his paper titled "Integrating Human Factors: The Future of Accident Investigation" presented at the ISASI 1997 International Seminar in Anchorage, Alaska, October 1997-Editor)*

According to FAA's *National Plan for Civil Aviation Human Factors: An Initiative for Research and Application, March 1995*, human error has been identified as a causal factor in 60 to 80 percent of air carrier, commuter, and general aviation accidents and incidents. Other sources, perhaps more bold in their methodologies, place the figures even higher.

Regardless of the actual number, the fact remains that human error is a factor in a significant number of aviation mishaps. Think of the last mishap that you investigated that did not involve some sort of human error. Some persons argue that, if properly conducted, almost any accident investigation is a human factors investigation. Often, as an investigation unfolds, human error emerges even in accidents lacking initial signatures of error.

Take, for example, a mechanical malfunction. Surely the part or component was not designed to fail halfway through its expected service life. Was it the result of a design error, or was it an inspection error? Perhaps it was an installation error. Aloha 243 and United 232 are good examples.

A weather accident.

My brother-in-law was critically injured when the plane in which he was a passenger crashed when windshear severely hampered aircraft performance during a missed-approach at Charlotte, NC, in July 1994. Of the 57 people on board, 37 were fatally injured. When he was released from the hospital, he said that the airline was not culpable because, in his words, the accident was an "act of God." However, as the months and the investigation progressed, the multitude of errors that enabled the accident were slowly uncovered. Weather dissemination errors by the air traffic controllers and errors of decision-making by the flight crew were among the human failings.

A terrorist act.

Yes, unfortunately, even this sort of tragedy is often the result of some error somewhere in the system. Pan Am was implicated with security breaches following the Lockerbie accident.

In some cases, the human error(s) may not be obvious at all. The errors may be deeply embedded within the system, perhaps far, far away from the scene of the accident site. An accident investigator's mission is to identity the factors that led to an accident so that corrective actions can be taken. How can investigators meet their mission--that is, identify all of the factors that led to the accident, and not just the obvious ones?

ICAO Human Factors Digest Number 7: Investigation of Human Factors in Accidents and Incidents, 1993, provides a major clue for ensuring the mission is met: "Knowledge of human factors and an understanding of how to apply this knowledge in an investigation offers the investigation authority a greater opportunity to identify root causes which may not have been recognized previously. Human factors has a basis in scientific methodology that can lend objectivity to the investigation and provide insight not obvious from a purely operational perspective."

The Knowledge Tool

French semiologist Jean Baudrillard wrote, "Information can tell us everything. It has all the answers. But they are answers to questions we have not asked, and which doubtless don't even arise." His insight is most critical to an investigation: if we don't ask the right questions, we'll never find the right answers

One way to ensure that we "ask the right questions" and look for the right things is to acknowledge that human factors will play a major role in a successful investigation, thus creating a commitment to integrate human factors into all investigations. The backbone of that commitment is the act of providing a very basic human factors education for all involved in mishap investigations. Everyone--from the accident investigation board members and the Investigator-in-Change (IIC), to the rank and file investigative staff and those working with safety recommendations and analyses. Even the report writers.

In all things, the task of finding something becomes more assured when you have a clear understanding and knowledge of what you are seeking. The same applies to mishap investigation. If the preponderance of accidents and incidents are rooted in human error, then doesn't it make sense to provide human factors training to all investigators to help them "ask the right questions" and "look for the right answers" as they relate to human error?

How much human factors training? Enough to "sensitize" the investigative staff on the intricacies of human error. Each investigator should receive enough training so that he or she has a basic feel for human factors issues.

Transportation Safety Board of Canada (TSB of Canada), for example, offers a very good five day human factors course. Each staff member involved with accident investigations and transportation safety issues attends this course. The Air Line Pilots Association (ALPA) Basic Aircraft Accident Investigation Course provides a one-and-a-half hour module demonstrating how human factors should be integrated into investigations. Now, one can not create human factors experts in an hour-and-a-half or even in five days, but that is not the objective. The idea is to heighten the awareness of basic human factors issues to apply in a mishap investigation.

Among the advantages to increasing the human factors knowledge base of air safety investigators is that they will likely feel more comfortable taking on human factors issues-issues that they may have previously been reluctant to tackle because of a perceived lack of human factors knowledge, or because of the fear of "crossing into someone else's territory"-the human performance specialist's territory. Experience has shown that the more comfortable a person becomes with a subject, the less reluctant he or she is in approaching that subject.

The same applies to air safety investigators: the more comfortable they become with human factors issues, the more likely they will undertake collection and analysis of potentially relevant human factors information. The more of these issues that are carefully explored, the more likely it is that the root causes of the mishap will emerge.

I am not suggesting that human factors specialists' roles be eliminated. Indeed, after TSB of Canada integrated human factors training, it found that the role of human factors specialists increased. Maury Hill, TSB of Canada's chief of human performance, attributes this increase to the investigative staff's realization that human factors is more than just "psychobabble," meaning that the staff sees the value of human factors in logically explaining mishaps. The staff's increased knowledge assists them in further developing theories and ideas that can be passed on to human performance specialists for confirmation or further analysis.

This approach parallels other disciplines of an investigation. Consider the on-site field investigator who picks up a bent piece of metal, examines it, and concludes from metal sheering or its bent shape that it must have failed in a certain fashion. If further expertise is needed, that piece could be sent to a metallurgy lab for closer examination.

In essence, human factors knowledge becomes an extra tool in the investigator's "go kit." However, as with any tool, it is up to the investigator to decide how best to use it, when to discard it, and when to call in an expert.

Getting started

Management needs to commit to integrate human factors, which carries with it the need to provide either industry or in-house training.

When evaluating options, one needs to look for a program that provides very specific information that can be readily applied by air safety investigators. Thus, the teaching of an "applied approach" is vital. Equally important is that the course material demonstrate direct correlation to the job of an accident investigator. If it does not have that correlation, a real risk exists that the notion that "human factors is just a bunch of academic stuff that really means nothing to accident investigators" will prevail.

For example, a red hot aviation topic is cockpit automation, and, in a particular HF course, automation was discussed in detail; however, it related to automation of factories. The word "cockpit" was barely heard. Corporate culture, another hot topic, centered on safety culture in the nuclear power industry.

One attendee expressed it this way: "There was a lot of material, and some of it probably had useful information embedded in it. But it would take a lot of time and effort for a typical investigator to translate this information into practical application." The consequence? After five days of classroom instruction, participants left with little information to help them investigate aviation safety issues.

Basic elements

Successful human factors courses depend upon established cornerstones. These include ICAO Human Factors Digest Number 7: Investigation of Human Factors in Accidents and Incidents, and the excellent text Beyond Aviation Human Factors, by Captain Dan Maurino, James Reason, Neil Johnston, and Rob Lee.

ICAO Human Factors Digest Number 7 is ideal for use as a starting point in curriculum development of a HF course. The following listing focuses on topics that are particularly relevant to air safety investigators. The bulk of these items is explained very well in the ICAO publication.

Human factors definition. Any successful course in human factors should begin by defining human factors. While the term "human factors" has been banished for the last decade, it helps to provide a very basic definition just to ensure that everyone is "singing off the same sheet of music." ICAO Human Factors Digest Number 7 states that human factors is the study of how the physical, physiological, psychological, and psychosocial variables affect a person's ability to perform.

In this case, physical deals with the person's basic physical condition-size, age, strength, motor skills, visual and auditory and other senses. Physiological refers to general health, and things like nutrition, incapacitation, illusions, stress, fatigue levels, and general lifestyles. Psychological involves mental capabilities, perceptions, information processing, attention span, workload, personality, mental and emotional state, knowledge including training, attitude and mood. Psychosocial are those events and stresses brought on by relations with family, friends and peers, death in family, financial problems, etc.

Systems approach.

A clear understanding of the term "systems approach" is critical. This is because people are greatly influenced by their surroundings. For example, the actions of flight crews are affected by factors present in the cockpit-things like interactions with other crew members, flight deck automation, and the physical human-machine interface. But also affecting crew performance are factors outside the cockpit, such as the operator's corporate culture, regulatory influence, and environmental conditions. When combined into the aviation context, each of these individual pieces form the aviation "system."

To learn why a person's actions may have led to a mishap, all of the human factors components must be examined to see how they may have interacted (or failed to properly interact). "People do not operate in a social or operational vacuum," explains Captain Dan Maurino, ICAO human factors specialist. He adds, "Their behaviors, actions and inactions can therefore only be understood if examined within the operational contexts within which they take place." A "systems approach" acknowledges that all components in the system may have played a role in enabling the mishap, and, therefore, each system component must be investigated to uncover any possible linkage.

"It is time to look at the systemic and organizational deficiencies which, by fostering human error, threaten the safety of the aviation system. No matter how well equipment is designed, no matter how sensible regulations are, no matter how much pilots excel in their performance, they can never be better than the system which bounds them," says Captain Maurino.

SHEL Model

The SHEL model is a useful investigative tool because it allows exploration of many factors that acted upon the individual in question. It removes focus from the individual, instead highlighting that individuals do not operate on their own, but rather interact directly with many other components in the system. The letters SHEL represent the words software, hardware, environment, and liveware.

S = Software (involves the transfer of information between the human and supporting systems such as checklists, manuals, publications, procedures, regulatory requirements, maps and charts, etc.)

H = Hardware (involves any physical or mental interactions between the person and the machine-design limitations, instrument/control design and location, instrument colors/ readability, seat design, eye reference position, etc.)

E = Environment (It encompasses "internal factors" such as personal comfort, and physical working conditions such as temperature and humidity, illumination/glare, noise interference, vibrations, air quality, i.e., high altitude physiology. It also encompasses "external factors" like weather conditions, and airport surroundings such as runway lighting, ice covered runways, external lighting, etc.)

L = Liveware (the nature of interactions and communications between individuals such as voice communications, phraseology, speech content, speech rate, language barriers, readback/hearback, crew briefings, CRM, crew coordination/ interaction, interaction with passengers, labor relations, pressures, supervision, non-verbal cues such as ground or hand signals, etc.)

The uneven edges between the SHEL components are symbolic of the fact that the interaction between the individual and these components is important, and any mismatch could result in potential error. These are the areas that warrant particular attention during safety investigations.

Reason Model

A working understanding of the Reason Model is essential when integrating human factors into air safety investigations. Dr. Reason believes that aviation incidents and accidents and others involving high technology industries are rarely caused exclusively by mistakes or failures on the part of "front line operators." Instead, he says that accidents often result from the interaction of a series of flaws known as latent conditions that have been embedded in the system.

Front line operators are those who are at the "sharp end of the pyramid," says Dr. Reason, meaning that these people are performing the actual hands-on tasks, as opposed to managers who are farther behind the front line. Examples of front line operators include pilots, air traffic controllers, and mechanics.

Reason classifies system failures according to how quickly the failure is manifested or made known.

Active failures

An active failure is typically committed by a front line operator. The failure's consequences are usually made known soon after the error was committed, such as flight crew forgetting to set wing flaps prior to takeoff, or a mechanic failing to replace engine O-rings.

Latent Conditions

Latent conditions or latent failures are systemic flaws, the consequences of which may not surface until long after being introduced into the system. These dormant conditions usually result from decisions, actions, or inactions of those who are far removed from the front line, such as managers or regulatory authorities.

Inadequate regulatory oversight of a rapidly expanding new-entrant air carrier is an example of a latent condition. In itself, that condition may not result in an accident; however, when combined with other active or latent failures the "window of accident opportunity" may be opened.

Each layer of the system can introduce flaws. Reason classifies "Decision Makers" as the layer that is furthest removed from the front line operations. He states that this layer contains the "architects and the high-level managers of the system," whose function is to set the system's strategies and philosophies. They are senior-level management or even regulatory officials. "A large part of their function concerns the allocation of finite resources, such as money, equipment, and time," says Dr. Reason. "Their aim is to deploy these resources to maximize both productivity and cost."

When these objectives conflict, flawed decisions can result that will be reflected throughout the system. Consider the aviation decision maker who decides to improve on-time performance at all costs, or the decision to do everything possible to maximize the corporation's financial picture. Taken independently, these decisions (latent conditions) may sound reasonable. However, if proper checks and balances are not in place, such decisions can have consequences that affect system safety at some future point.

Once decision makers set the strategies for the system, "Line Managers" are responsible for turning the ideas into practices. This is done by implementing standard operating procedures (SOPs), training programs, company directives, and the like. When these practices are implemented in less-than-optimum fashion, latent conditions are formed.

Preconditions

"Preconditions" are the production qualities and problems that reside within the system. Preconditions that affect the system in a positive manner include attributes like good equipment, good employee morale, good training programs, and positively motivated workers.

Conversely, unhealthy characteristics, such as an unproductive working environment, poorly motivated workforce, and poorly established procedures, are examples of latent conditions that can later interact with other failures to threaten system safety.

The act of the front line operators performing their job functions is what Reason terms "Productive Activities." An active failure occurs when a front line operator commits an unsafe act such as deviation from SOPs or omission of a checklist item.

Defenses

"Defenses" are the system's safety net, and the final system layer described by Reason. Pilot discipline, proper training, checklist usage, warning devices, and other "error trapping" techniques are examples of defenses. For example, a hurried crew may forget a critical item during taxi-out, only to catch that omission during the pilot's last minute scan of the overhead panel. Without these defenses, an accident may have occurred.

Defenses are sort of a "good news/bad news" situation. The good news, obviously, is that defenses prevent mishaps that otherwise might have occurred had the defenses not been employed.

The down side, however, is that a system's defenses are usually quite strong and effective; because defenses were used, no accident occurred. Their frequent usage can mask the presence of latent conditions. Because they are not manifested, latent conditions remain lurking in the shadows of the system, waiting to snare another unsuspecting worker. This, on a side note, highlights the importance of confidential incident reporting programs like NASA's Aviation Safety Reporting System (ASRS) and British Airways Safety Information System (BASIS), because these programs help flag latent conditions before they result in accidents or serious incidents.

Reason theorizes that an "accident trajectory" forms when unsafe acts or active failures interact with systemic latent failures. When defenses are breached, the trajectory opens the "window of accident opportunity," enabling an accident.

When investigating mishaps, the investigator should begin with the error(s) of the front line operator. This is where many previous investigations have stopped-with identification of obvious errors.

Once that error(s) is identified, investigators should then follow the accident trajectory, working through each layer in the system. As each layer is examined, the focus should be on identifying the latent conditions that could have influenced the actions of the front line operator and resulted in an accident or incident scenario.

Beginning or End?

The majority of aviation mishaps involve human error. The success of future accident investigations will depend largely on the methodology used to unearth the error(s), and how that discovery affects the remainder of the investigation. Does the investigation end with that discovery, or is this just the real beginning?

ICAO's Captain Dan Maurino suggests that the discovery of human error should be considered as the starting point of the investigation, and not the ending point that has punctuated so many previous investigations. Captain Maurino states that if and when an error(s) is found, the challenge becomes to then find the underlying contextual factors that fostered the error. "Error should be considered like fever: an indication of illness rather than its cause. It is a marker announcing problems in the architecture of the aviation system," says Captain Maurino.

What will be the starting point of your next investigation? If the investigation ends with discovery of a human error, then perhaps you're living in the past. Join the future of accident investigations: integrate human factors.

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Culture, CRM and aviation safety

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> Culture: *"the collective programming of the mind which distinguishes the members of one group from another"*
>
> (Hofstede, 1980, p. 21).

Aircraft and other industrial mishaps are now investigated with a view to comprehensively examining the systemic factors which may have contributed to the occurrence and the context within which they take place. The aviation psychology and human factors community has contributed significantly to the development of systemic investigation methods, in addition to techniques aimed at the prevention of accidents. The development and maintenance of appropriately targeted selection methods, comprehensive and operationally relevant human factors training programs, thorough systemic investigation techniques, and a positive safety culture can have a direct impact on the bottom line of organisational safety. Also important are the various cultures within which the world's aviation professionals carry out their operational duties, and the fit between those cultures and proposed safety solutions (eg., CRM training). This paper will examine the broader notions of culture, CRM, and aviation safety, and will discuss methods available to organisations to enhance their operational safety performance.

Fifteen years ago, it would have been difficult to foresee the extent to which we now view industrial mishaps as "organisational accidents". While much is still to be achieved, it is encouraging to see the depth to which some investigations now delve when attempting to get to the bottom of accident causality. Elements of the aviation industry have been leaders in the move towards a more enlightened consideration of the precursors to accidents and the contexts in which they occur. The Australian Bureau of Air Safety Investigation (BASI) is one such element, and BASI's reports on the 1993 Piper Chieftain accident at Young in New South Wales (Bureau of Air Safety Investigation, 1995) and the landing of a B747 at Sydney Airport with its nose-wheel retracted in October 1994 (Bureau of Air Safety Investigation, 1996), are excellent examples of the growing trend towards the systemic investigation and reporting of aircraft incidents and accidents.

Aviation and Australia are not alone in the search for deeper roots to accident causality. Amongst others, reports on the sinking of the *Herald of Free Enterprise* channel ferry (Sheen, 1987), the King's Cross Underground railway station fire (Fennell, 1988), the Clapham Junction railway accident (Hidden, 1989), and the March 1989 crash of an F-28 at Dryden in Canada (Helmreich, 1992; Moshansky, 1992; Maurino, Reason, Johnston & Lee, 1995) provide testament to this comparatively recent trend. They also add weight to the argument for a change in traditional yet rudimentary thinking regarding operator error, previously exemplified within aviation by widespread use of the term "pilot error". As observed by Lee (1996), if accident investigators continue to concentrate only on traditional "sharp end" factors, then the investigation agency itself becomes part of the safety problem.

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Understanding human error

A growing interest in developing our understanding of the antecedents of human error has precipitated an evolution towards a more thorough understanding of industrial mishaps. In particular, the work of Professor James Reason (1990, 1991, 1993, 1994) and his modelling of organisational accidents has been responsible for widespread improvement in the understanding of the causes and consequences of human error. Helmreich (1993a) employed Reason's notions of latent organisational pathogens, together with his own model of flight crew performance (Helmreich & Foushee, 1993) in a systemic analysis of the Avianca B707 fuel exhaustion accident at Cove Neck, New York. The approaches of both Reason and Helmreich are further explored and synthesised by Zotov (1996) in his thought-provoking proposal of an improved format for the investigation and reporting of the human factors of aircraft accidents. Pariès (1996) also contributes substantially to the development of our thinking on aircraft accident investigation with his discussion of an evolutionary shift of the aviation safety paradigm towards systemic causality and proactivity. Johnston (1996) provides an overview of this shift in his broader consideration of philosophies for systemic risk management.

Notions of culture

Underpinning much of the work on human error are notions regarding the influence of culture on individual and group behaviour. In spite of the belief of some observers that it is possible to create "culture free" work environments, there is little doubt that there are a variety of cultures within which aviation professionals carry out their daily duties which impact significantly on the operations of the world's airlines. While national culture was the first of these to come under scrutiny, there is now a growing recognition amongst researchers and practitioners that a range of sub-cultures exist (eg., organisational, vocational, occupational, safety) which also impact directly upon our professional and interpersonal behaviours in the work place. While a solution to creating a culture-free work environment has been proposed - "...fill it with Australians" - (Hamilton, 1992), in practice even this does not work and it is evident that we are all, to some extent, culturally-bound in terms of our behaviours and attitudes.

National culture

The seminal research of Hofstede (1980, 1991) laid the foundation for the considerable body of work which has since examined the role of national culture in relation to flight crew behaviour and safety on the flight deck (eg., Ooi, 1991, 1992; Johnston, 1993; Maurino, 1994; Merritt, 1993, 1996). Hofstede isolated four dimensions on which national cultures can be classified. Two of these dimensions are particularly relevant to the way teams function within aviation. One defines the nature of relations between subordinates and superiors (*Power Distance*), and the second (*Collectivism v Individualism*) reflects group interdependence versus independence. Anglo-Western influenced cultures tend to be high in individualism, and moderate to low in power distance. Many Asian and Latin-based cultures are collectivist, and high in power distance. As observed by Smith and Bond (1993), Hofstede's original work avoided the "ecological fallacy" that others have frequently implied from his findings; eg., that because Australia scores higher on his dimension of *Individualism* than Indonesia, then a particular Australian must be more independent or individualist than a particular Indonesian. Hofstede's mean scores represent the average of the scores of those who responded to the questionnaire.

The work of Ashleigh Merritt (1993, 1996) explores cross-cultural similarities and differences with respect to attitudes toward flight management and the link to safe operations. Using the NASA/UT Flight Management Attitudes Questionnaire, Helmreich and Merritt (1996) were able to identify some attitudinal characteristics which appeared to be "universally" applicable to airline pilots, and some in which large differences were displayed between the various cultures which made up their sample, as illustrated in Table 1.

Table 1

FMAQ Pilot "universals", and items showing significant cross-cultural differences in 19 organisations

(Adapted from Helmreich & Merritt, 1996)

Flight Management Attitudes Questionnaire Items - COMMUNICATION, COORDINATION, COMMAND & STRESS	**% Agreement across 19 Orgs.**
Universals	
Good communication and crew coordination are as important as technical proficiency for the safety of flight.	85-100%
The captain's responsibilities include coordination between cockpit and cabin crews.	85-100%
The pre-flight briefing is important for safety and for effective crew management	85-100%
The pilot flying the aircraft should verbalize plans...and be sure the information is understood and acknowledged.	85-100%
I like my job.	85-100%
Significant cultural differences	
Crew members should not question the decisions or actions of the captain except when they threaten the safety of the flight.	15-93%
If I perceive a problem with the flight, I will speak up, regardless of who might be affected.	36-98%
Personal problems can adversely affect my performance.	38-78%
I am more likely to make judgment errors in an emergency.	17-70%

In her doctoral study, which attempted to replicate Hofstede's original work with IBM[2] within the airline community almost three decades later, Merritt (1996) met with considerable success.[3] Her results indicate that aspects of airline pilot work such as communication and teamwork were acknowledged as universally important by those who took part in the study. Attitudes toward stress reflected a strong (but seriously mistaken) pilot attitudinal norm that the true professional is invulnerable to environmental stressors. (An extreme example of this - manifested by feelings of invincibility and disproportionately high risk-taking - can be found in Kern's (1995) fascinating case study of a USAF B52 accident at Fairchild AFB.) This result has implications for the effectiveness of CRM training, and will be discussed in that context below.

The strongest cross-cultural differences found by Merritt were in the areas of command (Hofstede's dimension of *Power Distance*) and flexibility with rules and

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[2] Hofstede's original work involved the mapping of several dimensions of national culture based on data gathered from IBM employees in 66 countries in the late 1960's and early 1970's.

[3] Merritt's study was based on data from more than 8,000 male commercial airline pilots, employed by 22 airlines, in 15 countries.

routines (*Uncertainty Avoidance*). Pilots from "Anglo" countries (USA, Australia, New Zealand, Ireland, and British-born pilots based in Hong Kong) held very similar views, while amongst the non-Anglo countries, the more hierarchical command styles were differentiated by the relative importance allocated to rank (Brazil), rules (Taiwan), and relationships (Philippines). The unequivocal finding of the study was that national culture is a powerful influence on work performance, and that pilot training and international aviation regulations should reflect an awareness of this.

Much of the work on culture focuses on the seemingly apparent and generalisable differences between mainstream eastern and western cultural values. However, this is a very blunt tool with which to examine cultural differences. If we look at geographically small and contiguous regions of Europe, for example, we can observe rather significant differences in the thinking, attitudes and behaviours of the people (eg. the English v the French). As reported by Johnston (1993, p. 369): "an American medical journalist resident in Europe consulted various physicians about a recurrent medical condition. She found that opinion varied between the American, French, British and German doctors she consulted. She found a diversity in clinical practice which was determined more by national characteristics than by medico-scientific logic. Her research confirmed that cultural factors were a notable influence on interpretation of the medical literature". Even though the differences may be more subtle, similar observations can certainly be made regarding the cultures contained within Asia (eg., Japan v China, Malaysia v Thailand), in spite of the fact that "westerners" commonly refer to an "Asian" culture or way of thinking, and the Middle East (eg., Israel v Syria). It is noteworthy that an area as geographically contiguous as Papua New Guinea is reported to contain people from cultures speaking no less than 717 (45%) of the world's almost 1,600 languages (Lightbody & Wheeler, 1985).

It seems that the formation of national culture may be comparable to the complexity of the determinants of individual personality. While the nature vs nurture debate has been one of ebb and flow over the years, it is most likely that an individual's personality results from a complex interaction of numerous genetic and environmental factors. So too it must be with national culture, which is influenced by genetics, ritual, religion, colonisation, major historical events, immigration, cultural blending, and physical environment factors such as terrain and climate.

Cultures within cultures

Building on this point, it is of course possible to discern cultural differences within a culture which, at least from an external point of view, may appear to be relatively homogeneous. The work of Semin and Rubini (1990) illustrates this point rather neatly. They employed a somewhat novel approach to examine the cultural differences between northern and southern Italians, comparing the types of verbal insults used by the two groups. Their hypothesis, that subjects from "more interdependent" Sicily would report a larger proportion of *relational* insults than those from "more independent" Bologna and Trieste was upheld, as can be observed from a selection of the less-graphic insult-types presented in Table 2.

Table 2
A selection of culturally-rooted insults

(Adapted from Semin and Rubini, 1990)

Individualist insults (distinctive to northern Italy)	Collectivist insults (distinctive to southern Italy)
You are stupid. *You are a cretin.* *Swear-words referring to religious fixtures.* *Swear-words referring to sexual nouns.*	*I wish a cancer on you and all your relatives.* *Your sister is a cow.* *You are queer and so is your father.* *You are a communist.* *Various insults relating to incest.*

Vocational and work-group cultures

It is also true that certain cultural norms can be associated with those who work in various industries and occupations. As with most vocations, aviation attracts a wide range of personalities from a variety of socio-economic and ethnic backgrounds, yet there are certain cultural norms that are generally shared. Within the aviation industry, there exist a range of sub-cultures which can be labelled as occupational or work group cultures. Examples include the occupations of pilot, flight attendant, maintenance engineer, ramp, air traffic control, etc. While these aviation professions commonly share various vocational norms, there are also significant differences between their sub-cultures. For instance, pilots and flight attendants work together as members of the same flight crew, but there are many differences between them in terms of stereotypical characteristics. The cockpit/cabin crew interface research conducted by Chute and her co-workers at NASA Ames (Chute, Wiener, Dunbar, & Hoang, 1996) analysed the nature of the jobs to reveal some generalised differences in the demographics and roles of the two work groups, and their origins, as depicted in Table 3.

Table 3
Relative crew differences by dimension

(Adapted from Chute, Wiener, Dunbar, & Hoang, 1996)

Dimension	Cockpit	Cabin
Gender	mostly Male	mostly Female
Age	mostly 30-60	mostly 20-40
Workspace	Confined	Spacious
Physical Activity	Stationary	Active
Noise Level	relatively Quiet	relatively Noisy
Terminal Workload	High	Low
Cruise Workload	Low	High
Cognitive Orientation	Technical	Social

As anyone who has worked within a large organisation with employees based in several different geographical locations will recognise, there may be powerful differences which exist within the one occupational group, between various locations. Airline ramp employees at a large airport base may be very different in terms of their sub-cultural attitudinal and behavioural norms from those at a regional airport, even though they work in the same industry, for the same carrier, in the same job category.

Organisational culture

While national, vocational and work group cultures have an undeniable influence on individual and group behaviour at work, organisational culture has the potential to have a very significant direct impact on the safety performance of organisations. It is organisational culture which ultimately shapes workers' perceptions of safety, the relative importance placed on safety, and members' activities regarding safety (Merritt & Helmreich, 1996a). A number of authors have provided rigorous discussion on the importance of an appropriate organisational safety culture and the role that human factors expertise can play in establishing and maintaining appropriate cultural norms (Johnston, 1991; Lauber, 1994; Maurino, 1994; Pidgeon & O'Leary, 1995; Merritt & Helmreich, 1996a).

The work of Westrum (1993, 1995) provides considerable insight into what we can learn about an organisation from the styles of management it employs. He begins from the premise that "aviation organisations require information flow as much as aircraft require fuel" (1995, p. 75), and moves on to examine three distinct patterns of coping with information used by aviation organisations: *pathological, bureaucratic,* and *generative*:

> The first pattern (pathological) is typical of highly conflicted organisations, where information is treated as a political weapon. The second pattern is familiar from the textbook description of redtape, etc. Organisations that are bureaucratic are good at handling routine situations, but are bad at dealing with change and emergencies. The Generative pattern is typical of 'high reliability' organisations and highly creative ones. In these organisations, personnel assume that they have a licence both to think and to communicate.

Table 4 illustrates the patterns of information flow typical to these three styles of organisation. It may be instructive to take a moment to reflect on the behaviour of your own organisation. When feedback is provided to management detailing operational problems, or better, also suggesting a novel solution to these problems, how does the organisation respond? In a generative organisation the bearers of such tidings are encouraged and in fact may be trained to behave in this manner. In bureaucratic organisations, messengers may be listened to, if red tape does not prevent their arrival, but new solutions are rarely investigated or implemented. In pathological organisations, where denial is commonplace, such messengers are "shot"... Which pattern best fits your organisation?

Table 4
Basic organisation communication styles
(adapted from Westrum, 1995)

Pathological	Bureaucratic	Generative
Information is personal power	Information is routine	Information is seen as a key resource
Responsibility is shirked	Responsibility is compartmented	Responsibility is shared
Messengers are shot	Messengers are listened to if they arrive	Messengers are trained
Bridging is discouraged	Bridging is tolerated	Bridging is rewarded
Failure is punished or covered up	Organisation is just and fair	Failure leads to inquiry/learning
New ideas are actively crushed	New ideas present problems	New ideas are welcomed

Westrum also contends that organisations do have characteristic responses to evidence of problems or novel ideas, and that these responses can be traced through the stages of the continuum presented below.

Pathological Organisation	Bureaucratic Organisation	**Generative Organisation**
Suppression ↑ Encapsulation ↑	Public Relations ↑ Local Fix ↑	Global Fix ↑ Reflective Inquiry

Figure 1
Organisational responses to anomaly
(Adapted from Westrum, 1995)

It is not suggested that there is a single organisational culture or corporate style for all organisations to aspire to. Just as many different personality types can make good airline pilots, cabin crew, or air traffic controllers, successful organisations within the same industry can be characterised by radically different cultures and operational styles. This becomes apparent when two independently successful companies are brought together by an organisational merger. By way of illustration, when the Japanese banking powerhouses Dai-Ichi and Nippon Kangyo were merged to form the leviathan Dai-Ichi Kangyo, a team of managers from both sides were assigned the task of developing a 200-word glossary explaining what each bank meant when using exactly the same words (Fisher, 1994). As employees from the two companies began working together they searched their dictionaries like tourists in a foreign land, asking for directions to the nearest toilet (bathroom; restroom)... Not without its parallels is the early 1990's merger of two large Australian airlines, both owned by the same government shareholder, each with admirable service and safety records, but with vastly different organisational cultures and corporate styles.

Safety culture and CRM

John Lauber (1994) has written and spoken at length about the importance of nurturing an appropriate "safety culture" within aviation organisations. A company's safety culture is inextricably linked with, but can be distinguished from its

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organisational culture. Again, if asked to we can probably all think of organisations, not just airlines, we know which we perceive as examples of good and bad safety cultures. This will depend on factors such as the way in which the organisation handles the often conflicting goals of safety and profitability, the trade-offs between the two, and the level of demonstrated commitment to safety. It also depends heavily on perceptions of the organisational communication styles as detailed by Westrum and noted in Table 4 above. For example, if an employee is concerned about the safety of a certain practice or procedure, are channels open for that concern to be communicated to management. If so, how will management respond? Is the flight safety department proactive or reactive? Are messengers shot?

Also important to the establishment of an appropriate safety culture is the recognition that human error is unavoidable and that it is the responsibility of a mature organisation to effectively manage that error. Reason (1994) sets out a framework to be followed to institute a program of Comprehensive Error Management. Helmreich and Merritt (1996, p. 145) develop Reason's argument to propose that the organisational acceptance of human error (but *not* violations) as ubiquitous and inevitable is a step towards the next (fifth) generation of CRM training:

> Using this approach, ...the goals of CRM become a new "troika" - *reducing the likelihood of error, trapping errors before they have an operational effect, and mitigating the consequences of errors when they do occur.* To make this shift requires that organisations formally recognise human fallibility and adopt non-punitive policies regarding everyday error. In essence, this requires normalisation of error within organisations, and acknowledgment of its ubiquity - but not complacent acceptance of its consequences. This places CRM in the context of the system and makes the superordinate goal one of addressing system issues that can foster or reduce error.

Specific behavioural techniques intended to enhance situation awareness and flight safety, such as cross-checking and verification of communication, preparation, planning, and vigilance, speaking up to express concerns, and sharing a mental model of the situation are all means of reducing the likelihood of an error occurring or trapping an error before it has an operational impact. These techniques, along with effective group decision making, and the recognition that they are not immune to the effects of stress, can equip crews to react effectively to, recover from, and mitigate the consequences of, those errors which may threaten the safety of flight (Helmreich & Merritt, 1996).

While there is still yet some distance to travel, CRM has come a long way since its origins in the early 1980's as cockpit resource management training (see Helmreich, 1993b; Maurino, 1996). Its principles have been extended from the cockpit to other elements of the aviation system (Hayward, 1995a; Merritt & Helmreich, 1996b), have been employed to achieve significant organisational change (see Hayward, 1995b; 1997), and it is now mandated by ICAO for airline flight crews and others (Maurino, 1995). What has been discovered is that culture plays a significant role in determining the response of participants to various styles of CRM training. One size does not fit all, and it is important that CRM training is tailored to fit with the culture - national, organisational, vocational - of the target population.

Enhancing operational safety

To conclude, several lessons may be extrapolated from the above to provide for the enhancement of operational safety.

Recognition that the various cultures within which aviation professionals operate do have an impact on their job performance may go a long way toward mitigating the undesirable effects of some of those cultures, and breaking down barriers between sub-cultures.

Development of a deeper understanding of the causes and consequences of human error can provide management with the foundation from which to launch effective error management strategies.

Organisational recognition and acknowledgment of the ubiquity and inevitability of human error is the next step in the development of these strategies.

Development and introduction of non-punitive policies regarding organisational responses to unintentional human error (*not* violations) is an essential component of error management.

Development and maintenance of an appropriate organisational culture and a positive safety culture is essential and will be supported by the above.

Human factors training programs must be operationally relevant, and must be targeted towards practical objectives, such as the avoidance, trapping and mitigation of human error.

If these programs are targeted at such practical operational objectives, their acceptance and success amongst line personnel will be significantly improved.

While quality CRM training and other modes of applied human factors training are invaluable aids to the reduction of human error, the best place to start an error management program is at the recruiting point.

This involves the introduction of an appropriately researched and targeted selection system, which is designed to select-in personnel with desired attributes, and select-out personnel who will not fit within the requisite safety culture of the organisation.

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Deadly Misunderstandings of English in Aviation

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Purpose

This document is a research report that looks into failures of the English language in aviation. A variety of resources have been examined. Those include technical documents, statistics, trends, organisational oversight, individual research, political and news commentary, along with some high profile accidents in which English language misuse was a link in the accident chain. It is the writer's opinion that if this language failure link could have been removed, the accidents would not have occurred, unless a new accident chain developed.

Prevalent industry opinion contends that, because of the stable accident rate over the past fifteen years, combined with tremendous growth of air travel world-wide, individual accidents are expected to increase. It is commonly agreed that this will not be perceived favourably by air travellers and improvements must be made if the air transportation industry is to move toward the accident free goal that the travelling public expects.

