85-25-3131

出席飛航安全基金會
第四十八屆年會會議報告

報告人：劉研究員韻珠

林工程師沛達

交通部運輸研究所

中華民國八十五年四月

行政院所屬各機關因公出國人員出國報告書審核表

出國計畫主辦機關代號：＿＿＿＿　全銜：中華航空事業發展基金會　聯絡單位：＿＿＿＿　聯絡人：徐專員俊伍　聯絡電話：514-5896

① 報告書名稱	出席飛航安全基金會第四十八屆年會	② 頁數	224 頁　附件：☑ 有　☐ 無

出國人員（表格不敷使用，請自行浮貼）	③ 姓名	④ 服務機關	⑤ 單位	⑥ 職稱官職等	⑦ 連絡電話
	劉韻珠	交通運輸研究所	運安組	簡任研究員	(02)349-6853
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					(　)
					(　)
					(　)
					(　)

⑧ 出國類別	☑1 出席國際會議 ☐2 考察 ☐3 進修 ☐4 研究 ☐5 實習 ☐6 其他活動（請註明）＿＿＿＿
⑨ 出國期間	自 84 年 11 月 5 日至 84 年 11 月 11 日
⑩ 繳交報告書日期	年　月　日
⑪ 派赴國家地區	美國西雅圖

⑫ 實際支用金額（以新台幣計）	☐1 出國計畫機關經費＿＿年度＿＿元 ☐2 其他機關經費（機關名稱：　）＿＿年度＿＿元 ☑3 國內團體經費（團體名稱：中華航空事業發展基金會）178,870 元 ☐4 外國政府或團體經費（國家或團體名稱：　）＿＿元 ☐5 國際團體（團體名稱：　）＿＿元
⑭ 出國計畫主辦機關審核意見	☑1 依限繳交出國報告書 ☑2 格式完整 ☑3 內容充實完備 ☑4 論述深入精闢 ☑5 建議具參考價值 ☑6 送本機關參考或研辦 ☐7 送上級機關參考 ☐8 送其他機關參考：（機關名稱：　） ☐9 陳請院長核閱 ☐10其他處理意見：
⑮ 層轉機關審核意見	☐ 同意主辦機關意見：☐ 全部/ ☐ 部分 ＿＿＿＿＿＿（填寫編號） ☐ 其他處理意見：
⑯本院研考會／省（市）政府研考會審核意見	☐ 同意主辦機關意見 ☐ 同意層轉機關意見 ☐ 送指定圖書館 ☐ 函請補正 ☐ 其他處理意見：

⑬ 內容提要

本所爲飛航安全基金會(Flight Safety Foundation, 簡稱FSF)之會員，本次該基金會第48屆年會承財團法人中華航空事業發展基金會補助本所兩位同仁出國經費，使能有機會蒐集世界各國最新飛安資訊，聆聽飛安相關專題演講，可謂受益良多。

本屆年會係由波音公司主辦，於民國八十四年十一月七日至十日爲期四天，假美國西雅圖Westin Hotel舉行。本次研討會與國際適航聯盟第25屆國際會議(International Federation of Airworthiness)聯合舉行。與會人數逾300餘人（含非全程參加者），四天會議中不同領域專業之專題報告共計二十五篇，包括年度全球民航機失事統計分析一篇、飛安前瞻一篇、航空營運管理七篇、航管與機場營運七篇、航空器之維修與設計六篇、航空公司安全管理三篇。專題涵蓋航空界各類需求，提供了不少最新研究結果。內容充實具體，對促進飛航安全深具正面效果。與會人員於專題報告後，均紛紛蒐集寶貴資料，攜回供參考，旨在吸取專家學者研究精華，作爲失事預防或安全計畫改進之參考。

一、本表請詳填後併同報告書處理。
二、出國計畫主辦機關即層轉機關時，不須填寫「層轉機關審核意見」。
三、機關代號依銓敘部、行政院人事行政局及台灣省政府人事處編印「全國公務人事資訊統一代號本」之「機關暨學校代號」填寫。
四、出國類別係屬「其他活動」者，僅須填寫①至⑫欄。

出席飛航安全基金會第 48 屆年會會議報告

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出席飛航安全基金會第48屆年會會議報告

壹、前　　言

本所爲國際飛航安全基金會(Flight Safety Foundation,簡稱FSF)之會員，本次該基金會第48屆年會承財團法人中華航空事業發展基金會補助本所兩位同仁出國經費，使能有機會蒐集世界各國最新飛安資訊，聆聽飛安相關專題演講，可謂受益良多。

