出國報告（出國類別：實習）

「飛航服務安全管理及案件調查」課程
出國報告書

服務機關：民用航空局飛航管制組
姓名職稱：熊時平技正
赴派國家：新加坡
出國期間：100 年 10 月 9 日起至 100 年 10 月 22 日
報告日期：100 年 12 月 14 日

目次

壹、 目的

一、 參加目的

新加坡民航學院(Singapore Aviation Academy, SAA)每年定期舉辦「飛航服務安全管理及案件調查」課程(Air Traffic Service Safety Management and Investigation)，課程時間共計 10 日，授課先從飛航服務安全管理角度切入，並針對風險管理、事件調查步驟、事件調查技巧等詳細介紹，藉由課堂講授、經驗分享及案例實作，提供學員在飛航服務安全及事件調查作業相關知識與技巧，對象包括飛航服務管理者、督導、安全管理者、事件調查人員、檢查員及管制員等，本次課程共計有 40 名學員，來自 25 個不同國家。

二、 行程

10 月 9 日	由桃園國際機場搭乘中華航空公司 CI753 班機至新加坡樟宜機場。
10 月 10 日至 21 日	參加「飛航服務安全管理及案件調

	查」課程。
10 月 22 日	由新加坡樟宜機場搭乘中華航空公司 CI754 班機至桃園國際機場。

三、 新加坡航空學院簡介

新加坡航空學院位於新加坡東方，靠近彰宜村，距離市區較遠，該地點並無捷運，只能搭乘公車或計程車；上課期間每日提供午餐及早午茶，避免學員食的不便，也讓學員有機會交流。

貳、 過程

一、每日課程

本課程自 100 年 10 月 10 日至 10 月 21 日，扣除週末例假日，共計 10 天，內容如下(詳細資料如附件一)：

第一日（10 月 10 日/星期一）

Session 1－Course Introduction & Overview

Session 2－Introduction to ATS Safety Management

Session 3－Safety Management Systems in ATS

Session 4－Introduction to Human Factors in ATS

第二日（10 月 11 日/星期二）

Session 5－Introduction to ATS Safety Investigation

Session 6－Human Performance Considerations

Session 7－Practical Resource Management

Session 8－Maintenance of Operational Standards

第三日（10 月 12 日/星期三）

Session 9 －Risk Management in ATS

Session 10－Understanding Human Error

Session 11－ATS Risk Management Exercise

Session 12－Human Factors Models as Investigative Tools

第四日（10 月 13 日/星期四）

Session 13－Systemic Occurrence Analysis Methods

Session 14－Communication Skills 1: Presentation Skills for ATS Investigators

Session 15－ An Introductory Investigation Exercise

Session 16－ Introductory Investigation Exercise continues

17:00－Escorted visit to Singapore ATC Centre & RCC

18:30－Course Dinner at SAA-Hosted by Singapore Aviation Academy

第五日（10 月 14 日/星期五）

Session 17－Cultural Considerations in ATS Operations

Session 18－Enhancing Safety Culture

Session 19－An IATA Perspective

Session 20－The Organisational Accident: A Case Study

第六日（10 月 17 日/星期一）

Session 21－Investigating in Practice : ICAO Annex 13 requirements and experience from the Singapore Air Accident Investigation Bureau (AAIB)

Session 22－The Legal Perspective : Air Traffic Control and the Law

Session 23－Practical Case Study (Runway Incursion)

Session 24－Practical Case Study continued (Runway Incursion)

第七日（10 月 18 日/星期二）

Session 25－Interviewing Skills for Safety Investigators 1

Session 26－Interviewing Skills for Safety Investigators 2

Session 27－Interviewing Skills for Safety Investigators 3

Session 28－Danger on the Ground - Case Study: Milan Linate

Session 29－The ATS Safety Audit Process

第八日（10 月 19 日/星期三）

Session 30－ATS Investigation in Practice

Session 31－Communication Skills 2: Report Writing for ATS Investigators

Session 32－Danger in the Sky

Session 33－ATCO Emergency Procedures Training

第九日（10 月 20 日/星期四）

Session 34－Major Case Study: A Systemic Investigation Introduction and Briefing ~ Course members work in assigned syndicates to conduct Major Investigation Exercise

Session 35~38－A Systemic Investigation

第十日（10 月 21 日//星期五）

Session 39~40－A Systemic Investigation continues

Session 41－Presentation of Investigation Team Reports

Session 42－Course Conclusion

二、 講師簡介

Brent Hayward，來自澳洲的航空心理學家，曾在澳洲空軍機關服務 12 年，也曾在 Qantas 航空公司服務 5 年 ，自 1995 年起擔任人爲因素及安全方面顧問，服務對象包括航空公司、軍方、EUROCONTROL、廠商、鐵路、航運、核能專業等。

John Guselli，澳洲人，自 1972 年開始從事管制員工作，1983 年晉升至管理階層，1992 年開始接觸飛航安全管理並成爲專家，曾在 1998-2000 年擔任雪梨奧林匹克航空計畫經理。

三、 學習課程概要

(一). 飛航服務安全管理系統介紹(Introduction to Air Traffic Services Safety Management Systems)

好的飛航安全管理系統可以幫助我們預防意外事件或事故的發生、提昇運作效率並能符合安全需求及責任。而安全管理與安全法規息息相關，透過系統性及明確的過程，對組織作出必要的管理。

安全管理的目的：

1. 識別出脆弱的環節，預防危害組織行爲的發生。

2. 增加組織效能。

3. 增加組織可靠度。

4. 達成對社會及法律面的責任。

5. 使組織在產業中永續經營。

安全管理必要準則：

1. 確保組織有安全的管理能力。

2. 確保組織有管理變化的能力。

3. 確保組織有管理風險的能力。

4. 對人爲因素作出控管。

5. 對人爲錯誤作出管理及預防。

過去的管理方式由單位主管直接對飛航服務各層面進行檢視審核；現在的安全管理方式要求管理單位應透

過系統性的方式管理，訂定統一的標準作業流程，而非以人治方式管理。

好的安全管理系統的設計必須具備下列條件：

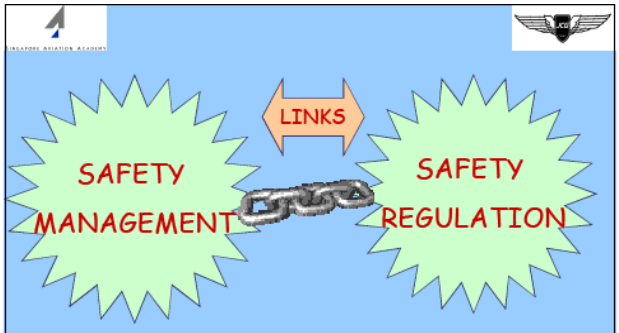
1. 所有資料必需文件化。
2. 從現有提供服務中識別出風險。
3. 管理風險。
4. 持續監控安全結果。

飛航服務安全管理計畫必須具備下列條件：

1. 全方位監控安全各層面並偵測未發生但可能發生的風險。
2. 持續進行飛航服務單位安全檢視。
3. 針對系統改變進行安全評估。
4. 訂定安全提升機制。
5. 訂定主動提報機制。

What are we here for?

- To help each other to:
  - → Defend against incidents and accidents
  - → Enhance operational productivity
  - → Meet contemporary safety obligations



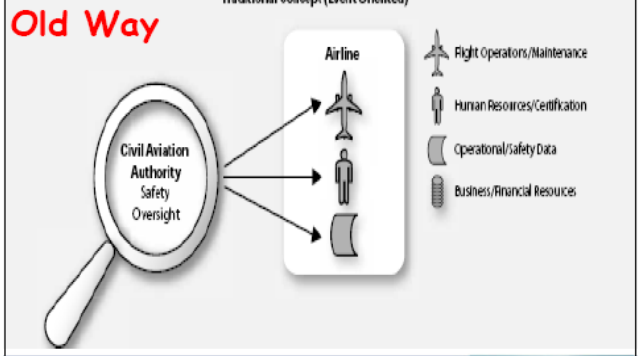
Why a Safety Management System

- Defence against adverse occurrences
- Greater Productivity
- Increased Reliability
- Social and Legal Responsibility
- Staying in Business!

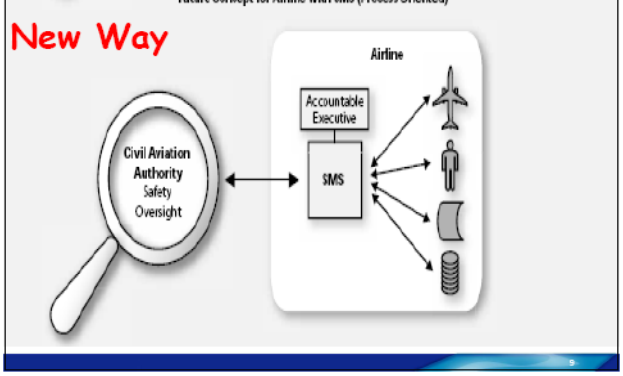
Principles of Safety Management

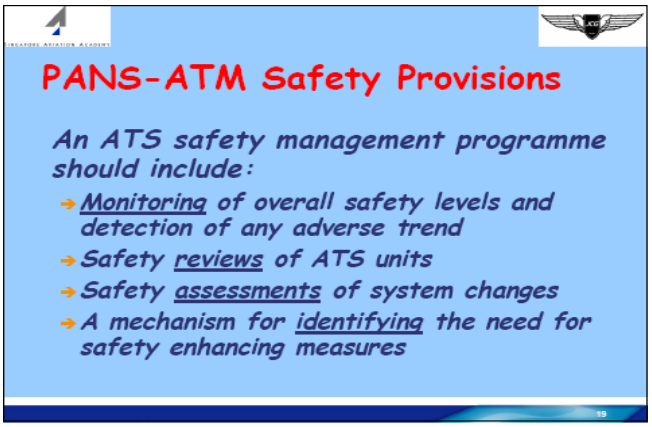
- Safety Governance
- Managing Change
- Managing Risk
- Human Factors
- Human Error Management