Every aspect that can improve aviation safety should be addressed -- not just the high profile issues, such as Controlled Flight Into Terrain (CFIT), but, also, English language failure deserves scrutiny and attention.

Introduction

Today, there is a great push by many nations to increase international airline service, causing a growing demand for training of personnel in 'aviation English.' Unfortunately, "loophole-filled regulations and intense airline cost pressures are frustrating more widespread implementation of English-language proficiency."(1) Political road-blocks exist both in the United States and elsewhere, which tend to make such training inefficient and often ineffective. These road-blocks take the form of high-level national and cultural sensitivities by many nations regarding the use of English as the standard for international air travel. Most nations hold their native language to be most important to their needs and to the needs of their citizens. To be bound to speak English internationally is very cumbersome to many of the world's aviation personnel including pilots, air traffic controllers, mechanics, flight attendants and others. Officials in the United States are also reluctant to set standards for use of English within aviation and other industries, for fear of the possibility of discord. Clearly, English is not acceptable for use in aviation by all nations. National interests everywhere tend to be a factor that slows the process for promoting clear and effective English language proficiency.

Other factors are the low priority assigned to communications failures when identified as a link in the accident chain, and the perception that fatalities and hull losses from English language misinterpretation are very rare, with little that can be done to improve the situation. This sort of rationalisation may be attributed to a diversion of emphasis to accident chain links perceived as higher in priority. The result is minimal attention to fixing the English Language accident link failures.

In some industries, this language ineffectivity is looked upon as more of a nuisance than critical or dangerous. However, many world-wide industries face substantial financial loss, because English language failure has been a factor in an accident where lives are lost and equipment destroyed. This most often occurs when such language communication is needed to further clarify, identify and rectify critical and dangerous situations or conditions, in which standard International English phraseology is insufficient. In aviation, this is typical during inflight emergencies, irregularities, or when essential air traffic control dialogue, beyond "canned" words or phrases, is necessary to break the communication failure link of an accident chain. "Inability to communicate in ordinary English will become more critical and political, when airlines carry 800 or more passengers in one aircraft, as is being planned," states Jerome Lederer, who was recently proclaimed and commended by President, Bill Clinton as the 'Father of Aviation Safety.'(24)

Anchorage

Anchorage International Airport is typical of many US facilities that have a growing influx of air carrier traffic from other nations. As a controller at Anchorage, Doug Thompson has experienced many unusual situations involving failures in the use or misuse of the English language in aviation operations. He recalls two incidents that could have become disasters if ATC intervention had not been provided.(2)

In the first, an Ilyushin-62 was cleared to land on runway 6R with instructions to turn off the runway and hold short of runway 6L. A Dash 8 was on a 3/4 mile final approach for runway 6L. The Ilyushin-62 crew did not reply. Again, the controller stated, "Hold short of runway 6L." The Ilyushin-62 pilot simply said, "Roger, thank you," and proceeded to cross runway 6L. The controller's "sixth sense" and experience came into play and he immediately sent the Dash 8 around to avoid a possible collision.

A second Alaskan incident involved another Ilyushin-62, in which spoken English was so poor that the controller could not understand the crew's intentions or situation. This occurred during the winter of 1995 with the weather at very low minimums. The aircraft was holding and when asked to indicate their alternate, the pilot responded, "We no make alternate." The aircraft landed at an unauthorised air carrier airport at Kenai, Alaska.

Doug summarises the way controllers handle such traffic when they first become aware of serious English deficiencies in their airspace. He explained, "Since we know what they are expecting to do, we get everyone else out of their way." "When pilots have marginal English language capability, we watch them carefully because if something occurs 'outside the box' (an event that requires clear understanding and the capability to speak plain English), then we have lost them" (the aircraft is incapable of being controlled). Reversion to control of other aircraft becomes the only option for such English language communication failure. This "loss of control" and "cautionary preferential treatment" of these carriers occurs from time to time in US airspace. Cost increases occur when US and other nations' air carriers must be directed away from their most efficient flight paths. Both incidents in these examples involved pilots who used English as a second language.

Government Oversight

In 1995 the US Secretary of Transportation convened an industry conference that, among other safety recommendations, pledged that commercial pilot tests for proficiency in speaking and understanding English would be mandated. The FAA studied the issue, but it was dropped. Aviation accident fatalities continued, due to English language misuse.

Society of Automotive Engineers (SAE)

The SAE G-10A CREW FITNESS SUBCOMMITTEE in 1995 asked, "If crew members cannot communicate effectively in the international language of aviation, English, are they fit-for-duty for operations within US Airspace?(3)

Flight Safety Foundation (FSF) Research

A few years ago, the FSF identified eleven specific links of the aviation accident "error chain."(4) English language failure in aviation clearly is represented in most of these links, with a tendency to overlap from one link to another.

These links can be useful as an analysis tool where misunderstanding or misinterpretation of English language communications was a factor. The list can assist in determining if any of the following events occurred:

- Ambiguity. Distraction or preoccupation. Confusion or an empty feeling.
- No one flying the aircraft.
- No one looking out the window.
- Use of undocumented procedure.
- Violating limitations or minimum operating standards.
- Unresolved discrepancies.
- Failure to meet targets.
- Departure from standard operating procedure.
- Incomplete communications.

During the past few years, the term **Situational Awareness** has become popular, and, depending on how it is defined, may be correlated to some of the eleven accident links.

Any of these links in the **"error chain"** that become evident usually slow and erode the crew reaction time needed for standard safe and efficient operations.

Some interesting accident prevention considerations become evident when relating these links to the five selected accidents on the following page. See, "Example Accidents in which Communications Failure Link Identified."

Europe and Asia Outlook

Proficiency in English among Air Traffic Controllers, Pilots and Mechanics is a world wide problem that is being addressed by new training, especially in the United States, Europe and Asia. "Controllers arrive at training schools with varying levels of training in English and leave with skills that are better, but still uneven."(5) A major difficulty for students from China is the fact that their language does not have common roots with English. The "V" and "R" sounds are the most difficult for many oriental speakers. China has set January 1, 1998, as the date when all controllers in their country will be communicating to all international flights in English. Even if the controller's first language is English, sometimes plain English words are needed for precise clarity.

Example Accidents in Which Communication Failure Link Identified--(Communication in English was incomplete, leading to confusion, followed by distraction.)

Event or Accident

Take-off ground collision, Tenerife, 1977: 582 fatalities. Two hulls destroyed. Financial loss.

Critical English Language Failure

Non-native English speaking Captain stating to non-native English speaking flight deck crew, "We are at take-off" (or similar communication).

Possible English Language Misinterpretations

1.We are ready to take the active runway for take-off, or 2.We are on the active runway awaiting take-off clearance, or 3.We are on the active runway proceeding to take-off.

Event or Accident

Crash landing, fuel exhaustion, New York, 1990: 72 fatalities. Hull destroyed. Financial loss.

Critical English Language Failure

Non-native English speaking First Officer with Captain unable to speak English, stating to English speaking Controller, "We are a little low on fuel."

Possible English Language Misinterpretations

1.Our fuel remaining is now slightly below what we had planned, or 2.Our fuel remaining is now considerably below what we had planned, or 3.Our fuel remaining is now dangerously below what we had planned.

Event or Accident

Crash into mountain side, Tenerife, 1980: 146 fatalities. Hull destroyed. Financial loss.

Critical English Language Failure

Non-native English speaking Controller, stating to English speaking flight crew, "Turn to the left," in lieu of, "turns to the left" or "holding with left turns."

Possible English Language Misinterpretations

1.We are being instructed to turn to a heading, or 2.We are being given a vector, or 3.We are being given a non-standard, but acceptable initial holding entry.

Event or Accident

Crash into mountain side, Cali, 1995: 160 fatalities. Hull destroyed. Financial loss.

Critical English Language Failure

Non-native English speaking Controller, stating to English speaking flight crew, "Cleared to Cali," in lieu of, "cleared as filed" or "cleared direct."

Possible English Language Misinterpretations

1.We are cleared to Cali via flight plan route, or 2.We are cleared to Cali via direct route, report abeam TULUA, or 3.We are cleared to Cali via direct route, TULUA report not required.

Event or Accident

Crash landing, Urumqi, 1993: 12 fatalities. Hull destroyed. Financial loss.

Critical English Language Failure

Non-native English speaking crew, asking amongst themselves in their native language, "What does pull up mean?"

Possible English Language Misinterpretations

Did not understand spoken English.

Successful and Unsuccessful Communications

Successful Communications

A TRANSMITS MESSAGE TO B WHO TRANSMITS AN ACKNOWLEDGMENT

BACK TO A. This becomes a successful and complete communication, if the result is that: A & B have the same exact understanding and visualization of the message.

Unsuccessful Communications

A TRANSMITS MESSAGE TO B WHO TRANSMITS AN ACKNOWLEDGMENT BACK TO A. This becomes an unsuccessful and incomplete communication, if the result is that: A & B do not have the same exact understanding and visualization of the message.

Some Reasons for Unsuccessful Communications (What)

1.Transmitter issues incomplete data.

2.Transmitter issues incorrect data.

3.Receiver does not acknowledge transmitter's message.

4.Receiver does not fully question and clarify the transmitter's somewhat erroneous message.

5.Receiver develops own interpretation of transmitter's message, based on expectations.

Some Reasons for Transmitter/Receiver Failure (Why)

1.Lapse in understanding of the intent of the transmission (possibly due to routine or fatigue).

2.Shortening the length, or changing the verbiage of the transmission (possibly to save time).

3.Attempting to deal with a transmission that is unclear without full resolution (possible assumption).

Some Root Causes of Communications Failure (Detection & Prevention)

1. Confusion

2. Distraction

3. Specific and contributory causes, i.e., misuse or misunderstanding of English language, dialect, personal presumptions, affect of culture and training, etc.,

There are pilots from many countries "who are expecting the conversations to be intelligible in English."(5)

English Language Issues in the United States

A language gap in America exists that in certain situations places non-native as well as native speakers in jeopardy. Most often this can occur when communication is attempted regarding life-threatening issues or events. This is especially hazardous if the communication is time critical. In the aviation sector as well as in other activities, the efficiency of safety oversight and management is influenced by speed and ease. "One of the elements of our society is people want things fast, they want things easy and they want things now."(6) Also, "Americans tend to be particularly ethnocentric and intolerant. We presume other people should know our language."(7) These are some of our society's cultural components that make learning the English language even more challenging.

English is a difficult language to master, requiring five to seven years to understand and speak effectively. Factors that add to the problems are slang, idiom and local accents, and many students of English for Speakers of Other Languages (ESOL) don't have the inclination or ability to take classes beyond the basic level. Pilots, controllers and other highly skilled and motivated students should do much better.

The cost to Federal, State and local governments for training of ESOL students approaches $1 billion annually, but the costs of poor English skills among foreign-born residents is rising to "more than $175 billion a year in lost productivity, wages, tax revenue and unemployment compensation."(8)

Linguistic litigation is rising and mainly involves discrimination issues. On the other hand, experts fear medical malpractice cases may also rise as a result of the flood of foreign-born health care professionals now practicing in the United States. The number of foreign physicians educated at foreign medical schools and practicing in the United States now represents 23% of the nation's physicians, according to the American Medical Association, which supports boosting English-language skills of foreign-born physicians.(9) "It's a growing issue. If a physician has difficulty with English and can't communicate with a patient, it can cause problems."

"Beginning in July of 1998, the Educational Commission for Foreign Medical Graduates will require an oral English exam, including how well doctors communicate with patients as part of its certification process."(11) One transportation sector, New York city's Taxi and Limousine Commission, is requiring its 45,000 licensed cab drivers to pass English proficiency tests.(12)

A factor that relates to non-native English speaking pilots and controllers is that "poor language skills make workers reluctant to articulate thoughts, which can crimp problem-solving and ideas."(13) This degrades a particularly important safety concept in aviation, that the crew has the final capability to cognitively decipher dangerous conditions and act as a last buffer to disaster.

A Manufacturer's Analysis

As the aviation industry moves toward greater international airline operations and activities, it would be reasonable to expect a rise in fatalities and hull losses as a result of language difficulties.

The Boeing Airplane Safety Engineering Group has analyzed and apparently confirmed this trend. Their ten-year study for the period between 1982 and 1991, indicated that fatalities for US operators at non-US locations, involving "ATC Systems and Communications, rose to the number three position. This could indicate that language difficulties may still be a problem."(14)

Also, the accidents for non-US operators at US locations indicates that "ATC Systems and Communications are in the number two spot for this grouping; again indicating that we may not have solved the problem of different languages or interpretation of instructions issued by ATC."(14)

Academia

Communication failure due to English language failure was recently discussed during three days of presentations at Prescott, Arizona. It was stated that in France for instance, "English entrance exams to state schools have been improved, but a [maintenance] problem still exists. Aviators or controllers can pass these tests at age twenty-three and be qualified for the rest of their life, but then may spend twenty years domestically, before advancing to international operations" [where it must be put to use effectively]. "Someone with medium English skills will have problems outside of routine communications." "We plead for more general English language training [to improve this situation]. Nothing is in place to require English language maintenance."(15)

Another presenter believes there is a very narrow focus to English language issues in aviation. "It is the main medium to exchange information and therefore it is a root problem" [when misused]. There are human solutions: "educate aviation personnel with a deeper understanding of language, its basic characteristics, how it works and the need to use it more mindfully." Code switching is normal for bi-lingual people. For instance, "at Tenerife, the Captain said, 'We are now at take-off,' instead of, 'standby for take-off.' Why did he say it this way? Because, that is the way it is said in Dutch!"(16)

"Today, more aircraft are going to more places and English is an element in airline safety. Language is a 'soft' technology as CRM used to be, but now it is considered a 'hard' issue and standards are needed."(17)

Within ATC, "technology changes are the big issue" together with "emergency and non-routine communications," according to the National Air Traffic Controllers Association (NATCA).(18) Data Link (electronic telemetry) systems and devices that can translate languages within the cockpit may produce a loss of situational awareness; therefore "NATCA and the Air Line Pilots Association (ALPA) are discussing and studying the concept."(18)

Incident data reporting systems can be an effective tool for determining and validating the existence of a hazard in the aviation system, and through analysis offering solutions. "These data can, and should, play an important role in creating policies and procedures for the safe operation of aircraft and air traffic control. When a safety hazard is suspected, incident data can often provide facts that prove or disprove its existence" and "if large numbers of reports on a topic are available, it is reasonable to assume that consistently reported aspects are likely to be true."(19) In the case of language related incidents, retrieval of such data from the National

Aeronautics and Space Administration's (NASA) Aviation Safety Reporting System (ASRS) produces a file several inches thick.

Language Translators

In the area of 'language machines,' basic research and software development in advanced computing applications has been underway for many years and is advancing rapidly. Natural language processing, artificial intelligence and graphical user interface designs have been part of this effort.

A software product named 'ULTRA' is a multilingual, interlingual prototype machine translation system. It currently translates among five languages: Chinese, English, German, Japanese, and Spanish.

Another is 'NORM,' which is a translator support system. It integrates multiple resources, including parallel corpus retrieval (a large collection of writings of a specific kind or regarding a specific subject) at the sentence level as well as machine readable dictionaries, thesauri and domain specific word lists as well as supporting multiple languages and fonts (style of printed type). Two current test users of this product are the US Department of Defense, and the Internal Revenue Service.

'Mikrokosmos' is a knowledge-based semantic analyzer that builds Text Meaning Representations and language independent semantic descriptions using a large world model (ontology) and a lexicon that maps input syntactic and lexical structures into text meaning structures.

Phrase and Clause Recognizers and Clause Analyzers are configurable components for use in a variety of other application systems.(20)

Currently, Russian scientists are very interested in commercialization of systems for non-aviation translation activities. They are developing translation software, such as 'Retrans,' that does not require special computer hardware.(21) "Such efforts could unlock a world of research and data for people who don't speak a foreign language."(22) Today, these language machines provide on screen translation capabilities and are very valuable for world-wide business uses. For example, if a business transaction was to involve companies from several countries, all of the communications documents could be completely generated in the native language of all parties to the transaction. This is done graphically, but is also adaptable to voice recognition methods.(23)

Using the present cadre of personnel (pilots and controllers), some safety specialists believe that this technology could be applied to bridge real-time language communication failures in air transportation, especially within ATC systems.

Summary

Although commercial air transportation provides the safest means of moving passengers and goods, issues that degrade safety continue to perplex the industry. The fatality rate has stagnated, and every means possible that can lower the rate must now be employed.

English language misuse or misunderstanding has been a causal link in several major accidents. Methods that can improve English language deficiencies in aviation are available, but are not being fully implemented. European and Asian countries are improving the English language skills of aviation personnel by the introduction of new training schools and changes in regulations.

Within the United States, awareness of safety degradation and resultant economic losses has spurred some regulatory and licensing changes. These mandate testing for the ability to communicate effectively in English. Litigation appears to be a fear that is driving many of these reforms.

Conclusions

Linguistic confusion in communicating in ordinary or technical aviation English has routinely been cited as a link in the accident chain, leading to fatal air carrier accidents. Human and financial losses result from aviation English language failure. No standard has ever been set that mandates testing to demonstrate proficiency in ordinary and aviation English. Political and legal roadblocks seem to slow the implementation of standardized testing and certification of aviation personnel to a known English proficiency.

Recommendations

Internationally--through the auspices of ICAO, member nations might be polled to review and determine the desirability of establishing aviation English standards. Nationally--through the auspices of government, individual nations might review and determine the desirability of establishing aviation English standards. Industrially--through the auspices of the aviation industry, entities and organizations might review and determine the desirability of establishing aviation English standards. Alternatively--in lieu of aviation English standards, a new approach may be feasible. With the rapid improvement of technology, hundreds of "language machines" are being designed and implemented for various uses. Some of the current designs can instantly convert most of the world's languages from any one language to any other language. Language transmission via telemetry could be established between ATC and an aircraft, between other aircraft, and between crew members in one aircraft. Data could be observed "on screen" via data-link, in one's own native language. Later, improvements could add direct audio translation and even selected video enhancements. Backup systems would be needed; however, the direct voice communications used today would probably always remain the principal backup.

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INTERVIEWING TECHNIQUES

THE INVESTIGATION INTERVIEW:

Any investigation will be assisted by a free flow of information. The effective investigator has a number of methods by which to obtain information that may be critical to the successful resolution of the process. In considering these options a successful investigator should have a substantial awareness of those human factors which can have a predisposing effect on the production of operational errors.

TECHNIQUES FOR EFFECTIVE INFORMATION GATHERING:

1. Prior to the commencement of the interview:

   Introduce all participants at the interview to each other Describe the rules for the conduct of interview Work to develop a mutual rapport. Record those details provided by the interviewee

2. During the interview:

   Encourage the interviewee to actively generate information. Allow the interviewee to describe what happened without omission of any details. Request detailed descriptions. Try to ask open-ended questions. Pause and reflect after each response from the interviewee. Do not interrupt. Listen actively. Pause before asking questions. Control the interview; don't dominate it.

3. Assisting the interviewee:

   Conduct a walkthrough at the place of the occurrence where possible. Attempt to recreate the original situation. Encourage the interviewee to concentrate. Encourage the concept of imagery. In developing these mental images; slow and steady is best. Empathise with the witness' situation. Adopt the witness's perspective. Utilise the interviewee's areas of expertise.

4. Concluding the interview:

   Ensure that the interviewee has nothing further to add. Thank them for their efforts. Leave contact details and request them to advise you of any aspect they may later recall.

5. Follow-up processes (one week later):

   Confirm or clarify any previous details Elicit further information that might not have been appropriate at the original interview

Witness interviewing techniques in aircraft accident investigation[4]

Brent Hayward *Asia Pacific Resource Management, Australia*[5]

Introduction

The gathering and evaluation of accurate and unbiased evidence is essential to the successful conduct of any aircraft accident investigation. It is well established however, both by experimental and anecdotal evidence, that human beings are notoriously unreliable as observers, particularly when asked to recall the detail of significant events.

A major potential for error occurs at the "playback" stage, when the recorded memory of an event is being accessed through interview. While most of us feel we can interview competently, and gathering evidence sounds simple, facilitating unbiased testimony is a surprisingly difficult and consistently underestimated task. Contrary to popular belief, getting witnesses to say what we want to hear is not representative of efficient interviewing technique. Even subtle, unintended variations in questioning technique or terminology can dramatically influence the content of recall.

Relevant to this, yet historically an aspect of some neglect, is the training of prospective witness interviewers: flight safety officers, board of inquiry members and accident investigators, in the techniques of eliciting accurate and unbiased testimony from witnesses.

The objective of this paper is to outline techniques which may prove useful to a prospective witness interviewers in coping effectively with evidence gathering in interview situations.

Limitations to the accuracy of witness recall

Figure 1 depicts some of the factors which have the potential to influence the accuracy of eyewitness recall and testimony, from the time of exposure to the event, the stimulus, until the time of describing, or relating the event, the output. These limiting variables are discussed below.

Stimulus characteristics

Naturally, various features associated with the event (stimulus qualities) will immediately limit the quality of the keenest observer's perception. The *clarity* of the event, for example whether it occurred by day or by night, or in a chaotic or comparatively serene environment; its *proximity* to the observer; its *complexity* as an event; its *duration* for the witness; and finally the *familiarity* of the event to the observer, will constitute critical limiting factors to total recall. In general, civilian eyewitnesses to military accidents have limited general knowledge of military aircraft or flying operations. Similarly, non-aviation personnel may be quite unfamiliar with the characteristics of aircraft or aviation in general. Consideration should be given to these event characteristics, especially when weighing the relative value and reliability of individual witnesses.

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[4] From the book: "Aviation Psychology: A Science and a Profession". (1998). Edited by Klaus-Martin Goeters. Aldershot, UK: Ashgate Publishing.

[5] Now Dėdale Asia Pacific

Human perceptual and personality factors

Human perception is rarely an accurate reflection of reality. Preconceptions, expectations, needs, cultural values and biases can all influence our perceptual interpretation of an event. Again there is much experimental evidence to support this thesis. Drawing an example form popular culture, 50,000 people at a football game may witness exactly the same event, yet half will agree with the umpire's interpretation, and the other half will disagree, often with considerable vehemence.

Psychologists have in the past performed extensive research on the manner in which mental "set" or expectancy on the part of the witness can influence perceptions of events. In a classic study of the phenomenon, Professor Allport of Harvard University had subjects briefly examine a drawing of several people in a subway train carriage, including a black man and a white man confronting each other, the white man holding a razor in his hand. Fifty percent of the subjects later reported that the razor was in the hand of the black man.

These individual interpretations of reality occur largely unconsciously. Another process which operates unconsciously to filter or distort the accurate perception of reality involves psychological defence mechanisms. Defence mechanisms are protections built into personality, designed to prevent frightening or threatening perceptions from reaching consciousness. They can be thought of as acting like shock-absorbers for the mind. They are activated unconsciously at the onset of a potentially harmful or disturbing stimulus, and can distort its interpretation in a way which makes it less-threatening and easier for the human ego to deal with. The result is that people faced with stressful, dangerous and in particular life-threatening events, are likely to be prevented from recalling such events accurately. In the extreme, post-traumatic amnesia may result from intolerable exposure to threat, erasing all conscious memory of the experience. Witnesses to an unusual, shocking or violent event may unknowingly experience similar defensive interference to perception.

Even after an event is recorded in memory with some degree of accuracy, it is subject to distortion. Apart from the normal process of *memory decay* over time, witnesses continue to process information from the world between an event and their retelling of it to an official investigator. Most commonly, the event becomes the major focus of their attention in this intervening period. As such, their story is retold, to friends, relatives, and possibly to the press. Caught up in the accident milieu, a witnesses' personal memories are likely to become fused with others' versions of the event, and their own recollections may well suffer *contamination* from these external sources.

Another common behavioural tendency is for people to claim – in an attention seeking manner – that they were present when a significant event took place, when they were not there at all. In an experiment in this area a journalist once fabricated a story about a naked woman stuck to a newly painted toilet seat in a small American town, and circulated it on newspaper wire services. He later visited the town and interviewed several citizens who claimed to have witnessed and even to have taken part in freeing the woman in this fictitious event. Several instances of similar behaviour have been apparent following major aircraft accidents.

Interviewer induced bias

A major source of inaccuracy in extracting eyewitness testimony occurs during the testimony interview. The biases, expectations, prior knowledge, or simply the ineptitude of the interviewer can dramatically influence a witnesses' recall of an event. Following discussion of some preliminary principles in eyewitness interviewing, these "interviewer input factors" will be addressed in this paper.

Initial interviewing considerations

Timeliness

It is paramount that interviews are conducted *as soon as is practicable* following the occurrence of the event under investigation. Post-event information (eg., through media coverage, or from others who saw or claim that they saw the accident) can supplement and in some cases supplant a previously acquired memory of circumstances and can seriously contaminate the individual's recall of what he or she actually saw.

Location

Flexibility in approaching the interview is an important determinant of success. Don't be afraid to move your interview location out into the scrub in search of valuable information. An eyewitness' recall will be much improved if he or she can be interviewed at the exact place from which they viewed the accident. In this situation however, do your best to avoid travelling to the interview site with the witness, as they will invariably start describing what was seen while in transit to the site. This will limit the power of *in situ* recall. The benefits of environmental cues, which can act as a powerful aid to memory, will be lost.

Rapport

Encourage the witness to relax and cooperate. Make appropriate introductions. Smile when you meet, and avoid being too businesslike or authoritative (first impressions <u>are</u> important). Explain the purpose of the interview, and how you are going to proceed. Ask permission to take notes and to make an audio tape recording of the interview (both are desirable) and explain why you're going to do so (to aid your poor memory).

Endeavour to establish an informal, even casual rapport with the witness. Help them to relax - they may well feel nervous or intimidated. Witnessing the event may have been a traumatic experience for them. Talk about the weather; the land; their work or family; etc. Then ease into the interview.

Status

Minimise any overt status differences between yourself and the witness. Dress appropriately. De-emphasise differences in rank or status. Don't appear officious or "expert". Again, be flexible and judge each situation on its merits. On occasion it may be appropriate for you to wear a flying suit, jungle greens or casual civilian clothing; <u>not</u> a suit and tie or military uniform. Civilians can be apprehensive about talking to "government men".

Language

Promote maximum communication by using language that the witness can understand and relate to. Avoid using military or aviation jargon, acronyms, or technical terminology with which the witness may be unfamiliar.

Emotional state

A witness may well be experiencing upset or distress over the accident, and although well enough to be interviewed, may not be especially alert, responsive or calm. Be sensitive to the individual's emotional condition, and structure the pace of the interview accordingly. Traumatic stress is also likely to have the effect of reducing the overall quality of testimony.

Questioning techniques

Unstructured free recall

The structure under which information is elicited is important. Beginning the interview with a period of "unstructured free recall", where the witnesses' cognitive set is widest, will provide greatest overall accuracy. As there are no specific questions, the imperative to respond is low. In most cases, witnesses will not be confronted with a situation for which they have no response, and are unlikely to make any statement if unsure. Direct or closed questioning can afford more detail, but, as will be explained below, may inhibit accuracy. The most efficient interviewing technique involves a marriage of these approaches, always commencing the main part of the interview with periods of unstructured free recall.

One simple approach is to ask the witness to begin at a point relevant to the accident and explain, in their own time and words, what was observed. It is *essential* that this initial recounting of events proceeds uninterrupted. In most cases this initial statement will be brief, incomplete and unclear. It is then up to the interviewer to elicit additional information and/or clarify points already raised by the witness. This must be accomplished without altering or biasing the information offered. So, complement the witness on their initial description, and ask them to start again, from an appropriate point, providing a little more detail as they go. This approach can be repeated several times before moving on to ask some more specific but still open-ended questions.

Open-ended questions

Open-ended questions are designed to produce broad-ranging, non-specific responses. As described above they are used to open up discussion in the form of unstructured recall. As follow-up questions, they encourage further general or broad responses based around the interviewee's frame of reference. With open-ended questions, the witnesses' cognitive set is wide, there is less likelihood of them being confronted with a question about which no response can be made, and it is less likely that witnesses will volunteer information about which they are unsure.

The open-ended probing technique is "non directive" in that it invites further content based on a previous response, but without defining the bounds or direction of the new content. A useful way to approach this phase of testimony is, after complementing the witness on the quality of his evidence, to begin by saying: "I'm a bit uncertain about what happened after..., can you begin there and go over things again for me please", or "can you tell me some more about...". The extra detail revealed in these second or third accounts of events is sometimes quite staggering. Direct questioning can then be employed to fill in any remaining gaps in the testimony (eg. "what colour?", "what size?", "which direction?").

Some further examples of open-ended questions are: Tell me again what happened after ...? Can you describe what you saw next? Can you tell me what the aircraft was doing then? How did he seem when you last saw him? What can you tell me about his behaviour around that time?

Encouraging responses

Encouraging responses include any verbal and non-verbal means by which the listener encourages the other person to continue talking. They are used to facilitate active listening; to indicate "tracking" (following and understanding); to encourage further talking; to indicate support or empathy; and as a means of minimising the possibility of influencing the direction of conversation. Examples of encouraging behaviours include: Head nods, eye contact Facial expressions Body language, attentiveness Voice tone, level Minimal speech: "uh-huh"; silence Brief repetition of words

Use these responses to give positive feedback as the witness is recounting what happened, demonstrating you are attentive and still following. When they have completed their initial description of events, compliment the witness on their recall of the situation before going on. This can raise confidence and reduce anxiety and thus promote better continued response. However, care must be taken to avoid providing too much positive feedback if the information being provided is beginning to confirm your hypotheses about what took place. Remain emotionally neutral.

Remember that good listening is an essential feature of good interviewing. It has been said that we have two ears and one mouth and that we should put them to use in those proportions: however, that would be too much talking for an accident investigator! Good investigators are perceptive, diplomatic, empathic, and above all, good listeners. There are only three reasons for the witness interviewer to be talking: to put the witness at ease and set the scene for the interview; to ask pertinent clarifying questions; and finally to summarise points and provide positive feedback and encouragement.

Paraphrasing

Paraphrasing involves re-stating what has already been said in summarised form. Paraphrasing is used to clarify or synthesise a possibly disjointed statement, and to confirm your perception, ie., to ensure that the message received was the message being sent. Paraphrasing has the additional benefit of demonstrating active listening, and a concern to hear your witness accurately. Some examples of paraphrasing pertinent to witness interviewing are:

So the aircraft banked sharply, turned to the left, and then the nose appeared to drop suddenly? You're saying he was pretty upset about failing the check, and became quite moody for a few days? You said there was a flash first, then a loud noise?

Closed questions

Closed questions are those which require only a single word or brief answer. They are used to seek specific detail, and probe for qualification to a statement, or to confirm specific information. They encourage precision in memory by requesting factual information. Using a sequence of closed questions enables a complex response to be broken down into it's component parts or details.

Closed questions constitute much of our day to day conversation, and are thus easy to ask. Remember however, that they restrict the witnesses' freedom and range of response, and are thus inappropriate in generating the free recall component of an interview. They should *never* be used at the beginning of an interview. As is frequently demonstrated in cinematic depictions of courtroom scenes, closed questions carry an implicit imperative to respond to a question even if the witness is unsure about the issue under scrutiny.

Examples of closed questions are: Where exactly were you standing? What would you estimate the speed of the aircraft was? Can you point to where you first saw the aircraft? How long did you take to get to the site? At what time was that?

Leading Questions

Leading questions anticipate the response. In the context of eyewitness interviewing, they have the specific purposes of checking perception/understanding; testing reaction to a proposal; or establishing agreement or disagreement about a particular statement. If required, they can confront the respondent's recall, even to the extent of appearing to question an unlikely or improbable recollection. Some examples of leading questions are: You're certain there were flames coming from the engine? You seem to be saying he had a history of showing off his flying skills? Did you really see it hit the water, or is that what other people have described?

Questions which lead to an anticipated answer have the obvious danger that they will lead to a particular, but not necessarily correct answer. This form of interviewer bias is very common and has the potential to seriously contaminate the eyewitness testimony. Interviewers should avoid asking leading questions even if it is thought that the answer to a question is obvious, and that time could be saved by avoiding lengthy deliberation by the respondent. "Was he happy and alert when you strapped him in?" may provide the expected response, but could miss out in terms of accuracy compared with "can you describe the demeanour of the pilot while you were strapping him in?".

Even subtle and unintended references can influence a witness to respond in a particular way. Questions like "how big?" or "how small?" (compared to the more neutral "what size?"), or "how fast/slow?" (compared to "what speed?") set a response frame of reference, which has been shown experimentally to alter recall.

Professor Elizabeth Loftus of the University of Washington is an expert on witness testimony, and has demonstrated that altering the semantic value of the wording in questions can cause witnesses to distort their reports. One experiment involved asking witnesses questions about a filmed car accident they had been shown. When witnesses were asked a question using the word "smashed" as opposed to "bumped" they gave significantly higher estimates of the speed involved in the collision and were more likely to report having observed broken glass at the scene – even though there was no broken glass present. Guard against the use of emotive terminology in your questioning of witnesses.

Care should also be taken to avoid corruption of the individual's recall during or even after initial interviewing. Any details introduced or disclosed by the interviewer may be included in or influence later testimony by the witness. Resist the temptation to demonstrate to the witness how much you already know about the accident. Play naive. Just as "pub conversations"; or media interviews can allow others' recollections to be confused with existing ones, the accident investigator should take care not to make reference to important details not already raised by the witness. Questions like "Was there any smoke coming out?", or worse, "what colour was the smoke?", before "smoke" has been mentioned by the witness, encourage confirmation on a detail about which the witness may have no information at all. A neutral, open-ended alternative would be of the form: "Did you notice anything else about the aircraft?"

Conclusion

To summarise, good eyewitness interviewing involves applying the same skills necessary for a well-conducted job selection interview, counselling interview, or performance appraisal interview. It is important to establish rapport and make the respondent comfortable with the interview situation. A greater quantity and quality of information will be obtained by a careful blend of open-ended questions, accompanied by encouraging responses, and followed up appropriately with "closed" or even leading questions towards the end of the interview.

Many possible sources of error and bias in eyewitness testimony can be controlled by the interviewer. Professional interviewing which minimises interference with the most accurate recollections of the witness will be of greatest value to the goal of a successful accident investigation.