本次研討會開幕典禮時該基金會董事長Stuart Matthews致辭表示，該基金會係成立於西元1945年，目前全世界已有75國與航空事業有關之團體會員近600個以及贊助者；該基金會爲發展飛航安全之學術組織，由國際知名之航空學術專家38人組成之董事會領導推動會務。其成立宗旨係爲推展航空安全相關資訊之溝通、飛安業務之評估與諮詢顧問服務、定期編撰新科技發展研究之論文或書刊、舉辦飛安研討會等，對提升各國民航飛行安全水準有極大之貢獻。該基金會不以營利爲目的，且不從事任何政治活動。與會人員包括各國之民航主管機關、研究機構、飛機製造業、發動機製造業、電子儀器、航行與助航、航管系統、機場管理與服務、機場消防、航空醫學、心理學、保險業等，涵蓋了整個航空專業領域。每年定期之飛安研習會與國際飛安年會中，在不同學術領域内，提供各種最新航空資訊與裝備，供全球航空界參考運用。

有鑑於全球多年來飛安事件之主要肇因約佔七成者係屬人爲因素，該會特別針對如何降低飛機失事人爲因素之預防，成立專案小組長期投下人力、物力，利用跨國航空專業人材，共同研擬有效之失事預防策略，每年在飛安研習會與年會中陸續提供全球航空業者參考改進。

該基金會同時亦接受會員體委託對其公司內部飛安組織與業務，作定期與不定期安全檢查，並提出有效之改進建議，作爲公司安全計畫改進之參考，對世界航空業者提升飛行安全之貢獻良多。

貳、行程紀要

本次出國行程自民國84年11月5日至11日，總計7日，主要活動地區爲美國西雅圖，詳細行程如下：

日　期	星期	地　點	行程紀要
84年11月5日	日	台北-美國西雅圖	搭乘長榮班機前往美國西雅圖 辦理報到手續
11月6日~11月9日	一~四	美國西雅圖	出席研討會
11月10日	五	西雅圖-台北	搭乘長榮班機返台

一、研討會概述

本屆年會係由波音公司主辦，於民國84年11月7日至10日爲期四天，假美國西雅圖Westin Hotel舉行。本次研討會由於係與國際適航聯盟第25屆國際會議(International Federation of Airworthiness)聯合舉行，與會人數約逾300餘人(含非全程參加者)，四天會議中不同領域之專題報告共計25篇，包

括年度全球民航機失事統計分析1篇、飛安前瞻1篇、航空營運管理7篇、航管與機場營運7篇、航空器維修與設計6篇、航空公司安全管理3篇。專題涵蓋航空界各類需求，提供了不少最新研究結果。內容充實具體，對促進飛航安全深具正面效果。與會人員於專題報告後，均紛紛蒐集寶貴資料攜回供參考，以吸取專家學者研究精華，作為失事預防或安全計畫改進之參考。

二、會議內容概要

本次研討會除11月6日係為諮詢委員、主講人與主持人之總會議外，各會員代表則為6日下午辦理報到，並參加當日晚間之歡迎酒會。正式研討會自7日開始針對前述各項專題進行報告與研討，茲將會議之議程詳細說明如下：

MONDAY.NOVEMBER 6

0900~1200 IFA Technical Committee Meeting *(St. Helens)*
0900-1200 IFA Scholarship Meeting *(St. Helens)*
1230-1530 FSF International Advisory Committee (IAC) Meeting *(Vashon I & II)*
1430~1700 IFA Executive Council Meeting *(St. Helens)*
1600~1700 Speakers' and Session Chairmen's Meeting *(Cascade Ballroom)*
1830~2100 Opening Reception
Hosted by Boeing at the Museum of Flight.
Buses depart from the Virginia Avenue entrance of the hotel between 1830 and 1930.

TUESDAY.NOVEMBER 7

Session I Opening Ceremonies and Welcome
(Cascade Ballroom)

0830~0930 "Opening of Seminar"- Capt. Osvaldo Oliveira, chairman, IAC, and head of Flight Safety Department, TAP Air Portugal
"Welcome to Seattle "- Boeing Commercial Airplane Group
"Remarks"- Stuart Matthews, chairman, president and CEO, FSF
"Remarks"- Stewart John , OBE, president , IFA
"Remarks"- Mike O'Brien, director, technical business development, IATA
"Keynote Address"- David R. Hinson, administrator, U.S. Federal Aviation Administration (FAA)

0930~1000 Refreshments(Cascade Ballroom Foyer)
Sponsored by British Airway

Session II The Safety Perspective(Cascade Ballroom)
Session Chairman-Earl Weener,Ph.D,chief engineer,SystemsEngineering, Boeing Commercial Airplane Group

1000~1045 "Safety Statistics"-Paul Russell, chief engineer, Airpland Safety Engineering, Boeing Commercial Airplane Group

1045~1130 "FSF CFIT Task Force Update"- Earl Weener, Ph,D, chief engineer, Systems Engineering, Boeing Commercial Airplane Group

1130~1200 Questions and Answers

1200~1330 Lunch (Grand Ballroom I) Sponsored by GE Aircraft Engines, SNECMA

Session III Management in Aviation Operations
(Cascade Ballroom)
Session Chairman —Gerald R. Mack, director, Airplane Certification, Boeing Commercial Airplane Group