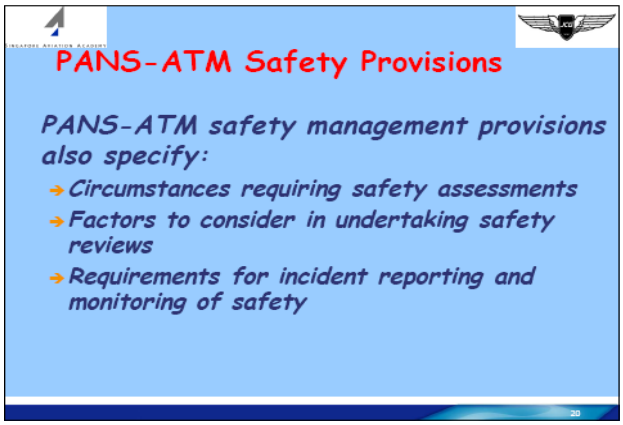
Old Way



New Way







(二). 與飛航服務相關之人爲因素介紹(Introduction to Human Factors in ATS)

與飛航管理系統中相關人爲因素項目：

1. 溝通：在1989年發生的Flying Tiger貨機爲例，管制員頒發許可爲「descend two four zero zero(下降至2400呎)」，駕駛員誤以爲是「descend to four zero zero(下降至400呎)」，而導致該班機撞上437呎的山丘，造

成4人死亡。

2. 重大改變衝擊與管理。

3. 情境察覺。

4. 疲勞與壓力：疲勞包含睡眠不足、飲酒、及因輪值夜班造成生理時鐘不規律等因素而引起的生理倦怠感，造成人的工作表現能力下降。壓力對人體的生理及心理兩方面同時具有影響，且會累積；不論是短期與長期的影響，對個人與組織皆有害處。

5. 資訊的處理與認知。

6. 文化：文化差異是人因不可忽略重點，因飛航服務的跨文化特性相當明顯，而文化差異包括國情、組織文化、專業能力等方面，其影響是相互且交錯的，其綜合表現出來的結果，都會影響到飛航安全。

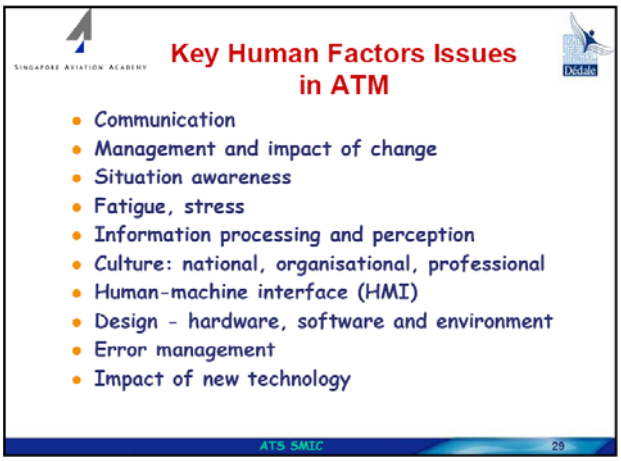
7. 人機介面（HMI）。

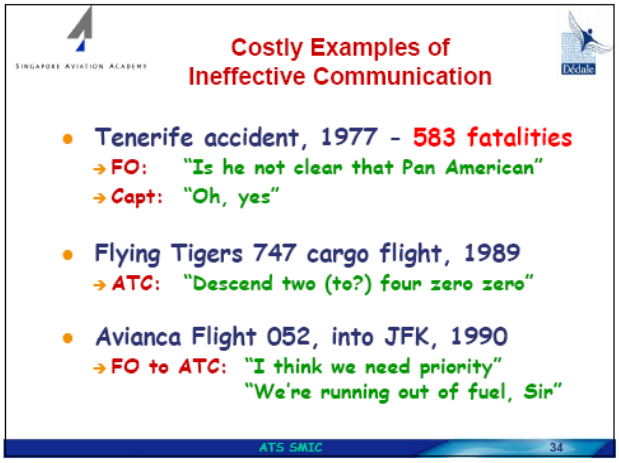
8. 設計面—硬體、軟體及環境。

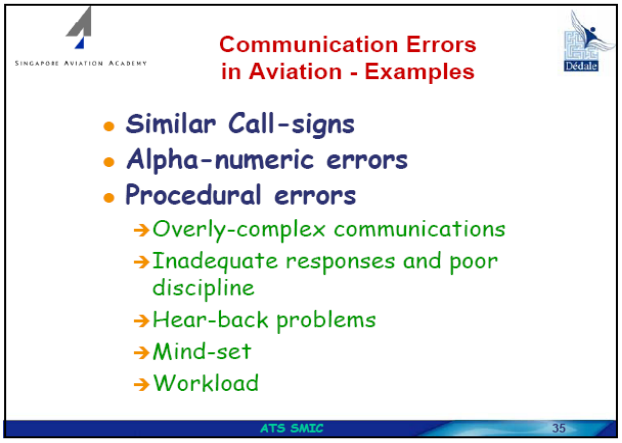
9. 錯誤管理。

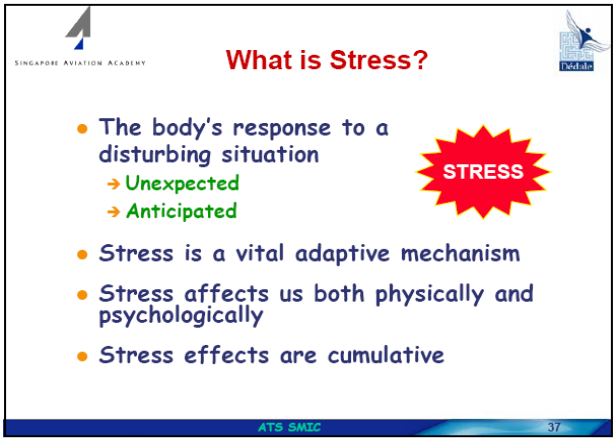
10. 新技術的衝擊：大多數人會排斥改變，尤其

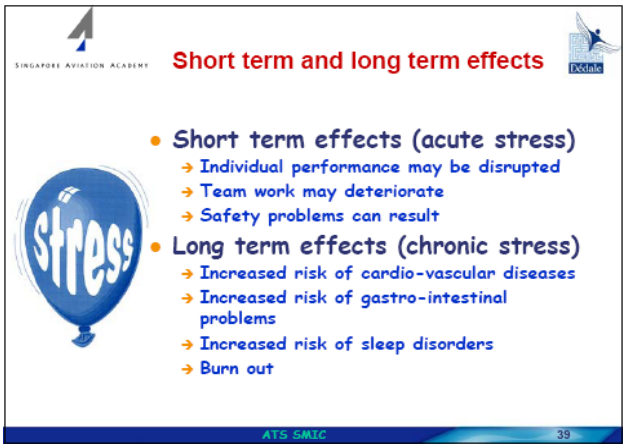
在已熟習的環境、習以爲常的作業方式、熟練的操作介面下，新的變化及改變更容易讓人抗拒，而飛航服務系統、技術及環境不斷更新進步，如何讓新的技術、觀念、作業被接受，對於飛航安全維護是相當重要的課題。

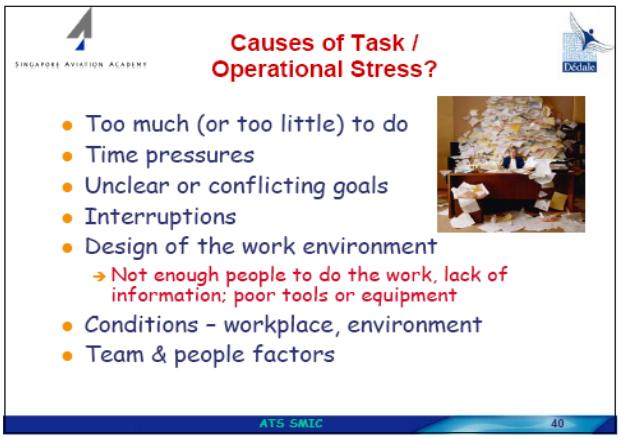


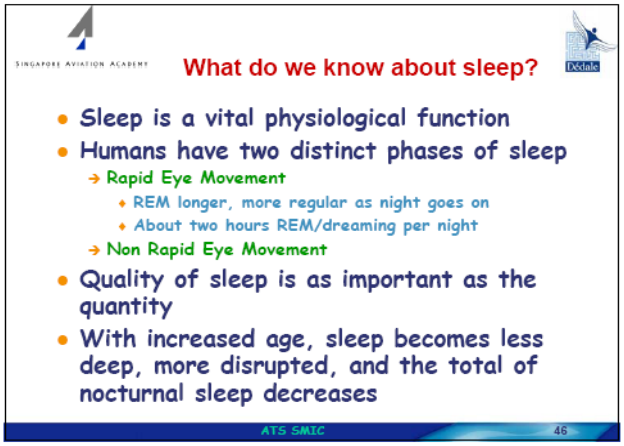


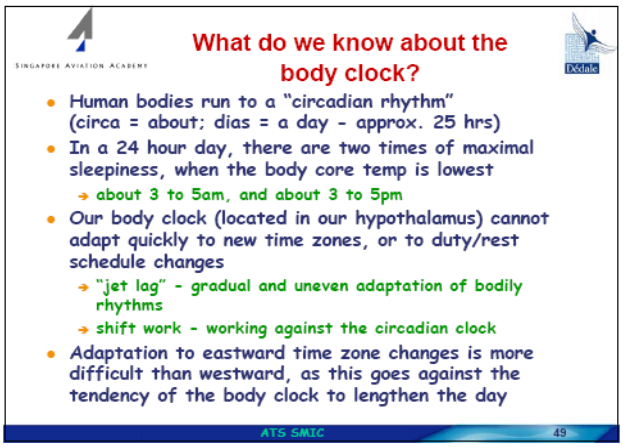












(三). SHEL 模型（SHEL model）

1. SHELL Mode：S 代表軟體(Software)、H 代表硬體(Hardware)、E 代表環境(Enviroment)、H 代表人(Human)。使用 SHEL Mode 可以指出系統發生問題各介面的連結處，而兩個 L 代表人與人之間關聯。