Interviewer's Checklist

Attitude

- Calm
- Clear
- Uninvolved
- Non-judgemental
- Empathetic

Preparation

- Purpose clear
- Clear direction of investigation
  - POPE
    - People
    - Organisation
    - Procedures
    - Equipment
      - Prior knowledge of the circumstance of the incident
      - Reports and other material
      - Copies made and secured
      - List of points to be covered
      - Questions prepared
      - Who is going to do/ask what
      - Recording media
      - List of all interviewers, interviewees and observers

The Interview Room

- Table and chair layout
- Windows and doors – access and comfort
- Heating, air conditioning, lighting
- Privacy
- Security

The interview

Timing

- How soon after the incident?
- Day of the week
- Time of day
- Available time
- Uninterrupted/ Breaks
- Notification to all parties

Rapport

- Introductions
- Personal Space
- Establish purpose of the interview with the interviewee

Interviewer's body language

Posture
Gesture
Orientation
Expression
Comfort: tea, coffee, water
Courtesy with control
Analyse and monitor your own communicative behaviour

Listening

Active listening
Active gaze
Look interested – consistently
Listen for particular choice of words
Listen to stress and intonation
Observe non-verbal cues
Look for incongruence
Paraphrase for clarification
If paraphrase not acceptable – ask for restatement
Do not introduce new information
Do not divert speaker unless essential
Maintain empathy – feel where they are coming from
Do not let your mind jump ahead
Do not focus on the answers you were hoping for
Hear the meaning – do not try to remember everything
Do not just write when you hear something surprising

Questioning

Open → Encourage more information
Closed → Impose structure and focus
Explore information, not your feelings
Ask easier questions first – establish the answer mode
Avoid complex questions
Avoid lengthy questions
Avoid irrelevant questions
Give time for answers
Try not to interrupt unless necessary
Do not answer for the interviewee
Do not try to 'rescue' the interviewee
Do not get into an argument
Avoid ineffective questions, for example:
Cooperative → narrrow responses
Punitive → put them on the spot
Hypothetical → offers rather than asks for an opinion

Imperative → makes demands
Screened → your needs, not theirs
Set up → creates vulnerability
Rhetorical → assumes an answer
Trick → trap

Control

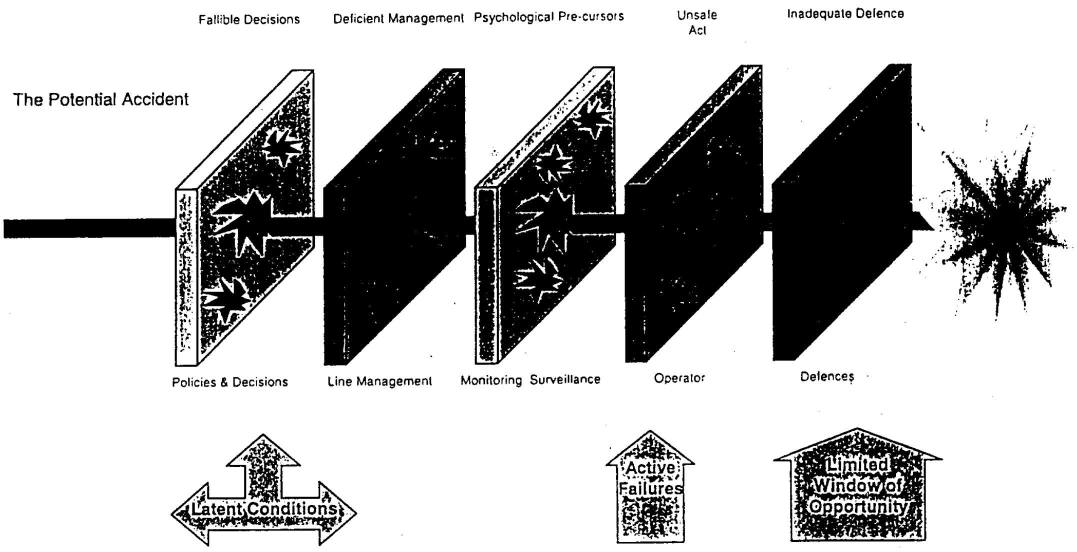
Empathy and sympathy does not mean loss of control
Remember the objectives
Take time if necessary to review your notes
Be prepared to bring the investigation back on track
Analyse constantly why you are saying what you are
Avoid triumphant, knowing or shared looks
You will learn more from cooperation than coercion
Be thorough – pay attention to detail
Build in time to reflect and summarise
Be prepared to probe

After the interview

Agree the content with the interviewee
Agree to a final statement
Do not betray your hopes or disappointments
Thank the interviewees
See them out – do not send them out.

CONCEPTUAL MODELS IN INCIDENT INVESTIGATION

Reason



The Reason Model Checklist

Inadequate Defences

These are systems or procedures that act as a final barrier to prevent an occurrence and should be established to take account of limitations and latent failures within the system. Inadequate or a lack of defences would fail to identify and protect against technical and human failures arising from unsafe acts, local factors or latent failures.

- Were adequate safety devices in place?
- Were safety devices appropriately designed e.g. fail safe?
- Were the defences designed to take into account limitations of human performance?
- Were the individual(s) involved adequately trained in the use of the system and its defences?
- Were the individual(s) involved knowledgeable about the system and its defences?
- Were the safety systems deliberately ignored or misused?

Unsafe Acts

These are errors, violations or omissions having an immediate adverse effect on system safety. These unsafe acts are typically associated with operational personnel which, in aviation , normally compromise people such as air traffic controllers, pilots, engineers, cabin crew etc.

- Did the individual(s) in the incident commit an unintended action or actions?

SHELL

The SHELL Model Checklist

Liveware - The Individual

Physical Factors:

Was the individual capable of performing the required task?

What physical impediments or limitations to successful performance were present?

How did these physical or sensory limitations create difficulties or illusions that affected the task?

Psychological Factors

Training, knowledge and experience

Was the individual's training, knowledge and experience sufficient, relevant and applicable to the situation?

How did the nature and recency of the experience, training or knowledge influence the individual's self-confidence, ability to complete the actions or perceived level of workload?

Perceptions, information processing, attention span and workload

Was there an inaccurate perception or mental representation of the task performed?

Did the individual suffer from any misperceptions, delayed perceptions or illusions caused either by the visual or vestibular system or by circumstances surrounding the event?

Did the required level of attention or the amount of information to be processed exceed the individual's own limitations?

Did the individual's ability to handle the events causes biases in judgement and change the perceived workload level?

Did psychosocial factors motivate or influence the individual's approach to a situation or the ability to handle stress or unforeseen events? Did they contribute to the degree of fatigue experienced?

Mental state, personality, attitudes and mood.

Was the individual'psychologically fit for the task?

What do the facts indicate abut the individual's attitudes towards work, others and self?

How did these attitudes influence motivation, quality of work and judgement?

How did the individual's personality and mental state influence their approach to the situation?

How did the individual's ability to cope with stress and to respond to emergencies influence the event sequence?

Physiological factors

Was the individual physiologically fit to perform the required task?

How did physiological fitness influence the individual's performance and judgement?

How did the individual's ability to handle stress, fatigue or disease affect actions, behaviour and judgement?

Was the individual affected by any type of physiological deprivation?

- Was an action of one of the individuals concerned:
- a slip concerned with attention failure (omission, reversal, mistiming)?
- a lapse concerned with memory failure (place-losing, forgetting)?
- A mistake concerned with skill, rule or knowledge based activities (misapplication of a good rule, application of a bad rule, lack of knowledge)?
- Did the individual(s) in the incident commit an intended action or violation (routine, exceptional or sabotage)?

Psychological Precursors of Unsafe Acts

Preconditions or psychological precursors that create the potential for a wide variety of unsafe acts. These are local factors that could involve task, situational or environmental factors which directly influence performance in the workplace. Deficiencies in these factors can promote the occurrence of unsafe acts.

- Did any environmental factors in or outside the workplace affect the individual in the execution of the task?
- Were personnel suitable for the position?
- Were personnel adequately trained for the task(s)?
- Did personnel have adequate knowledge of the system requirements?
- Were personnel aware of their limitations e.g. strengths, situational awareness, stress, motivation?

Line Management Deficiencies

These can be active or latent failures caused by an member, both individually or collectively, in line management or supervisory positions.

- Were there policy decisions made at higher level management or national level that were misinterpreted at line management?
- Were decisions or actions at line management made in terms of correct or unbiased knowledge of available resources e.g. equipment, plant, personnel, experience, available time?

Fallible Decisions

These latent failures are normally present well before the onset of a recognisable accident or incident sequence and may often remain unnoticed within the system for some time. The fallibility of government or higher management policies, decisions or actions may only become apparent when combined with local triggering factors to break through the system's defences.

- Were there decisions or actions or omissions by upper level management which have implications in this incident?
- Did policies or objectives exist which were inconsistent with the operational goals within the system e.g. in terms of production goals, resources etc?

Did the following exist:

- Clear statements of aims and goals?
- Adequate organisational structure?
- Effective communications?
- Adequate divisional responsibility?
- Did the policy makers have suitable knowledge of the system and operation requirements?

Liveware - Liveware

Did the interaction or communications with other people in the work environment influence the performance of individuals, their attitudes, levels of stress, perceived task demands and workload levels?

Did verbal and non-verbal communication, or the lack of it, influence the sequence of actions in an inappropriate way?

Did visual signals replace, support or contradict oral information?

How would you evaluate the teams interactions and compatibility in terms of personality, experience level and working habits?

How did the team work together? How did they make use of their resources?

Did management policies regarding personnel issues affect the working conditions, experience and knowledge level of employees?

Were policies and standards existing, available and current? Were they adequately implemented, accepted, monitored and supervised?

How did the supervisor to staff ratio influence operations?
What was the union's influence on policies, workers and management?

What kind of operational environment did management promote and how did it affect employees' decision-making and choice of actions?

Liveware - Hardware

How did interactions between the individual and the equipment influence information processing capabilities?

How did the design or layout influence response time, action sequencing, habit patterns, workload or orientation?

Liveware - Software

Were manuals, checklists, maps or any written documents readily available? Were they adequate? Were they used?

Were the format, content and vocabulary used consistent from one document to another? Were they easy to understand and use? Were they logical and appropriate?

How did written or computerised information induce errors, influence response time or generate confusions?

How did computer displays and keyboard compatibility cause confusion, influence response time or hide blatant errors?

How did automation affect the individual's actions and workload, work conditions, attitudes towards work and mental representation of the task?

Liveware - Environment

Were there any environmental factors which might have led the individual to take shortcuts or make biased decisions or which might have created illusions by affected vestibular, visual or auditory perceptions?

Were there any indications that the weather, the aerodrome or control room environment gave cause to delays that could have led to shortcuts, reduced safety margins or limitations that affected the individual's choice of actions.

Were there economic or regulatory pressures which biased decision-making?

Detecting and Eliminating the Hazard Through Reason[6]

The subject of this paper concerns the use of the Reason model of accident causation as an investigation tool for the purpose of enhancing air safety. The investigation in Australia of a recent commuter airline accident, and a number of serious air traffic control incidents, will be used as case studies to demonstrate the application of those principles in the detection and elimination of hazards.

The main purpose of the investigation of air safety occurrences is the prevention of aircraft accidents. To that end, a primary objective of such an investigation is to establish what happened, how it happened, and why the occurrence took place. It is of equal and often greater importance for the investigation to determine what the occurrence reveals about the safety health[7] of the broader aviation system. That information can be used to make recommendations aimed at reducing or eliminating the probability of a repetition of the same type of occurrence and, where appropriate, to maintain or increase the overall level of air safety.

For the purposes of broad system analysis, the Bureau of Air Safety Investigation uses an analytical model researched and developed by Professor James Reason of the University of Manchester. The principles of the Reason Model are described in detail in his book *Human Error* (1990), and were further developed in a paper presented to the ISASI 22nd ANNUAL Seminar 1991 *Identifying the Latent Causes of Aircraft Accidents Before and After the Event.*

The Reason accident causation model was developed, in part, from a comprehensive study of catastrophic failures of complex socio-technical systems in a range of industries - including the Herald of free Enterprise car ferry disaster, Chernobyl, Challenger, Bhopal, etc. The model is becoming an industry standard for investigating the relationship between the actions of individuals and the role of management policies and procedures in accidents and incidents in a number of industries, including aviation.

ICAO has recommended the adoption of an all encompassing systems approach to the investigation of aircraft accidents and incidents. The Reason model is one such approach, and ICAO has issued guidance material on the use of the model for investigating the role of management policies and procedures in aircraft accidents and incidents (ICAO circular 240-AN/144 Human Factors Digest No 7, p 6)

Central to Reason's approach is the concept of the 'organisational accident',

> in which *latent failures*, arising mainly in the managerial and organisational spheres, combine adversely with local triggering events (weather, location, etc.) and with the *active failures* of individuals at the 'sharp end' (errors and procedural violations) (Reason, 1991, p1)

The analytical framework of the model developed by Reason distinguishes between *organisational factors*, *local factors* and *active failures*. The basic elements of the model are presented below.

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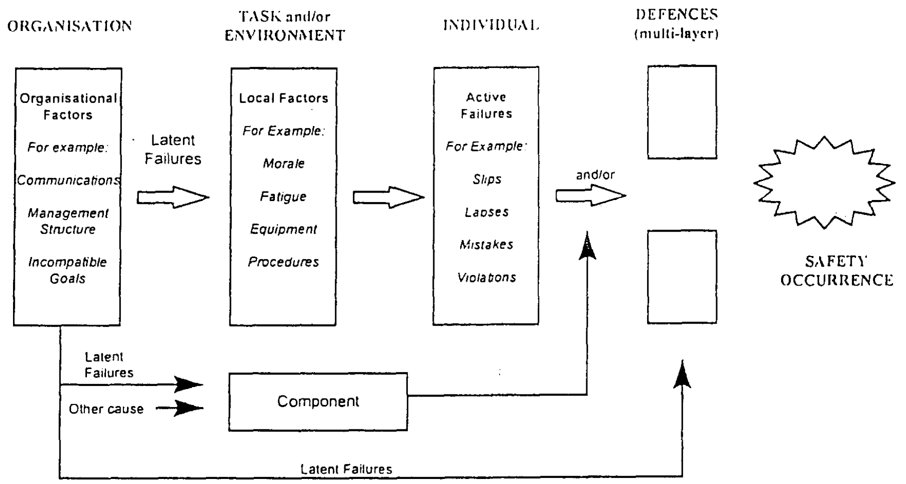
[6] Michael J Cavenagh and Barry Sargeant. Paper presented at the 25th ISASI Annual International Seminar - Paris 1994.

[7] Safety health is an overall measure of indices such as quality of management, design, operations, procedures, communications, control, maintenance etc. These indices reflect an organisation's intrinsic resistance to hazards (Reason.J,1993.)
Safety health is an important concept, as incidents and accidents are generally too infrequent to be used alone as a measure of the safety success of an organisation, or to support effective safety management.



Common elements in any organisational occurrence are:

latent failures: arising mainly from management decisions or actions whose repercussions may only become apparent when they combine with local triggering factors to breach the system's defences. These latent failures are normally present well before the onset of a recognisable accident sequence, and may have remained unnoticed within the systems for a considerable time.

local factors: these are task, situational and environmental factors which directly influence performance in the workplace. Deficiencies in these factors can promote the occurrence of unsafe acts.

active failures: are those errors or violations having an immediate adverse effect. These unsafe acts are typically associated with operational personnel, which in aviation comprise people such as pilots, air traffic controllers, maintenance staff, cabin crew etc.

inadequate or absent defences: which failed to identify and protect the system against technical and human failures arising from the three previous elements.

Experience has shown that safety occurrences are rarely the result of simple errors or violations but are more likely to be due to a combination of these with a number of pre existing latent factors. Any one of these latent factors in the occurrence is, by itself, insufficient to cause a breakdown of safety. However, when combined with local events such as active failures and/or unusual environmental circumstances such as extreme weather conditions, the resulting combination of factors may result in a safety hazard. Should the system's defences be absent, or inadequate, a failure of the system may be inevitable.

An insight into the safety health of an organisation can also be gained by an examination of its safety history, and of the environment within which it operates (Reason, J, 1993). For example, a series of apparently unrelated safety events may be regarded as 'tokens' of underlying systemic failure types within the overall safety system, such as training deficiencies, ineffective supervision of flight operations, inadequate aircraft maintenance procedures etc.

From his analysis of failures of complex socio-technical systems in a number of industries, Reason identified twelve General Failure Types (GFT's) that should apply to any aviation system and which feature in many aircraft accidents. Together, they constitute the 'vital signs' of an organisation. Measures of these GFT's provide an indication of an organisation's 'safety health'.

Those GFT's are (Reason 1991, p9)

Incompatible Goals

Inadequate Communications

Inadequate Control & Monitoring

Inadequate Defences

Poor Procedures

Inadequate Maintenance Management

Organisational Deficiencies

Poor Planning

Design Failures

Unsuitable Materials

Poor Training

Inadequate Regulation

In the past 12 months, BASI has conducted two quite different investigations using the Reason model. One of these was reactive, and followed a night commuter CFIT accident. The other was largely proactive and involved the systemic examination of the Australian ATC system utilising a number of serious air traffic control incidents as tokens of underlying GFT's. These two investigations will be described in detail.

1. The Commuter Accident: Using Reason Reactively

This accident occurred at Young, New South Wales, on 11 June 1993, when a Piper Chieftain aircraft engaged in an RPT flight crashed during a night circling approach in poor weather conditions, with the loss of seven lives. The accident was consistent with controlled flight into terrain (CFIT). Significant contributing factors appeared to be flight crew judgement, poor weather conditions and equipment deficiencies. On the surface, the investigation looked like being a relatively straightforward study of an isolated occurrence.

However, during the initial phase of the investigation, evidence began to point to significant deficiencies in the operation of the airline, and in its interaction with the regulatory and licensing authorities. In effect, the circumstances of the occurrence had all the hallmarks of an 'organisational accident'. As a result, it was decided to undertake the investigation using the Reason accident causation model, in a reactive mode, as an investigative tool.

Methodology

At a very early stage of the investigation the structure of the final report was formulated by the investigation team. Although the report was to follow the existing standard ICAO format, it was essential to ensure that the factual evidence included those elements which encompassed the relationships between the individuals associated with the occurrence, and the design and characteristics of the systems within which those individuals operated. In that regard, the use of the Reason model proved to be very effective in facilitating the identification of those elements in a systematic and structured fashion. It was found that examination of potential GFT's served as a checklist in providing useful pointers to further areas of investigation.

Throughout the investigation process the information gathered was continually evaluated with regard to the Reason model. This was necessary to determine whether further evidence was required, or of other lines of investigation needed to be opened. As a result, a comprehensive body of evidence was able to be gathered in a logical fashion, enabling the analysis of the factual evidence to be carried out in a structured way, to show the correlation between the actions of the operating crew and the psychological factors which promoted those actions.

Active Failures: Individuals

The unsafe act of the operating crew was the failure to maintain adequate obstacle clearance whilst conducting a visual circling approach at night.

Local Factors: Task/Environment

The local task and environmental factors which facilitated the failure of the flight crew to maintain adequate obstacle clearance were:

adverse weather conditions, requiring flight below the prescribed minimum descent altitude during the circling approach to maintain 'visual reference' with the ground and runway lights.

inadequate flight crew knowledge and skills. Both the captain and second pilot had not been route checked for the route being flown.

lack of operational procedures. The second pilot was being carried as a functional replacement for the autopilot; and there were no company procedures for two pilot operations.

aircraft equipment deficiencies, including inoperative heading indicators on the captain's flight instrument panel associated with an inoperative autopilot.

the visual cues available to the flight crew were inadequate as a sole reference to judge terrain clearance accurately during the circling approach at night. The cues which were available could have been subject to misinterpretation.

skill fatigue of the handling pilot resulting from a high cockpit workload exacerbated by disruption to his normal flight instrument scanning pattern because of aircraft equipment deficiencies.

instrument approach and landing procedures that did not direct the aircraft to the runway centreline but required a visual circuit procedure entirely dependent on the skill and judgement of the flight crew.

inadequate provision to the crew of terrain information within the circling area, in both operational documentation and obstacle lighting.

local company procedures did not provide any guidance to the flight crew for terrain avoidance.

Organisational Factors

Variants of many of the GFT's identified by Reason were found to exist within the management and organisation of both the airline and the regulatory authority, as shown below:

The airline:

No clear statement of goals
Organisational structure
Financial resources
Ineffective communications
Poor planning and operational procedures
Poor control of the safety of flight operations
Poor maintenance management
Poor training

The regulatory authority

Organisational goals
Poor division of responsibilities
Poor planning
Inadequate resources
Ineffective communications
Poor control
Poor operating procedures

A significant organisational factor affecting the operation of the airline was inadequate financial resources. This factor tended to influence many aspects of the management of the airline. As a result, it appeared there was a significant management bias towards commercial considerations at the expense of safety. During the two years in which the airline had been operating prior to the accident, inadequate financial resources had been a continuing problem. Following the commercial deregulation of local air transport routes, the company had to compete with other airlines on a route structure which had previously provided inadequate commercial returns to a single operator. The was no mechanism for the CAA, or any other agency, to consider any possible linkage between the financial circumstances of an operator and its continuing capability to conduct safe operations.

It is important to emphasise that although poor financial performance was found to be associated with the GFT's involved in this particular occurrence, it does not necessarily follow that safety is automatically negatively affected by commercial considerations. What is important is for the investigation to determine whether or not this is the case.

For a number of years prior to this accident the regulatory authority had been devolved to the industry, primarily as a means of reducing costs and operating efficiency. Although the stated mission of the regulatory authority as 'to enable more people to benefit from safe aviation through a focus on safety, efficiency and service', the vision and associated mission statement of the division within the regulatory authority responsible for safety regulation was directed to fostering a safe and viable industry at a minimum cost. A latent organisational failure was identified as a difference between the corporate mission statement to the Authority, which placed a clear primacy on safe air travel, and that of the Division which appeared to emphasise the viability of the industry as its major concern. This was evidenced by a seeming reluctance by the regulatory division to take early and decisive action to ensure that the company complied with appropriate operational standards, despite consistent breaches of those standards by the company.

In addition, the number of regulatory staff responsible for the surveillance of flight operations had steadily declined. Consequently, target levels of surveillance could not be achieved. As a result, the actual operational performance of the airline in question was relatively unknown to the regulator, although what was known had consistently raised concerns. Moreover, the CAA's surveillance planning did not appear to take account of the need to systematically monitor the overall safety health of RPT operators. This would have required the identification and monitoring of valid safety health indicators. Detection of adverse trends in any of the indicators would be expected to trigger more detailed surveillance activity directed at having a closer look at all aspects of the safety operation. Had such a system been in place, and provided sufficient resources were available to carry out the task, safety deficiencies may have been identified, resulting in timely corrective action.

Failed or absent defences

These were identified as follows:

obstacle lighting within the circling area met the published requirements but the terrain struck by the aircraft was not illuminated, although it was higher than other terrain which was illuminated.

a second pilot was carried as an autopilot replacement. However, there were no company procedures in place to cover multi-crew operations and thus capitalise on the potential safety value of the additional crew member.

the aircraft was not fitted with any form of terrain alerting capability, nor was it required to be.

the level of in-flight surveillance actually achieved by the regulatory authority failed to meet the minimum requirements specified by the regulator. As a result, the potential opportunities for identifying and rectifying safety deficiencies which might have contributed to the accident were lost.

Throughout the course of this investigation a number of safety recommendations were made to the relevant authorities. These related to both safety deficiencies specifically relevant to this occurrence, and to several which had the potential to result in future accidents.

Summary

The investigation of this accident, which had initially appeared to be a relatively straightforward CFIT occurrence, in fact revealed very significant deficiencies in the way in which the airline was operated, and in the way which the operations of the airline were regulated. Most importantly, this investigation identified organisational deficiencies which had broader implications for the safety of this category of operation throughout the Australian aviation system.

Although the physical data collection processes were no different to other investigations, the methodology used to manage the direction of the investigation, and to analyse the data collected, used the principles of the Reason model as an investigation tool. Whereas in the past, investigations have trended to focus mainly on the failures of operational personnel, mechanical failures, weather etc. Reason recognised that it was necessary to go beyond identifying these traditional casual factors and to investigate and rectify the underlying latent failures arising mainly in the managerial and organisational spheres. These normally only become apparent when combined with local triggering factors such as unsafe acts which directly lead to the accident, If an investigation fails to identify such systematic factors, a similar accident is likely to occur again.

The success of this investigation depended to a considerable degree on the methodology used. The Reason model, when used reactively, was found to be very effective in identifying and establishing the complex relationships between those at the 'sharp end' and the hidden or latent failures which were the precursors to this 'organisational accident'.

2. The ATS Investigation: Using Reason Proactively

Within Australia, in mid-1993, there were a number of serious air traffic control incidents within a fairly short timeframe involving a major air traffic services (ATS) centre. Each occurrence had been investigated by BASI in the traditional way by interviewing controllers, examining procedures, replaying AVR tape recordings etc. Although there appeared to be little commonality between the local factors identified in each case, there was concern that more needed to be done to ensure the ongoing safety of the air traffic control system. A decision was therefore taken to conduct a systematic investigation to identify any common organisational factors underlying the most serious of these incidents which had occurred during this period.

By way of background, the Australian air traffic control system was undergoing a number of changes during the period in which the incidents occurred. These included significant changes to airspace classifications as well as the introduction of teams at ATS units, and involved high training loads. The changes are discussed in further detail later in this paper.

Methodology

The investigation set out to collect information from three basic sources which align with the individual, task/environment and organisational components of Reason's model. From an analysis of this information, assessments could be made regarding the health of the overall ATS system. In turn, this would allow specific, targeted recommendations to be made which would improve the safety of the ATS system.

Active Failures: Individual

An examination of the incidents provided details of the types of active failures that occurred. These included:

Failure to indicate correctly an amended level on a flight strip.

Failure to coordinate an amended level with the next sector.

Failure to confirm an assigned level.

Clearing traffic on a track, at a level or to a level, which resulted in confliction with other traffic.

Local Factors: Task/Environment

Significant local factors associated with the air traffic control task and the environment were identified from interviews with controllers and with local management.

A sample group of controllers was selected covering the various control positions within the centre, together with a cross section of experience levels. Each controller was asked the same series of questions in a structured interview. The same questions were also directed to the centre manager. Questions covered the following areas:

Local procedures - adequacy, problem areas, relationships with other units, air route structures, departure/arrival procedures.

Training - facilities, instructors quality, training standards.

The effects of change.

Human factors - general knowledge, effects of fatigue/ stress, availability of counselling.

Relationship with management - up/down communications, accessibility, feedback.

Working environment - air conditioning, layout, equipment, rest facilities, lighting, recreational facilities.

Morale

The interviews highlighted a number of issues concerning procedures, the working environment, and human factors which were related solely to the local environment. Some other issues arose, however, which were organisational in nature. These included the management of change, communications with management, and training requirements (forthcoming changes in the air traffic system necessitated high training rates).

These organisational aspects provided an indication of at least some of the areas which needed to be addressed in the next phase of the investigation. Did they extend through the system, or was it at just the workface levels where such difficulties were perceived, and were such perceptions valid?

Organisational Factors

Organisational factors were addressed by interviewing both higher level and local management. In accordance with the Reason model, areas addressed included organisational structure, people management, commercial and operational pressures, planning and scheduling, communications and change management, The objective was to find out from each manager where he/she fitted in the organisation, what were the main problem areas, which thing functioned well, what he/she would like to see changed and why, how die he/she communicate to superiors and subordinates, how was change handled , were resources sufficient, what was his workload, etc. by comparing, cross checking, and correlating the various responses, and indication of areas where there was weaknesses or problems could be identified, together with possible remedial measures to overcome them.

Change and Training. The organisation was under considerable pressure as a result of consolidation of ATC sectors, introduction of a teams structure into the centre, and training for new airspace arrangements. The time constraints associated with each change, as well as the magnitude of the changes, meant that each level within the organisation was under considerable pressure to achieve various targets.

According to organisational theorists such as Miller (1992), the key to managing any change or reorganisation lies in balancing the technical and procedural dimensions with the people dimensions of the change. Managers, particularly in organisations engaged in complex operations, such as air traffic control, ten to focus on the technical and procedural components of the change. This entails determining the staff levels, moving functions, developing procedures, and acquiring hardware. While these tasks are important, they can overwhelm the entire change effort if the human aspects are adequately addressed. The ultimate success of reorganisation or change is dependent upon how successfully the organisation manages its people through the change process.

The investigation revealed that ATS management had devoted significant resources towards educating controllers regarding the impact of the airspace changes and the benefits associated with the introduction of teams. Despite these efforts, however, the messages appeared not to have been fully accepted or understood by controllers.

There was a marked disparity between the controllers' perception of how the changes would affect their workload and operations compared with the views held by management. While the reasons for these differences were not clear cut, it was considered possible that:

The culture at the workface was resistant to change. As a consequence, the group was unwilling or unable to leave its "comfort zone of competence" (Miller , R.L 1992).

The effects and benefits that the changes would bring to the individual controller, the organisation, and the industry had not been adequately presented or addressed during training.

The effects and benefits which were presented were not accepted by the controllers.

Miller argues that the human side of change is neither logical nor reasonable and involve employees feeling such emotions as doubt and fear. Employees can feel frightened about surrendering old work habits and roles, and about losing the "comfort zone of competence" that they have acquired over the years. Managers can perceive these signs from employees as unwarranted resistance to change. In turn, this can lead to employees being reluctant to share their feelings openly for fear viewed as troublemakers.

Some strategies suggested by Miller for successfully managing change include:

Providing continuing information about the change.

Giving visible support to all those involved with the change.

Being sensitive to those who are at different stages of acceptance of the change.

Providing a safety net when people make mistakes.

Ongoing change in the ATS environment is inevitable. For change to be successful, it must be accepted. From the information gained during this investigation, the success of future changes could be improved by better management of the human side of the change process. This involves devoting more attention and resources to the processes and mediums by which the organisation educates its employees about change, so as to obtain understanding and commitment on the part of all those who will be affected by the change.

Communications and Corporate Culture. An important determinant of the safety health of complex information-handling systems is the effective two-way flow of information within that system. The investigation placed emphasis on examining the effectiveness of organisational communications within the ATS system.

The investigation found that the office of the manager of the ATS centre was geographically separated from the centre itself. This limited the amount of face-to-face contact between the workface and the manager. As a result, opportunities for communication, feedback and discussion of issues were limited. Controllers were critical of both the amount and frequency of information received from management. A frequent comment was that they did not understand the reasons why decisions and changes were made. They indicated a close interest in issues which affected their work and the working environment and felt that management was not satisfying their needs in this regard.

Theorists argue that the flow of information within an organisation is dependent upon the corporate culture[8] of that organisation. Westrum (1993) in Reason (1993) has suggested that there are three basic organisational cultures - pathological, bureaucratic, and generative. These are documented as follows:

---

[8] Corporate culture is defined as the shared values (what is important) and beliefs (how things work) that interact with an organisation's structures and control systems to produce behavioural norms (the way we do things around here). (Uttal (1993), in Reason (1993)).

Pathological	Bureaucratic	Generative
Don't want to know	May not find out	Actively seek information
Messengers are shot	Messages are listened to if they arrive	Messengers are trained
Responsibility os shirked	Responsibility is compartmentalised	Responsibility is shared
Failure is punished or covered up	Failures (incidents and accidents) lead to local repairs	Failures prompt far-reaching inquiries leading to organisational reforms
New ideas are actively crushed	New ideas present problems	New ideas are welcomed

In the present case, the investigation indicated that the corporate culture of ATS organisation was essentially "bureaucratic". However, given its nature and role, the "generative culture" is that which is optimal for the role of the organisation. This culture emphasises the need for, and benefits which derive from, "training the messengers", developing more channels of communications, and examining the strategic or national implications of local failures.

Operational Pressures and Strategic Planning. In recent years, there have been significant changes in the organisation and management of air traffic serves within Australia. These have occurred in conjunction with major equipment and airspace changes. The demands of these changes were evident in the high workload throughout all levels of the organisation, and the rapid pace terms of "windows of opportunity" within which various specific changes could be implemented.

The investigation revealed a situation in which the demands for changes and the perceived benefits of such change seemed at times to outweigh the need for a stable work environment through which changes could be implemented. In some respects, the 'big' changes appeared to over-ride other lesser changes to the detriment of both.

While this situation reflected the operational pressures to which the management was subjected, it also revealed an apparent lack of consideration for "small scale" change within the overall strategic planning environment. Considerable efforts were made by the organisation in the planning and implementation of the developments upon which major projects are reliant. However, this national strategic plan seemed to fail to take account of local considerations which exist at a district level and which can effect the progress of major projects. These local factors need to be incorporated into the national strategic plan to ensure the effectiveness of all new programs.

Summary

The Reason Model provided an 'investigator friendly' methodology, which was easily adapted to the ATS environment to 'go behind' the conventional contributory factors and examine the functioning of the whole organisation as a system.

This investigation highlighted a number of organisational factors relating to the management of change, communications, and planning within the organisation, improvements in which have the potential to enhance the safety health of the organisation. A number of recommendations were made concerning these issues.

Finally, it is important to note that this investigation would not have been possible without there having existed, at the time the investigation was first proposed, a well established, close relationship between the investigating body and the ATS organisation, and the strong commitment to safety held by that organisation. Further, the success of the investigation was due to the willing and full cooperation of all levels of management and line controllers throughout the investigation process.

Conclusion

The two investigations described in this paper illustrate the application of the Reason Model to air safety investigations. The model identified, in a logical and structure sense, the key areas of an organisation which should be examined to determine latent failures which exist in the organisational and managerial domains of the organisation. In this context, it is a powerful tool to maximise the effectiveness of investigations. As Reason says, "individual errors at the sharp end are like mosquitoes. You can swat them, but there will still be plenty more to plague you. The only effective and ling-lasting remedy id to drain the swamps in which they breed. In this case, the "swamps" are unfriendly designs, conflicting goals, "clumsy technology", and corporate cultures that do not learn from precursor incidents or share information effectively either internally or with related organisations." (Reason, 1993, p12).

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SAFETY MANAGEMENT AND SAFETY CASES

Introduction

An important characteristic of safety management is a formal risk management process. This involves the assessment of systems and processes to identify where they may contribute to an aircraft accident or air safety incident, and how mitigating controls should be implemented to prevent such accidents or incidents. This is an ongoing process that is undertaken during the various lifecycle stages of components of the airways system. The conduct of the risk management process and the presentation of its findings to management and to the safety regulator is fundamental to providing evidence to assure the safe operation of the airways system.

One way of presenting such findings and arguing that an airways service is safe is by preparing a Safety Case. A Safety Case is a report that documents the risk assessment and corresponding control measures for changes to the airways system.

A Safety Case can be considered as a tangible product of an effective Safety Management System.

What is a Safety Case?

The Safety Case is a structured and comprehensive argument together with evidence of whether the System* to which it pertains is safe for operational service. A Safety Case documents:

> the hazards involved in the provision, or change in provision, of an airways service;
>
> the significance of the hazards in terms of their level of risk; and
>
> the means whereby the hazards are managed to reduce the risk to accepted levels.

Risk reduction is demonstrated by the development and resolution of Safety Requirements. Safety Requirements are the actions, procedures, performance requirements or standards that must be met to ensure the safety of the System or airways service being provided or implemented. A key to the success of a Safety Case is the provision of traceable assurance that Safety Requirements have been considered and met. A Safety Case records the findings of the process that was used to:

- identify Safety Requirements at an operational functional level;
- identify and resolve potential hazards at the design stage;
- manage the safe installation and transition of the System ready for operational use; and
- manage the initial and ongoing safe operation of the System.

**Note: The System comprises the facilities, equipment, personnel and procedures, which, in combination form part of the airways system used by an organisation to provide an airways service to the aviation industry.*

REPORT WRITING

WRITING THE REPORT

Usually every ATS investigation will end in a written report. This is to be expected as the medium of communicating the lessons of the occurrence. Systemic investigations will utilise all relevant reports. Each member state and organisation will have a specific administrative format for investigative reports.

In the production of both the draft and the final report, the following aspects might be worthy of consideration:

- The purpose of the report.
- The total inclusions in the report (who, where, when, what and why).
- A glossary of the terms used in the report.
- ICAO compliance.
- National legislation.
- International agreements.
- Provisions for the release of information.

Target Audience

- Who is the target audience?
- What are the characteristics of the target audience?
- What implications does this have for your report?

Some Basic Rules

- Avoid using CAPITAL LETTERS unnecessarily.
- Say exactly what you mean.
- Use simple words and simple language.
- Use **bold**, *italics* and underlining for effect.
- Use a sensible heading structure
- Be precise in the use of punctuation.
- Use the same word for the same meaning.
- Spell check and proof read before publication.
- Do not use long sentences
- Use bullet points and numbering.
- White space
- Cover page
- Index
- Table of contents

The Place of Written Reports

Written incident investigation reports are primary means of communication by the incident investigator. Remember that, as the investigator, it is **your** report. Your managers may adopt the report, endorse it or reject it.

When writing the report it is important to keep the following points in mind:

- Readers may not read it from start to finish. Different readers may only read parts of it.
- Decisions will be based on the contents of your report.
- The report may be read more widely than the writer first intended.