2. SHELO Mode：延伸的 SHEL 模型，O 代表組織

(Organisation)，組織在整個系統具有決定性的影響，遂擴大將組織對系統影響納入分析研究。

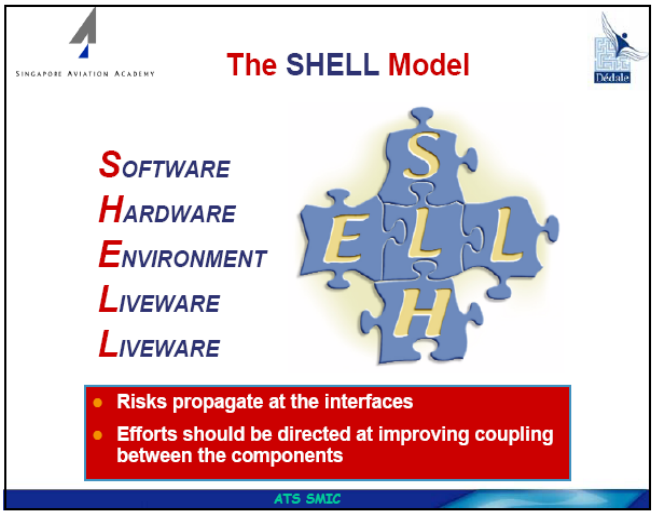
3. Reason-Based SOAM Model：此爲 EUROCONTROL 依據 SWISS CHEESE MODEL 所延伸發展的事件調查方法：

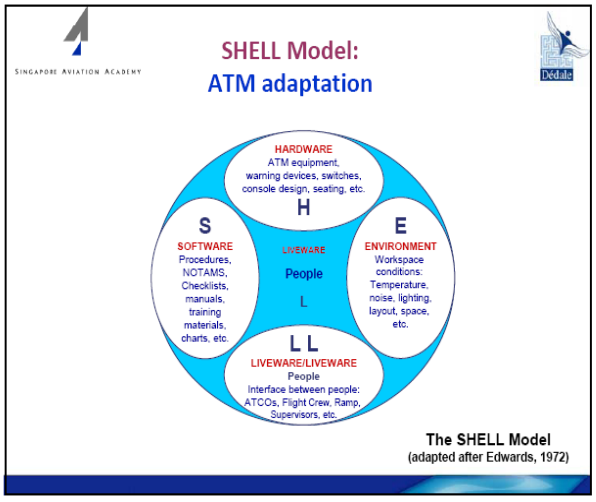
(1). 潛在情況（Latent Conditions）：包括和組織相關的因素(Organisational and System Factors) 及情境因素 (Contextual Conditions)， 很多潛在危險因子通常是隱藏在系統裡，如防護措施未做好，或是這些危險因子未被識別出來，一但安全圍籬被突破，錯誤的結果就會發生。

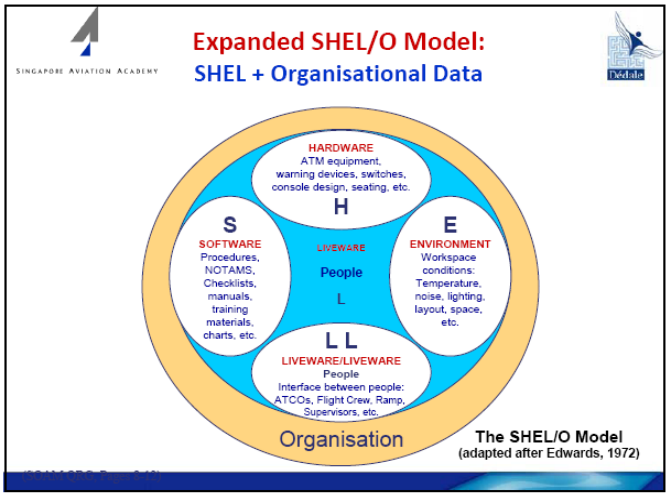
(2). 主動式錯誤因子（Active Failure）：如發生錯誤或違反規定，對系統將造成負面影響與衝擊，這一部分發生通常都牽涉到人的部分(Human Involvement)，而且是系統中具備刺破防護網能力的人員，如管制員、飛行員、維修人員等。

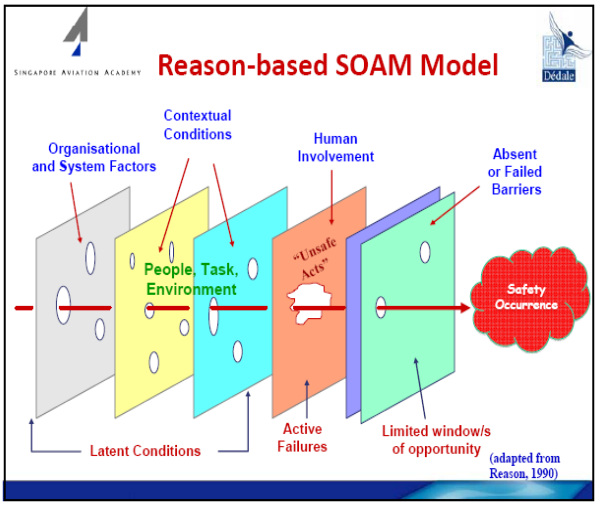
(3).窗戶的縫隙(Limited windows of opportunity)：這裡提到的是避免事件發生的最後機會，也就是防護措施失效後(Absent or Failed Barriers)，意外將無法避免。

(4).因此識別出這些防線很重要。系統中通常有多重防護來防堵意外的發生。它們也被稱作「last minute control measures」。









(四). 調查人員之訪談技巧 (Interviewing Skills for Safety Investigators)

1. 理論：

(1).訪談目的係爲獲得正確有效的資訊，方能重新建立事件原貌,瞭解事件發生過程及原因。

(2).訪談對象：與事件相關的人員，如員工、事件目擊者、專家、家屬、督導、管理階層、民眾等。

(3).注意事項：訪談者的人格特質，如年齡、文化、教育背景、自願或被迫等，此部份涉及資訊之可靠性及客觀性。

a. 識別出關鍵證人。

b. 面試的優先順序。

c. 協請專家鑑定。

d. 評估資訊可信度。

e. 如需錄音，應先詢問被訪談人員意願。

(4). 可能影響目擊者記憶的因素，包括外部資訊、人格特質、回憶、時間等。

(5). 個人主觀認知部份，同一事件因不同立場，不同觀點所獲得資訊將有所差異。

(6). 訪談基本原則：

a. 事前完整準備。

b. 及時，避免因時間變化而造成記憶不完整或受外來因素的改變。

c. 地點，可以善用環境來幫助回憶。

d. 態度和善，避免造成訪談者不適。

e. 語言，避免使用專業術語或縮語。

f. 儘量進行個別訪談。

g. 要能適時接受訪談者可能使用情緒性字眼。

(7).訪談流程：

a. 自我介紹。

b. 營造舒適的環境，避免外界干擾。

c. 說明自己的角色及訪談目的。

d. 選擇使用記筆記、錄音或錄影的方式紀錄訪談過程，如錄音或錄影先詢問被訪談人員意願。

e. 隨時針對訪談情況，決定要到此爲止或繼續追根究。

(8).問題的順序及技巧

a. 自由回想，如：「可以請你回想一下當時發生了什麼事嗎?」。

b. 開放性問題，如：「可以告訴我，你接下來看到了些什麼？」、「後來呢？」。

c. 引導式問題，目的在確認某項結論是否

得到受訪者認同，或用來證實某項假設是否正確；這種問題於訪談中較少使用，因爲已經給受訪者一個回答的方向了。

d. 鼓勵受訪者：仔細聆聽並讓受訪者感受到尊重，可以利用肢體語言來表達鼓勵，如眼神、點頭、面部表情、聲音表情、重覆受訪者用語、簡短但讓受訪者知道有在聆聽，如「嗯」、「是」、「對」等。

e. 順著受訪者回答的內容，再從中開發新問題。

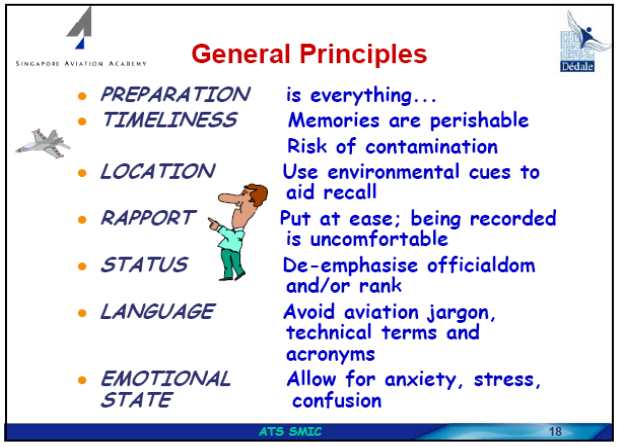
f. 可以重新整理組合受訪談者的回覆，讓受訪者確認。

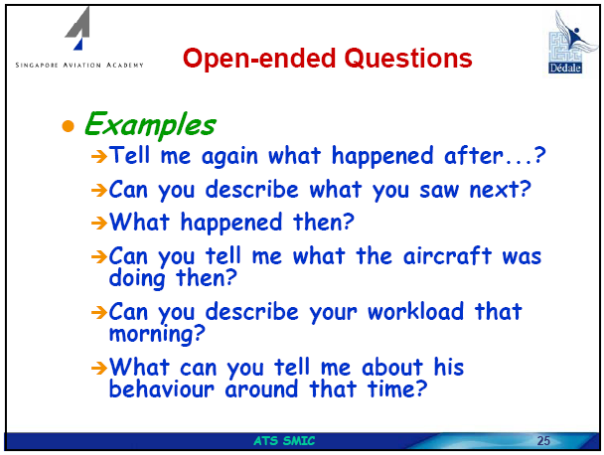
g. 適時運用其他技巧或工具：如請受訪者畫圖、使用監視器的帶子來回溯現場、在白板上標示、指出地點等。

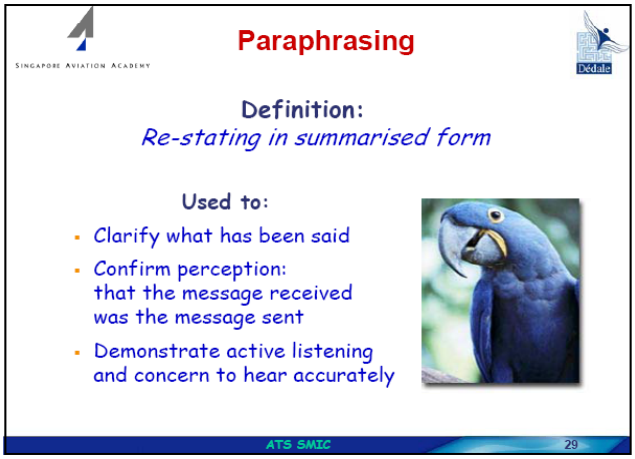
(9).結論：進行訪談過程中，訪談者提供的資料

不盡然都可以採信，所以調查人員應該先做好準備，在訪談過程中擷取有用的資訊，以還原及了解事件發生的原因。

經交叉訪談的結果出現差異時，應回歸到已蒐集到的證據上；另外也可藉由專家的協助，增加判斷基礎。







Encouraging Responses

Definition:

Any verbal or non-verbal means by which the listener encourages the speaker to continue talking

Used to:

- Listen, actively
- Indicate 'tracking'; following and understanding
- Encourage further comment
- Indicate support or empathy
- Avoid influencing the direction of conversation

ATS SMIC 26

Paraphrasing

Examples:

- *You saw the train approaching, then heard the screech of brakes, before the car ran into the fence?*
- *You're saying he was quite upset about failing the test?*
- *You said there was a flash, then a loud noise?*
- *If I understand you correctly, his behaviour was the same as usual that day?*

ATS SMIC 30

Leading Questions

Definition:

Questions that anticipate the answer

Used to:

- Check perception and understanding
- Test reaction to a proposal
- Establish agreement or disagreement

ATS SMIC 33

Other things to avoid

- Negative questions (keep positive)
  - you weren't overloaded, were you?
- Multiple part questions (keep it simple)
  - did you...? and was it...? and if so, ... ?

ATS SMIC 36

The Cognitive Interview

- Memory enhancement technique
- Involves
  - "reinstating the context" of the event
    - Involves a patient and detailed review of activities preceding the event
  - Recalling the event in a different sequence
    - eg., in reverse
  - Reviewing the event from different perspectives
    - eg., as if replayed via surveillance camera tape
- Increases the quantity of information obtained
- Does not jeopardise witness credibility (as hypnosis does)

Fisher & Geiselman

ATS SMIC 37

Other tools:

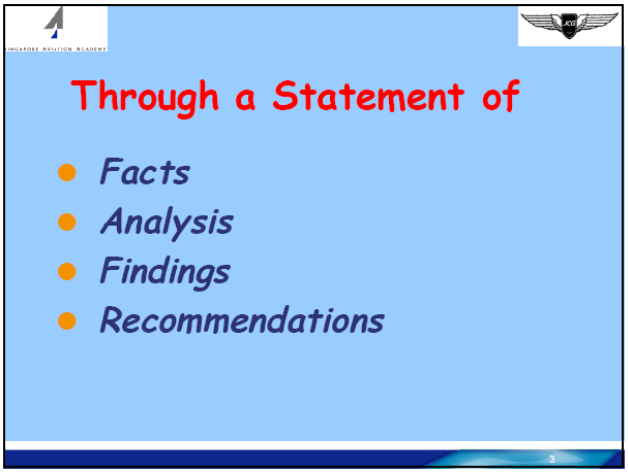
- Ask the witness to draw the scenario
- Use Bullet Points on Whiteboard
- Use 'models'
- In situ ~ point to location, etc.
- Ask what they think happened

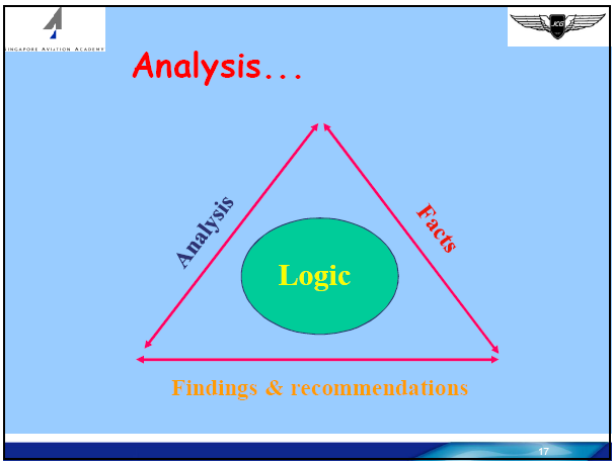
ATS SMIC 40

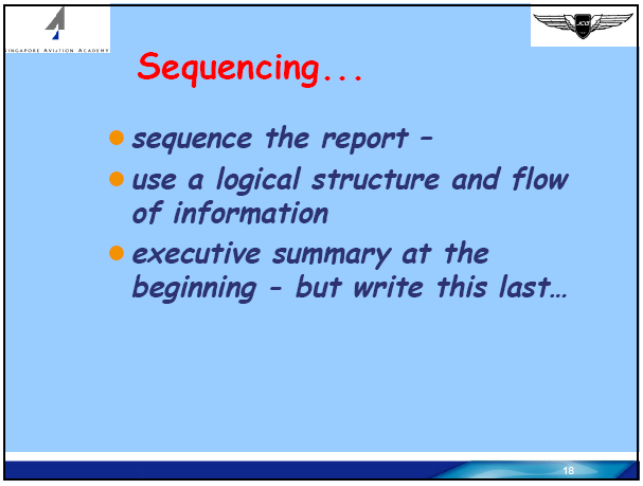
(五). 調查報告撰寫(Report Writing for ATS

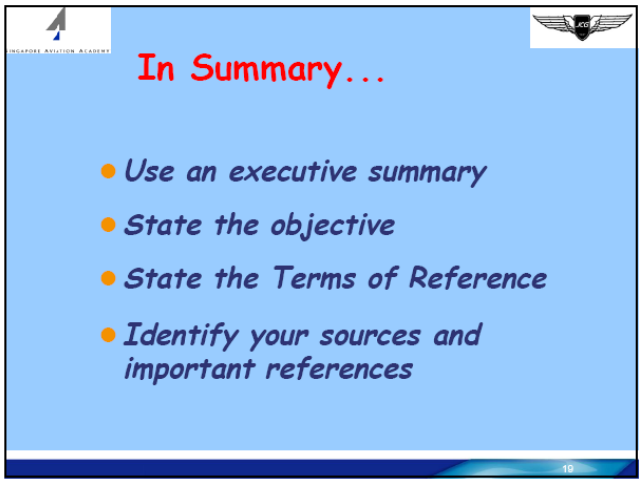
Investigators)

調查報告的撰寫重點是要讓人看得懂，報告重點要掌握有系統、有邏輯性，並以良好規劃方式呈現；內容包括事實、分析、分析後的發現及建議。調查報告中最困難的部分就是提出建議，建議必須是經過分析結果或有理論基礎，建議必須具有可行性，建議同時必需具有經濟效益，如果需要花費大筆金錢的建議，會造成被建議者實作的困難，亦無法解決問題，建議不應該越權，作出無理的要求，建議應指明負責人員，建議是可被持續追蹤並了解是否有被執行，建議應對整個組織及系統安全有幫助。









(六). 案例分享(Überlingen Mid-air collision over Lake Constance, Germany 01 July 2002)（附件二）

2002 年 7 月 1 日德國當地時間 23 時 35 分，Bashkirian Airlines 航班 2937（機型 Tupolev Tu-154M），搭載 57 名乘客及 12 名機組人員 ，由俄羅斯首都莫斯科飛往西班牙的巴塞羅納，另一架爲 DHL 貨機航班 611（機型-波音 757），機上共有 2 名飛行

員，從巴林國際機場經義大利的貝爾加莫國際機場（Aeroporto di Bergamo-Orio al Serio）飛往比利時的布魯塞爾，這兩架航班在德國南部毗鄰瑞士邊界的康斯坦茨湖上空相撞並墜毀，造成 71 人罹難，其中包括 50 名未滿 18 歲的青少年。

依據國際慣例，失事事件由發生地之飛安事件調查主管機關負責，本案由德國聯邦航空失事調查局（Bundesstelle für Flugunfalluntersuchung, 以下簡稱 BFU）進行調查，在花了 22 個月時間，BFU 於 2004 年 5 月 19 日公布了事件調查報告。