The Purpose of a Report

Reports may be used for any or all of the following purposes:

- Putting an argument
- Briefing a person or group
- Stating the facts
- Conveying progress or status
- Presenting an idea for consideration
- Making recommendations.

The V5 – Airservices Australia Incident Investigation Format

The Airservices Australia "V5" format is shown below. The pro forma has notes to assist in completing the form.

Additional notes:

Section 4

Provide a transcript of the relevant air/ground, intercom and other recorded communication.

Hints for preparing a transcript:

1. Write down exactly what was said, exactly as it was said. The exact phraseology may be a significant factor in the incident.

Example: Write "flight level three three zero", not "FL330".

1. Where the communications are difficult to interpret, indicate this in the transcript. Do **not** journalise.

Other Information

The V5 is a Microsoft Word™ document. As such, you can include diagrams, tables, charts or any other information that will make the report easier to read.

Before submitting a report, it may be a good idea to ask someone to proof read it. Ask someone who has had no connection to the investigation to read it and to look for any errors, areas of uncertainty, ease of readability etc.

Remember, however, not to breach **confidentiality**.

AIR TRAFFIC SERVICES
Occurrence Investigation Report[9] (V5)

Section 1 (to be completed by the Investigating Officer)

Section 1.1 Investigation Details

ESIR Reference		
	Name	Position
Investigating Officer		
Investigation requested by		
Report completion date		

Section 1.2 Executive Summary

1.2.1 Summary of Occurrence

(Please provide a brief description of this occurrence, include information such as the "what", "when" and "where". This description could simply be copied from the incident notification in ESIR2000.)

-

1.2.2 Summary of Facts

(This section is designed to provide the reader with the basic factual evidence (eg aircraft proximity, staff licensing). These facts can be presented in point form)

-

1.2.3 Summary of Contributory Factors

(Briefly list those factors which contributed to the incident (eg The controller was distracted by a possible radio failure), no explanation is required at this point).

-

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[9] CONFIDENTIALITY PROVISION
The information contained herein is confidential and the property of Airservices Australia and has been created solely for safety purposes. No part of this work may be reproduced, recorded, distributed or copied in any form or by any means or otherwise disclosed to any party outside Airservices Australia or used for any other purpose without the prior written consent of Airservices Australia.

Section 2 Investigation report

(This section is designed to provide the reader with an understanding of why and how the incident occurred. In each sub-section you are asked to provide a description of pertinent issues and then an understanding of how these issues impacted on the occurrence scenario. If a section is not relevant to the event under investigation, note the sub-section as being "Not applicable".

-

REMEMBER: The information presented within this section should justify both your findings and recommendations).

2.1 The Task

2.1.1 Description

(Provide an overview of the task, include any relevant information on handover, workrate and complexity, information flow between ATS unit or to/from pilot, integrity of the information available, were positions combined).

-

2.1.2 Analysis

(Provide an evaluation of the effect of the information referenced above on the circumstances leading to the incident, relevant information may include: the effect of complexity of the performance of the task, the influence of workload fluctuations, the effect of the handover/takeover process. This analysis should be reflected in your assessment of the task related Local Factors within ESIR2000).

-

2.2 Personnel

2.2.1 Description

(Provide information on the personnel involved in the incident, this does not necessarily need to be limited to those directly implicated. Information should include: age, experience, licence and rating status, recency and currency, training issues).

-

2.2.2 Analysis

(Analyse the effect of the information referenced above on the incident, relevant information may include lack of recency on the sector, absence of relief or supervisory staff, the failure of annual assessments to identify ATS officer performance deficiencies, low levels of experience. This analysis should be reflected in your assessment of the Personnel related Local Factors within ESIR2000).

-

2.3 Environment

2.3.1 Description

(Provide a brief description of any relevant factors including time of day, distractions, lighting, cramped working conditions.)

-

2.3.2 Analysis

(Provide an evaluation of the effect of the information referenced above on the circumstances leading to the incident, relevant information may include noise levels, inadequate lighting, position of the sun making sighting aircraft difficult, performance during the very early hours of the morning. This analysis should be reflected in your assessment of the task related Local Factors within ESIR2000).

-

2.4 Equipment

2.4.1 Description

(Information in this section should include any aspects that related to the use and functionality of the ATS equipment that specifically influenced provision of service prior to or during incident.)

-

2.4.2 Analysis

(Analyse the role with airborne and ground based equipment played in incident scenario, relevant information may include: equipment useability, ergonomics, false warnings, information display.)

-

2.5 Procedures

2.5.1 Description

(Provide details of any information related to airspace procedures and design, including the design of SIDs, STARs, ambiguity and discrepancies within procedures, the complexity of procedures, inconsistencies between what the ATS officer did and laid down procedures).

-

2.5.2 Analysis

(Provide an assessment of the above and how it impacted on the incident, you may wish to consider the use of procedures, validity of procedures).

-

2.6 Documentation

2.6.1 Description

(Use this section if any deficiencies in ATS specific documents (eg MATS, Local Instructions) or publications (eg AIP, charts) were highlighted during the investigation).

-

2.6.2 Analysis

(Describe the impact of the deficiency on the development of the incident).

-

2.7 Flight Crew

2.7.1 Description

(Describe the role that the flight crew played in the incident scenario. Aspects may include their knowledge, experience, and reliance on information from ATS).

-

2.7.2 Analysis

(Analyse the role that the flight crew played in the incident).

-

2.8 Organisational Issues

2.8.1 Description

(On occasions, an investigation may reveal organisational deficiencies, eg lack of system defences, poor training regime, rosters. Use the section below to describe the organisational deficiency.)

-

2.8.2 Analysis

(Describe the link between the organisational deficiency and the incident. This description should be used to support your ratings in the Organisational Factors section of ESIR2000)

-

2.9 Performance of System Defences

(This section can be used to document the performance be it good or bad of the ATS system's defences. For example: was the ATS system only alerted to the impending conflict by a STCA, did the vigilance of another ATS officer alert the ATC to the problem).

2.9.1 Description

(Briefly describe which procedure, piece of equipment or person alerted the system to the incident).

-

2.9.2 Analysis

(Evaluate the relative performance of the ATS system's (both ground and air based, technical, procedural and human) defences).

-

2.10 Other Issues

(This section should be used for information which directly relates to the incident but which cannot be covered in the sections above.)

2.10.1 Description

-

2.10.2 Analysis

-

Section 3 Findings

(Within this section, note the significant findings from the investigation. These findings should also be included within the Local and Organisational Factors screens in the Core Investigation area.

Positive and negative findings can be reported. Recommendations that emanate from this investigation should be linked to these findings, if you cannot establish a link then the recommendation is likely to be inappropriate.)

Note the significant findings of the investigation under one of the three headings below:

3.1 Active Failures

(What errors or violations led to the incident, eg misinterpretation of verbal information)

-

3.2 Local Factors

(From the analysis sections above, isolate the significant factors associated with the workplace that contributed to the incident, eg distractions, ambiguous procedures).

-

3.3 Organisational Factors

(From the Organisational Issues section, note any significant factors that contributed to the incident, eg excellent professionalism displayed by staff.)

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Section 4 Record of ATS Tape Details Relating to the Occurrence

Time	*From*	*To*	*Tape Record*

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CASE STUDIES

The Detroit Incident

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON DC 20594
AIRCRAFT ACCIDENT REPORT
NORTHWEST AIRLINES, INC., FLIGHTS 1482 AND 299
RUNWAY INCURSION COLLISION DETROIT METROPOLITAN/ WAYNE COUNTY AIRPORT
ROMULUS MICHIGAN
DECEMBER 3, 1990

Note: This is an edited version of the original NTSB report. Some sections have been omitted.

FACTUAL INFORMATION

1.1 History of the Flights

1.1.1 General

On December 3, 1990, at 1345 eastern standard time, Northwest Airlines (NWA) flight 1482, a McDonnell Douglas DC-9, and Northwest Airlines flight 299, a Boeing 727 (B-727) collided near the intersection of runways 09/27 and 03/21C at Detroit Metropolitan/Wayne County Airport (DTW), Romulus, Michigan. The Dc-9 was to be a regularly scheduled passenger flight to Pittsburgh, Pennsylvania and the B-727 was to be a regularly scheduled passenger flight to Memphis, Tennessee. Both airplanes were operating under Federal Aviation Regulations (FAR) part 121 and Instrument Meteorological Conditions prevailed at time at DTW. The B-727 was on its takeoff roll on runway 3C at the time of the collision, and the DC-9 had taxied onto the runway just prior to the accident. The B727 was substantially damaged, and the DC9 was destroyed during the collision and subsequent fire. Of the 40 passengers and 4 crew members aboard the DC9, 7 passengers and 1 flight attendant received fatal injuries. None of the 146 passengers and 8 crew members on the B727 were injured.

1.1.2 B727 Taxi and Takeoff Activity

Flight 299 was initially scheduled to depart at 1210, but an airplane change delayed the flight crew from boarding the incoming airplane until 1245 at Gate F11. Following normal turnaround procedures, the flight was pushed back for taxi around 1331. The flight was initially cleared by the west ground controller for runway 3C via a right turn form the gat; and to hold short of OSCAR 7, a taxiway just short of the C concourse (see figures 1 and 2) The flight crew noted that the visibility was ¾ mile, as reported on the Automatic Terminal Information Service (ATIS) information DELTA . They also noted that the visibility was deteriorating as they began taxiing.

The flight crew of the B727 was instructed to contact the east ground controller near OSCAR 9 and was then instructed to taxi to runway 3C via OSCAR 6, to FOXTROT taxiway, and to advise the east ground controller when crossing runway 9/27. The captain then asked the first officer to monitor the radio for updated ATIS information and to check the company takeoff visibility minimums for runway 3C. The takeoff minimum for runway 3C was ¼ mile visibility which coincided with the ¼ mile visibility then being broadcast as part of the new ATIS information ECHO. As they taxied through the OSCAR 6 area, the flight crew observed an NWA DC9 taxiing eastbound on the outer taxiway towards OSCAR 4. This airplane was NWA flight 1482, the DC9 involved in this accident. The B727 captain stated, "I lost sight of this aircraft as it taxied away from me. It appeared to be entering an area of lower visibility." Shortly thereafter, they also heard a discussion on east ground control frequency concerning a taxiing airplane missing the OSCAR 6 intersection.

The B727 then crossed runway 9/27 and the crew reported to the ground controller that they were clear of that runway. They continued taxiing along Foxtrot taxiway as the No 3 engine was started. As they turned on X-Ray taxiway, ground comntrol reested their position, then cleared them to the local control frequency. At this time, the captain noted that he could see, "... the end of the apron of 3C ...", a distance of approximately 1,800 feet. The second officer commented around that time that the weather was deteriorating significantly. The B727 then stopped at the hold line for runway 3C and reported to the local controller at 1344:08 that they were ready for taekoff. The flight was cleared for takeoff at 1344:15. Power was advanced at 1345:03, 48 seconds after the receipt of takeoff clearance. The captain later testified at the Safety Board's public hearing that since the ATIS was reporting ¼ mile visibility and he had adequate visual references to maintain the runway centreline, he believed that his decision to take off was correct.

Five seconds into the takeoff roll the first officer stated "Definitely not a quarter mile, but ah, at least they're callin' it." According to the flight crew, the airplane entered an area of reduced visibility as it accelerated through about 100 knots. The captain stated that the DC9 suddenly appeared on the right side of the runway in the path of the right wing of his airplane. He then shouted and moved his body to the left while moving the yoke to the left and slightly aft. Following the impact at 1345:40, he rejected the takeoff and stopped the airplane using maximum braking. The collision occurred 1 minute and 25 seconds afetr the tower cleared the B727 for takeoff.

1.1.3 DC9 Preflight Activity

This flight was the captain's first without supervision after an extended period off flying status for medical reasons. Both flight crew members arrived at NWA operations several hours early. The captain said that he wanted to pay a "courtesy visit" to the NWA chief pilot, and also to review the paperwork for the flight. During this period, the first officer made revisions to his flight manuals. The pilots first met at the gate, and the captain advised the first officer that he was calling for a mobile crane to check for ice on the empennage of the DC(. The flight crew completed their pre-start activities about 40 minutes before scheduled departure. They spent this 40 minutes discussing their aviation backgrounds, expected flight duties, and briefing for the takeoff.

Also, according to the first officer's post-accident testimony, shortly after he met the captain, he was asked by the captain whether he was experienced in DTW operations. The first officer responded, "yes". According to the first officer's post accident statement, the first officer indicated that what he had meant by his response to the captain's question was that he was familiar with pushback procedures and radio frequency change-over points at DTW rather than the surface operations and physical layout of the airport.

1.1.4 DC Taxi Activity

At 1335:31, the DC9 was cleared to taxi from gate C18 by the west ground controller with the following instructions:

1482 right turn out of parking, taxi runway 3 Center, exit ramp at Oscar 6 contact ground now 119.45.

The captain stated that the visibility was deteriorating as they began taxiing, but he was able to find and follow the "yellow line" (the taxiway centreline) . The captain testified that he intercepted the taxiway centreline at or near the point where it forks to the left to become the centreline of the Outer taxiway heading east. About this time, the first officer stated, "Hey, it looks like it's goin' zero zero out here." Shortly thereafter, ground control requested their position. The first officer reported that they were abeam the fire station. At this time, they were given an additional taxi clearance: "Roger, Northwest 1482, taxi Inner, Oscar 6, Fox, report making the, ah, right turn on X-Ray." About ½ minute later, the first officer stated, "Guess we turn left here." When the captain expressed some doubt about this left turn, the first officer replied, "Near as I can tell. Man, I can't see (expletive) out here."

At 1339:22 the captain stated, "Well anyway, flaps twenty and takeoff check when you get the time." The first six items on the takeoff checklist were then completed by the crew.

In a subsequent discussion with ground control about their position, the first officer stated to the controller: "approaching the parallel runway on Oscar 6 ... headed eastbound on Oscar 6 here..." He then said that they had missed Oscar 6 and that they "...see a sign here that says, ah, the arrows to Oscar 5. Think we're on Foxtrot now." According to the first officer, he realised that they had missed taxiway Oscar 6 after he observed the sign for that taxiway behind him. The controller then stated " Northwest 1482, ah, you just approach[ed] Oscar 5 and you are you on the Outer?" The first officer then responded "yeah, that's right."

Ground control then gave the additional instruction: "Northwest 1482, continue to Oscar 4, then turn right on X-Ray."

The captain continued to taxi eastbound on the Outer taxiway at a very slow rate. The first officer estimated later that during this period the visibility was about 500 feet. (see figure 3.)

Beginning at 1342:00, as the airplane was nearing the Outer/Oscar 4 intersection, the following dialogue occurred between the captain and first officer (FO):

Captain:	This, this a right turn here, Jim?
FO:	That's the runway.
Captain:	Okay, we're goin' right over here then [possible query]
FO	Yeah, that way. [pause of 21 seconds] Well, wait a minute. Oh, # this, uh, ah. pause of 8 seconds] I think we're on ah, X-Ray here now.
Captain	Give him a call and tell him that, ah.....
FO	Yeah this is nine. We're, we're facing one six zero yeah. Cleared to cross it.
Captain	When I cross this which way do I go? Right?
FO	Yeah.
Captain	This, this is the active runway here, isn't it?
FO	This is, should be nine and two seven. [pause of 5 seconds] It is. [pause of 3 seconds] Yeah, this is two seven.
Captain	Follow this. [Unintelligible word] we're cleared to cross this thing. You sure?
FO	That's what he said, yea. [pause of 2 seconds] But this taxi light takes us... [pause of 2 seconds] Is there a taxiway over there?

At this point, the captain of the DC9 set the parking brake. Also at this time, 1343:24, the B727 crew members were performing their takeoff checklist and were 1 minute and 36 seconds from beginning their takeoff roll. Intra-cockpit dialogue in the DC9 continued:

Captain:	Nah, I don't see one. [pause of 11 seconds] Give him a call and tell him that, ah, we can't see nothin' out here. [pause of 32 seconds until the captain released the parking brake, followed by 16 second pause] Now what runway is this? [pause of 7 seconds] This is a runway.
FO:	Yeah, turn left over there. Nah, that's a runway too.
Captain:	Well tell him we're out here. We're stuck.
FO	That's zero nine.

At this time, 1344:40, the B727 flight engineer was calling the takeoff checklist complete, and the airplane was about 24 seconds from beginning its takeoff roll. At 1344:47, the captain of the DC9 attempted to contact ground control. However, because he was initially transmitting on some unknown frequency or over the inter-phone, he was unable to make contact until 11 seconds later. The dialogue in the cockpit of the DC9 and radio transmissions beginning at 1344:47 are as follows:

Captain to	Hey, ground, 1482. We're out here we're stu... we can't see anything out here. [lapse of 8 seconds] Ah, ground, 1482. [unsuccessful

Ground:	transmissions]
Ground Control	Northwest 1482, just to verify, you are proceeding southbound on X-Ray now and you are across nine two seven.
Captain to Ground:	Ah, we're not sure, it's so foggy out here we're completely stuck here.
Ground Control	Okay, ah, are you on a ru- taxiway or on a runway?
Captain to Ground:	We're on a runway we're right by ah zero four.
Ground Control	Yeah, Northwest 1482 roger, are you clear of runway 3 Center?
FO [to captain]	We're on runway 21 Center.
Captain to Ground:	yeah, it looks like we're on 21 Center here.
Captain or FO	[expletive]
	Pause of 10 seconds from captain's last transmission to ground control
Ground Control	Northwest 1482, y'say you are on 21 Center?
Captain to Ground	I believe we are we're not sure.
FO [to captain]	Yes we are.
	Pause of 5 seconds from captain's last transmission to ground control
Ground Control	Northwest 1482 roger, if you are on 21 Center exit that runway immediately sir.

The two airplanes collided 7 seconds after this last instruction from the ground controller. Concerning the actual runway incursion, the captain stated during post-accident interviews that he initiated a right turn at Oscar 4 and, after several seconds, stopped taxiing. About this time, ground control advised the flight to report crossing runway 9/27. The captain said that he continued taxiing in a right turn following the yellow line, which subsequently disappeared. In his written statement, the captain said that at that point:

I stopped the aircraft and could just see the beginning of a white line. [The first officer] was talking to ground control, and I saw off to my left side what looked like a flashlight or a small diamond. I realised it was a white light, which told me I could be on an active runway. I taxied the airplane to the left of the runway edge and stopped. I picked up the mike and told ground control we do not know where we are, or we are lost (something like that). I then looked up and saw the Boeing 727 coming right at us.

In his written statement the first officer said:

When we reached O-4, [the captain] had slowed our taxi speed to a crawl, as warranted by the low visibility and commenced a right turn. I remember proceeding onto a runway during this turn which I thought was RW 9-27. However, I was unable to see across the runway at this point. As we crossed a runway centreline I could now see there was no taxiway on the other side. I checked my heading indicator to confirm that we were on RW21-03. Visibility at this time at our location was 200' or less. As I reached for the mike to relay this to ground (they) called and asked our position. I believe my response was, I think we are on RW21, or words to that effect. At that instant ground said exit that runway or get off that runway immediately. Simultaneous to that transmission I heard, then immediately saw the B727. He was on centreline, all gear on the ground with its right wing tip tracking right at our cockpit.

Following the collision, the captain shut off the fuel control levers. The first officer stated that he instinctively ducked over to the left as the B727 wing tip grazed his side of the cockpit. An evacuation of passengers was ordered immediately over the airplane public address system by the captain. The tailcone exit was not opened during the evacuation. The external tailcone release mechanism was not activated by any flight crew member or airport rescue and fire fighting (ARFF) personnel. The internal tailcone release mechanism was later found to have been mechanically inoperable. A flight attendant and a passenger succumbed in the tailcone.

1.1.5 Tower Activity During Taxi and Takeoff Sequence

Controllers involved in the accident sequence were the east ground controller, the local controller, and the area supervisor. An off-duty controller, about to come on duty, asked the local controller if he wanted to change the reported prevailing visibility but did not directly participate in the control of airplanes.

1.1.5.1 East Ground Controller

The east ground controller stated that the first time he became unsure of the DC9's position was when the flight crew advised that they were "completely stuck here." This transmission was from the captain at 1345:02, 37 seconds prior to impact, and one second before the increasing engine noise was recorded on the B727 cockpit voice recorder (CVR). The controller stated that when the flight crew advised him that they were " right by O-4" 5 seconds later, he became more concerned because he was aware that taxiway Oscar 4 led onto runway 3C. In his written statement taken on December 4, 1991, he stated that he loudly announced to the local controller "I've got a lost aircraft out here, he might be on a runway" after the 1345:29 transmission from the DC9. He said that the are supervisor then "stood up" and told everybody to stop their traffic.

During post-accident interviews, he could not recall if he had heard the B727 receive its takeoff clearance from the local controller. He said that he was aware that the Federal Aviation Administration (FAA) DTW Facility Operational Position Standards (OPS) Handbook had identified Oscar 4 as a potential are for runway incursions.

1.1.5.2 Local Controller

The local controller heard the east ground controller state that an aircraft was lost and that the ground controller thought he was on the runway. He made the determination that the B727 was already airborne based on the engine sounds and the time that had elapsed since he had cleared that flight for takeoff. He did not observe the B727 on the bright radar indicator tower equipment (BRITE) but stated that he did make an announcement that the airplane was airborne.

He said that he did not try to warn the B727 about the runway incursion because he believed that the B727 was airborne when he became aware of the lost airplane. He further stated that his belief that the airplane was airborne was based on engine sounds and the "time span since the takeoff clearance had been issued." When asked whether he had ever issued an abort instruction to an airplane on the runway, he answered in the affirmative but could provide no details.

1.1.5.3 Area Supervisor

During here initial interview with the Safety Board, the area supervisor stated that prior to the accident she was standing by the cab coordinator position, observing the overall operation, but that she was not wearing a headset to listen to controller activity. During hearing testimony, however, she stated that she was seated at a desk, doing paperwork when she first noticed that something was amiss. She observed that all runway and taxiway lights were on with the exception of the runway lights for the inactive runway 9/27. She also stated that the centreline lights for runway 3C were on and set to step 5 but that she could not actually observe these lights. Centreline lighting is bi-directional only.

She said that here first indication that something was wrong was when the east ground controller stated "[expletive], I think this guy's lost." She then directed all controllers to "Stop all traffic." When the ground controller advised that the airplane might be on the runway, she said, "I said stop everything" in a loud voice. She stated that she did not hear engine noises that she would have associated with a departing airplane.

In a later interview, when asked if her statement to stop all traffic included the supposition that she wanted airplanes on takeoff roll to abort, she stated, "It meant everything, when I say stop all traffic, everything gets stopped." When she was asked why the local controller had not complied with here statement, she replied that the local controller was the only person who knew where the traffic was and that he was the only one who could make the decision.

The accident occurred in daylight instrument meteorological conditions (fog) at 42°, 12.9 minutes north latitude, and 083°, 20.9 minutes west longitude.

1.2 Injuries to Persons

1.2.1 The DC9

Injuries	Crew	Passengers	Others	Total
Fatal	1	7	0	8
Serious	0	10	0	10
Minor/None	3	23	0	26
Total	4	40	0	44

1.2.2 The B727

Injuries	Crew	Passengers	Others	Total
Fatal	0	0	0	0
Serious	0	0	0	0
Minor/None	8	146	0	154
Total	8	146	0	154

1.3 Damage to Aircraft

The B727 received substantial damage to its right wing during the collision with the DC9. Boeing technicians estimated that repairing the airplane would cost about $4,850,000.

The DC9 was destroyed during the collision and subsequent ground fire. The insurance company representative that handled the claim stated that the hull loss amount was $1,200,000.

1.4 Other Damage

No other significant damage occurred.

1.5 Personnel Information

1.5.1 Cockpit Crew Members

1.5.1.1 The DC9 Captain

The captain, 52, was hired by Pacific Airlines Inc, on August 1, 1966, as a first officer on the Fokker F27. In accordance with several merger contracts, this was also considered his date of employment with NWA. He progressed to captain, check airman, and senior check airman on this airplane as Pacific Airlines merged with Airwest, Inc., an airline that eventually became Hughes Airwest, Inc. He became a captain on the DC9 on December 27, 1978, and flew in that capacity with Hughes Airwest and during the subsequent Hughes Airwest with Republic Airlines until February, 1984, when he was medically disqualified from flying because of kidney stones. Republic Airlines merged with NWA in October 1, 1986. He received regular disability stipends during his period of medical disability. According to the captain, these payments lessened the effect of a financial bankruptcy he experienced during his layoff.

He was reissued a first-class airman medical certificate on October 11, 1990, with the limitation that the "Holder shall wear glasses that correct for distant vision, and possess glass that correct for near vision." He held an airline transport pilot certificate with ratings for the DC9, F27, and airplane multi-engine land, and commercial privileges for airplane single-engine land. He also held a non-current flight instructor certificate that was issued on March 30, 1967. He had accumulated about 23,000 total flying hours, 4,000 of which were in the DC9.

Following his return to flight status by MWA, he completed the DC9 initial Pilot Training course on November 6, 1990. He began his flight simulator training 6 days later. He completed that training on November 20, 1990, by passing a proficiency check in the simulator. He completed his Initial Operating Experience (IOE) of 22.8 flight hours from November 29 through 30, 1990, and his line check (a continuation of his final IOE flight) also on November 30. The subsequent departure involved manoeuvring the airplane below 3,000 feet within a 3 mile distance measuring equipment (DME) arc, in turbulent air. The check airman for this line check stated, "I was pleased with [his] performance."

NWA retraining requirements for an individual who has not received a captain's assignment for more than 6 years exceed those required by FARs for routine captain upgrades and are more comprehensive than those of the NWA training plan FARs for routine captain upgrades. The captain of the DC(attended a 10-day, 80-hour ground school, whereas NWA usually requires a 5-day, 40-hour course for routine upgrades. The FARs require no ground school. The captain was required to accomplish a full 6-session flight simulator course and a simulator proficiency check ride, whereas NWA usually only requires training to proficiency in the simulator prior to a flight check. FAR flight training requirements in this area are "recent experience" and the completion of a proficiency check ride. Also, NWA required the captain to complete 12 IOE flights, whereas NWA usually requires none. The FARs also do not require IOE flights for new captains. During his training, the captain accomplished four departures and arrivals at DTW. NWA did not offer its line captains formal Cockpit Resource Management (CRM) training at the time of the accident. Subsequent to the accident, Northwest began requiring a 1-day course in CRM for all its pilots during training.

1.5.1.2 The DC9 First Officer

The first officer, 43, retired form the United States Air Force (USAF) on October 31, 1989 at the rank of major. His Air Force line assignments included copilot, aircraft commander and instructor pilot duties in the Boeing B52 Stratofortress hey bomber, as well as instructor pilot duties in the T38 Talon jet trainer. His first line assignment was to a B52 squadron in 1971, and he accumulated about 3,254 hours in various models of that airplane, 1,380 of which were as an instructor or evaluator pilot, prior to his retirement with the rank of major. Between B52 assignments, he was also a pilot in T38 airplanes, accumulating about 1,025 flying hours, about 780 hours of which were as an instructor. A review of his military flying records revealed no accidents, and his record of military flying evaluations dating back to 1975 revealed no failed check rides or written examinations.

The first officer was hired by NWA on May 25, 1990. He held an Airline Transport Pilot Certificate with ratings for the CE-500 (Cessna Citation) and airplane multi-engine land, issued November 6, 1978. He also held flight engineer certificate No. 507560424e, with a rating for turbojet-powered airplanes, issued on March 21, 1979. His FAA first-class airman medical certificate was issued on April 30, 1990, with no limitations. He estimated that he had accumulated about 4,685 total flying hours, 185 of which were in the DC(.

The first officer completed his initial DC9 training on July 5, 1990, and successfully passed a simulator proficiency check the next day. The check airman commented, "Good initial proficiency check." He was then given a Line Oriented Flight Training (LOFT) period of normal procedures in the simulator on July 7, and aircraft flight training (three takeoffs, including one with a V1 cut; Three landings; and four instrument approaches) on July 11, 1990. His IOE and line check flight were completed on July 27, 1990. NWA did not offer formal CRM training to its line first officers at the time of the accident.

The first officer testified that he had flown 22 departures and arrivals at DTW. He believed that one or two of them had been under the Instrument Flight Rules (IFR).

1.5.1.3 The B727 Captain

The captain of the B727, 42, was hired by NWA on May 9, 1983, and held an Airline Transport Pilot Certificate with ratings for B727, airplane multi-engine land. and commercial privileges for the L300 and airplane single engine land, issued April 6, 1990, and his last line check was completed on May 30, 1990. His FAA first-class airman medical certificate was issued on August 2, 1990, with no limitations. He also held a flight engineer certificate. At the time of the accident, he estimated that he had approximately 10,400 total flying hours, 5,400 of which were in the B727.

1.5.1.4 The B727 First Officer and Second Officer

The first officer on the B727, 37, was hired by NWA in September, 1985, and held an Airline Transport Pilot Certificate. His FAA first-class airman medical certificate was issued on July 9, 1990, with no limitations. At the time of the accident, he estimated that he had accumulated about 5,400 total flying hours, of which 2,350 were in the B727.

The second officer on the B727, 31, was hired by NWA in July, 1989. He held an Airline Transport Pilot Certificate and a flight engineer certificate issued in September 27, 1989, with a turbojet-powered airplane rating. His FAA first-class airman medical certificate was issued on February 20, 1989, with no limitations. At the time of the accident, he had accumulated about 3,300 flying hours, of which 900 were in the B727.

1.5.2 The Flight Attendants

1.5.2.1 The DC9 Flight Attendants

The lead flight attendant on the DC9 was hired by NWA on June 17, 1988, and received her last recurrent emergency procedures training on August 11, 1990. The second flight attendant was initially hired by North Central Airlines (an airline that later merged with Republic, then NWA) on March 15, 1968, and received her last recurrent training on February 27, 1990. Both of them were qualified for flight attendant duty on B747-200/400, B727, B757, DC!), DC9 and Airbus 320 airplanes. The lead flight attendant testified that although she had not entered a tailcone or a tailcone exit mockup in training, she had pulled a tailcone exit release handle in training in August 1989. Training records of the second flight attendant indicated that she pulled the exit release handle during training in February 1989.

An off-duty flight attendant aided in the evacuation of the airplane. She was hired by NWA on March 10, 1990. She had not received recurrent training because she had only been employed by the company for about 9 months at the time of the accident.

1.5.2.2 The B727 Flight Attendants

All flight attendants on the B727 were current in the airplane and received recurrent training during 1990.

1.5.2.3 NWA Flight Attendant Training

The FAA approved NWA flight attendant initial training program lasts 6 weeks. The DC9 specific training consists of 8 hours and 45 minutes of instruction and a 30 minute written examination. The training includes instruction in emergency evacuation, emergency procedures, emergency equipment, water survival and ditching procedures. One hour of training is allotted to "hands-on practice" in which each flight attendant is required to open a cabin door and an overwing exit, and "simulate operations of the control for the aft exit hatch and tailcone." At the time of the accident, the tailcone exit training device was a platform that included a tailcone release handle positioned at the end of a rod that was attached to the platform. The tailcone release handle was not installed in retaining clips. NWA used a 9-minute Hughes Airwest produced video tape describing the DC9 tailcone operation. The film shows the operation of the tailcone's external release handle and states:

> *Crewmembers should know the location of the handle. It could be important to free passengers or flight attendants who may be trapped in the tailcone.*

Aside from information provided by this video tape, NWA training does not specifically instruct crewmembers to activate the tailcone external release handle.

Following the accident, NWA flight attendant on-board service managers (supervisors) gave a 15 question exit operations quiz to 238 flight attendants who were scheduled to fly on DC9 type airplanes. Four of the 238 individuals tested required re-training.

1.5.3 The Air Traffic Controllers

1.5.3.1 The Area Supervisor

The area supervisor, 35, entered on duty with the FAA on July 25, 1982, and began working at DTW on November 10, 1985. She became a full-performance level (FPL) controller and was certified in her current position in September 1990. Her last over-the-shoulder evaluation[10] and tape talk session[11] occurred in October 1990. She was certified to take prevailing visibility observations on May 26, 1990.

1.5.13.2 The Local Controller

The local controller, 25, entered on duty with the FAA and began working at DTW on June 5, 1988. He became an FPL controller and was certified as a local controller in January 1989. His last over-the-shoulder evaluation was in September 1990, and his last tape talk session was in October 1990. He was certified to take visibility observations on April 7, 1990.

He had no prior FAA assignments before DTW, but he had 5 years of earlier military Air Traffic Control (ATC) experience with the US Army. He was medically qualified as a controller with no waivers or limitations and was not a pilot.

1.5.3.3 The East Ground Controller

The east ground controller, 26, entered on duty with the FAA on February 20, 1985, and began working at DTW on July 1, 1990. He was certified on the east ground control position on September 30, 1990, and was not an FPL controller. His last over-the-shoulder evaluation was in April 1990, and his last tape talk session was in May, 1990.

His only previous controller assignment as in the ATC tower at Saginaw, Michigan, where he was an FPL controller. He was medically certified as a controller with no waivers or limitations. He was also a non-current private pilot with about 80 hours of total flying time.

1.5.3.4 The West Ground Controller

The west ground controller, 28, entered on duty with the FAA on April 29, 1986, and began working at DTW on May 7, 1989. He became an FPL controller on November 12, 1989. His last over-the-shoulder evaluation was on August 20, 1990, and his last tape talk session was on March 25, 1990.

His only previous FAA assignment prior to DTW was in the Willow Run, Michigan, ATC tower, where he was an FPL controller. He was medically certified by the FAA with no waivers or exceptions.

1.5.3.5 The Tower Cab Observer

The tower cab observer, 32, entered on duty with the FAA on December 13 1981 and began working at DTW on October 10, 1989. She became an FPL on April 13, 1990. Her last over-the-shoulder evaluation was on December 2 1990, and her last tape talk session was on November 14, 1990. Her other FA assignments included the towers in Pontiac and Flint, Michigan, and Indianapolis, Indiana. She was certified to take visibility observation on May 26, 1990.

1.6 Aircraft Information

1.6.1 The DC9

N3313L, a DC-9-14, was acquired by NWA on August 1, 1986. It was operated exclusively by NWA until the accident, at which time it had a total of 62,253.2 operating hours and had undergone 88,255 cycles. It was equipped with two Pratt and Whitney JT8D-7 engines. FAA service difficulty reports (SDRs) on emergency equipment and exits revealed two write-ups. One, in July 1989, concerned a low-pressure indication on the service door slide bottle, and the other, in July 1990, involved an inoperative emergency light by the main cabin door . There were no open items in the maintenance logs for the airplane.

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[10] An evaluation by the supervisor while the controller is actually controlling traffic.

[11] A training method involving a critique of ATC recording tapes of the controller's activities related to the actual control of aircraft.

1.6.1.1 DC9 Tailcone Maintenance

The Safety Board examined NWA DC9 maintenance at its Atlanta maintenance base. The examination included interviews with maintenance and quality control shift foremen and managers, inspection of the airline's computer generated maintenance and inspection forms (CITEXT cards), which were used while performing routine maintenance, and reviews of personnel training records. Several deficiencies were found concerning the airline's DC9 maintenance program.

During a "C" check concluded on the accident DC(on November 19, 1990, 66 operating hours prior to the accident, the tailcone was reportedly jettisoned twice and reinstalled without any apparent problems. Replacement of the top left slider block/latch was the only maintenance performed in the tailcone area. During the replacement of the slider block/latch, its cabling was misrigged and neither mechanic who replaced the latch nor the general inspector who inspected the work noted that the latch cabling was not properly rigged in accordance with the DC9 maintenance manual. Examination of the CITEXT cards containing procedures and instructions for conducting maintenance during a DC9 "C" check did not accurately reflect information found in the DC9 Maintenance Manual.