經還原事件原貌，事發當晚蘇黎士區域管制中心由管制員 Peter Nielsen 管制這兩架航班，Peter 是一位經驗豐富的管制員，他擔任管制員已經 8 年；事發當時另一位管制員在休息室休息，這情況並不符合單位的規定，但長久以來管制員在夜間航行量較少時，會合併席位，讓大家輪流休息，而管理單位也默認及忽視這樣的行爲。

當晚區域管制中心正進行相關裝備檢修，Peter 需要負責兩具雷達螢幕上的交通，兩具雷達螢幕相距約 1

公尺，Peter 則以椅子滑行於兩個席位間提供管制服務，約於晚上 20 時 11 分，兩位技術人員告訴 Peter，Skyguide 公司已經授權他們對主雷達進行維修，維修期間雷達螢幕運作將變慢，如果期間有飛機接近，系統也不會發出警告，另外他們還必須關閉通話系統，但是會切換到備用系統，這影響部分監控和通訊功能，但是 Peter 仍未請求支援，而獨自一人在席位上提供服務。

而在事件發生前，鄰近的德國航管中心早已發現異狀，但是 4 條通信線，有 3 條因維修而切斷，唯一剩下的 1 條因占線，讓鄰近的德國航管中心無法聯絡上 Peter。

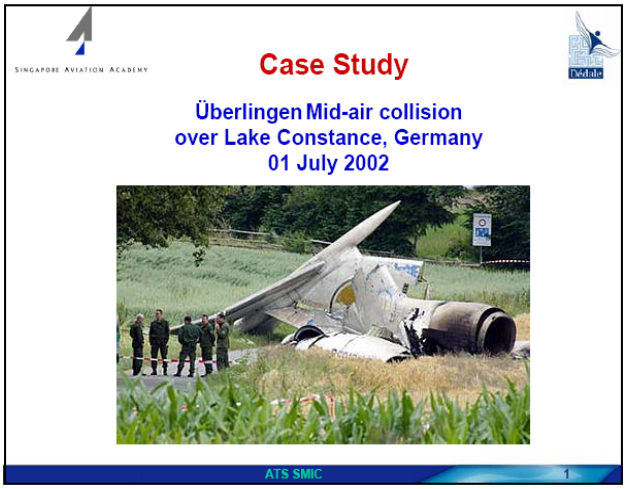
調查指出，Skyguide 公司以 1 名管制員執勤爲常態，但卻不符安全規範，而事發當時 Peter 管制 15 架飛機，承受極大壓力；如當時 2 名管制員均在席位上，應有機會避免這場空難。

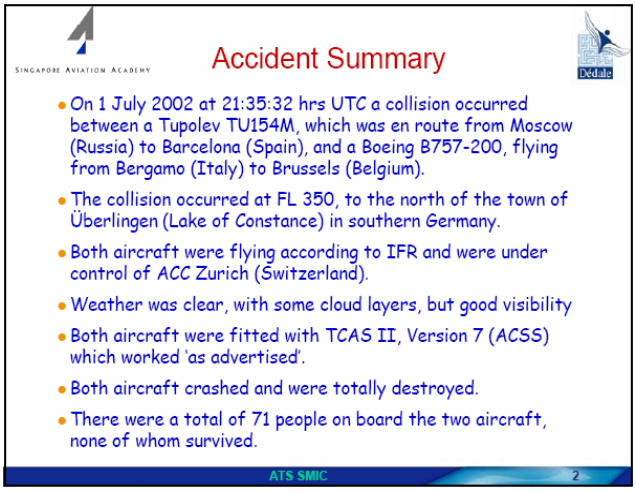
另外，Bashkirian Airlines 航班俄羅斯籍機長聽從 Peter 的指示下降高度，而未遵照空中防撞系統 TCAS 的指示爬升避讓，而同時間 DHL 駕駛員卻是遵照 TCAS 指示爬升高度，而造成兩個航跡交錯的航班在同

一個高度擦撞。

調查報告指出，其實在 Überlingen 事件發生前約 1 年半，日本上空曾差點發生一場空難，兩架共載有 677 人的巨無霸噴射機在空中擦身而過，猛烈的回避動作造成 100 人受傷，而其中部分人員傷勢嚴重。如果當時飛行員的反應慢上幾秒可能會造成史上最嚴重的空難。當時某位飛行員也是聽從管制員指示，而非依照 TCAS 的指示，而事後國際民航組織 ICAO 對這件事卻未有任何回應或處置。

而 Überlingen 事件，同樣也是 ICAO 未明確規定 TCAS 的使用原則，如果 ICAO 曾詳細調查前述日本的事件，並提議修正 TCAS 相關程序，這起空難也許就不會發生。

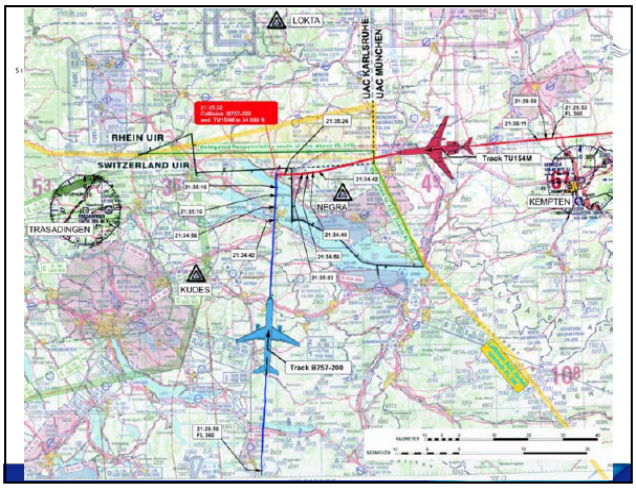




Factual information: Sequence of events

UTC	min:sec	Event
21:26:36	8:56	B757-200 climbs to FL 360
21:30:11	4:54	TU154 M initial call to ACC Zürich in FL 360
21:34:42	0:50	TCAS of both a/c report conflict „traffic, traffic“
21:34:49	0:43	ATC instructs TU154 to descend (expedite) to FL 350
21:34:56	0:36	The TU154 crew initiates a descent. Simultaneously a „Resolution Advisory“ of TCAS of both a/c occur. The B757 shall descend; the TU154 M shall climb. The B757 follows that command; the TU154 continues to follow ATC instruction
21:35:10	0:22	B757-TCAS „Resolution Advisory“ to „increase descent“
21:35:24	0:08	TU154 M-TCAS „Resolution Advisory“ to „increase climb“
21:35:32	0:00	Collision @ FL 350

ATS SMIC 5

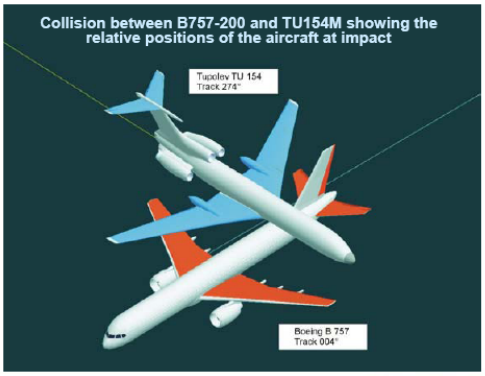


Factual information: ATC

- Although in German airspace, Zurich ACC was responsible for ATC
- The ATC system in Zurich was being operated in „fallback-mode“ while work was being carried out to re-arrange the airspace sectors
  - The visual mode of the Short Term Conflict Alert (STCA) tool was not available – however, the controller on duty was not aware of this
  - Horizontal minima was 7 NM instead of 5 NM
  - Direct telephone lines were not available
- One controller was covering two work stations; The second controller was in the rest area.
- Upper Area Control Centre (UACC) Karlsruhe realized the danger of collision via their STCA and tried to phone ACC Zurich. No phone connection was possible.

ATS SMIC 7

Collision between B757-200 and TU154M showing the relative positions of the aircraft at impact



ATS SMIC 9

1. Defining Absent or Failed Barriers

Describe the “last minute” control measures which failed or were missing, and therefore did not prevent the occurrence

- **Check Question:**

  “Does the item describe a work procedure, aspect of human awareness, physical obstacle, warning or control system, or protection measure designed to prevent an occurrence or lessen its consequences?”

ATS SMIC

2. Defining Human Involvement

Describe the errors and / or violations (actions or omissions) by a person / people at the scene which “triggered” the occurrence

- **Check Question:**

  “Does the item describe an error and / or violation that took place immediately before, and contributed to the occurrence?”

ATS SMIC

Contextual Conditions

Task, Environment and People

- **Latent Conditions that existed prior to and at the time of the event**
  - → They set the context for / allow the event
- **Have a direct influence on human actions (errors and/or violations)**
- **Include aspects of:**
  - → the task
  - → the work environment, and
  - → people's physical or emotional state, knowledge & attitudes and capabilities

3. Defining Contextual Conditions

- Describe the context of the event ~ the conditions existing immediately prior to and / or at the time of the occurrence
- **Check Question:**

"Does the item describe an aspect of the workplace, local organisational climate, task demands or a person's attitudes, personality, performance limitations, physiological or emotional state that helps explain their actions?"

Organisational Factors

The organisational and system factors (failures) which created, or allowed, the prevailing 'Contextual Conditions'

- Training
- Workforce Management
- Accountability
- Communication
- Organisational Culture
- Competing Goals
- Policies and Procedures
- Maintenance Management
- Equipment and Infrastructure
- Risk Management
- Change Management
- External Environment

4. Defining Organisational Factors

- Describe the organisational and system factors (failures) which created, or allowed, the prevailing contextual conditions
- **Check Question:**

"Does the item describe an aspect of an organisation's culture, systems, processes or decision-making that existed before the occurrence and which resulted in the relevant contextual conditions or allowed those conditions to continue?"