The final quality control inspection, after completion of the "C" check was not conducted by a quality control inspector, as outlined on the appropriate CITEXT card. Rather, this inspection was accomplished by a mechanic who had been designated by his crew chief to conduct the inspection and who had no formal training on the maintenance, operation and inspection of the DC9 tailcone. It was also learned that some newly hired mechanics had not received formal DC9 training for as long as 18 months after being hired by NWA. The position of DC9 maintenance training manager had been created 2 months prior to the accident and was still vacant at the time of the accident.

An NWA senior foreman with 13 years experience stated that about 40 percent of DC9 tailcone release handles that were pulled during routine maintenance had failed to jettison the tailcones when the specified 25 to 35 pounds of tension were exerted. In post-accident interviews, neither the quality control inspectors nor the mechanics who worked on the accident airplane's tailcone during the "C" check recalled whether the tailcone release handle shaft was fractured at that time. Also, they recalled that during the "C" check the handle had been safety wired in its stowed position. Investigators found no records of anyone having entered the tailcone between the final "C" check inspection and the accident.

1.6.1 The B727

N278US, a B-727-251-2A, was purchased by NWA from Boeing in November 1975. It was operated exclusively by NWA until the accident, at which time it had a total of 37,710.2 operating hours and 27,933 cycles. It was equipped with three Pratt and Whitney JT8D-15A engines. The single deferred maintenance item in the airplane maintenance logs concerned an inoperable quantity gauge on the potable water system.

Interviews with flight attendants on N278US revealed that the cabin interphone was inoperative. Although a mechanic was called to investigate this discrepancy before the flight departed the gate, the interphone was not repaired and the item was not entered into either the cabin or cockpit maintenance logbooks. The B727 Minimum Equipment List (MEL) states that the airplane can be flown with an inoperative cabin interphone if the public address system is operating properly, which it was on this airplane. However FAA regulations require that a known deficiency either be corrected or entered into the maintenance logbook according to MEL procedures before pushback.

1.7 Meteorological Information

1.7.1 National Weather Service Activity

National Weather Service (NWS) weather observations at DTW are made by weather observers (Meteorological Technicians). Observations are made at the NWS facility in the Executive terminal Building about 3,100 feet north-east of the approach end of runway 21C. The DTW tower is about 7,210 feet south-west of the NWS office. Weather observers maintain a Basic Weather Watch as defined in federal Meteorological handbook No 1.

The NWS observations up to and after the time of the accident (1345 eastern standard time) were as follows:

Time – 1250; type – record special; sky partially obscured; ceiling – measured 200 feet overcast; visibility – ¾ mile; fog; temperature 41° F; dewpoint – 40° F; winds 120° at 11 knots; altimeter – 29.55 inches; RVR not available, .4 of the sky hidden by fog. 1 inch of snow on the ground, rain ended 1210.

Time – 1330; type – special; ceiling – indefinite 100 feet, sky obscured; visibility – ¼ mile; fog; winds 120 degrees 11 knots; altimeter – 29.52 inches; RVR not available.

Time – 1348; type – local; ceiling – indefinite 100 feet, sky obscured: visibility ¼ mile; fog; temperature -- 46° F; dewpoint -- 46°; winds 110 degrees 11 knots; ; altimeter – 29.49 inches; RVR not available.

1.7.2 Automatic Terminal Information Service (ATIS)

Until about 1335, Detroit ATIS information Delta was being broadcast as follows:

Detroit ATIS information Delta. 1750 Zulu [1250 eastern standard time] weather, sky partially obscured, measured ceiling 200 overcast, visibility three quarters, fog, temperature 41, dewpoint 40, wind 120 at 9, altimeter 29.54, pr4essure falling rapidly. ILS approach runway 3 right, plan runways 3 right 3 center. Notice to airmen: runway 3 left closed, runway 9/27 closed, metro VOT out of service, southside taxiway Uniform pad closed, use caution for a 110 foot crane south of T hangars and also a 310 foot crane south runway 9/27 between runways 3 center and 3 left, runway 3 right outer marker out of service, runway 3 center runup pad closed, braking action advisories are in effect. Field conditions: caution is advised of for [sic] the outer edges of the ramp has snow piles up to 6 feet, flow procedures are in effect for numerous airports. Initial contact advise controller you have ATIS information Delta.

About 1322, the NWS office received a message from the DTW tower, via its electrowriter , that the prevailing visibility was ¼ mile. About 1335, the following new ATIS was broadcast:

Detroit Metro ATIS information Echo: 1830 Zulu [1330 eastern standard time] special weather, indefinite ceiling 100, sky obscured, visibility one quarter, fog, temperature 41, dewpoint 40, wind 110 at 9, altimeter 29.50, ILSW runway 3 right approach in use, departing runways, 3 right and 3 center. Notice to airmen: runway 3 left runway 9/27 closed, runway 3 right outer marker out of service, Detroit Metro VOT out of service, southside taxiway Uniform pad closed, runway 3 center runup pad closed, braking action advisories are in effect, use caution for a 310 foot crane south of runway 9/27 between runways 3 left and 3 center, use caution for a 110 foot crane in the south "T" hangars, gatefold procedures are in effect for Chicago Midway, Minneapolis/ St. Paul, Charlotte, Atlanta Hartsfield, La Guardia, JFK, Newark, Greater Cincinnati, Syracuse, Toronto International and Rochester. Advise controller on initial contact that you have info Echo.

1.7.2.1 SIGMET Foxtrot 3

SIGMET (significant meteorological information) Foxtrot 3 was valid from 1230 to 1630 and called for severe turbulence below 8,000 feet for an area that included DTW. Information from this SIGMET was not placed on the DTW ATIS as required by FAA directives. In addition, information from this SIGMET was not included in the weather data provided by NWA meteorologists to the flight crews of the B727 or the DC9 involved in this accident.

1.7.3 Weather Observations in the DTW Tower

DTW controllers, who are trained and tested as visibility observers by the FAA, are allowed to take prevailing visibility observations and relay them to aircrews and the DTW NWS office. A checklist in the DTW tower states that a visibility chart, annotated with visibility markers, such as concourses, terminals, towers and antennas, must be used to determine prevailing visibility. According to Federal Meteorological Handbook No 1, prevailing visibility is defined as the greatest visibility equalled or exceeded throughout at least half the horizon circle. The 180° arc of the circle having the greatest visibility need not necessarily be continuous.

The on duty local controller, the on duty tower supervisor, and an off duty controller stated that they made prevailing visibility observations just prior to the accident. The on duty controller also had comments concerning the visibility.

The local controller stated that he made a ¼ mile prevailing visibility observation around 1320, 25 minutes prior to the accident. He did not use the visibility reference chart or have the visibility reference markers memorised. He testified that his observation was based on the fact that he used the visibility reference chart to determine a ¼ mile prevailing visibility a few times in the past and was very familiar with what a prevailing visibility of ¼ mile looked like.

The tower supervisor testified that she checked his observation within "minutes" prior to the accident. The local controller said he actually made his observation some time prior to 1322. She concurred with his ¼ mile call and, in hearing testimony, was quite specific concerning the visibility markers she used for this verification. However, she also stated that did not use the visibility reference chart. In addition, she said that she did not know the visibility that the NWS was reporting prior to and at the time of the accident. Federal Meteorological Handbook No1 states that the lower of the tower or the surface visibility is the controlling factor for airplane operations on an airport.

An off duty controller, preparing to come on duty, made a visibility observation using the reference chart between 1330 and the time of the accident. She determined that the prevailing visibility at that time was 1/8 mile. Following her observation, she asked the local controller whether he wanted to change the visibility reading (without elaborating that she believed the visibility was then 1/8 mile) and the local controller responded that the ¼ mile call was good.

The east ground controller stated that he concurred with the ¼ mile call. However he also said that he could not see aircraft at the ends of A, B, or C concourses around the time of the accident. The ends of the concourses, which are visibility markers, are less than ¼ mile from the DTW tower.

1.8 Aids to Navigation

No navigation aids were used by either airplane during the accident sequence of events. DTW's ATC tower is not equipped with Airport Surface Detection Equipment (ASDE).

1.9 Communications

A review of FAA Form 7230.4, Daily Record of Facility Operation for the DTW air traffic control tower, did not disclose any recent transmitter or receiver problems affecting the abilities of either airplane to communicate with the tower prior to the accident. Subsequent to the accident, all primary and secondary (main and standby) radios using frequencies 119.45 (east ground control), 121.8 (west ground control), 118.4 (local control east) and 135.0 (local control west) were found to be operating within normal parameters. In addition, the controllers and flight crew members involved in this accident stated that no radio problems existed that hampered their ability to communicate.

1.10 Aerodrome Information

1.10.1 General

DTW is about 15 miles south of downtown Detroit, Michigan. The field elevation is 639 feet above sea level. The airport is certificated in accordance with the applicable provisions of Title 14 CFR Part 139. DTW is served by four runways: 3L/21R, 3C/21C, 3R/21L and 9/27. At the time of the accident, runway 9/27 was closed for snow removal. Runway 3C/21C is 8,500 feet long and 200 feet wide. The first 4,387 feet of runway 3C is grooved concrete, and the remaining 4,113 feet is grooved asphalt

DTW Airfield Inspection forms of daily inspections, which were conducted between November 21, 1990, and December 3, 1990, and weekly airfield runway lighting reports made between November 28, 1990, and December 3 show no discrepancies in airfield marking, lighting circuits, or runway and taxiway signage. FAA annual airport/safety certification inspection records for 1988-1990 show several discrepancies. On sep1 17, 1990, a Letter of Correction was written by the FAA Certification Inspector as a result of her inspection. It stated that the light s on runway 3C/21C were in need of repair and that daily airfield inspection reports had omissions in them. The lighting discrepancies were corrected on September 18, 1990. The FAA inspector assigned to DTW at the time of the accident was not a pilot.

The National Aeronautics and Space Administration's Safety Reporting System (NASA's ASRs) issued an alert bulletin (ASRs Alert Bulletin 91:01) on January 3, 1991, concerning a near incursion on runway 21R at DTW. The event occurred after the accident and ASRs personnel received the anonymous report from an airline crew some time later. Although the bulletin was directly addressed to the Airport Manager at DTW, the deputy Director of Wayne County Division of Airports testified that his office received a copy of the bulletin from the Airport Certification Office that oversees DTW. It could not be confirmed why Detroit Metropolitan/Wayne County Airport did not receive the bulletin directly from NASA's ASRs.

1.10.2 Runway 3C/21C Lighting

Lighting on runway 3C/21C pertinent to this investigation includes high intensity runway edge lights (HIRLS) and bidirectional centreline lighting (CL). The distance between runway edge lights is 200 feet, except at the western edge of runway 3C/21C near the intersection of runway 9/27, taxiway O-4 and the outer taxiway, where the edge lights are 584 feet apart. FAA Advisory Circular (AC) 150/5340-24, Runway and Taxiway Edge Lighting System, dated September 3, 1975, states: "Where a runway is intersected by other runways or taxiways, a semiflush light ... should be installed to maintain the uniform spacing for HIRLs."

The distance between runway centreline lights is 50 feet. Neither the National Oceanic and Atmospheric Administration, nor the Jeppesen Sanderson, Inc., flight information publications depicted centreline lights on runway 3C/21C at DTW. NWA pilots use Jeppesen Sanderson documents.

Witnesses in the runway 3C/21C area at the time of the accident did not note whether the runway centreline lighting was illuminated. Because of the directional nature of this system, these light were not visible from the DTW control tower. The FAA tower supervisor stated that prior to the accident, the centreline lights were turned on by means of a toggle switch and set to step 5 (the highest setting) via a rotating rheostat switch. Post-accident testing of the centreline lighting panel in the tower revealed the following:

The "on-off" toggle switch was spring loaded and could be placed between the "on" and "off" positions; however, it was difficult to get the switch to remain in the center position. When in the centre or the "off" position, the centreline lights were not illuminated.

The panel behind the rheostat was labelled with a felt-tipped marker indicating the 5 intensity steps (the numbers 1 through 5), two "off" positions, and an unidentified "hashmark".

When the rheostat was placed in the two "off" positions and at the hashmark, the centreline lights on the runway were at their lowest level.

When the rheostat was placed between the numbers corresponding to the 5 intensity steps, the centreline lights were at their lowest intensity level; however, as the switch was rotated to the next highest setting, the lights brightened to that setting.

The switch detents corresponded to the 5 intensities. When the switch was in a detent, the lights illuminated to the level corresponding to that detent.

The rheostat did not conform to FAA specifications outlined in AC 150/5345-3D, dated August 8, 1986, because it did not have a stop to prevent rotation past the last intensity setting (step 5) and to prevent continuous rotation in either direction. The provisions of this document are mandatory for Federally funded projects.

The runway 3C centreline lights were on a separate electrical circuit and therefore were not part of any other airport lighting that was intentionally turned off prior to the accident.

On May 31, 1991, the Safety Board issued Safety Recommendation A-91-39 to the FAA concerning airport lighting panel rotary switches. A response is pending. The recommendation asked the FAA to inspect all lighting panel rotary switches to ensure that they comply with the specifications outlined in AC 150/5345-3D. The AC states in part:

The switches shall have a minimum angular throw of 30° between detents and shall be equipped with a stop to prevent rotation past the last position and continuous rotation in either direction.

A taxiway hold position light (damaged and inoperable prior to the accident) was installed on the island between the outer taxiway and runway 3C/21C. This assembly is a dual, alternately flashing set of yellow lights, intended to delineate the entrance to runway 3C/21C. The taxiway hold position light was not required airport equipment under the FARs.

1.10.3 Airfield Guidance Signs

All taxiway identification signs (informational signs with yellow backgrounds and black lettering) and runway identifier signs (mandatory signs with red backgrounds and white lettering) observable along the route taken by the NWA DC9 met or exceeded the specifications concerning size and coloration, as stated in AC 150/5345-44D, Specification for Taxiway and Runway Signs, dated April 30, 1984. After the accident, investigators were unable to agree on the precise taxiway segment identifications near Oscar 4 after reading the available signs in that area.

1.10.4 Airfield Surface Markings

Reflective paint was not used for taxiway centreline or hold line markings, and its use was not required. The inner taxiway centreline from gate C18 eastbound past the fire station was visible. However, about 200 feet of the centreline as it curved through the Oscar 6 area varied in conspicuity between "very faded" to "not visible" under day VFR conditions, according to investigators who observed the taxiway. The taxiway centreline that led from the inner taxiway to taxiway Oscar 6 towards runway 9/27 was visible. The inner taxiway centreline between Oscar 6 and Oscar 4 varied in conspicuity from "faded" to "visible". On the outer taxiway , the painted taxiway centreline was observed to vary in visibility from "faded" to "visible" between Oscar 4 and Oscar 6. About 50 feet of the centreline on the Pouter taxiway near Oscar 5 was unpainted because of recent pavement surface maintenance. An airport management official stated during the public hearing that the taxiway centreline are painted twice a year and that because of weather, the lines were to be repainted in the spring of 1991.

Concerning hold lines between taxiways and runways, AC 150/5340-1F, Marking of Paved Areas on Airports, dated October 22, 1987, states in part:

(T)he hold markings are installed perpendicular to the taxiway centreline.

The runway hold line on the extended portion of Oscar 4 between the two islands was parallel with runway 9/27 rather than perpendicular to the taxiway centreline.

1.11 Flight Recorders

1.11.1 Digital Flight Data Recorders (DFDRs)

The DFDRs on both airplanes were Fairchild Model F800 devices. There was no evidence of any internal damage to either recorder. An examination of the recovered data from both recorders indicated that they operated within established parameters and that there was no abnormal loss of synchronisation during the pertinent portions of the recordings.

The DC9 data plot covers 11 minutes and 52 seconds and contains all data recorded during the taxi sequence. The altitude and airspeed inputs for the DC9 were not plotted because the data did not display any significant changes during the entire taxi operation. The B727 data plot contains the 2 minute segment of the data set that covers the turn onto the runway through the takeoff roll and subsequent takeoff abort. All parameters for the B727 during this period were plotted

1.11.1 Cockpit Voice Recorders (CVRs)

Both CVRs were Fairchild Model A-100A devices. Neither CVR received any internal damage during the collision sequence. The recordings obtained from both the recorders were of good to excellent quality. On the B727 recorder, a power interruption of unknown origin occurred at 1346:57.5, about 1 minute and 18 seconds after the collision. The DC9 recording ended at impact.

Appendix D[12] contains the full transcript of the DC9 recording and the last 5 minutes of the B727 recording (initiation of the takeoff checklist to the end of the recording). The flight crews from each of the accident airplanes suggested clarifications and additions to the transcripts. They are also at appendix D.

1.12 Wreckage and Impact Information

1.12.1 The B727

The B727 was only damaged on its right side, most of which affected the right wing. Approximately 13.5 feet of the outboard wing had been sheared off during the collision. Much of the debris from this wing area was found in and around the DC9. The remaining portion of the wing was attached to the fuselage but was heavily damaged. Most of the Nos. 4, 5, and 6 leading edge flaps had broken off, but the actuators were still in place. Most of the forward, lower fixed edge panels aft of the No 4 leading edge flap had also broken off. The Nos 7 and 8 leading edge slats and slat tracks had separated from the wing and were found on the runway beside the DC9. Among other wing components, the lower, outboard end of the inboard aileron was slightly damaged, as was the outboard end of the outer spoiler.

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[12] Appendix D is not included in this copy

The three fuselage mounted engines did not appear to sustain any damage as a result of the collision. They were not examined internally. Both right tires exhibited several cuts on their treads and sidewalls.

1.12.2 The DC9

1.12.2.1 General Damage Description

The interior of the passenger cabin was extensively damaged by the fire. All cabin sidewall and ceiling panels, stowage bins and seat cushions, except for some small pieces, were destroyed by fire. The remains of double seat frames from about their bottom seat pans to the floor were intact an in place from the left overwing hatch to the aft lavatory. All other seat frames were generally not as intact and had more fire damage. Many of the seat frames on the right side of the cabin were displaced rearward from their normal positions.

The airplane's fuselage was cut in a straight line just below the bottom of the windows ion the right side of the airplane. The cut line remained along the right side of the fuselage, and the fuselage structure above this cut line to the top was destroyed by fire. The majority of the fuselage was burned from just aft of the cockpit to just forward of the aft bulkhead, from the top to just above the window line on the left side of the airplane.

The accessory compartment between the aft pressure bulkhead and the fibreglass tailcone contained considerable amounts of soot. Plastic electrical wiring support loops and insulation on some small wires in that area had melted. The thermal insulation the aft side of the pressure bulkhead was not fir damaged.

The right horizontal stabiliser's bottom surface and the right side of the vertical stabiliser contained heavy amounts of soot. The outside of the tailcone area contained soot, mostly on the right and lower sides, but fire did not burn through. The outside of the tailcone exhibited a 1- to ½ inch mark that exposed a fibre matrix surface.

The left wing was undamaged and all left wing control surfaces were intact. The right wing was heavily damaged, and about 3.5 feet of the wing tip was missing. Portions of the right wing tip were found in the right main landing gear door of the B727. Several areas of the wing's top skin just aft of the leading edge were torn. Scrape marks existed on several areas of the upper surface of the DC9 right wing. These scrape marks and those on the right wing of the B727 indicated a collision angle between the two airplanes of approximately 5°.

The interior of the cockpit contained a light amount of soot and exhibited some charring of the ceiling and sidewall just inside the folding entrance door. The folding entrance door was found in several pieces with the cockpit side of the door relatively clean and the cabin side of the door charred. The first officer's middle window was cracked but intact, and the first officer's instrument panel was deformed aft. Small pieces of debris from the wing tip of the B727, including shards of green glass from the right navigation light lens, were found in the cockpit of the DC9. The right side of the nose of the airplane exhibited a large gash beginning just under the first officer's middle window and extending aft to the galley service door.

The left engine was intact and did not exhibit any external damage except for soot found in the inlet and exhaust areas. The right engine was knocked off its pylon by the B727 during the collision sequence. It was found beside the DC9 in a heavily battered and burned condition. Neither engine was examined internally.

Forward Exit Systems

The L-1 door could not be closed because of interference between the upper aft corner of the door and the door fuselage jamb. The door's operating handle could not be rotated to its fully closed position. The L-1 evacuation slide cover was found inside the cabin near the L-1 exit lying loosely on top of the wadded up R-1 slide, with no fire or smoke damage. Black shoe prints were found on the aft side of the cover. The L-1 evacuation slide was deflated and found wadded up on the cabin floor next to the L-1 exit. The girt bar was found installed in its floor fittings. The slide's manual inflation handle was twisted inside the girt skirt. When the slide was unfolded by investigators, the manual inflation handle was still attached to the top of the girt in its stowed position.

The R-1 galley service door was found in three pieces on the cabin floor. The R-1 slide cover was found undamaged on top of the wadded up L-1 slide. The R-1 girt bar and its floor fittings were not damaged; however, foreign material was found inside the aft floor fitting. The R-1 slide was not inflated and the girt end of the slide was in its proper position. The slide cover latch and cable assembly were properly installed around the girt bar in the center girt skirt cutout. The entire right side of the valise was missing and the edges of the slide were charred.

1.12.3 Collision Sequence

Based upon the locations of various DC9 components, embedded in the structure of the B727, and vice versa, and various impact marks and scratches on both airplanes, a collision sequence of events was established.

The first contact occurred when the right wing tip of the B727 struck just below the first officers middle window on the DC9. Exact magnetic headings of the two airplanes at the time of impact could not be determined because one or both of them may have slewed slightly because of pilot input or during the collision. However, it was established that the B727 was nearly on centreline and the DC9 was near the right edge of runway 3C.

As the B727 passed the DC9, tearing of the DC9 fuselage began, and simultaneously the wing tip of the B727 began to disintegrate. As the wing tore through the DC9 fuselage, the outboard mid-canoe fairing of the inboard flab on the under-side of the B727 right wing came in contact with the right main landing gear of the DC9. About the same time, the B727 right main landing gear door impacted the right wing tip of the DC9. The Dc9 wing tip was sheared off and a portion of it remained lodged in the B727 gear door. The B727 right wing continued to cut through the right side of the DC9 fuselage until its No 8 leading edge slat came into contact with the right engine cowl of the DC9. The right wing of the B727 then sheared off at the 13.5 foot point as it came in full contact with the right engine of the DC9, which then separated from its pylon. See figures 5a and 5b for a graphic presentation of the impact sequence.

1.13 Medical and Pathological Information

1.13.1 General

Interviews with crew members in both airplanes and air traffic controllers involved in this accident suggested that they received proper rest before duty. With the exception of the captain of the DC9, all of them had eaten breakfast and lunch prior to the accident. The Dc9 captain stated that his last meal prior to the accident consisted of chicken, a bowl of chilli and cheese stick appetisers and was completed at about 2100 on December 2. The captain decide to skip breakfast the following morning in order to report early to the airport, and he ate no other food before the accident.

1.13.2 Post-accident Toxicological Testing

Federal regulations require Part 121 air carriers to have a drug testing prcgram to prevent illegal drug use in the workplace. NWA has a post0accident drug testing program that was approved by the FAA under 14 CFR 121457. According to FA regulations, urine is collected for drug analysis; alcohol is not one of the drugs identified in the testing procedure. Further, urine collected under this authority and procedure may not be used for any reason not covered in 49 CFR Part 40, "Procedures for Transportation Workplace Drug Testing Program." These procedures are essentially the drug testing guidelines developed by the Department of health and Human Services (DHHS) for federal employee drug-free workplace programs, which require tests of urine for 5 drugs or drug classes; opiates, amphetamines, cocaine, PCP and marijuana at cut-offs specified by DHHS.

Alcohol abuse prevention in the transportation industry was the subject of an Advance Notice of Proposed Rule-making issued in the Federal Register on November 2, 1989, by the Office of the Secretary of the Department of Transportation (DOT).

In addition to the FAA mandated testing program, NWA has its own post-accident drug testing program for its employees. This program includes the collection of blood for alcohol measurements and the collection of urine to test seven drugs or drug classes. The drugs include the five drugs or drug classes in the FAA mandated program and benzodiazepines and barbiturates. Because 49 CFR 40.21(c) states that the urine specimen may only be used to test for the five approved drugs, NWA obtained separate specimens (urine and blood) from its employees to test for the additional two drug classes and alcohol.

1.13.2.1 NWA Post Accident Testing Program

Under NWA's in-house drug testing program, the cockpit crews of both aircraft and two flight dispatchers provided blood and urine specimens for drug testing. The captain and first officer of the DC9 provided these specimens at 2010 and 1910 respectively. The captain, first officer and flight engineer on the B727 submitted specimens at 1950, 2010 and 2025, respectively. The cockpit crew members of both aircraft and the flight despatchers tested negative for all drugs, including alcohol. Flight attendants on the two aircraft were not requested to provide specimens.

1.13.2.2. FAA Post-Accident Drug Testing Program

Urine specimens were collected from the cockpit crew members of both aircraft separately for the FAA-mandated post-accident drug testing program. Urine specimens were collected from the captain and first officer of the DC9 and the captain, first officer and flight engineer of the B727 at the same time the specimens were taken for the NWA program. According to FAA representatives, the specimens were negative for the five drug types.

1.13.2.3 Drug Testing of Air Traffic Controllers

Federal employees in safety-sensitive positions, such as air traffic controllers, are subject to post-accident drug testing under DOT order 3910.1A. This order prescribes DOT's policy and procedures for implementing Executive Order 12564, Drug-Free Federal Workplace. The Executive Order and the Drug Free Workplace do not include testing for alcohol use. The DOT Drug Testing sets forth the procedures to be followed in determining who is to be selected for drug testing following an incident or accident. For air traffic controllers, the following steps are to be followed:

The Flight Standards Division Manager (FSDM), or the Air Traffic Division Manager (ATDM), or the Airway facilities Division Manager (AFDM) will be notified of an accident or event by the regional communication center. Upon such notification, the appropriate manager will determine whether the event qualifies as a covered event, described in section II.A.1. This determination shall be based on all available facts.

Following a determination that the event qualifies as a covered event, the appropriate division managers shall take all practical steps to identify each employee whose performance may have been a contributing factor to the event.

After identification of each employee, as specified in paragraph 2, the appropriate division manager shall exclude from testing any employee so identified when specific and objective information collected in the course of review of the known facts surrounding the event shows that the employee's work performance at or about the time of the event could not have been a contributing factor in the event.

In this accident, the decision about which controller to test was made by the manager of the Air Traffic Division (ATD), FAA Great Lakes region, whose office is in Des Plaines, Illinois. According to his testimony at the Safety Board's public hearing on this accident, he reviewed the sequence of events of each controller by phone conversations, just prior to and at the time of the accident and concluded that only the east ground controller would be subject to drug testing. This decision was made in conjunction with legal counsel at FAA Headquarters in Washington, D.C. The ATD manager stated that based on the information available, he decided to test only the east ground controller. The manager reviewed the time sequence of events and decided that the local controller should not be tested because the controller thought that NWA flight 299 had already taken off when the supervisor told everyone to stop their traffic. Although the manager determined that the flight had not taken off before the ground controller made the statement that an aircraft was lost on the airport and the supervisor ordered all flights to be halted, the manager stated in testimony, "there were no acts he [local controller] could have taken that would have stopped it."

According to the manager's testimony, after he decided to test the ground controller, a urine specimen was obtained around 1730 (about 4 hours after the accident). To do this in a timely manner, the manager testified that he had the urine specimen collected by a doctor on the Detroit area rather than using the DOT urine collection contractor, Upjohn Corporation, which would have required an individual to travel to Detroit form the east coast. According to verbal reports from the FAA, the controller tested negative for the drugs (opiates, cocaine, marijuana, PCP and amphetamines).

The ATD manager testified at the public hearing that he has a few employees involved in an alcohol rehabilitation program. However, he made it clear that he does not have the authority to test for alcohol use.

The Safety Board formally requested that the FAA provide blood and urine samples from all FAA personnel in the tower at the time of the accident. This request was made several times prior to the investigative team's arrival in Detroit. The controllers declined to provide specimens for such testing. Because the local controller refused to provide urine or blood samples to the safety Board for further independent testing, the local controller's use or non-use of alcohol or other drugs not in the National Institute of Drug Abuse (NIDA) protocol immediately before the accident could not be determined.

Conclusions

3.1 Findings

1. All flight crewmembers, flight attendants, and air traffic controllers were properly certificated to perform their duties.

2. Visibilities at the time and are of the collision varied, with the lowest estimated horizontal visibility near 100 feet. The official prevailing visibility determined by National rather Service and Federal Aviation Administration personnel, was ¼ mile.

3. The b-727 captain attempted a takeoff in runway visibility of less than ¼ mile.

4. The runway centreline lights on runway 3C/21C were not illuminated at the time of the accident.

5. The placement of taxiway signs, the conspicuity of taxiway markings, and runway lighting were inadequate at DTW at the time of the accident.

6. The DC-9 flightcrew failed to follow their assigned routing in the taxiway Oscar-6 area.

7. The flightcrew contributed to their confusion by failing to taxi toward and intersect the centreline of the inner taxiway where it paralleled the edge of the concrete as they left the parking area. If they had done so, the centreline leading to Oscar-6 would have been more apparent to them.

8. The complex intersection of taxiway Oscar-4, and runways 09/27 and 3C/21C was a recognized danger area with a strong potential for runway incursions but was nevertheless inadequately marked.

9. The pilots of the DC-9 failed to consistently cross-check the airplane's heading with the headings of their taxi routing.

10. A reversal of command roles occurred during the accident sequence in which the first officer made most of the decisions regarding taxi activity and the captain tacitly relinquished his command role.

11. The first officer misled the captain concerning his familiarity with DTW and failed to follow the captain's direct instructions on three occasions prior to the runway incursion.

12. If the captain and first officer of the DC-9 had received thorough training in cockpit resource management, the command role reversal might not have occurred.

13. The captain of the DC-9 question his position a full 53 seconds before the collision; however, neither he nor the first officer advised the ground controller of their uncertainty at that time. If they had done so, the local controller might have taken action to prevent the B-727 takeoff.

14. The east ground controller missed several opportunities to take appropriate action to resolve confusion on the part of the DC-9 crew.

15. The east ground controller, after he realized the DC-9 might have taxied onto an active runway, did not take timely action to correct the problem.

16. If advanced Airport Surface Detection Equipment-3 had been installed in the tower and if the controllers had been trained in its use, the system might have prevented the runway incursion and subsequent collision by allowing the controllers to keep track of the DC-9.

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17. The flightcrew of the DC-9 was not initially aware of their incursion onto the runway because the runway 3C centreline lights were not on and the runway edge lighting was not continuous.

18. The lead flight attendant if the DC-9 was not in her assigned seat when the accident occurred, failed to properly secure the R-1 emergency evacuation slide girt bar into the floor brackets, and, along with tother trained crewmembers, did not inflate the L-1 evacuation slide, thereby slowing the evacuation and increasing the number of injuries to the passenegers.

19. The lead flight attendant failed to fully open the L-1 door, which may have covered the emergency evacuation slide's inflation handle.

20. The emergency response and fire fighting was timely and effective.

21. The DC-9 tailcone emergency release handle and the release handle lock housing contained a depression worn into the surface b6y the swaged steel ball on the release safety cable.

22. During the Dc-9's "C" check, the interior tailcone release handle was not broken and it was safety wired. No records were found indicating that the tailcone area had bee entered after the "C" check and prior to the accident.

23. The flight attendant and a passenger died of asphyxia secondary to smoke inhalation in the tailcone. The interior tailcone release handle was broken when one of them attempted to jettison the tailcone.

24. Northwest Airlines' maintenance and inspection of the DC-9 tailcone exit system was inadequate.

25. The tailcone's lower right latch was returned to its fully closed position when the male passenger stepped or collapsed onto it, which caused the interior release handle to move to the position in which it was initially found.

26. The Federal Aviation Administration surveillance of Northwest Airlines' Atlanta maintenance base was inadequate.

27. The Federal Aviation Administration failed to recognize important signage, lighting amd marking discrepancies, which, if they had been identified and corrected, could have contributed to avoiding the accident.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was a lack of proper crew coordination, including a virtual reversal of roles by the DC-9 pilots, which led to their failure to stop taxiing their airplane and alert the ground controller of their positional uncertainty in a timely manner before and after intruding onto the active runway.

Contributing to the cause of the accident were (1) deficiencies in the air traffic control services provided by the Detroit tower, including failure of the ground controller to take timely action to alert the local controller to the possible runway incursion, inadequate visibility observations, failure to use progressive taxi instructions in low-visibility conditions, and issuance of inappropriate and confusing taxi instructions compounded by inadequate backup supervision for the level of experience of the staff on duty; (2) deficiencies in the surface markings, signage, and lighting at the airport and the failure of Federal Aviation Administration surveillance to detect or correct any of these deficiencies; (3) failure of Northwest Airlines, Inc., to provide adequate cockpit resource management training to their line aircrews.

Contributing to the fatalities in the accident was the inoperability of the DC-9 internal tailcone release mechanism. Contributing to the number and severity of injuries was the failure of the crew of the DC-9 top properly execute the passenger evacuation.

4. RECOMMENDATIONS

As a result of this investigation, the National Transportation Safety Board makes the following recommendations:

--to the Federal Aviation Administration

Improve standards for airport markings and lighting during low-visibility conditions, such as standards for more conspicuous marking and lighting; evaluation of unidirectional taxi lines for use on acute angle taxiways; and requirements for stopbars or position hold lights at all taxiways that intersect active runways.

Identify, at all 14 CFR 139 certificated airports, complex intersections, where a potential for pilot confusion exists. Where needed, require additional lighting and signs.

Require that the CFR 139 certificated airports use reflectorized paint for airport surface markings.

Require that CFR 139 certificated airports install semiflush runway edge lights in accordance with Advisory Circular 150/5340-24.

Include directions, in the forthcoming Advisory Circular for Surface Movement Control Guidance Systems, that 14 CFR 139 certificated airports, which operate at runway visual ranges of 1,200 feet or less, follow ICAO Annex 14 standards.

Include guidance in Advisory Circular 150/5220-4, Water Supply Systems for Aircraft Fire and Rescue Protection, that addresses the need for fire departments to be notified in a timely manner when hydrants and water supply systems used for fire fighting are inoperable.

Issue an Advisory Circular addressing acceptable methods the design, construction, operation, and maintenance of mock-ups used for exit training during crewmember emergency training, and provide guidance to FAA inspectors to ensure that emergency equipment training devices accurately replicate the intended operational environment.

Require that air traffic control tower managers reemphasise the concept and use of progressive ground movement instructions during low-visibility ground operations in Local Operations Position Standards Handbooks.

Require that air traffic control tower managers emphasise to local controllers the need for positive determination of airplane departures in IFR conditions when direct visual observations of departing airplanes are not possible.

Develop and implement procedures fro redundancy of critical controller tasks and expedite the development and installation of hardware systems to supplement such redundancy.

Require that during National Aviation Safety Inspection Program (NASIP) inspections, the majority of the team members be from different FAA regions than the FAA personnel being inspected.

Require that an assessment of local FAA surveillance effectiveness be a formal part of NASIP inspections, so that NASIP findings can be used to correct observed deficiencies of local inspectors as well as those of the airlines.

Require that the subject of low-visibility taxi problems become a recurring subject in all airline operations manuals and pilot training forums.

--to Detroit Metropolitan/ Wayne County Airport.

Install semiflush runway edge lights in accordance with Advisory Circular 150/5340-24

Implement a program for the prompt repainting of faded taxiway and runway markings when they are seen during daily airport inspections, rather than waiting for a set schedule for overall airport restriping.

--to Northwest Airlines, Inc.

Immediately institute comprehensive line crewmember Cockpit Resource Management training as part of Northwest Airlines' Line-Oriented Flight Training and coordinated crew training programs.