"Immediate Causes":

The following immediate causes were identified:

- The imminent separation infringement was not noticed by ATC in time.
- The instruction for the TU154M to descend was given at a time when the prescribed separation to the B757-200 could not be ensured anymore.
- The TU154M crew followed the ATC instruction to descend and continued to do so even after TCAS RA advised them to climb. This manoeuvre was performed contrary to the generated TCAS RA.

From BFU Investigation Report, May 2004

"Systemic Causes":

The following systemic causes were identified:

- The integration of ACAS/TCAS II into the aviation system was insufficient and did not correspond in all points with the system philosophy.
- The regulations concerning ACAS/TCAS published by ICAO and as a result the regulations of national aviation authorities, operations and procedural instructions of the TCAS manufacturer and the operators were not standardised, incomplete and partially contradictory.
- Management and quality assurance of the air navigation service company did not ensure that during the night all open workstations were continuously staffed by controllers.
- Management and quality assurance of the air navigation service company tolerated for years that during times of low traffic flow at night only one controller worked and the other one retired to rest.

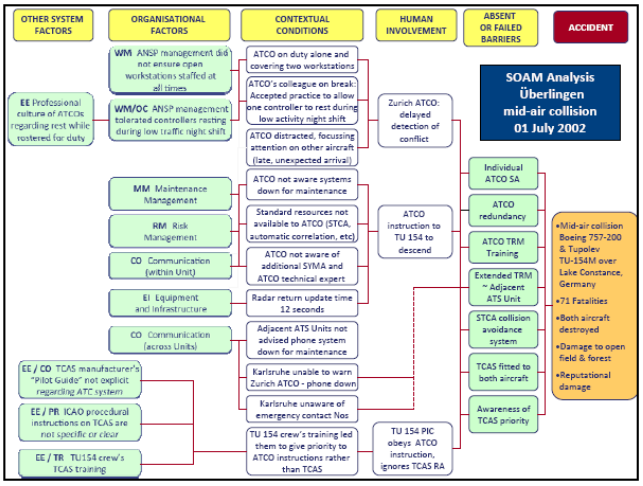
From BFU Investigation Report, May 2004

Systemic factors

- **Industry wide issues**
  - Integration of ACAS/TCAS II into the aviation system has not been properly carried out
  - Different, incomplete and partly contradictory procedures
  - Lack of standardisation
- **Air Navigation Service Provider**
  - Lack of an integrated safety management system
  - One controller only on duty at ACC Zurich has been tolerated for years, insufficient number of controllers
  - Lack of redundancy – mutual monitoring; coping with unforeseen traffic occurrences
  - Inadequate defences to protect the system from the consequences of human error

Primary lessons from this accident

- All the major contributing factors were human in nature, both at the individual and management levels
- As with virtually all aviation accidents, the key contributing factors to the Ueberlingen collision were present before the collision, and could have been identified and rectified
- Emphasises the need for comprehensive integrated safety management systems



BFU

The BFU Final Report on the Ueberlingen collision was issued on 19 May 2004, and is available for download at:

www.bfu-web.de

參、 心得及建議

一、 心得

本次奉派至新加坡學院參加「飛航服務安全管理及案件調查」計 10 天課程，學習到事件調查的技巧與方法、如何規劃及完成訪談、撰寫有意義的調查報告等，課堂中兩位澳洲籍的講師，相互串場並利用活潑生動的講授方式、案例分享、觀看影片、分組實作等，讓學員們能更快速的吸收及了解。

在分組討論過程中，大家相互分享所學及提供自己國家作業方式，而即便是依據國際規範運作規劃出屬於自己國家的飛航服務調查作業，也會因國情不同、文化不同、組織差異不同而有所差異，但調查最終目的同樣都是要發掘出事件發生的真正原因、潛在原因，並預防事件再次發生。

另外，國際民航組織持續不斷推廣「安全文化、由下而上」、「鼓勵主動提報提升飛航安全」、「調查過程主要期能發掘潛在風險因子、降低危險發生機率、不以處罰爲目的」等觀念，似乎在部份國家仍未採行，遂在本次課程中，講師也針對這些安全觀念，分享了相關資訊。

二、 建議

有關航空器意外事件或失事調查在我國是由行政院飛航安全委員會負責，而民航局仍負責其他飛安相關事件調查，如涉及駕駛員或管制員造成的隔離不足事件或潛在飛安風險等。本次課程雖然著重在意外或失事事件調查方法及實作，但對於需從事一般飛航事件調查人員來說，有實質上的幫助，像是訪談的技巧、證據的蒐集及過濾、調查經過的撰寫、避免事件再次發生給予的建議等，而事件相關資料的蒐集必須是全面性、全盤性的，在經過系統性的課程訓練後，對於調查人員進行作業時，能更加順利，因此建議爾後負責事件調查人員均能參加此課程，以提升調查品質。

附件一

Singapore Aviation Academy
ATS Safety Management and Investigation Course
10-21 October 2011

DAY 1
Monday 10 October 2011

0845	*Course registration*	
0900	**Course Welcome and Opening Ceremony**	*SAA & Singapore Ministry of Foreign Affairs*
1000	*Welcome Refreshments*	
1030	**Session 1** **Course Introduction & Overview** • *Course orientation and objectives*	*Brent Hayward & John Guselli*
1145	**Session 2** **Introduction to ATS Safety Management** • *Key issues*	*John Guselli*
1230	*Lunch*	
1330	**Session 3** **Safety Management Systems in ATS** • *Common elements* • *Regulation* • *Measurement* • *Safety Cases*	*John Guselli*
1500	*Refreshment Break*	
1515	**Session 4** **Introduction to Human Factors in ATS** • *Human Factors origins and objectives* • *Human factors activities* • *Key issues in ATS*	*Brent Hayward*
1700	**End of Day 1**	

Singapore Aviation Academy
ATS Safety Management and Investigation Course
10-21 October 2011

DAY 2
Tuesday 11 October 2011

0900	Review of Day 1	
0915	**Session 5** **Introduction to ATS Safety Investigation** • *ICAO Annex 13* • *Purpose and objectives* • *Role of the ATS investigator* • *Investigator qualities and ethics*	*John Guselli*
1030	*Refreshment Break*	
1100	**Session 6** **Human Performance Considerations** • *Information processing* • *Perception / Memory* • *Situational awareness* • *Decision making* • *Communication* • *Stress & Fatigue*	*Brent Hayward*
1230	*Lunch*	
1330	**Session 7** **Practical Resource Management** *Practical Resource Management exercise*	*John Guselli &* *Brent Hayward*
1500	*Refreshment Break*	
1515	**Session 8** **Maintenance of Operational Standards** *Applied Resource Management exercise*	*John Guselli &* *Brent Hayward*
1700	**End of Day 2**	

Singapore Aviation Academy
ATS Safety Management and Investigation Course
10-21 October 2011

DAY 3
Wednesday 12 October 2011

0900	Review of Day 2	
0915	**Session 9** **Risk Management in ATS** • *Components* • *Likelihood and Consequence* • *Categorisation* • *Practical Exercise*	*John Guselli*
1030	*Refreshment Break*	
1100	**Session 10** **Understanding Human Error** • *Principles of Human Error* • *"We all make mistakes…"* • *Errors vs violations* • *The "Inside" view*	*Brent Hayward*
1230	*Lunch*	
1330	**Session 11** **ATS Risk Management Exercise** • *Practical risk management activity*	*John Guselli & Brent Hayward*
1515	*Refreshment Break*	
1530	**Session 12** **Human Factors Models as Investigative Tools** • *Individual vs Systemic approaches* • *SHEL/O ~ The expanded SHEL model* • *Reason's "Swiss Cheese" Model*	*Brent Hayward*
1700	**End of Day 3**	

Singapore Aviation Academy
ATS Safety Management and Investigation Course
10-21 October 2011

DAY 4
Thursday 13 October 2011

0900	Review of Day 3	
0915	**Session 13** **Systemic Occurrence Analysis Methods** • *Human Involvement* • *Contextual Conditions* • *Organisational and System Factors* • *Barriers ~ Absent or Failed*	*Brent Hayward*
1030	*Refreshment Break*	
1100	**Session 14** **Communication Skills 1:** **Presentation Skills for ATS Investigators** • *Effective communication to management and staff*	*John Guselli*
1200	*Lunch*	
1300	**Session 15** **An Introductory Investigation Exercise** *"The John Hawkins Affair"*	*John Guselli &* *Brent Hayward*
1500	*Refreshment Break*	
1515	**Session 16** **Introductory Investigation Exercise** *continues*	*John Guselli &* *Brent Hayward*
1700	**Escorted visit to Singapore ATC Centre & RCC**	*Raymond Seah* *Senior ATC Manager* *CAAS*
1830	**Course Dinner at SAA** *Hosted by Singapore Aviation Academy*	*Delegates & Guests*
	End of Day 4	

Singapore Aviation Academy
ATS Safety Management and Investigation Course
10-21 October 2011

DAY 5
Friday 14 October 2011

0900	Review of Day 4	
0915	**Session 17** **Cultural Considerations in ATS Operations** *The influence of national, organisational and professional cultures*	*Brent Hayward*
1045	*Refreshment Break*	
1115	**Session 18** **Enhancing Safety Culture** *"Safety Culture Evolution"*	*Brent Hayward*
1200	*Lunch*	
1400	**Session 19** **An IATA Perspective**	*Gordon Griffiths* *Assistant Director* *IATA Asia Pacific*
1500	*Refreshment Break*	
1515	**Session 20** **The Organisational Accident: A Case Study** *"The Dryden Accident" ~ Review and Analysis*	*Brent Hayward*
1700	**End of Week 1**	

Singapore Aviation Academy
ATS Safety Management and Investigation Course
10-21 October 2011

DAY 6
Monday 17 October 2011

0900	Review of Week 1	
0915	**Session 21** **Investigating in Practice** *ICAO Annex 13 requirements and experience from the Singapore Air Accident Investigation Bureau (AAIB)*	*Chong Chow Wah* *Senior Investigator* *AAIB, Singapore*
1030	*Refreshment Break*	
1100	**Session 22** **The Legal Perspective** *Air Traffic Control and the Law*	*Tan Siew Huay* *CAA of Singapore*
1230	*Lunch*	
1330	**Session 23** **Practical Case Study** *(Runway Incursion)*	*John Guselli &* *Brent Hayward*
1500	*Refreshment Break*	
1515	**Session 24** **Practical Case Study** *continued* *(Runway Incursion)*	*John Guselli &* *Brent Hayward*
1700	**End of Day 6**	

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DAY 7
Tuesday 18 October 2011

0900	Review of Day 6	
0915	**Session 25** **Interviewing Skills for Safety Investigators 1** *Witness interviewing skills*	*Brent Hayward*
1045	*Refreshment Break*	
1115	**Session 26** **Interviewing Skills for Safety Investigators 2** *Seeing isn't always believing* *(Witness interview simulation)*	*John Guselli &* *Brent Hayward*
1230	*Lunch*	
1330	**Session 27** **Interviewing Skills for Safety Investigators 3** *Positive model: Witness interviewing in practice*	*Brent Hayward &* *John Guselli*
1415	**Session 28** **Danger on the Ground** *Case Study: Milan Linate*	*Brent Hayward &* *John Guselli*
1545	*Refreshment Break*	
1600	**Session 29** **The ATS Safety Audit Process** • *Operational* • *Human Factors issues*	*John Guselli &* *Brent Hayward*
1700	**End of Day 7**	

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DAY 8
Wednesday 19 October 2011

0900	Review of Day 7	
0915	**Session 30** **ATS Investigation in Practice**	*John Guselli*
1030	*Refreshment Break*	
1100	**Session 31** **Communication Skills 2:** **Report Writing for ATS Investigators** • *Writing to be understood* • *Communicating Findings and Recommendations* • *Report writing in practice*	*John Guselli*
1230	*Lunch*	
1330	**Session 32** **Danger in the Sky** *Case Study: The Ueberlingen Mid-Air Collision*	*Brent Hayward &* *John Guselli*
1530	*Refreshment Break*	
1545	**Session 33** **ATCO Emergency Procedures Training** *"ASSIST" ~ courtesy of EUROCONTROL*	*Brent Hayward*
1700	**End of Day 8**	

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DAY 9
Thursday 20 October 2011

0900	Review of Day 8	
0915	**Session 34** **Major Case Study:** **A Systemic Investigation** *Introduction and Briefing ~* *Course members work in assigned syndicates to conduct Major Investigation Exercise*	*John Guselli & Brent Hayward*
0930	**Session 35** **A Systemic Investigation** • *Investigation commencement and planning*	*Syndicate work*
1030	*Refreshment Break*	
1100	**Session 36** **Systemic Investigation** *continues* • *Data gathering ~ interviews*	*Syndicate work*
1230	*Lunch*	
1330	**Session 37** **Systemic Investigation** *continues* • *Data gathering ~ interviews*	*Syndicate work*
1530	*Refreshment Break*	
1545	**Session 38** **Systemic Investigation** *continues* • *Data analysis*	*Syndicate work*
1700	**End of Day 9**	

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DAY 10
Friday 21 October 2011

0900	**Session 39** **Systemic Investigation** *continues* • *Preparation of investigation team reports* • *Course members work in syndicates to complete Investigation Team presentations*	*Syndicate Work*
1030	*Refreshment Break*	
1100	**Session 40** **Systemic Investigation** *continues* • *Preparation of investigation team reports*	*Syndicate Work*
1200	*Lunch*	
1400	**Session 41** **Systemic Investigation:** **Presentation of Investigation Team Reports**	*Syndicates*
1545	**Session 42** **Course Conclusion** • *Course evaluation* • *Feedback*	*SAA, John Guselli & Brent Hayward*
1600	**Presentation of Course Certificates**	*SAA & Singapore Ministry of Foreign Affairs*
1630	**Close of the** **2011 ATS Safety Management and Investigation Course**	

附件二

Nunes, A. & Laursen, T. (2004) Identifying the factors that led to the Ueberlingen mid-air collision: implications for overall system safety. Proceedings of the 48th Annual Chapter Meeting of the Human Factors and Ergonomics Society, September 20 - 24, 2004, New Orleans, LA, USA.

IDENTIFYING THE FACTORS THAT CONTRIBUTED TO THE UEBERLINGEN MIDAIR COLLISION

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Zurich Area Control Center
Switzerland

On the night of July 1, 2002, a Boeing 757 collided with a Tupolev-154 at 35,000 feet, resulting in 71 fatalities. Initially, this accident was immediately blamed on two individuals. First, the pilot of the Tupolev aircraft whose command of the English language was questioned when repeated descent instructions from ATC were not immediately responded to. The second individual was the controller on duty, who was accused of not exercising the abilities needed in order to detect the presence of a conflict between aircraft and resolve them. In this paper, we provide an analysis of the event, highlighting fundamental human and system errors that occurred that night: errors that contributed to the worst midair collision in recent history.

INTRODUCTION

The primary goal of the air traffic control (ATC) service is to provide for the safe, orderly and expeditious movement of traffic through the national airspace system. In performing this critical task, the controller relies on a variety of tools that include but are not limited to a radar screen that provides a top-down view of the airspace, an assigned radio frequency which may be used to communicate with the pilot and various forms of conflict alert systems that provide notification of potential aircraft collisions. This synchrony between man and machine has for the most part ensured that the cycle of air safety is maintained. On the night of July 1, 2002, this cycle was broken when a DHL Cargo airliner collided with a Bashkirian Airlines jet over German skies. This paper represents a systematic effort on the part of the authors to identify the underlying 'human' and 'system' factors that led to this midair collision, bridging the gap between theory and application, in an attempt to illustrate that systems can and do fail, sometimes with devastating consequences.

Known Sequence of Events

The Boeing 757 (registered to DHL) was en route from Bergamo (Italy) to Brussels on a heading of 004 degrees at FL 260. The Tupolev-154 (registered to Bashkirian Airlines) was flying from Munich to Barcelona on a heading of 254 degrees at FL 360, correcting its heading twice within the last minute to end up on heading of 274 degrees. Both aircraft were equipped with the Traffic Collision and Avoidance System (TCAS) and their trajectories put them on a converging course at a 90° angle in airspace above Lake Constance, Germany. Under a contractual agreement between the German and Swiss government, this airspace was under the authority of the Zurich Area Control Center (ACC). After making contact with the B757, the Swiss controller issued two clearances to the B757. First he cleared the B757 to climb to FL 320 and at time 21.26.36 to climb to FL 360. At time 21.30.11 the T-154 called in. After that, the Swiss controller did not initiate any contact with either aircraft until just seconds before the TCAS system aboard gave both pilots a traffic advisory. Following this, the controller instructed the T-154 to descend from FL 360 to FL 350 to avoid collision with the B757. However, the TCAS on board the T-154 and B757 instructed the pilots to climb and descend respectively. After receiving contradictory instructions, the T-154 pilot opted to obey controller orders and began a descent to FL 350 where it collided with the B757, which had followed its own TCAS advisory to descend. All 71 people were killed.

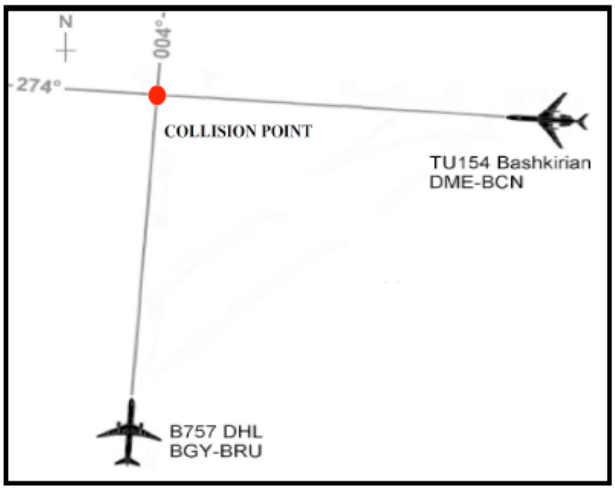

Figure 1: Trajectories of B757 and T-154

At first glance, knowledge of the timeline of events would suggest that there were two individuals who were solely to blame for the accident. Firstly, the Russian pilot who disobeyed his TCAS system and followed controller instructions to descend instead of climbing. Second and more importantly, blame should lie on the controller who was fully aware of the presence of both aircraft in his sector but waited for more than four minutes before issuing a descent clearance and a traffic information report to the Russian pilot. The controller's most important task is to ensure safety in the sector. The controller failed in that task: or did he?

Identification of Contributing Factors

Contributing Factor 1. Single Man Operations

On the night of the accident, there were two controllers on duty working. Only one controller works at a given time, while the other controller is on break, an accepted and long standing arrangement. The presence of only one controller working the radar screen represents one of the underlying causes of the accident, namely lack of supervision or assistance in safety-critical situation. This Single Man Operation (SMOP) was a controversial procedure implemented in 2001, despite numerous protests from the controller union. Whereas during the day there are a greater number of controllers on duty, making it easier to catch potential errors, the policy did not specifically state that the SMOP should not be used at night; a period during which staffing levels are extremely low, making it harder to catch errors. This procedural lack of clarity puts greater monitoring burden on the controller at night. Procedures did state however, that when the SMOP is in effect, a conflict detection system be on and fully functional. The Zurich ACC's system, known as the Short Term Conflict Alert (STCA), provides the controller with a two-minute alarm, which visually indicates the presence of a conflict.