In addition, the Safety Board reiterates the following safety recommendations to the Federal Aviation Administration:

> Integrate the NASIP team leader in the closeout of the tem findings.
>
> The regulations concerning drug testing of the U.S. Department of Transportation employees should provide testing requirements that include and drugs beyond the five drugs or classes specified in the Department of Health and Human Services (DHHS) guidelines and that are not limited to the cutoff thresholds specified in the DHHS guidelines. Provision should be made to test for illicit and licit drugs as information becomes available during an accident investigation.

Note: This is an edited version of the original NTSB report. Some sections have been omitted.

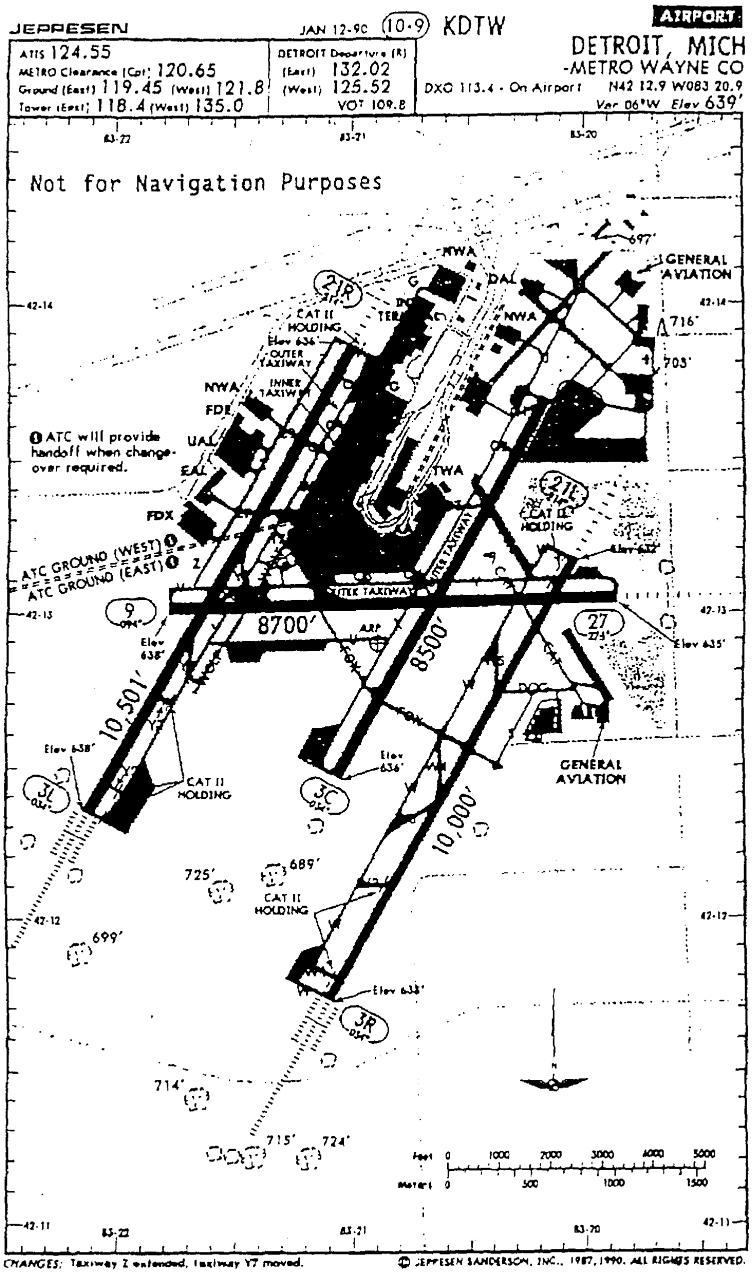

Figure 1: Detroit Landing Chart (Jeppesen)

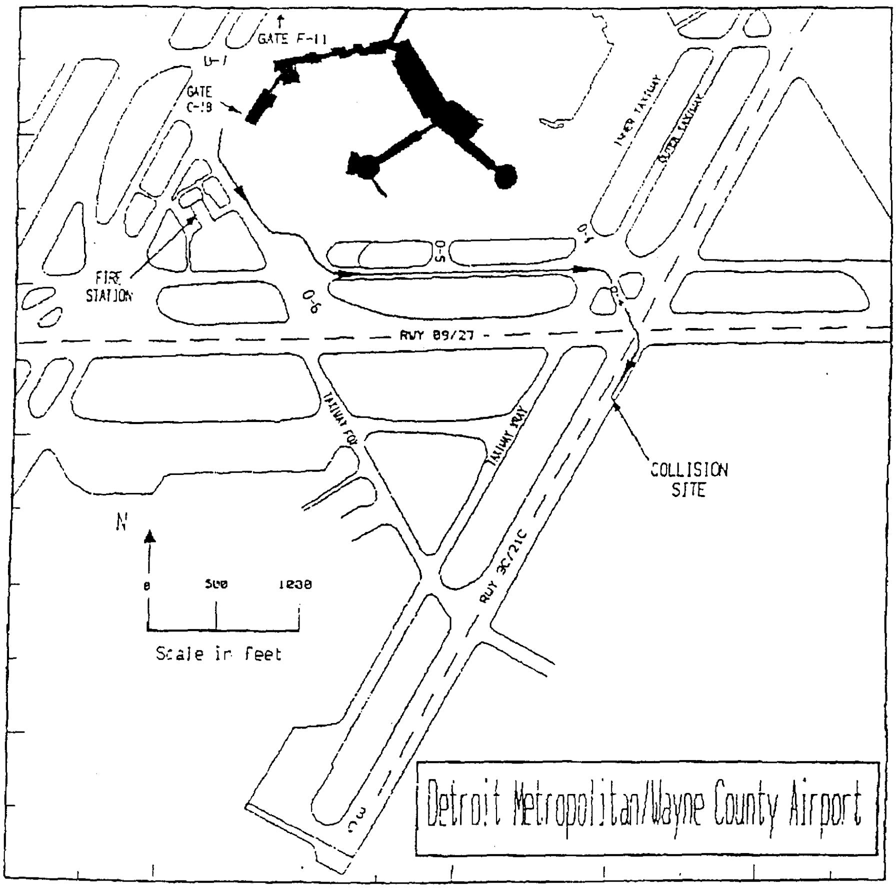

Figure 2: Detroit Layout and DC9 Taxi Route

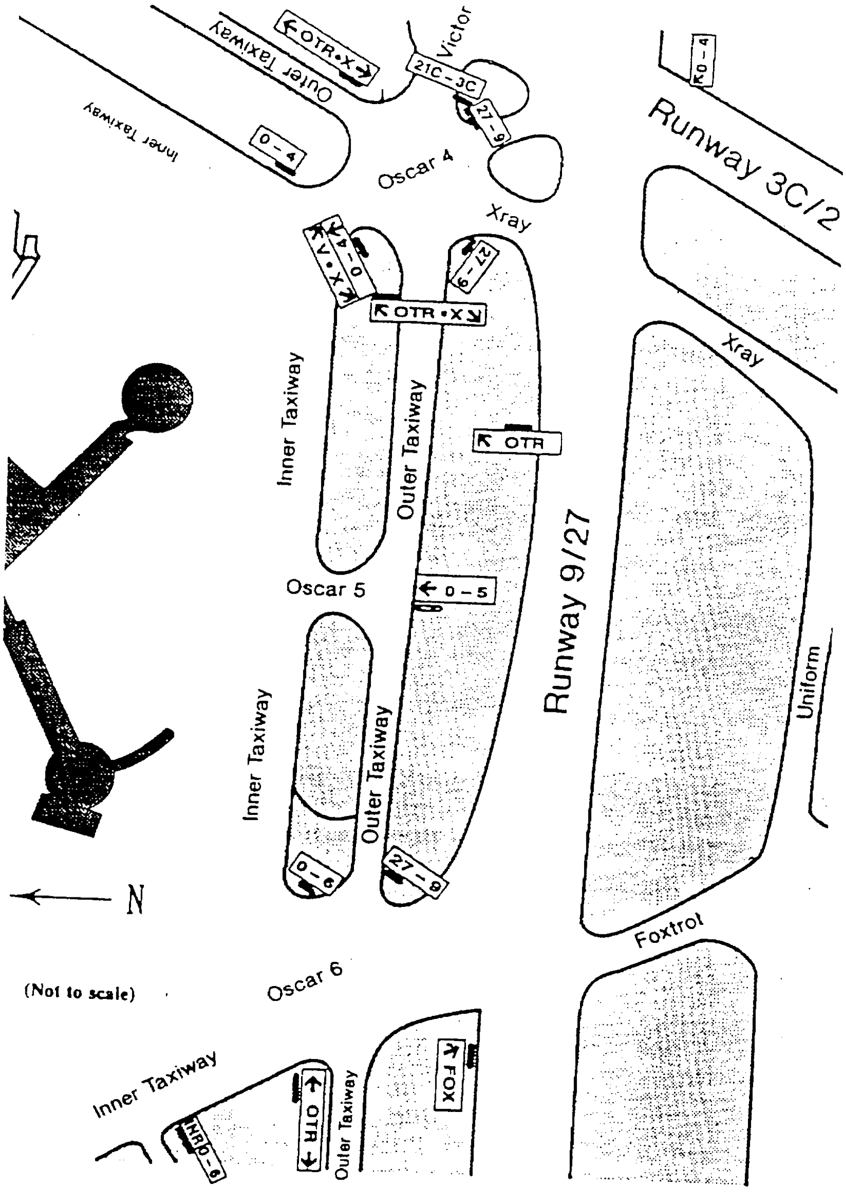

Figure 3: Detroit Taxiway Signs

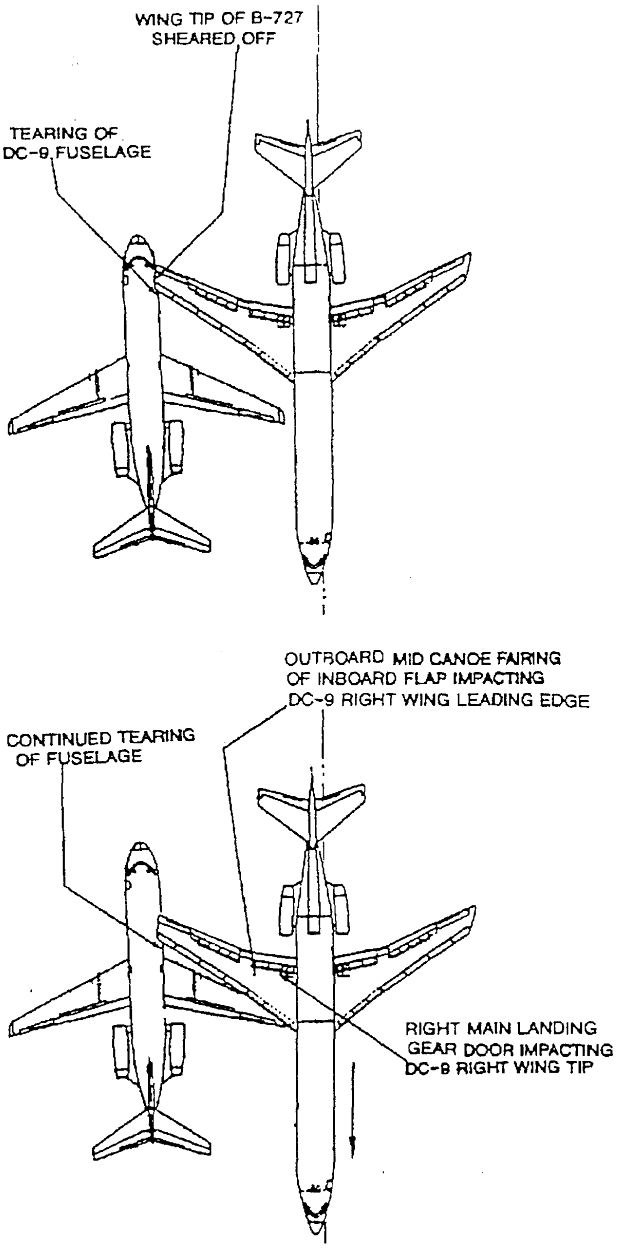

Figure 4: Detroit Impact Sequence 1

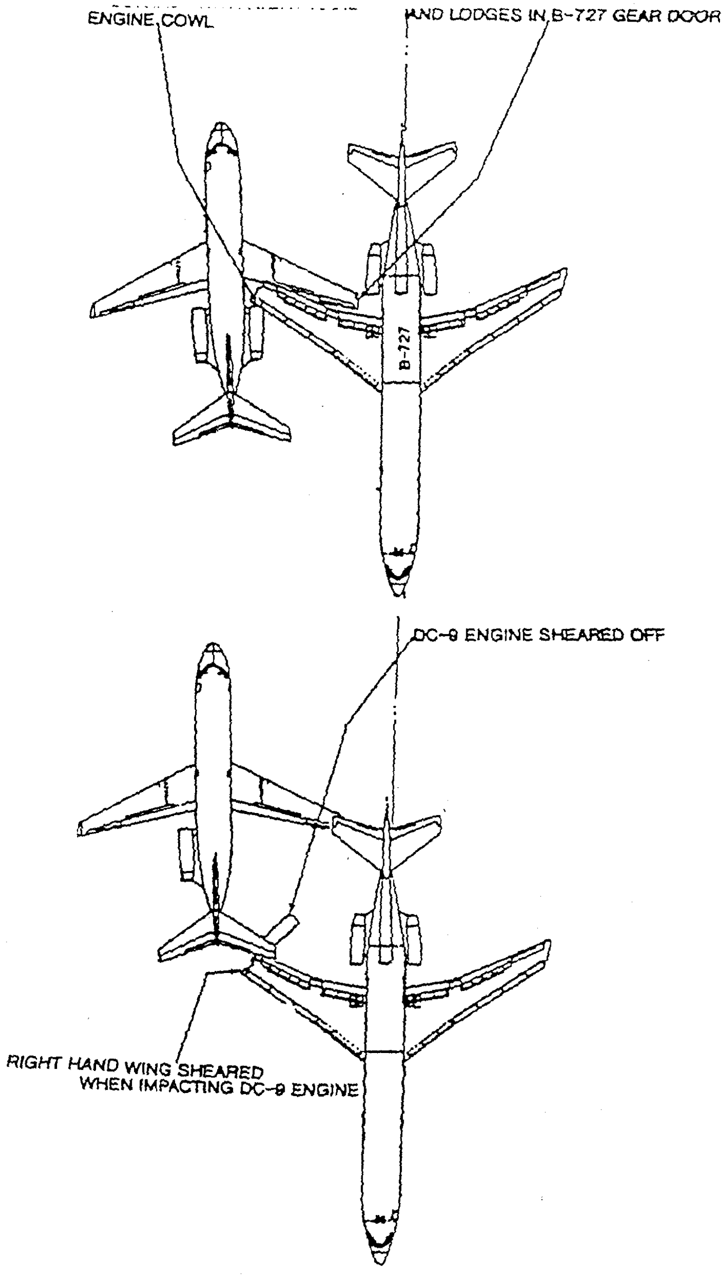

Figure 5: Detroit Impact Sequence 2

The Lambourne Incident

Report on an incident near Lambourne VOR on 3 July 1997 AIRPROX (C): Boeing 747 and Gulfstream G IV

Aircraft Incident Report No. 4/98 (EW/C97/7/1)

Note: This is an edited version of the original AAIB report. Some sections have been omitted.

Air Accidents Investigation Branch[13]

<u>Contents</u>

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[13] Used with permission from the United Kingdom Air Accidents Investigation Branch.

5. Appendices

Appendix 1 - Track Plots

Appendix 2 - ATC RT Transcripts

Appendix 3 - London and Luton Stars

Figure 1 Figure 2 Appendix 4 - SMF listing and plots

Figure 1 Figure 2 Appendix 5 - AIRPROX reporting and investigation [Extract from AIC]

Operator:	i) Japan Airlines (JAL)	ii) ITT Corporation
Aircraft Type and Model:	i) Boeing 747-300	ii) Gulfstream IV
Nationality:	i) Japan	ii) United States
Registration:	i) N213JL	ii) N153RA

Location of incident: 14 nm east of Lambourne VOR between Flight Level 120 and 115

Latitude: 51° 38.73' North Longitude: 000° 34.2' East

Date and Time: 3 July 1997 at 1443 hrs

All times in this report are UTC

Synopsis

The investigation was conducted by Mr R StJ Whidborne (Investigator in Charge), Mr A F Rhodes (Operations) and Mr R J Tydeman (Operations). The investigation was assisted by Ms D A Westley, an Air Traffic Control specialist employed by the Directorate of Safety and Operations of the National Air Traffic Services Limited (NATS), who was appointed by the Secretary of State under Regulation 8(8) of the Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 1996.

A loss of separation occurred between a Boeing 747-300 (B 747) and a Gulfstream IV (G IV) in the London Terminal Control Area, which is Class A controlled airspace. The B 747 was en route from Kansai, Japan, to London (Heathrow) Airport; the G IV was en route from Olbia, in Sardinia, to London (Luton) Airport.

The B 747 began its descent after entering the UK Upper Information Region (UIR) from Holland and was controlled through the Clacton Sector for arrival at London Heathrow. It was cleared initially to Flight Level (FL) 290 then FL 150, and later to FL 110, whilst routing direct to the Lambourne VOR and maintaining 290 Kt. On making contact with Heathrow Intermediate North Director the B 747 was cleared to descend to FL 90, to leave Lambourne on a heading of 270°, and to reduce speed 'now' to 210 Kt.

The G IV entered the UK FIR from France and was controlled through the Lydd Sector for arrival at Luton via the Detling VOR. When the G IV contacted the Lambourne controller it was level at FL 130 and was permitted to maintain high speed whilst given a radar heading of 340°, it was subsequently cleared to FL 120.

As the G IV reached FL,120 the pilot reported that his Traffic Alerting and Collision Avoidance System (TCAS) was indicating traffic in his one o'clock position. The controller initially thought that there was 1,000 feet vertical separation between the two aircraft and declared this, but he then gave the G IV avoiding action, after the pilot reported that the traffic was 300 feet below him, to turn to the left which took it out of the path of the B 747.

At the same time the B 747 crew complied with the first of two TCAS Resolution Advisory (RA) messages. The first instruction was to climb followed by a subsequent instruction to descend. Subsequent analysis of the recorded radar data showed the closest proximity of the two aircraft was 0.83 nautical miles (nm) horizontally with vertical separation of 100 feet; the next element of the recorded radar data indicates that the vertical separation had then increased to 200 feet with the horizontal separation reducing to 0.66 nm.

The following causal factors were identified:

1. The B 747, having left FL 120 then stopped descending some 300 feet below this level whilst reducing speed from 290 Kt to 210 Kt. FL 120 was assigned to the G IV by the bandboxed Terminal Control North East Departures/Lambourne controller before the proper vertical separation had been established after its direct routing towards Luton had brought it into lateral conflict with the B 747.

2. The North East Departures / Lambourne controller did not apply the procedure given in MATS Part 1 regarding level assessment of SSR Mode C (height information) when giving clearance to the G IV to FL 120. The controller should have waited for the B 747 to have had a readout of at least FL 116 (400

feet below the vacated level) before clearing the G IV to descent. The controller then did not monitor the Mode C readout of the B 747 to ensure that it was 'continuing in the anticipated direction'.

3. Despite reporting to the Heathrow Intermediate North controller that the aircraft had vacated FL 120, the B 747 did not descend at the minimum rate mandated for the UK and detailed in the UK Air Pilot (500 ft/min). If it was not possible to comply with this requirement, the crew were required to inform the controller but did not do so.

4. The Heathrow Intermediate North controller, unaware that the aircraft speed was 290 Kt, called for a combined speed and level change which resulted in the B 747 having a minimal rate of descent while its speed reduced.

5. The B 747 crew did not report their speed control, which had been imposed by Clacton SC, to the Lambourne Sector, thereby allowing the controllers to assume a standard speed of 250 Kt.

6. Since the TCAS manoeuvre was not fully co-ordinated by both aircraft's TCAS, one of which was not selected to TA/RA, the B 747's initial RA reduced the separation distance.

Five safety recommendations are made.

1 Factual information

1.1 History of the flight

1.1.1 Controller identification

The B 747 had been controlled by the Clacton Sector controller (CLACTON SC) before he released it to the Lambourne Sector controller (TC LAM). At the time of the incident it was receiving an ATC service from the Heathrow Intermediate North Director (LL INT N).

The G IV had been receiving an ATC service from the Lydd Sector controller who released it to the Lambourne Sector controller (TC LAM). At the time of the incident the positions were 'bandboxed' as TC Sector North East Departures / Lambourne controller (TC NE / LAM).

The sequence of handovers was thus:

B 747 --»Clacton --»Heathrow Intermediate North--» Lambourne--»

G IV --»Lydd -----»became NE Departures/Lambourne

1.1.2 The Boeing 747

The B 747 on a flight from Kansai, Japan, to London (Heathrow), began its descent at 1427 hrs after entering the UK FIR from Holland. It was cleared to FL 150 by the CLACTON SC with instructions to report the speed control of 290 Kt, which had been imposed at 1432 hrs, to TC LAM. On transfer to TC LAM the pilot reported leaving FL 192 for FL 150 but neglected to inform the controller of the speed control. The flight was given a radar heading and further descent in stages to FL 120. Before reaching this level the B 747 was given descent clearance to FL 110 and cleared direct to the LAM VOR. At 1441:32 hrs the flight was released to the LL INT N controller before TC LAM was 'bandboxed' with TC NE.

At 1441:49 hrs the B 747 crew established communication with the LL INT N controller. On receipt of this initial call LL INT N issued the following clearance, "Descend to FL90 and leave Lambourne heading 270°, reduce speed now to 210 knots". At this stage the B 747 was beyond the selected range of LL INT N's radar display and remained so until after the incident.

1.1.3 The Gulfstream IV

The G IV on a flight from Olbia, Sardinia, to London (Luton), entered the UK UIR from France through the LYDD sector and was cleared from overhead Abbeville to route via DETLING on a Lorel 3E arrival (refer to paragraph 1.10.3). Subsequently, the flight was requested to expedite its descent to FL 130 to be level at DETLING and was later cleared to the position BOYSI which is within the northern part of the London Terminal Area. To achieve the descent profile required by LYDD SC the flight had maintained a rate of descent of over 4,000 ft/min. At 1441 hrs the G IV contacted the TC LAM controller when at FL 130 and was permitted to maintain high speed. At 1442:15 hrs it was given a heading of 340° in order to provide a shorter routing to Luton. Luton inbound flights are often handled in this manner, however, on this occasion the assigned heading placed the G IV on a track which resulted in a conflict, in plan, with the B 747. At this stage standard vertical separation existed but at 1442:38 hrs the G IV was cleared to descend to FL 120. The aircraft was in receipt of a radar control service from TC NE / LAM at this time since the two sectors had been combined (bandboxed).

1.1.4 The loss of separation

The aircraft were converging at right angles to each other, the B 747 on a westerly track towards LAM VOR and the Gulfstream on an assigned radar heading of 340°. The respective tracks and relevant timings are shown in Appendix 1. The B 747 had been transferred to LL INT N from TC LAM descending to FL 110 and was then further cleared by LL INT N to FL 90 whilst attempting to decelerate. When TC NE / LAM considered that the B 747 had vacated FL 120, based on his observation of the flight's Mode C readout on his radar display, he cleared the G IV to that level. However, whereas the G IV descended rapidly to FL 120 the B 747 actually stopped its descent at FL 117 resulting in a serious loss of separation. TC NE/LAM was first warned of the developing situation by the crew of the G IV who relayed information generated by their TCAS; the LL INT N controller was alerted by the activation of the Short Term Conflict Alert (STCA): 'avoiding action' instructions were then issued to both flights. Vertical separation was further reduced when the B 747 climbed back to FL 122, in response to a RA message generated by the TCAS. The minimum separation was 0.83 nm horizontally and 100 feet vertically. Four seconds later the vertical separation increased to 200 feet with a corresponding horizontal separation of 0.66 nm.

1.1.5 The TCAS event

The B 747 was in level flight at FL 117 when its TCAS issued a Traffic Advisory (TA) at 1443:20 hrs; the associated TCAS display indicated that there was traffic approximately 3 nm to the left and 300 feet above. The crew were unable to see this traffic since they were in cloud at the time. The G IV was maintaining a high forward speed and was descending to FL 120 at a rate of approximately 2,000 ft/min. The TCAS reacted to this traffic by issuing a ' CLIMB' RA to the crew of the B 747 whose handling pilot disconnected the auto pilot and followed the climb instruction; the TCAS then reversed its RA to 'DESCEND'. The aircraft reached a maximum altitude of FL 122 before commencing the descent. The aircraft was subsequently given avoiding action by the ATC controller. The crew did not inform ATC of the TCAS event.

The G IV, which had been maintaining high speed as instructed by ATC, was levelling at FL 120 when the crew received a TA for traffic which was indicating 300 feet below them in their one o'clock position at a range of about 3 nm. The pilot queried this traffic with ATC but was told that it was 'maintaining a thousand feet below'. The controller later stated at interview that in giving this information he may have misread the Mode C Secondary Surveillance Radar labels as '107' instead of the actual '117', possibly as a result of some label overlap on his display. The pilot pointed out that the traffic was indicating about 300 feet difference and TC NE / LAM, realising that this was in fact the situation, then gave him avoiding action via a turn to the left. The TCAS on the G IV aircraft did not issue an RA, probably because it was selected to TA (see paragraph 1.6.3 for a fuller explanation).

Neither crew saw the other aircraft prior to the incident. As the crew of the G IV entered the left turn onto 250°, as instructed by ATC, they saw the other aircraft briefly before it went back into cloud. The crew of the B 747 were in the descent element of the RA when they briefly saw the other aircraft in a left turn. One of the pilots of the B 747 estimated that the other aircraft was approximately 200 metres (0.1 nm) away with 100 feet to 200 feet vertical separation; he could clearly see the belly of the G IV aircraft. Analysis of data from Debden radar for each aircraft suggest that the minimum distances occurred at 14:43:58 hrs, when the lateral separation was 0.83 nm with 100 feet vertical separation, and at 14:44:02 hrs, when the lateral separation had reduced to 0.66 nm and the vertical separation was now 200 feet. However, these separations are based on interpolations of the raw data and may not accurately reflect the true separations.

1.2 Injuries to persons

There were no injuries.

1.3 Damage to aircraft

Not applicable.

1.4 Other damage

Not applicable.

1.5 Personnel information

The flight crews of the two aircraft involved in the incident were correctly licensed, medically fit and properly rested to perform their duties. Both aircraft crews were familiar with operations in the London TMA.

1.5.1 North East Departures Sector Controller NE (TC NE)

Male aged 27 years

Operational experience: Two years at the unit with 8 months experience on the position (NE Departures).

Time on duty: 2 hours 13 minutes

Time since last break: 10 minutes

1.5.2 Heathrow Intermediate North Director (LL INT N)

Male aged 29 years

Operational experience: Heathrow Approach for two years and six months; previously at Gatwick

Time on duty: 1 hour 43 minutes

Time since last break: 20 minutes

1.5.3 Lambourne Sector Controller (TC LAM)

Female aged 28 years

Operational experience: One year 11 months in the position

Time on duty: 2 hours 13 minutes

Time since last break: 9 minutes

1.5.4 Training

The training of controllers has to match the requirement to deliver a safe and efficient service against rising traffic levels. After 'ab initio' training, specific role training, generally Area or Aerodrome in the first instance, is provided up to validation. Thereafter there is a continuous process of assessing individual controller's operational competence. CAA licensing requirements call for controllers to practice emergency and incident handling on an annual basis using simulators.

1.5.5 Controller familiarisation

ATC controllers are encouraged to familiarise themselves with the working environment of the modern flight deck. During training, students on the NATS Student Controller Training Course are given 15 hours of flying training in a two week familiarisation module. In addition an Airline Awareness Course is also given to student controllers. It includes Flight Management System simulator experience and includes two European familiarisation flights. Training for a Private Pilot's Licence is no longer available. NATS also provide a two week Customer Awareness Course for more experienced controllers. During their service controllers may undertake familiarisation flights on a voluntary basis.

In practice a shortage of trained controllers combined with the requirements of their job means that few controllers manage to achieve flight deck experience on a modern flight deck. It is this type of experience which will be of most benefit to controllers operating within Terminal Control (TC) to give them an understanding of the problems which can be encountered as flight crews comply with ATC instructions. Equally, flight crews need to be familiar with the problems encountered by ATC staff controlling a busy segment of airspace.

Dissatisfaction with the existing arrangements and the need for improved familiarisation training was identified in a number of reports submitted by controllers to the Confidential Human Factors Reporting Programme (CHIRP). Issues Nos. 42 and 43 of 'Feedback', CHIRP's monthly publication, reported on the practical difficulties of arranging familiarisation flights for controllers and commented on the rare attendance of flight crew in ATC units. Most common obstacles were time pressures on work schedules, lack of status as supplementary crew members for the observing controllers, and lack of duty time combined with allowances to facilitate such activity. The reports commented on the mutual benefit both to pilots and controllers of a structured system of familiarisation training.

1.6 Aircraft information

1.6.1 Boeing 747-300

The 747-300 aircraft was standard for the type and was fitted with a Performance Management System (PMS). The purpose of the PMS is to allow the pilot to enter, store and modify en route the intended vertical profile of the aircraft. This can be achieved by entering the required speed and/or altitude and then following the flight director commands either through the autopilot or in manual flight. When in a descent mode the PMS will prioritise speed: i.e. if a descent and a speed reduction is entered the PMS will command the speed reduction whilst maintaining essentially level flight and then, once the speed is achieved, it will command the descent.

When decelerating the use of speedbrake with flaps is prohibited. Thus if instructed to decelerate from 290 Kt to 210 Kt the optimum procedure for the crew would be to close the throttles and select speedbrakes until approaching the minimum manoeuvre speed for the clean configuration when the speedbrakes would be stowed and flap 1 selected. In this instance the aircraft was at an estimated AUW of 258 tonnes which relates to a Vref of 143 Kt, the associated minimum manoeuvre speed for the clean configuration was therefore 223 Kt. However, because the aircraft was in icing conditions the crew would have been unable to close the throttles fully since a minimum of 50% N1 is required when above 10,000 feet in such conditions. The limiting speed for the selection of flap 1 was 275 Kt.

1.6.2 Gulfstream IV

The G IV was equipped with a Honeywell digital integrated flight control system which would normally command a 3° descent profile when in the descent. When descending at 300 Kt this would equate to approximately 2,000 ft/min rate of descent.

1.6.3 Airborne Collision Avoidance System

The TCAS alerts the crew to traffic that may present a collision threat and provides the crew with a vertical avoidance manoeuvre. TCAS is independent of, but does not replace, the ground based ATC system. The TCAS equipment uses the transponder to interrogate the transponders of other aircraft in the vicinity to determine their range, bearing and altitude. TCAS generates a Traffic Advisory (TA) when another aircraft becomes a potential threat, no manoeuvres are required for a TA. If the confliction continues and becomes an imminent threat, a Resolution Advisory (RA) is generated. The RA provides a vertical restriction or manoeuvre to maintain or increase separation from the traffic.

The TCAS operating mode is controlled from the transponder panel. TCAS is normally operated in the TA/RA mode. However, provision is made to allow operation in the TA only mode in order to prevent undesired RAs: e.g. during engine out operations when the aircraft may be unable to follow a climb command. Both aircraft in this instance were equipped with TCAS using the current software standard, referred to as 'Version 6.04A (enhanced)'.

The crew of the B 747 had their TCAS equipment selected to the TA/RA mode since they received both sets of instructions to which they responded promptly and correctly. The crew of the G IV could not confirm the TCAS selection at the time of the incident, although their normal procedure was to select TA/RA prior to take off and they had no reason to deviate from this on this particular flight. When this crew received the initial TA they queried the vertical separation with ATC and it was this which alerted the controller to the need for avoiding action. However, the G IV crew did not receive an RA at all. Moreover, the logic embedded within the current TCAS software does not allow for reversals in RAs during encounters with other TCAS equipped aircraft operating in the RA mode yet in this case such a reversal occurred. It is therefore apparent that the TCAS in the G IV was being operated in the TA only mode at the time of the incident. It should be noted that, at the time of the incident, the carriage and use of TCAS in UK airspace was not mandatory for any category of aircraft.

1.7 Meteorological information

The synoptic situation at 1400 hrs on the day of the incident comprised an area of low pressure centred over northern England with an unstable southerly airflow over the area. The weather consisted of scattered showers with visibility of 15 to 20 km or more. The mean sea level pressure was 1006 mb and the temperature at 12,000 feet was -12°C. The cloud base was scattered at 2,000 feet and broken at 5,000 feet with tops about 12 to 16,000 feet amsl. The wind at 10,000 feet was 220°/25 to 30 Kt; at 18,000 feet it was 200° /20 to 30 Kt. Both aircraft were in cloud at the time of the AIRPROX.

1.8 Aids to navigation

The G IV had been instructed to maintain a radar heading given by the controller. The B 747, from flight deck interpretation of ground based navigation aids, was tracking towards the LAM VOR. The performance and accuracy of navigational aids were not relevant to the circumstances of the incident.

1.9 Communications

On entering the UK FIR the B 747 was controlled by the LATCC Clacton Westbound Sector and the G IV was initially controlled by the Lydd Sector. Both flights were released by their respective controllers to the Lambourne Sector who in turn transferred the B 747 to the Heathrow Intermediate North controller and the G IV remained with Lambourne which was then bandboxed with TC North East Departures as TC NE / LAM. After the AIRPROX had occurred the B 747 was handed over to Heathrow Final Director and the G IV to Luton Approach control.

Relevant extracts from the recorded transcripts involving the above controller positions (except for Luton) are shown in Appendix 2.

1.10 Aerodrome information (Air Traffic Control environment)

1.10.1 Statistics

In the calendar year 1997 LATCC provided an ATC service to 1,579,034 General Air Traffic flights within controlled airspace. Of these flights 928,661 operated within the London TMA. In the same period, 25 AIRPROX reports were filed within the TMA of which 16 were AIRPROX (C) incidents. Four have already been reviewed by the Joint Airprox (C) Assessment Panel (JAAP). They considered that three of these were Category 'C' (no risk of collision) and one was Category 'B' (possible risk of collision). One of the remaining AIRPROX s relates to this particular incident and another, involving a Boeing 737 and a BAe 146, was investigated by the AAIB whose report was published in April 1998. Six of the remaining ten incidents involved horizontal separations of greater than 1 nm but have yet to be reviewed and categorised by the JAAP.

1.10.2 The London Terminal Control Area

The London TMA (Terminal Manoeuvring Area, subsequently redesignated Terminal Control Area) airspace complex has evolved over a period of more than forty years and is established to enable aircraft operating into and out of the various London airports to be provided with a controlled, known traffic environment. Air Traffic Services within the London TMA are provided by the National Air Traffic Services Limited (NATS) from the London Area and Terminal Control Centre (LATCC) at West Drayton. The design and establishment of the airspace is the responsibility of the Civil Aviation Authority's Directorate of Airspace Policy and consists of Class A airspace with varying base levels extending to an upper level of FL 245 (Class A airspace requires all aircraft within it to operate according to the Instrument Flight Rules under an air traffic control separation service). Currently, the airspace covers an area which generally encompasses the London Heathrow, London Gatwick, London Luton, London Stansted and London City airports together with their associated instrument holding areas and the surrounding airspace is divided into a number of air traffic control (ATC) sectors.