Contributing Factor 2. Downgraded Radar

On that night, maintenance work was being done on the main radar system, which placed radar services in their fallback-mode. As a result, separation minimums between aircraft were increased from 5 miles to 7 miles (corresponding to approximately one minute). The fall-back radar mode also meant that the STCA was not available. Here again, we identify a contributing factor to the accident. Given the limits, of human perceptual ability (Hopkin, 1995), controllers may rely on conflict detection aids to help them identify potential problems before they occur. Unit procedures specifically mandated that the STCA be available when SMOP were taking place: but it was not.

Contributing Factor 3. Dual Frequency Responsibility

The en route controller is generally responsible for monitoring an assigned frequency using a single radar display. However, at night, it is not uncommon for sectors to be amalgamated, resulting in the controller having to monitor more than one frequency. The division of auditory attention across multiple frequencies does not result in any performance costs that warrant concern given the low traffic load observed at night. On the night of the accident, the controller was monitoring two radio frequencies, the first used by en route aircraft and the second for aircraft on approach to the Friedrichshafen airport (FHA) in Germany. There are two important issues to note here. Firstly, arrival traffic at that airport at night was extremely rare. Secondly, the controller chose to have the radar information for traffic approaching the airport displayed on a separate monitor. As a result, the controller had to monitor two display consoles that were separated by over a meter, resulting in the maintenance of divided attention for a sustained period of time. As fate would have it, there were two aircraft on approach that night to the airport. The controller had earlier coordinated the approach for the first aircraft to land on runway 06. Following this, the second aircraft on approach requested runway 24 at FHA. In order to provide this clearance, the en route controller first had to obtain permission from the airport tower. To do so, he had to use the automated phone system

Contributing Factor 4. Phone System

The automated phone system used in the Zurich ACC enables controllers to communicate with one another at the touch of a button. In addition to inter-facility coordination, the controller can also communicate with ATC facilities in Germany to coordinate local approaches such as that to the FHA airport. On the night of the accident the main telephone system was also out for maintenance and the back-up system had a software failure, which no one in the company had noticed, not even during tests run three month before the accident. As a result, when the controller tried to contact the FHA tower to inform them that the second aircraft was requesting a different approach, he could not get through. Given that the phone system had worked perfectly since its implementation (more than four years ago), the controller had a high degree of trust in the system and as a result did not think the system had failed, rather believing he had dialed the wrong number. He continued his attempts to reach the FHA tower while neglected to maintain his usual scanning pattern on the other radar console, which depicted the B757 and T154 converging at the same altitude. The severity of the malfunctioning phone system cannot be underestimated. Two minutes before the collision occurred, controllers working the Upper Area Sector at Karlsruhe, Germany noticed the situation unfolding, given that their own STCA had gone off, and tried to contact the Swiss controller to warn him. Despite numerous attempts, they could not get through to him because of the malfunction in the phone system. The controller's communication with the outside world was essentially cut-off. The next line of defense at this point was TCAS.

Contributing Factor 5. TCAS

TCAS is designed to provide not only traffic advisories but also resolution recommendations to avoid a midair collisions and it was in fact this system that alerted the pilots of both

aircraft to the pending conflict a full seven seconds before the controller, who was busy vectoring another aircraft in for landing using a separate radar screen. After the pilots were alerted to the collision, the TCAS instructed the DHL pilot to descend and the T154 pilot to climb. However, note that the T154 had already been instructed by the controller to descend. This choice exacts that two technical issues be considered. Firstly, TCAS does not provide the controller with information regarding resolution advisories: the pilot only knows these advisories. Therefore, the controller had no way of knowing that the system had instructed the T-154 to climb, resulting in an 'honest' decision error (Shappell & Wieggman, 1997) on the part of the controller. Second and more importantly, TCAS does not account for situations where one of the aircraft does not follow its instructions. In the present case, T-154 disobeyed its own TCAS instructions to climb (the pilot opting to follow controller instructions) and descended to FL 350. The result in the B757 cockpit, was an instruction to increase the rate of descent rather than remaining level at its original altitude of FL 360. Had this been done, safe separation would have been maintained. This inability of TCAS to make the controller aware of what resolution advisories were issued to the pilot or account for the execution of alternative actions by the pilot represent major limitations of the system; limitations that we postulate played a role in this event. Another piece of the puzzle is to understand the pilot actions before the collision

Contributing Factor 6. Corporate Culture

Data analysis suggests that whereas the B757 pilot followed the TCAS advisory to descend, the T-154 pilot opted out of following this advisory to climb and followed controller instructions to descend. This raises the issue of why the pilots of two separate aircraft would respond to the system in such a different way. When presented with conflicting information between ATC and TCAS, European pilots are advised to follow TCAS whereas Russian pilots are trained to take both into account before rendering a decision. In most instances, the latter group will follow ATC. This may help explain why the B757 pilot (who was British) and the T154 pilot acted in the manner observed.

A 'CLEARER' PICTURE

In light of this information, one now gains a clearer picture of what exactly happened that night. When the second controller left the workstation to take a break, the first controller was working his shift without any assistance. Notwithstanding issues related to lack of supervision and vigilance effects that are associated with monitoring under low traffic load (the effects which may be magnified at night), the primary conflict alert system, whose use was mandated in that situation was turned off. The dynamic event began at 21.20.08 when the controller made radar contact with the B757 as it entered the sector at FL 260. Shortly thereafter the B757 was cleared to FL320 and at 21.26.36, the aircraft was cleared to climb to FL 360 as per the pilot's request. At this point, the controller had not made radar contact with the T-154 until 21.30.11.

After both aircraft had entered the sector, the controller became preoccupied handling the approach of an aircraft (Airbus A320) to a separate airport that required him to use a different radio frequency and more importantly a different monitor: this act in itself pushed the limits of divided auditory and visual attention. In handling the approach, the controller had to call a tower using a phone system that had been reliable since it was installed. As a result the controller had high trust in the system. Therefore, when the controller experienced problems using it, he did not question its effectiveness but rather his own abilities in using the system. First the controller experienced an automation surprise (Dekker, 2002) and this resulted in cognitive tunneling (Wickens & Hollands, 2000) on the part of the controller as he struggled to get the system to work in one workspace, while neglecting the radar screen in another, a radar screen that depicted two aircraft converging at the same altitude. In Karlsruhe, which has overlapping radar coverage with the Zurich ACC, the STCA went off at 21.33.34. At this point the controller working the sector notified his supervisor and tried in vain for over a minute (from 21.33.36 to 21.34.45) to contact Zurich ACC to notify the controller of the pending conflict, but was unable to do so given the phone system malfunction. Note that as per standard procedure, whereas it would have been possible to use the worldwide emergency transmission code of 121.5 to warn the aircraft in question directly of the possible collision, this required prior approval from the Zurich ACC (which currently had responsibility for the aircraft), and this was not possible for the aforementioned reasons.

When the controller finally noticed the conflict, he immediately instructed the T-154 at 21.34.49 to descend not knowing that the aircraft's TCAS had instructed the pilot to climb. This lack of knowledge represents a possible design flaw in the TCAS system, which does not provide the controller with sufficient information about aircraft maneuver recommendations, leaving the controller 'out-of-the-loop' in terms of knowing the pilot's perceived maneuver choices. Similar design 'flaws' also led to the TCAS's system's inability to account for non-compliance on the part of one user, evident when it continued to instruct the B757 aircraft to increase its descent rate even after the T-154 had begun to execute the same maneuver, putting both aircraft on a collision course. Finally, cultural differences led the crew of one aircraft to following TCAS recommendations and another to ignore it, under high temporal pressure. This series of events culminated in the mid-air collision.

Other Factors

It is important to note that the factors identified here are by no means comprehensive. There were in fact many other elements that may have contributed to the accident. For example, one issue has been that the fact that the aural STCA that sounded when both aircraft were 6.5 nm (32 seconds) away from one another was not heard by anyone in the control room, raising concern over its audibility. Although this is a valid argument, it is worthwhile noting that the aural STCA

system sounded at 21.35.00, well after the controller had already started reacting to the evolving conflict situation. Therefore, in the event that someone had heard the alarm go off, it would have only pointed out the urgency of the situation: one which the controller had already started dealing with. Therefore, the factors listed above are what we consider to have contributed substantially to the event and the absence/reversal in any one of them may well have averted the collision. For example:

- Had the first controller not been on a break (Factor #1), the impending conflict may have been pointed out a lot sooner, giving more time for conflict resolution.
- Had radar service not been downgraded (Factor #2), the STCA system would have provided the controller with over a two-minute visual warning of the collision instead of the 32-second auditory alarm that he received.

Therefore, it is a reasonable assertion that whereas there were multiple factors that contributed to the mid-air collision, the effects of some of these factors were more profound than others.

CONCLUSION

The mid air collision over Ueberlingen, Germany on the night of July 1, 2002 is the worst in recent history, and many of the factors that contributed to it (such as communication shortcomings), mimic those of seen in previous mid-air collisions (Zagreb, 1976; Delhi, 1996). Analysis of the event based on technical reports and operational experience, clearly shows how multiple human and system factors can conspire to produce the observed outcome and it provides empirical support for theories that highlight the difficulty associated with divided attention across single channels, trust in automation, and decision-making under time pressure. And ultimately, it is testament to the supposition that in this profession, time is a luxury that the controller cannot afford.

ACKNOWLEDGEMENTS

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