The ATC task is to integrate the flightpaths of aircraft arriving at and departing from the various airports with those of overflying aircraft and those wishing to join the airways system in the London area. Appropriate separation standards are applied throughout. The complex nature of the operation is eased by the use of Standard Terminal Arrivals (STARs) and Standard Instrument Departures (SIDs) which specify predetermined tracks and altitudes to be flown by arriving and departing traffic. Normal ATC co-ordination procedures are augmented by the use of 'Standing Agreements', these allow aircraft to enter the airspace of an adjacent sector without individual co-ordination as long as certain conditions regarding altitudes or flight levels, routings etc, are met. Standing Agreements are fundamental to the operation of a busy ATC unit such as LATCC, since they facilitate the flow of traffic between sectors working on the basis of what a controller expects from an adjacent sector, without the need for individual telephone co-ordination. Within this environment controllers are also required to exercise tactical control of the situation using radar facilities to ensure that safe and efficient use is made of the airspace.

1.10.3 Standard Terminal Arrival Route (STAR) for Luton

The LOREL 3E STAR is in place to facilitate the safe handling of aircraft inbound to London Luton Airport (the destination of the G IV) and London Stansted Airport from the south which need to cross the predominantly eastbound/westbound flow of the LATCC Terminal Control North East (TC NE) sector. An extract from the UK Aeronautical Publication (AIP), showing STARs via LOREL (east) and STARs via LAMBOURNE, which were current at the time of the incident, is shown at Appendix 3.

Aircraft following the STAR are required to be at specified levels (published in the 'descent planning' table of the STAR charts) in order to comply with the relevant Standing Agreement. For aircraft following the LOREL 3E STAR, the Standing Agreement into the receiving TC sector requires an aircraft to be level at FL 130 by Detling. The Lydd sector controller, controlling the G IV, was tasked with ensuring that the flight achieved this requirement. The TC NE sector controller is required to ensure that FL 130 is available for traffic routing on a LOREL 3E STAR.

1.10.4 Short Term Conflict Alert

Short Term Conflict Alert (STCA) is an automated system which alerts controllers to potential conflicts between aircraft using the radar display. As the name suggests STCA is designed to look for conflicts in the short term, i.e. the next two minutes. STCA has been gradually introduced into more complex airspace in the UK and has been covering operations in the London Terminal Control Area since November 1995. .

STCA is designed to improve safety by alerting air traffic controllers to potential conflicts involving at least one aircraft under their control. STCA recognises an aircraft under ATC control by reference to its Mode A code. Conflict alert warnings will only be given for two aircraft where at least one is controlled from an ATC centre equipped with STCA.

To assist flexibility within the NATS system distinct 'regions' of airspace are defined. Typical STCA region types are 'en route', TMA, advisory, approach, departure, and stack. Different STCA software parameter values can be set for each STCA region type; these will depend on the airspace and the separation standards applied.

Alerting aircraft are identified on the radar display by flashing target labels in colours to denote the severity of the conflict. Low severity alerts are shown in white and high severity alerts are shown in red. A separate pop-up conflict alert list on the controller's screen allows rapid identification of aircraft in conflict. This is particularly useful if target labels are overlapping.

LL INT N recalled that the STCA had immediately displayed in red, denoting a high severity alert. An analysis of the recordings of the STCA system relating to this encounter was conducted by the Department of Technical Research and Development of NATS using radar data from the incident. This indicated that the alert would have gone straight to red because of the late stage at which the situation went from a safe to an unsafe condition. The analysis notes that the B 747 was level at about FL 117 whilst the G IV was descending towards FL 120. The aircraft were converging laterally, however, the G IV was initially predicted to pass safely beneath the B 747 before lateral separation fell below the STCA linear prediction alerting criteria (2.0 nm for TMA regions). When the G IV slowed its rate of descent and began to level at FL 120 STCA 'imminent' linear prediction conditions were met and an alert immediately declared. The alert continued as the aircraft closed laterally with less than 500 feet vertical separation. The alert stopped as both aircraft had begun lateral avoidance manoeuvres. Furthermore, STCA has no knowledge of cleared levels and therefore could not predict that the G IV would level until the manoeuvre had begun. The analysis assessed that STCA had performed in accordance with its specification.

The next generation of system 'safety nets', which includes medium term conflict detection, is being developed in conjunction with European partners. This is being developed to detect potential separation conflicts between approximately 2 and 20 minutes ahead of Closest Point of Approach (CPA).

1.10.5 Separation Monitoring Function

Separation Monitoring Function (SMF) has been in service at LATCC since December 1993. It continuously and automatically monitors the separation between transponding aircraft and will detect any breach of pre-defined separation criteria that takes place within the coverage of the LATCC en route radar system. SMF is not a Collision Avoidance System. The equipment provides post-event notification to assist in determining circumstances and factors that led to the loss of separation. The equipment uses radar to determine the horizontal separation between aircraft, and transponder mode C to measure the vertical separation. At the time of this incident the equipment was set to detect any pairs of aircraft simultaneously within 2 nm and 600 feet of each other.

Filtering and categorisation is used to identify instances where the use of reduced separation is permitted. Any breach of the pre-determined criteria which cannot be attributed to any known ATC procedure is automatically notified within 5 minutes to unit managers, enabling the investigative process to commence. A printed diagram, depicting the aircraft involved in both the horizontal and vertical plane, can be produced for every loss of separation detected by SMF. The aircraft have different plot symbols which are updated every 4 seconds. The callsigns of the aircraft and the location of the incident are shown at the bottom of the diagram. The SMF listing and diagrams for this incident are shown at Appendix 4.

1.11 Flight recorders

The flight recorders fitted to both aircraft were not removed for analysis. Adequate data for the investigation was available from the recordings of ATC RT frequencies and secondary radar returns.

1.12 Wreckage and impact information

Not applicable.

1.13 Medical and pathological information

Not applicable.

1.14 Fire

Not applicable.

1.15 Survival aspects

Not applicable.

1.16 Tests and research

1.16.1 TCAS simulation

This AIRPROX incident was evaluated on a TCAS simulator operated by the Defence Evaluation and Research Agency and located at Malvern, Worcestershire. The simulator utilises the same software as that installed on the airborne equipment. The validity of this simulator has been verified by evaluating a large number of known models and comparing the output to those of the known events. Whilst there is a reasonable level of confidence in the fidelity of the simulation it is sensitive to slight variations in the input data which in this instance was recorded radar data. The TCAS algorithms evaluate the data once every second whereas the rate of acquisition of the radar data is dependent on the rate of rotation of the radar head which is typically once every 8 or 9 seconds. Missing data is therefore obtained by interpolation and consequently its accuracy cannot be assured.

When this particular TCAS event was first simulated, the radar data used was that which had been remotely transmitted to Malvern and this resulted in a 'DESCEND' RA. The simulation was later run using the radar data which had been impounded at LATCC and this resulted in an initial 'CLIMB' RA which then reversed to a 'DESCEND' RA thereby recreating the event as described by the crew of the B 747. The difference in the result of these two simulations is due to slight differences in the input data. Although both sets of data originated from Debden radar, the recording impounded at LATCC and the local recording at Malvern have different time stamps associated with the plots. This difference resulted in slightly different trajectory reconstructions. The consequence was that both simulations adjudged that

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a crossing 'CLIMB' RA provided the better separation. However, the LATCC based simulation has a high confidence in the conflicting aircraft's tracked vertical rate and issued the RA promptly, which, as the encounter developed and the conflicting aircraft levelled off, reversed to a 'DESCEND' RA. The Malvern based simulation has a lower level of confidence in the vertical profile and, due to a bias within the algorithms against crossing RAs with a low confidence level, delayed issuing the RA . When the RA reversed in sense it was no longer a crossing RA and so it was then issued as a 'DESCEND' instruction.

1.16.2 Aircraft simulation

The flight profile of the B 747 during the period prior to the TCAS event was investigated in a full flight simulator. This modern simulator was equipped with an aircraft standard PMS equivalent to that fitted to the incident B 747. The aircraft parameters and environmental conditions were simulated to match those occurring at the time of the AIRPROX .

The PMS had a default setting to command a speed reduction to less than 250 Kt when descending below FL 100. In order to ensure that this was not a factor in the flight profile, the simulator was allowed to descend from FL 150 to FL 80 with an initial airspeed of 290 Kt and the default speed reduction armed. The airspeed of 290 Kt was maintained with a steady rate of descent until FL 111 when the rate of descent reduced to 1,000 ft/min and the airspeed slowly reduced to 250 Kt by FL 105. This default setting did not contribute to the flight profile of the incident B 747 when it levelled at FL 117.

The simulator was repositioned in level flight at FL 120 and 290 Kt and was then commanded to descend to FL 90 at 210 Kt. The speed of 210 Kt was not accepted by the PMS which recognised the minimum speed in the clean configuration of 223 Kt and so 225 Kt was entered until flap 1 could be selected. It was noted that the PMS always prioritised the speed reduction above the descent command. Once the required parameters were entered the subsequent flight profile was timed with 50% N1 maintained on the engines to provide anti-icing protection. The simulator commenced a very shallow descent of about 150 ft/min and slowly reduced speed. After 60 seconds the airspeed was 250 Kt at FL 119 and flap 1 was selected, after 120 seconds the airspeed was 225 Kt at FL 114.

The simulator was then repositioned to FL 120 at 290 Kt from where it was commanded to enter a descent to FL 110, thus more closely matching the flight profile of the incident B 747. As it left FL 120 the speed reduction of 225 Kt was entered followed by the command to descend to FL 90. In this instance the simulator levelled at FL 117 and followed a deceleration rate that was a close approximation to the previous test. The use of speedbrake to 250 Kt, prior to the selection of flap 1, made little difference to the rate of deceleration. In a subsequent test the simulator was controlled through the autopilot / flight director mode controls on the glareshield, rather than through the PMS, with the pilot prioritising speed; the deceleration rates were once again similar to the initial test.

1.17 Organisation and management information

1.17.1 Manual of Air Traffic Services

The Manual of Air Traffic Services Part 1 (MATS Part 1) contains instructions that are applicable to all air traffic control units. The following extracts are relevant to this AIRPROX (C):

MATS Part 1

Section 1, Chapter 3, Paragraph 5 - Changing Levels

'An aircraft may be instructed to climb or descend to a level previously occupied by another aircraft provided that:

a) a vertical separation already exists,

b) the vacating aircraft is proceeding to a level which will maintain vertical separation, and

c) either:

(i) the controller observes that the vacating aircraft has left the level, or

(ii) the pilot has reported vacating the level.'

Section 1, Chapter 5, Paragraph 9 - Level Assessment using Mode C

'An aircraft which is known to have been instructed to climb or descend may be considered to have left a level when the Mode C readout indicates a change of 400 feet or more from that level and is continuing in the anticipated direction.'

Supplementary Instruction No 1 of 95:

'SPEED RELATIONSHIPS AND SPEED CONTROL

Speed Control Technique

'It is important to give crews adequate notice of planned speed control. Descents will be planned at a given speed and rate, but some changes requested by ATC will make a difference. High descent rates and low airspeeds are not normally compatible. Restrictions issued while the descent is in progress will cause problems to the crew. Any significant speed reductions may require the pilot to level off to lose speed before returning to the descent. Advance planning is even more important with heavy jets. At the bottom of a high speed descent their inertia will be great and both time and distance will be needed to reduce speed for ATC purposes.

Summary

- *Give crews notice of any planned speed restrictions/control*
- *Do not ask pilots to 'slow down and go down'*

Supplementary Instruction No 3 of 1997:

'USE OF STANDARD RTF PHRASEOLOGY BY CONTROLLERS

Attention is drawn to the need for the use of standard phraseology when an appropriate 'standard phrase' exists. This is particularly important when the pilot involved is not speaking his or her native tongue. Several incidents, some involving losses of separation have occurred when controllers have modified the standard phraseology when communicating.

Controllers are also reminded that they are required to listen to and verify the accuracy of readbacks by pilots. This is particularly important when either conditional clearances are issued or the transmission contains more than one level or heading; As a guide, a controller should not include more than 3 items of information that require a read back. If there is a language difficulty than this number must be reduced, if necessary items passed and acknowledged singly.'

1.17.2 UK Aeronautical Information Publication (AIP)

The following information to pilots concerning 'Minimum Rates' was set out in RAC Section 3-1-16, paragraph 6.1:

'In order to ensure that controllers can accurately predict profiles to maintain standard vertical separation, pilots of aircraft commencing a climb or descent in accordance with an ATC clearance should inform the controller if they anticipate that their vertical speed during the level change will be less than 500 feet per minute or, if at any time during such a climb or descent, their vertical speed is in fact less than 500 feet per minute.'

1.17.3 Reporting and investigation of AIRPROX

1.17.3.1 Reporting

AIRPROX incidents may be reported by either pilots or controllers. Depending on their origin the reports are investigated by the Joint Airprox Section of the Directorate of Airspace Policy, CAA in the case of pilot reports and by the Safety Regulation Group of the CAA, under the provisions of the Mandatory Occurrence Reporting (MOR) scheme, in the case of controller reports. Where the circumstances appear to have involved a serious risk of collision, in other words where an accident nearly occurred, the incident may be investigated by the AAIB under the provisions of the Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 1996. All three investigation bodies may make recommendations to prevent a re-occurrence of similar incidents.

Instructions for the reporting and investigation of AIRPROX are given in the UK Aeronautical Information Publication (UK AIP) Section RAC 3-1. The same information is repeated in the UK Aeronautical Information Circular (AIC) 105/1995 (Pink 118) 16 November 1995. Extracts taken from the UK AIP are reproduced at Appendix 5.

1.17.3.2 Investigation processes

In the latter part of 1997 a study was commissioned jointly by the DETR and the Ministry of Defence to examine existing arrangement for the investigation of AIRPROX incidents and to recommend any improvements. The terms of reference given to the review included:

'The review should examine the current processes used by the Joint Airprox Working group (JAWG) and Joint Airprox Assessment Panel (JAAP), identify their strengths and weaknesses, and consider whether the interests of aviation safety would be better served by combining their activities in a single body covering the various types of AIRPROX occurrence.'

In anticipation of the conclusions and recommendations of the review, this report simply notes the current position in relation to AIRPROX investigations.

1.17.4 Airborne Collision Avoidance Systems

At the time of the incident there was no mandatory requirement for the fitment or use of TCAS by aircraft operating in UK airspace. In November 1995, Ministers from European Civil Aviation

Conference (ECAC) states adopted a common policy agreeing in principle that TCAS II be mandated for carriage and use in ECAC airspace from 1 January 2000. The CAA position, including an implementation schedule by weight category and passenger seating configuration, is given in AIC 26/1996 dated 26 March 1996. The AIC noted 'UK air operators of qualifying aircraft are encouraged to modify them accordingly in the intervening period. Approximately 30% of such aircraft already have TCAS II installed.'

Guidance on the non-mandatory use of Airborne Collision Avoidance Systems (ACAS) in UK FIR and UIR is given in the UK AIP.

The UK AIP Section RAC 3-1 states:

'15.1 General

15.1.1 The Civil Aviation Authority's position on ACAS is to permit operation of suitably equipped and operated aircraft in UK Airspace. The Traffic Alert and Collision Avoidance System - TCAS II is accepted as a suitable system provided its installation is certificated by the State of Registry, and that its operation by flight crew is in accordance with instructions for the use of this equipment specified in their company's operations manual.

15.2 Traffic Advisories (TA) and Resolution Advisories (RA) and Air Traffic Control (ATC)

15.2.1 Traffic Advisory (TA)

15.2.1.1 ATC does not expect pilots to take avoiding action on the basis of TA information alone. Requests for traffic information should not be made unless the other aircraft cannot be seen and the pilots believe their aircraft is about to be endangered.

15.2.2 Resolution Advisory (RA)

15.2.2.1 ATC expects pilots to respond immediately to a RA. If required, avoiding action should be the minimum necessary for conflict resolution. ATC should be informed as soon as possible of any deviation from an ATC clearance.

15.2.2.2 Pilots should be aware that any deviation from an ATC clearance has the potential to disrupt the Controllers tactical plan and may result in a reduction of standard separation between aircraft other than those originally involved. It is vital that flight crew maintain a good look out and return to their original flight path as soon as it is safe and practical to do so.'

1.17.5 Safety Management System

The Safety Regulation Group (SRG) of the CAA has, since 1991, accepted a Safety Management System (SMS) [Safety Case] based approach as an acceptable means of compliance with Article 77 of the Air Navigation Order and SRG requirements. NATS, as a service provider, began the introduction of a formal SMS in 1991. The first approval based upon the safety case, SMS regulatory approach was awarded to NATS for one of its ATS units in late 1993.

The NATS SMS spans all NATS activities. It provides a clear definition of its policy and general approach to safety. It defines safety management principles including best practices that are implemented within the organisation. It allocates safety accountabilities at all levels of the organisation. Safety management procedures are described, emphasising the proactive management of safety.

The safety of present operations is reviewed and monitored through a number of NATS SMS principles and procedures e.g. safety performance monitoring and trend analysis, lessons learned from incident investigations, internal audits and SRG audits. In addition promotion of a safety culture encourages the reporting of safety concerns.

1.17.5.1 Safety assurance

ATS safety assurance is provided through safety cases. The safety case provides a documented account of the evidence, arguments and assumptions to show that system hazards have been identified and adequately controlled, both in operational and engineering areas and that qualitative and quantitative safety requirements are achieved. The NATS SMS forms the basis upon which a model is being produced by Eurocontrol as the standard for wider implementation across Europe. The NATS SMS, with constant development, is under frequent review by both NATS and the SRG.

Two kinds of safety case, which are different management tools each serving a different purpose, are identified. They are system safety cases (SSC) and unit safety cases (USC).

System safety cases

The objective of a SSC is to present sufficient evidence and reasons to show that a planned system change to the operational environment is adequately safe to be introduced into operational service. These are prepared for all new ATC Systems and maintained throughout their operational life. The structure and content of a SSC varies according to the size and scope of the planned change.

Unit safety case

The objective of the USC is to present sufficient evidence that the operational safety of a unit is adequate for its defined role. It provides assurance to the unit operational managers and the regulator. Furthermore, the USC provides the focal point through which SRG approval is awarded and maintained. LATCC, including AC and TC operations, Heathrow and Gatwick have approved USCs.

1.7.5.2 Precedents

With acceptance of SMS based approval (since 1991) it was deemed unrealistic to demand retrospective safety assessment of a long standing service such as LATCC AC. In this case the USC primarily argued the adequacy of the operation in place at the time based upon the past historical performance. In the case of LATCC TC a SSC existed for the move of the TMA function into the new TC operations room at LATCC in October 1993. The SSC addressed all the risks associated with the new equipment and changes to ATC procedures. Thus the USC provided an argument based upon a mixture of past historical performance and the SSC.

1.17.6 Human Factors

The International Civil Aviation Organisation (ICAO) published a series of digests dealing with human factors in aviation. Digest No. 8 deals specifically with Human Factors in Air Traffic Control. Several of the topics covered are pertinent in the context of this incident. Chapter 5 of ICAO Circular Human Factors Digest No. 8 deals with 'The Human Element - Specific Attributes' and discusses the attributes of Stress, Boredom, Fatigue, Confidence and Complacency. In discussing Error Prevention it particularly notes:

'Human beings are fallible and air traffic controllers remain fallible and subject to error no matter how experienced and proficient they become. While every effort should be made to prevent human error

it is not sensible to predicate the safety of the ATC system on the assumption that every human error can be prevented. Some errors will occur and the system must remain safe when they do by being designed to be error-tolerant.'

2 Analysis

2.1 General

This analysis is in three parts. The first part examines this particular AIRPROX in which a number of factors relating to procedures and human factors contributed to the loss of separation. The second part of the analysis examines existing and proposed equipment which may assist pilots and controllers in the maintenance of mandatory traffic separation. These are the technical solutions to human fallibility. The third part examines the systematic safeguards against simple operating lapses and procedural errors which formed the basis of this particular AIRPROX .

2.2 The loss of separation

2.2.1 The tactical situation

The aircraft were brought into lateral proximity as a result of the G IV being given a direct routing towards its destination, Luton, on a track that crossed that of the B 747. The crew of the B 747 did not report the speed control, as requested, when handed over to TC LAM and accordingly the controller could not pass it on to LL INT N. Both controllers thought that, in accordance with the procedure, the B 747 would be at the correct speed, less than 250 Kt, by the Speed Limit Point (SLP), which is 12 miles east of LAM VOR (see STARS via LAMBOUNE at Appendix B). However, these set procedures are varied by controllers for tactical reasons and the system thus comprises a mix of procedure and traffic management. This calls for some judgement on the part of controllers but it is essential that their information is accurate and up to date. In this case the lack of speed control reporting deprived the controllers of a full understanding upon which to base their tactical planning.

Once TC LAM had cleared the B 747 to contact LL INT N there was little other traffic and so the controller briefed TC NE on the traffic situation, arranged to 'bandbox' the positions (as TC NE/LAM) and went off duty for a short break.

LL INT N was unaware of the high energy state of the B 747, which was not yet showing on his radar display. Therefore, even had he wished to do so, he could not select a display of its ground speed. However, he was entitled to expect it to be at 250 Kt in the absence of any speed control report. If he had known the actual speed (290 Kt), his instruction to 'slow down and go down' may have appeared to him to have been obviously inappropriate. His initial clearance to the B 747 was made up of three parts: a descent to FL 90, instructions to leave Lambourne on a heading of 270_ and the requirement to reduce speed 'now' to 210 Kt. The pilot entered the descent and speed reduction into the Performance Management System (PMS) which, by design, prioritised the speed reduction. Whilst attempting to achieve this deceleration the PMS commanded a reduction in descent rate such that the aircraft levelled at FL 117 for the 50 second period prior to the TCAS instructions. The crew of the B 747 did not inform the controller that they had ceased descending.

At the same time, and knowing that the B 747 had been cleared to FL 110 before being passed to LL INT N, TC NE/LAM cleared the G IV to descend to FL 120 although it had not yet achieved the mandatory 400 feet descent from FL 120 that would allow him to clear another aircraft to that level. Shortly afterwards, when the G IV crew queried their TCAS indication with him, he stated at interview after the incident that it was possible that he misread the SSR label as '107' (i.e. 10,700 feet) instead of '117' (i.e. 11,700 feet), thus explaining his impression of at least 1,000 feet vertical separation which he initially reported to the G IV.

Both aircraft were fitted with TCAS and it was because of the information provided by this equipment that the G IV crew first alerted ATC to the loss of separation when they reported traffic indicating in their one o'clock 300 feet below them. Subsequently the B 747 crew obeyed an RA to 'CLIMB' and then to 'DESCEND' as the equipment reacted to a rapidly changing situation in which the G IV had been descending at a high rate before levelling at FL 120. Perversely, for a collision avoidance system, the RA messages actually reduced the separation values, however, since one of the TCAS units was operating in the 'TA only' mode, a co-ordinated vertical manoeuvre between the two aircraft was not available. Meanwhile, LL INT N had his attention drawn to the conflict by the 'Red' alert of the STCA. Because of the range setting he had selected, the B 747 was not yet showing on his screen. However, he was able to confirm the identity of the conflicting aircraft from the alert listing on screen and promptly issued an avoidance turn to the B 747, which was under his control. Following the TCAS report by the G IV, TC NE/LAM now recognised the conflict and issued a prompt avoidance turn.

2.2.1 Procedures and regulations

Supplementary Instruction No. 3 of 1997 in MATS Part 1 includes guidance to controllers on readbacks by pilots and the number of instructions issued together when there is a language difficulty. No more than three items which require a readback are to be given, and if there is a language difficulty then this number must be reduced. Study of the transcript of communications between the B 747 and the LL INT N controller show that in the main the Japanese crew had no difficulty in communication. Close study of the instruction passed at 1441:58 hrs revealed a difficulty in reading back the three instructions which were passed. The instructions "DESCEND TO FLIGHT LEVEL NINE ZERO AND LEAVE LAMBOURNE ON HEADING TWO SEVEN ZERO DEGREES REDUCE YOUR SPEED NOW TO TWO TEN KNOTS" was read back as follows "JAPANAIR FOUR TWO ONE ROGER DESCEND TO NINE THOUSAND TO NINE THOUSAND LEAVE ERRR LAMBOURNE HEADING TWO SEVEN ZERO DESCEND ERR SPEED REDUCE TO TWO ONE ZERO KNOTS". The controller quickly confirmed that the cleared level was FL 90 and not nine thousand feet. Given the need to understand and execute these three instructions, albeit routine in nature, it is to the credit of the B 747 crew that they were quickly acknowledged and followed. Nevertheless, the delivery together of three items of information was not helpful. It is recommended that the CAA should reconsider the analysis which led to Supplementary Instructions No 3 of 1997 to see whether, in the light of this incident, any amendment is necessary. [Recommendation 98-35]

During investigation of the incident the LL INT N controller said that his use of the word 'now', in ordering the speed reduction, had no significance to him and he was unaware that he had used the word. It is noteworthy that in a later instruction (just before 1445 hrs) the controller said "STOP YOUR DESCENT NOW FLIGHT LEVEL ONE HUNDRED." On both occasions that the word 'now' was used it can be seen that its position in the sentence gives a certain rhythm and, to an English native tongue, is used as much as a punctuation device as a command. However, those for whom English is a second language, are likely to interpret each word literally and therefore in this case the controller's instruction for speed reduction probably received a greater emphasis than he had intended.

2.2.1.2 Aircraft performance in the descent

A variety of tests were performed in the full flight simulator in order to understand more fully the flight profile of the B 747 whilst its crew attempted to comply with the controller's instructions. With limitations prohibiting the simultaneous use of flaps and speedbrakes coupled with the necessity to provide engine anticing protection through a relatively high minimum power setting the task of decelerating the aircraft from high speed was obviously a time consuming one. However, the crew were asked to complete this deceleration whilst in a descent. The simulator results indicate that in that flight regime a reduction from 290 Kt to 210 Kt cannot be achieved in less than 120 seconds in level flight. This is irrespective of whether the PMS prioritises the speed, as it is programmed to do, or whether the pilot does so by responding to the instruction to reduce speed 'now'. The guidance contained in the Supplementary Instruction 1/95 relating to speed control techniques for controllers is therefore correct.

2.2.1.3 Aircraft performance - minimum rates of climb or descent

The crew of the B 747 flew level at FL 117 for a period of 50 seconds prior to the event having been given a clear instruction to descend, however, they did not inform the controller that they were no longer descending. Under the provisions of the UK AIP, pilots of aircraft commencing a climb or descent in accordance with an ATC instruction are required to inform the controller if at any time during such a manoeuvre the vertical speed is less than 500 ft/min. The lack of such a report by the B 747 crew, which was required under the circumstances, therefore contributed to this AIRPROX incident.

2.2.2 Human factors

2.2.2.1 Error prevention and tolerance

The control of air traffic in a busy TMA such as London is a challenging environment in which to work. Most controllers seem to relish the challenge and strive towards an ever more efficient service to the flights they control. It is probable that these conditions in themselves contribute to the general high level of achievement. Any excessive competitive element appears to be well controlled by the safety system. Commercial pressure to increase traffic flow was not a feature of this particular incident which occurred at a time of low traffic level, i.e. there was no overload.

As in other areas of civil aviation, the possibility of human error is always present. The ICAO Circular 'Human Factors in Air Traffic Control' states '.......it is not sensible to predicate the safety of the ATC system on the assumption that every human error can be prevented.' Given this reality, an adequate safety system including a 'safety net' is essential. The NATS Safety Management System including equipment safeguards is discussed in paragraphs 2.4 and 2.3 respectively.

2.2.2.2 Familiarisation training for controllers

Despite the advice given in Supplementary Instructions No 1 of 1995: Do not ask pilots to 'slow down and go down', LL INT N appears to have overlooked the problem that his three part instruction to the B 747 was likely to cause. Greater familiarity with the flight deck operation of aircraft such as a B 747-300 could only benefit the controller's appreciation of the situation. Similarly, pilots would benefit from a close understanding of the ATM system. Whilst familiarisation training is encouraged by NATS management it is presently unstructured and under resourced. The CAA, in conjunction with the various ATS providers, should ensure that controllers are familiar with those operating characteristics of the aircraft for which they are likely to be responsible and which affect the provision of ATS. Consideration should be given to suitable methods which may include the use of simulators and familiarisation flights as a means of achieving this objective. [Recommendation 98-36]

2.3 Avionics and electronic equipment

2.3.1 TCAS

An analysis was conducted of the TCAS avoidance manoeuvre carried out by the B 747. It is probable that the initial 'CLIMB' RA was derived from the observed high descent rate of the G IV which the equipment would assume would continue, since it was unaware of the other aircraft's cleared altitude. This descent rate would have been approximately 2,000 ft/min because the G IV flight management system would command a 3_ descent profile regardless of the aircraft's speed which at this time was approximately 300 Kt.

When the B 747 TCAS equipment observed that the G IV had levelled at FL 120 and, therefore, that by climbing it was liable to collision it then issued a reversed RA to 'DESCEND' . At the time of the CPA the two aircraft were 0.83 nm apart horizontally and 100 feet apart vertically. Avoidance was as a combined result of the TCAS RA and the turn given to the G IV by TC NE / LAM.

The current TCAS software does not allow for reversals in RAs during encounters with other TCAS equipped aircraft operating in the RA mode. Avoiding manoeuvres are co-ordinated between aircraft which both have selected TA/RA on their TCAS. If this situation had existed in this incident the 'CLIMB' RA given to the B 747 would not have occurred and the CPA would have been greater. The maximum benefit of TCAS will depend on optimum usage of TA/RA selections.

TCAS is a proven aid in collision avoidance. By 1 January 2000 its use in ECAC airspace will be mandated for the larger types of aircraft. In this case its availability was fortuitous, being fitted to both of the aircraft involved in the AIRPROX, probably because the aircraft operated from time to time in the US where mandatory provision has been required for some years. Increasing use of the equipment by European operators, including 30% of UK air operators' qualifying aircraft in 1996, reflects the perceived safety benefit of such systems.

In anticipation of the mandatory use in ECAC airspace of this highly desirable safety aid, consideration should be given now to the optimisation of its operation. In particular the optimum use of TA/RA selections will need to be considered. It is therefore recommended that the CAA, in conjunction with other ECAC members should revise the UK AIP relating to the present and future operation of TCAS, taking account of the relevant ICAO Standards and Recommended Practises. [Recommendation 98-37]

2.3.2 SMF and STCA

SMF is not a Collision Avoidance System. The equipment provides post event notification to assist in determining circumstances and factors that led to the loss of separation and as such is a valuable tool.

Short Term Conflict Alert (STCA) is designed to alert controllers to potential conflicts between aircraft via the radar display. LL INT N recalled that the STCA had immediately displayed in red rather than the SSR labels flashing white initially. This was later confirmed by the simulation conducted by the Department of Technical Research and Development of NATS using radar data from the incident.

Therefore, in this instance, in which the aircraft proximity was extremely close, the STCA provided little useful warning of a potential conflict and the concept of a safety net for the controller was minimal. This was not an equipment or design shortcoming but rather the inability of the current conflict alert system to provide sufficient warning in this particular scenario. Indeed up until a short time before the encounter the equipment was predicting a safe condition; it was the dynamics of the G IV levelling off, which could not be known beforehand by STCA, that changed the conditions. If an effective Medium Term Conflict Alert system (MTCA) had been available, with the capability of looking more than 2 minutes ahead, then the confliction leading to this AIRPROX may have been predicted at an earlier stage but the problems of excessive or 'nuisance' warnings are well recognised. It is therefore recommended that NATS should re-evaluate the performance and operational use of the current STCA equipment in order to ensure that the maximum amount of warning, consistent with traffic density, is provided to controllers. [Recommendation 98-38]. Furthermore, NATS should ensure that the development and introduction of an effective MTCA system is given a high priority [Recommendation 98-39]. These two measures, taken together, should provide a more effective 'safety net' for controllers.

2.4 Safety Management Systems and Safety Cases

2.4.1 Safety Cases and Safety Analysis

The NATS developed Safety Management Systems for ATMS are relatively recent and are an appropriate and logical approach to the assurance of safety in a complex process such as air traffic management in the London TMA. The system focuses both upon change and present operations. However, it cannot be regarded as a panacea and the probability of human error (see paragraph 2.2.2.1) must be balanced with the error tolerance of the system. The SMS provides a formal framework against which all forms of hazard, including human error, can be identified and managed so that they can be reduced, as far as practicable, to a tolerable level. The use of NATS SMS and safety cases for the approval and ongoing safety regulatory oversight of NATS operations and other units is also a satisfactory approach.

The ingredients of this AIRPROX include procedural errors by a flight crew and controllers (human error) combined with limited error tolerance of the system (STCA and TCAS). The SMS should allow lessons to be learned leading to preventative measures.

2.4.2 Statistics

The number of AIRPROX incidents in the London TMA is relatively small. In 1997 there were 16 AIRPROX (C) reports from a total of 928,661 flights. The category of risk assessed for each incident will vary from 'no risk of collision' to 'actual risk of collision'. As a general rule any loss of separation detected by the SMF will give rise to a report and this equipment was set to function when aircraft were within 2 nm and 600 feet of each other. Any loss of separation is more significant than the actual proximity of the encounter since it reveals a breakdown in the safety system. Although a margin for error may be designed in to the system, which itself should be error tolerant, reports of AIRPROX are the current indicator of system safety. This incident, involving a proximity of 0.63 nm and 200 feet, was closer than most of the reported incidents but it also included significant features relating to the performance of the 'safety net' (STCA and TCAS) such that a detailed investigation was warranted.

2.5 AIRPROX investigation

At the time of the incident there were two separate processes for the investigation of AIRPROX (P) and AIRPROX (C). In addition, some of the more serious incidents are investigated by the AAIB. The effective investigation of accidents and incidents is an essential prerequisite to the prevention of occurrences in the future. In 1997 the DETR and the MOD arranged to review the existing procedures and, at the time of this report, the conclusions and recommendations of the review team are not known.

The establishment of such a review of the investigation process for both types of AIRPROX suggests an awareness that there may be some safety benefits to be had from revised arrangements. Were it not for the existing review, this investigation would have examined such arrangements in the light of this and other incidents to see if the safety issues could be adequately addressed under present arrangements. Accordingly no recommendation is made at this time.

2.6 Summary

A combination of factors led to this serious loss of separation. The B 747 crew had not reported its speed, as instructed, when changing ATC frequencies and subsequent controllers were unaware of its high energy state. When asked to 'go down and slow down' the B 747, for reasons directly related to its energy management, ceased descending and flew level whilst reducing its airspeed from 290 Kt to 210 Kt. However, the crew did not inform ATC that they had ceased descending, as UK procedures required them to do. Meanwhile, TC NE was attempting to expedite the G IV's flight towards Luton and had already departed from the STAR by allowing a direct routing at high speed. This brought the G IV into lateral conflict with the B 747 and it was the assignment of FL 120 to the G IV, without the required indication that the level had been properly vacated by the B 747 which allowed the confliction.

The design of the Air Traffic Management System (ATMS) remains safe so long as the procedures are followed implicitly by pilots and controllers alike. However, variation of the published procedures, such as the imposition of speed control and clearance for direct routings, are permitted for tactical reasons provided appropriate co-ordination between controllers is carried out. The expeditious flow of traffic may be thus enabled. If this flexibility is to be maintained then the error.tolerance of the ATMS must be assured. A major component of this assurance is the 'safety net' and those elements which are not human based comprise the STCA and TCAS. This incident has shown potential weaknesses which can be safeguarded by more rigid adherence to procedures and enhancement of the existing technology based alerting systems. Recommendations for both of these objectives have been made.

3 Conclusions

(a) Findings

ATC controllers

1. The ATC controllers and flight crews were properly qualified, competent and adequately rested at the time of the incident.

2. Traffic conditions in the LATCC TC airspace were light at the time of the incident and the AIRPROX did not result from an overload situation.

3. The fact that the Lambourne sector was 'bandboxed' with North East Departures (TC NE/LAM) at the time of the incident was not a contributory factor.

4. TC NE/LAM did not notice that the B 747 had stopped descending and therefore the recently vacated level (FL 120) was not yet available to the G IV.

5. LL INT N could reasonably have expected the B 747 speed to be 250 Kt in the absence of any contrary report. His instruction to 'reduce speed now to 210 knots' was therefore modest compared to the actual requirement (from 290 Kt). Nevertheless, in instructing the B 747 to 'slow down and go down' LL INT N overlooked the effect of these instructions on such types of aircraft, including problems associated with their energy management.

6. Periodic familiarisation with modern flight decks and procedures, as part of their validation process, would enhance the understanding of controllers. Confidential reports suggest that a number of controllers wish to receive such familiarisation training on an official basis.

B 747 operation

7. The crew of the B 747 were properly licensed, qualified and adequately rested to perform the flight.

8. The crew of the B 747 did not report the speed control, as requested, when handed over to TC LAM and consequently the controller could not pass this information on to LL INT N.

9. In order to achieve the selected speed reduction, the B 747 PMS caused the aircraft to fly level at FL 117 for some 50 seconds before its TCAS instructed a climbing avoidance manoeuvre. The crew did not inform the controller that they had ceased descending and were not achieving the expected rate of descent of at least 500 ft/min.

10. The instruction to reduce speed 'now' may have been interpreted literally by the B 747 crew in prioritising that requirement. This was not the controller's intention.

Electronic equipment

11 All radar and communication systems serving LATCC TC at the time were fully serviceable.

12. Although the TCAS equipment fitted to the B 747 operated normally, the RA instruction actually reduced the separation distance because of the particular circumstances of the encounter. These comprised the high descent rate of the G IV and the lack of a co-ordinated vertical manoeuvre since RA was not selected on both devices.

13. Collision avoidance was as a combined result of the TCAS and the turn given to the G IV by the controller which the crew executed with commendable haste.

14. The carriage and use of TCAS was not mandated at the time of the incident but its availability and use by both aircraft was fortuitous.

15. The STCA performed to its specification for this encounter. The particular circumstances and manner in which the encounter developed limited the equipment's ability to give more that an immediate, high severity red alert.

16. If a Medium Term Conflict Alert had been available and in service, with the ability to detect potential separation conflicts greater than two minutes ahead, the confliction which led to this AIRPROX may have been predicted at an earlier stage.

Management and organisation

17. In relation to the total number of flights within the London TMA the number of AIRPROX (C) incidents is relatively small. Investigation of those reported reveal few with such close proximities as this incident.

18. The NATS developed SMS represents an appropriate approach to the assurance of safety and management of risk in a complex process such as air traffic management in the London TMA. The use of NATS SMS and safety cases for the approval and ongoing safety regulatory oversight of NATS operations and other units is also a satisfactory method of demonstrating compliance with the requirements.

19. Existing arrangements for the investigation of AIRPROX (P) and (C) are under review at the behest of the DETR and the MOD. Revised arrangements have the potential to address the safety issues more effectively.

20. The ATMS 'safety net', designed to provide continued safety assurance following procedural lapses, was unable to prevent the loss of separation because the STCA could only provide a very late warning and the TCAS manoeuvre was not fully co-ordinated between the conflicting aircraft.

(b) Causes

The following causal factors were identified:

1. The B 747, having left FL 120 then stopped descending some 300 feet below this level whilst reducing speed from 290 Kt to 210 Kt. FL 120 was assigned to the G IV by the bandboxed Terminal Control North East Departures/Lambourne controller before the proper vertical separation had been established after its direct routing towards Luton had brought it into lateral conflict with the B 747.

2. The North East Departures / Lambourne controller did not apply the procedure given in MATS Part 1 regarding level assessment of SSR Mode C (height information) when giving clearance to the G IV to FL 120. The controller should have waited for the B 747 to have had a readout of at least FL 116 (400 feet below the vacated level) before clearing the G IV to descent. The controller then did not monitor the Mode C readout of the B 747 to ensure that it was 'continuing in the anticipated direction'.

3. Despite reporting to the Heathrow Intermediate North controller that the aircraft had vacated FL 120, the B 747 did not descend at the minimum rate mandated for the UK and detailed in the UK Air Pilot (500 ft/min). If it was not possible to comply with this requirement, the crew were required to inform the controller but did not do so.

4. The Heathrow Intermediate North controller, unaware that the aircraft speed was 290 Kt, called for a combined speed and level change which resulted in the B 747 having a minimal rate of descent while its speed reduced.

5. The B 747 crew did not report their speed control, which had been imposed by Clacton SC, to the Lambourne Sector, thereby allowing the controllers to assume a standard speed of 250 Kt.

6. Since the TCAS manoeuvre was not fully co-ordinated by both aircraft's TCAS, one of which was not selected to TA/RA, the B 747's initial RA reduced the separation distance.

4 Safety recommendations

The following safety recommendations are made:

4.1. The CAA should reconsider the analysis which led to Supplementary Instructions No 3 of 1997 to see whether, in the light of this incident, any amendment is necessary. [Recommendation 98-35]

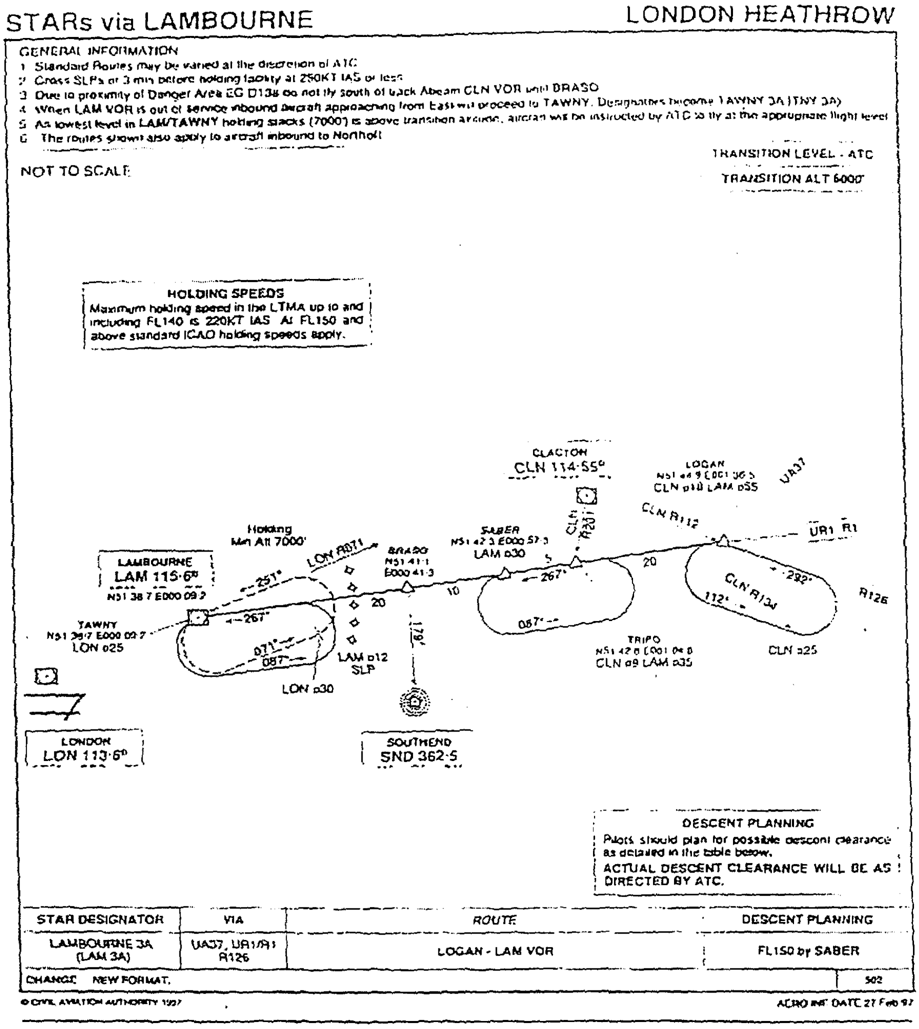
4.2 The CAA, in conjunction with the various ATS providers, should ensure that controllers are familiar with those operating characteristics of the aircraft for which they are likely to be responsible and which affect the provision of ATS. Consideration should be given to suitable methods which may include the use of simulators and familiarisation flights as a means of achieving this objective. [Recommendation 98-36]

4.3. The CAA, in conjunction with other ECAC members should prepare UK AIP instructions relating to the present and future operation of TCAS, taking account of the relevant ICAO Standards and Recommended Practises. [Recommendation 98-37]

4.4 NATS should re-evaluate the performance and operational use of the current STCA equipment in order to ensure that the maximum amount of warning, consistent with traffic density, is provided to controllers. [Recommendation 98-38]

4.5 NATS should ensure that the development and introduction of an effective MTCA system is given a high priority. [Recommendation 98-39]

R StJ Whidborne
Inspector of Air Accidents - Air Accidents Investigation Branch
Department of the Environment, Transport and the Regions August 1998



STARs via LAMBOURNE

LONDON HEATHROW

GENERAL INFORMATION

1. Standard Routes may be varied at the discretion of ATC
2. Cross SLPs or 3 min before holding facility at 250KT IAS or less
3. Due to proximity of Danger Area EG D138 do not fly south of track Abeam CLN VOR until BRASO
4. When LAM VOR is out of service inbound aircraft approaching from East will proceed to TAWNY. Designators become TAWNY 3A (TNY 3A)
5. As lowest level in LAM/TAWNY holding stacks (7000) is above transition altitude, aircraft will be instructed by ATC to fly at the appropriate flight level
6. The routes shown also apply to aircraft inbound to Northolt

TRANSITION LEVEL - ATC

TRANSITION ALT 6000'

NOT TO SCALE

HOLDING SPEEDS

Maximum holding speed in the LTMA up to and including FL140 is 220KT IAS. At FL150 and above standard ICAO holding speeds apply.

DESCENT PLANNING

Pilots should plan for possible descent clearance as detailed in the table below.

ACTUAL DESCENT CLEARANCE WILL BE AS DIRECTED BY ATC.

STAR DESIGNATOR	VIA	ROUTE	DESCENT PLANNING
LAMBOURNE 3A (LAM 3A)	UA37, UR1/R1 R126	LOGAN - LAM VOR	FL150 by SABER

CHANGE: NEW FORMAT. 502

© CIVIL AVIATION AUTHORITY 1997

AERO INF DATE 27 Feb 97

Figure 6 STARS via Lambourne

STARs via LOREL (east) LONDON LUTON

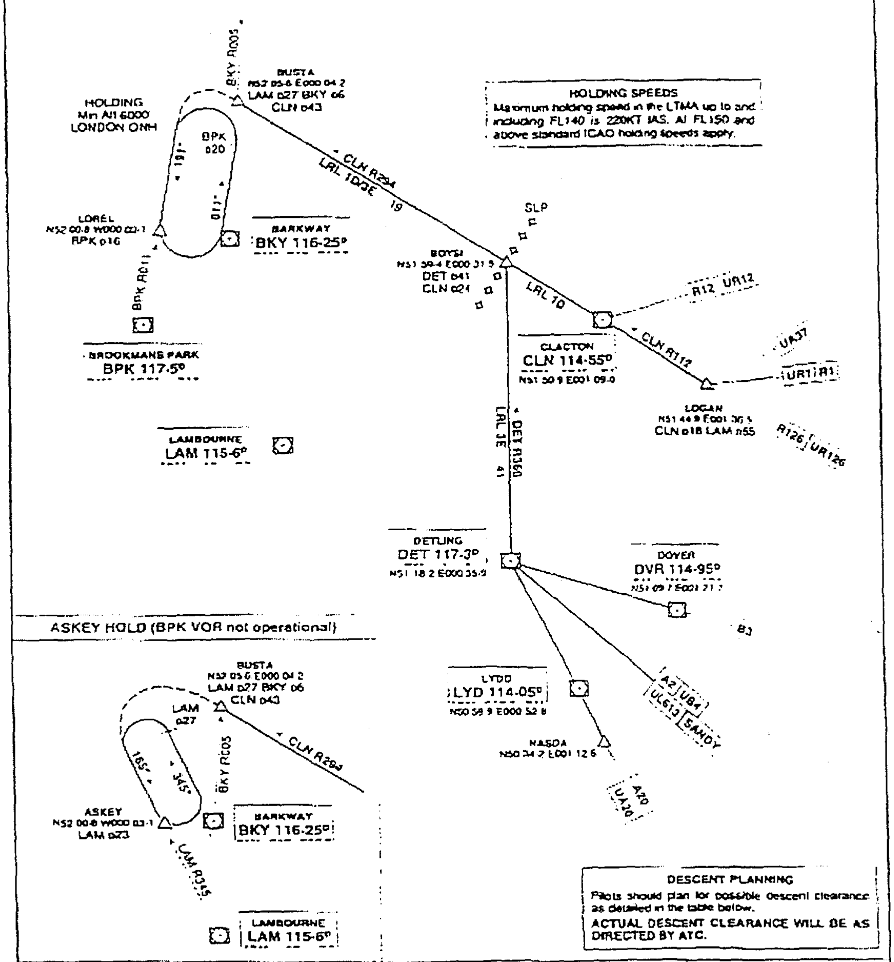
GENERAL INFORMATION

1. Standard Routes may be varied at ATC discretion
2. Cross SLPs or 3 minutes before holding facility at 250KT IAS or less
3. When BPK VOR is out of service routes terminate at ASKEY and designators become ASKEY 1D, 3E

NOT TO SCALE

TRANSITION LEVEL - ATC

TRANSITION ALT 6000'



HOLDING SPEEDS

Maximum holding speed in the LTMA up to and including FL140 is 220KT IAS. At FL150 and above standard ICAO holding speeds apply.

DESCENT PLANNING

Pilots should plan for possible descent clearance as detailed in the table below.

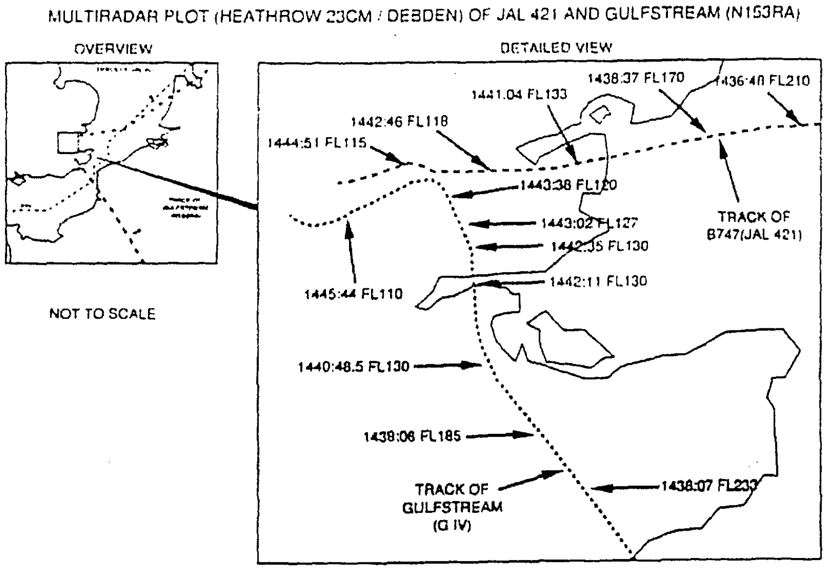
ACTUAL DESCENT CLEARANCE WILL BE AS DIRECTED BY ATC.

STAR DESIGNATOR	VIA	ROUTE	DESCENT PLANNING
LOREL 1D (LRL 1D)	UA37, UR1/R1 UR126/R126, UR12/R12	CLN VOR - BUSTA - LOREL	FL140 by CLN
LOREL 3E (LRL 3E)	UA20/A20, B3, A2,UB4, UL613	DET VOR - BOYSI - BUSTA - LOREL	FL130 by DET

CHANGE LOREL 1B STAR WITHDRAWN. LOREL 1D ALSO SERVES R12 & UR12 555

© CIVIL AVIATION AUTHORITY 1997 AIRD INF DATE 22 May 97

Figure 7 STARs via LOREL (east)



TRACK PLOTS

Figure 8 Lambourne Track Plots

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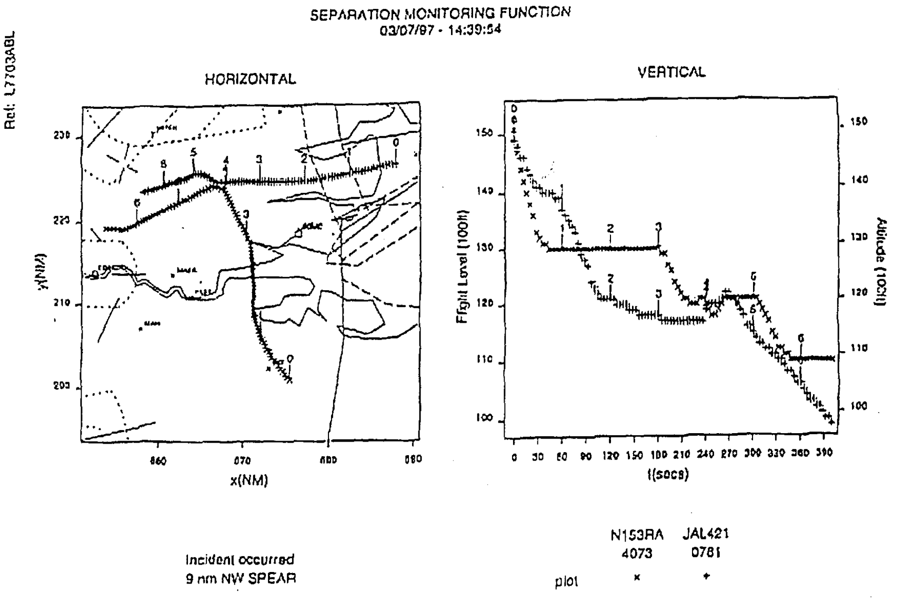

Figure 9 Lambourne SMF

Lambourne Incident ATC Transcripts

Area Clacton Westbound Sector: 118.475 MHz

Control (Callsign: LONDON)

Boeing 747: (Callsign: JAL 421)

To	From	Recorded intelligence	Time
JAL421	LONDON	JAPANAIR FOUR TWO ONE CONTINUE DESCENT TO FLIGHT LEVEL ONE FIVE ZERO	
LONDON	JAL421	JAPANAIR FOUR TWO ONE CONTINUE TO ONE FIVE ZERO	1431
JAL421	LONDON	JAPANAIR FOUR TWO ONE WHAT IS YOUR SPEED	1432:30
LONDON	JAL421	IS THREE TWO ZERO KNOTS	
JAL421	LONDON	ROGER REDUCE TO TWO NINE ZERO KNOTS PLEASE	
LONDON	JAL421	ROGER JAPANAIR FOUR TWO ONE REDUCE TWO NINER ZERO	1433
JAL421	LONDON	JAPANAIR FOUR ZERO ER CORRECTION FOUR TWO ONE REPORT YOUR SPEED NOW TO LONDON ON ONE TWO ONE DECIMAL TWO TWO	1437
LONDON	JAL421	JAPANAIR FOUR TWO ONE ONE TWO ONE TWO TWO GOOD DAY	
JAL421	LONDON	BYE BYE	

Area Control Lydd Sector 128.425 MHz

(Callsign: LONDON)

Gulfstream IV (Callsign: N153RA)

To	From	Recorded intelligence	Time
LONDON	N153RA	ER GOOD AFTERNOON LONDON CONTROL NOVEMBER ONE FIVE THREE ROMEO ALPHA WERE JUST OUT OF FOUR ZERO EIGHT FOR THREE FIVE ZERO	1427
N153RA	LONDON	NOVEMBER ONE FIVE THREE ROMEO ALPHA LONDON MAINTAIN FLIGHT LEVEL THREE FIVE ZERO ON REACHING ABBEVILLE DETLING LOREL THREE ECHO FOR LUTON	1428
N153RA	LONDON	NOVEMBER ONE FIVE THREE ROMEO ALPHA DESCEND TO FLIGHT LEVEL TWO SIX ZERO	1430
LONDON	N153RA	CLEAR DOWN TO TWO SIX ZERO ER ROMEO ALPHA	
N153RA	LONDON	NOVEMBER ONE FIVE THREE ROMEO ALPHA CONTINUE YOUR HEADING UNTIL ADVISED	
LONDON	N153RA	OKAY MAINTAIN PRESENT HEADING UNTIL ADVISED ROMEO ALPHA HEADING IS TWO TWO THREE TWO SEVEN	
N153RA	LONDON	ROGER	1431
N153RA	LONDON	NOVEMBER ROMEO ALPHA DESCEND FLIGHT LEVEL TWO ONE ZERO	1433
LONDON	N153RA	DOWN TO TWO ONE ZERO FOR FIVE THREE ROMEO ALPHA	
LONDON	N153RA	ER ONE FIVE THREE ROMEO ALPHA CLEAR DOWN TO TWO ONE ZERO	
N153RA	LONDON	NOVEMBER THREE ROMEO ALPHA THATS CORRECT BREAK	
		(non pertinent instruction to another aircraft)	
N153RA	LONDON	NOVEMBER ROMEO ALPHA DESCEND FLIGHT LEVEL ONE NINE ZERO	
LONDON	N153RA	CLEAR DOWN TO ONE NINE ZERO ROMEO ALPHA	1435
N153RA	LONDON	NOVEMBER ROMEO ALPHA INCREASE RATE OF DESCENT TO FLIGHT LEVEL ONE NINE CORRECTION TO FLIGHT LEVEL ONE NINE ZERO YOU CAN EXPECT ONE THREE ZERO AT DETLING	

LONDON	N153RA	OKAY ER INCREASING DESCENT DOWN TO ONE NINE ZERO AND WERE CLEAR DOWN TO ONE THREE ZERO AFTER DETLING	1436
N153RA	LONDON	YOU ARE NOW CLEAR TO FLIGHT LEVEL ONE THREE ZERO BE LEVEL AT DETLING	
LONDON	N153RA	OKAY ONE THREE ZERO BE LEVEL AT DETLING ROMEO ALPHA	
N153RA	LONDON	NOVEMBER ROMEO ALPHA EXPEDITE THROUGH FLIGHT LEVEL TWO FOUR ZERO PLEASE	1437
LONDON	N153RA	OKAY WERE EXPEDITING NOW WERE DOING ABOUT FOUR THOUSAND FEET A MINUTE THROUGH TWO FOUR ZERO	
LONDON	N153RA	ROMEO ALPHAS OUT OF TWO FOUR ZERO NOW FOR ONE THREE ONE THREE ZERO	1438
N153RA	LONDON	ROMEO ALPHA ROGER EXPEDITE ALL THE WAY TO ONE THREE ZERO PLEASE	
LONDON	N153RA	WERE DOING THE BEST WE CAN ER WERE DOING FOUR THOUSAND EIGHT HUNDRED FEET A MINUTE	
N153RA	LONDON	OKAY	
LONDON	N153RA	ER WERE STILL MAINTAINING THE HEADING ASSIGNED OF THREE TWO SEVEN IS THAT WHAT YOU WANT US TO HAVE SIR	
N153RA	LONDON	AFFIRM	
LONDON	N153RA	-GER	
LONDON	N153RA	ER ROMEO ALPHAS OUT OF ONE NINE ZERO NOW FOR 1439 ONE THREE ZERO	
N153RA	LONDON	ROGER	
N153RA	LONDON	NOVEMBER ROMEO ALPHA RESUME OWN NAVIGATION DIRECT TO BOYSI	
LONDON	N153RA	DIRECT TO BOYSI ROMEO ALPHA	
N153RA	LONDON	NOVEMBER ROMEO ALPHA CONTACT LONDON ONE TWO ONE DECIMAL TWO TWO	
LONDON	N153RA	ONE TWO ONE TWO TWO FOR ROMEO HAVE A GOOD DAY SIR	1440

LONDON - (transmitter switched)

Terminal Control Lambourne Sector: 121.225 MHz

(Callsign LONDON)

Boeing 747	**(Callsign: JAL 421)**
Gulfstream IV	**(Callsign: N153RA)**

To	From	Recorded intelligence	Time
LONDON	JAL421	LONDON CONTROL JAPANAIR FOUR TWO ONE LEAVING FLIGHT LEVEL ONE NINER TWO FOR ONE FIVE ZERO	1437
JAL421	LONDON	JAPANAIR FOUR TWO ONE FLY HEADING TWO SIX ZERO	
LONDON	JAL421	JAPANAIR FOUR TWO ONE HEADING TWO SIX ZERO	
JAL421	LONDON	JAPANAIR SIX TWO ONE DESCEND FLIGHT LEVEL ONE FOUR ZERO	
LONDON	JAL421	JAPANAIR CONFIRM FOUR F- FOUR TWO ONE FOR US	1439
JAL421	LONDON	JAPANAIR FOUR TWO ONE AFFIRM SORRY ABOUT THAT	
LONDON	JAL421	ER JAPANAIR FOUR TWO ONE ER DE- DESCEND TO ONE FOUR ZERO	
JAL421	LONDON	JAPANAIR FOUR TWO ONE DESCEND FLIGHT LEVEL ONE THREE ZERO	
LONDON	JAL421	JAPANAIR FOUR TWO ONE DESCEND TO ONE THREE ZERO	1440
JAL421	LONDON	JAPANAIR FOUR TWO ONE DESCEND FLIGHT LEVEL ONE TWO	

		ZERO	
LONDON	JAL421	JAPANAIR FOUR TWO ONE DESCEND TO ONE TWO ZERO	
LONDON	N153RA	HELLO LONDON GULFSTREAM ONE FIVE THREE ONE 1441 NOVEMBER ONE FIVE THREE ROMEO ALPHA LEVEL ONE THREE ZERO PROCEEDING ROUTE TO BOYSI	
N153RA	LONDON	NOVEMBER ONE FIVE THREE ROMEO ALPHA ROGER YOU CAN KEEP UP HIGH SPEED MAINTAIN FLIGHT LEVEL ONE THREE ZERO	
LONDON	N153RA	MAINTAIN ONE THREE ZERO ROMEO ALPHA	
JAL421	LONDON	JAPANAIR FOUR TWO ONE ROUTE DIRECT LAMBOURNE DESCEND FLIGHT LEVEL ONE ONE ZERO	1441:21
LONDON	JAL421	JAPANAIR FOUR TWO ONE DIRECT LAMBOURNE ER DESCEND TO ONE ONE ZERO	
JAL421	LONDON	JAPANAIR FOUR TWO ONE CONTACT HEATHROW ONE NINE DECIMAL SEVEN TWO GOOD BYE	1441:32
LONDON	JAL421	JAPANAIR FOUR TWO ONE ONE NINE DECIMAL SEVEN TWO GOOD BYE	

Terminal Control Heathrow Intermediate Director (North) 119.725 MHz

(Callsign: HEATHROW)

Boeing 747 **(Callsign: JAL 421)**

To	From	Recorded intelligence	Time
HEATHROW	JAL421	HEATHROW GOOD DAY SIR JAPANAIR FOUR TWO ONE:49 LEAVING FLIGHT LEVEL ONE TWO ZERO FOR ONE ONE ZERO A BOEING SEVEN FOUR SEVEN THREE HUNDRED	1441
JAL421	HEATHROW	-PANAIR FOUR TWO ONE THANK YOU DESCEND TO FLIGHT LEVEL NINE ZERO AND LEAVE LAMBOURNE HEADING TWO SEVEN ZERO DEGREES REDUCE YOUR SPEED NOW TO TWO TEN KNOTS	1441:58
HEATHROW	JAL421	JAPANAIR FOUR TWO ONE ROGER DESCEND TO NINE THOUSAND TO NINE THOUSAND LEAVE ERRRR LAMBOURNE HEADING TWO SEVEN ZERO DESCEND ERR SPEED REDUCE TO TWO ONE ZERO KNOTS	
JAL421	HEATHROW	-PANAIR FOUR TWO ONE JUST CONFIRM THAT'S CLEARED AT FLIGHT LEVEL NINE ZERO	
HEATHROW	JAL421	LEVEL NINER ZERO JAPANAIR FOUR TWO ONE	
JAL421	HEATHROW	-PANAIR FOUR TWO ONE MAKE AN IMMEDIATE RIGHT TURN HEADING THREE ONE ZERO DEGREES AVOIDING ACTION TURN	1444
HEATHROW	JAL421	LONDON JAPANAIR THREE FOUR TWO ONE HEADING THREE ONE ZERO	
JAL421	HEATHROW	AND YOU HAVE TRAFFIC WHICH INDICATES TWO HUNDRED FEET BELOW YOU IN YOUR TEN O'CLOCK RANGE OF ONE AND A HALF MILES IT'S JUST TURNED WEST BOUND NOW	
JAL421	HEATHROW	JAPANAIR FOUR TWO ONE THAT TRAFFIC'S GONE AWAY NOW YOU CAN ROUTE DIRECT TO LAMBOURNE	
HEATHROW	JAL421	JAPANAIR FOUR TWO ONE NOW DIRECT LAMBOURNE THAT (????unintelligible words) BY T CAS	
JAL421	HEATHROW	-PANAIR FOUR TWO ONE THAT TRAFFIC'S NOW CLEAR WELL IN YOU'RE LEFT HAND SIDE AND IS CURRENTLY MAINTAINING FLIGHT LEVEL ONE TWO ZERO BUT IS ER NOW THREE MILES DISTANT HEADING WESTBOUND	
JAL421	HEATHROW	JAPANAIR FOUR TWO ONE DESCEND ER STOP YOUR DESCENT NOW FLIGHT LEVEL ONE HUNDRED	
HEATHROW	JAL421	JAPANAIR FOUR TWO ONE ER CONFIRM DESCENT TO ONE ZERO ZERO	1445
HEATHROW	JAL421	HEATHROW DIRECTOR ER JAPANAIR FOUR TWO ONE	

		CONFIRM DESCENT TO FLIGHT LEVEL ONE ZERO ZERO	
HEATHROW	JAL421	HEATHROW THIS JAPANAIR FOUR TWO ONE	
JAL421	HEATHROW	-PANAIR FOUR TWO ONE DISREGARD MY LAST DESCEND FLIGHT LEVEL NINER ZERO	
HEATHROW	JAL421	ROGER JAPANAIR FOUR TWO ONE DESCEND TO NINER ZERO	1446

Terminal Control [Bandboxed with Lambourne Sector at 1442 hrs]*

Heathrow North East Departures (Callsign: LONDON)

118.225 MHz / 121.225 MHz (Cross coupled)*

Boeing 747 (Callsign: JAL 421)

Gulfstream IV (Callsign: N153RA)

To	From	Recorded intelligence	Time
N531RA	LONDON	NOVEMBER ONE FIVE THREE ROMEO ALPHA TURN LEFT HEADING THREE FOUR ZERO	1442
LONDON	N531RA	LEFT TO THREE FOUR ZERO ROMEO ALPHA	
N531RA	LONDON	NOVEMBER ONE FIVE THREE ROMEO ALPHA DESCEND FLIGHT LEVEL ONE TWO ZERO	1442:38
LONDON	N531RA	DOWN TO ONE TWO ZERO ROMEO ALPHA OUT OF ONE THREE ZERO NOW	1442:41
LONDON	N531RA	AND ROMEO ALPHA WE HAVE ER TRAFFIC HERE AT ONE O'CLOCK	
N531RA	LONDON	ROMEO ALPHA AFFIRM THAT TRAFFIC ER MAINTAINING A THOUSAND BELOW	
LONDON	N531RA	AND WE GOT ONE INDICATING ABOUT THREE HUNDRED FEET DIFFERENCE SIR	1443
N531RA	LONDON	NOVEMBER ONE FIVE THREE ROMEO ALPHA TURN LEFT HEADING THREE ONE ZERO	
LONDON	N531RA	THREE ONE ZERO ROMEO ALPHA	
N531RA	LONDON	THREE ONE ER ROMEO ALPHA AVOIDING ACTION NOW TURN LEFT HEADING TWO NINER ZERO	
LONDON	N531RA	TWO NINE ZERO ROMEO ALPHA	
N531RA	LONDON	NOVEMBER ONE FIVE THREE ROMEO ALPHA THAT ER TRAFFIC CORRECTION AVOIDING ACTION NOW TURN LEFT HEADING TWO FIVE ZERO	
LONDON	N531RA	TWO FIVE ZERO ROMEO ALPHA	
N531RA	LONDON	NOVEMBER THREE ROMEO ALPHA TRAFFIC IN YOUR THREE O'CLOCK RANGE HALF A MILE	1444
LONDON	N531RA	YEAH WERE IN THE TURN	
N531RA	LONDON	NOVEMBER FIVE ONE THREE ROMEO ALPHA TRAFFIC NOW IN YOUR FOUR O'CLOCK RANGE OF HALF A MILE	
LONDON	N531RA	YEAH WERE IN ER V WERE IN A BIT OF CLOUD SO CANT SEE HIM SIR	
N531RA	LONDON	ROGER	
LONDON	N531RA	GOT HIM ON T CAS	
N531RA	LONDON	ROGER THAT TRAFFIC NOW ER TURNING RIGHT ER OUT OF THE WAY	
N531RA	LONDON	NOVEMBER ONE FIVE THREE ROMEO ALPHA YOU'RE CLEAR OF THE TRAFFIC NOW DESCEND FLIGHT LEVEL ONE HUNDRED	

LONDON	N531RA	DOWN TO ONE HUNDRED WERE ON A HEADING OF TWO FIVE ZERO	
N531RA	LONDON	ROGER CONTINUE THAT HEADING FOR THE MOMENT	
N531RA	LONDON	NOVEMBER THREE ROMEO ALPHA STOP DESCENT FLIGHT LEVEL ONE ONE ZERO	1445
LONDON	N531RA	DOWN TO ONE ONE ZERO ROMEO ALPHA	
N531RA	LONDON	NOVEMBER ONE FIVE THREE ROMEO ALPHA TURN RIGHT ONTO A HEADING OF THREE THREE FIVE	
LONDON	N531RA	RIGHT TURN TO THREE THREE FIVE ROMEO ALPHA LEVEL ONE ONE ZERO	
N531RA	LONDON	THANKS MAINTAIN FOR THE MOMENT WERE GONNA POSITION YOU TOWARDS THE LIMA UNIFORM TANGO FOR LANDING TWO SIX AT LUTON	1446
LONDON	N531RA	OKAY WE HAVE THE TRAFFIC WE HAVE INFORMATION MIKE	1447
N531RA	LONDON	NOVEMBER ONE FIVE THREE ROMEO ALPHA DESCEND TO ALTITUDE FIVE THOUSAND FEET SET LUTON Q N H ONE ZERO ZERO EIGHT	
LONDON	N531RA	FIVE THOUSAND ONE ZERO ZERO EIGHT ROMEO ALPHA	
N531RA	LONDON	ROGER YOU'VE GOT APPROXIMATELY TWENTY FIVE MILES TO GO AND YOU'RE ON A LONG BASE LEG FOR TWO SIX	
LONDON	N531RA	ROMEO ALPHA THANK YOU	1448
N531RA	LONDON	NOVEMBER ONE FIVE THREE ROMEO ALPHA YOU CAN KEEP UP YOUR SPEED IF IT HELPS TO GET YOUR HEIGHT OFF TURN RIGHT ONTO A HEADING THREE FOUR FIVE	
LONDON	N531RA	RIGHT TURN TO THREE FOUR FIVE ROMEO ALPHA	
N531RA	LONDON	ROMEO ALPHA REPORT HEADING AND PRESENT SPEED TO LUTON APPROACH ONE TWO EIGHT DECIMAL SEVEN FIVE	
LONDON	N531RA	TWENTY EIGHT SEVEN FIVE GOOD DAY SIR	1449
N531RA	LONDON	BYE BYE	