1330~1335 "Function Follows Form : Practical Tips for

Building CRM/Human Factors—oriented Organizational Structures"—John Lauber, Ph. D., vice president, Corporate Safety and Compliance, Delta Air Lines, and Capt. Ray Justinic, human factors coordinator, Delta Air Lines

1335~1420 "Managing and Regulating Aviation Safety: A New Emphasis and a New Relationship "—M.J. Overall, head of licensing standards, U.K. Civil Aviation Authority (CAA)

1420~1445 "International Aviation Safety Assessment Program"—Tom Accardi, director, Filght Standards Service, U.S. Federal Aviation Administration (FAA)

1445~1515 Refreshments (Cascade Ballroom Foyer) Sponsored by U.S. Air Line Pilots Association

1515~1540 "The lmplementation of joint Aviation Requirements"-Klaus Koplin,secretary generalm, Joint Aviation Authorities(JAA)

1540~1605 "The Regulatory Role in Maintenance Management"-Jack Hessburg, chief Mechanic. Boeing Commercial Airplane Group

1605~1630 "Safety by Design"-P.T Hopton, Director, Trent Project, Commercial Aero Engines, Rolls-Royce

1630~1700 Questions and Answers

1700 IFA Annual General Meeting (Cascade Ballroom)

WEDNESDAY.NOVEMBER 8

Session IV ATC and Airport Area Operations

(Cascade Ballroom)

Session Chairman-Capt. Roy Humphreyson,executive manager,U.K. Filght Safety Committee

0830~0855 "Safe Winter Operations"- Keith Hellyer. British Airways(presented by P.J.Durrant)

0855~0920 "Aircraft/Runway Performance Studies"- Thomas J.Yager, senior research engineer, Structural Dynamics Branch, Structures Division , U.S.National Aeronautics and Space Administration (NASA) Langley Research Center

0920~0945 "Airport Ramp Safety and Crew Performance Issues"- Capt. Roy Chamberlin, Charles Drew Marcia Patten and Robert Matchette, all affiliated with U.S.National Aeronautics nhe Space Administration (NASA)Aviation Safety Reporting System (ASRS)

0945~1015 Refreshments(Cascade Ballroom Foyer) Sponsored by Rolls-Royce(Video about ramp safety will be shown during refreshments.)

1015~1040 "The SAS Ramp Safety Program"- Ivar Busk, airside safety coordinator, Scandinavian Airlines System(SAS)

1040~1105 "Air Traffic Management in Developing Regions"- James L.Pierce, chairman and CEO, Aeronautical Radio Inc.(ARINC)

1105~1130 "CNS/ATM in India"- Vijay Kumar Ginotra, deputy manager, Flight Safety, Indian Airlines

1130~1200 Questions and Answers

Session V Maintenance and Design(Cascade Ballroom)
Session Chairman- John W.Saull,head, Operation Standards Division, Safety Regulation Group, U.K. Civil Aviation Authority (CAA)

1330~1355 "Maintenance Errors and Their Prevention"- Grodon Dupont, spedial Programs Coordinatior, Systems Safety, Transport Canada

1355~1420 " Maintenance Error Decision Aid"- Jerry P.Allen Jr. consultant, Maintenance Human Factors, Customer Service Division , Boeing Commercial Airpland Group

1420~1445 "Maintenance Personnel Qualification and Training"- R.C.Williams, Maintenance Director, Joint Aviation Authorities (JAA)

1445~1515 Refreshments (Cascade Ballroom Foyer) Sponsored byFlightSafety International

1515~1540 "NASA Program Related to the Structural Integrityof the Aging Commercial Transport Fleet"- D.E. Bowles, deputy, Composites and Aircraft Structural Integrity Programs, and J.G. Davis Jr., U.S. National Aeronautics and Space Administration (NASA) Langley Research Center

1540~1605 "Determination of Maintenance Program, Design andJustification of Repairs for Primary Composite Structures"- Alain Tropis, Composite Structures, Stress Department, Aerospatiale

1605~1630 "Fokker Turboprop Aircraft - Aging Aircraft Activities and How They Were Prevented on New Aircraft"- Hans Wareman, manager, Maintenance Support, Technical Support, Turboprop Aircraft, Fokker Aircraft B.V.

1630~1700 Questions and Answers

1900 Reception (Grand Ballroom Ⅱ)

2000 Awards Banquet (Grand Ballroom Ⅰ)
Hosted by Air Canada and Delta Air Lines, Wine, Fokker Aircraft

THURSDAY.NOVEMBER 9

Session Ⅵ Airline Safety Management
(Cascade Ballroom)
Session Chairman —Capt. Joao martins de Abreu, director of operations, linhas Aereas de Mocambique

0830~0900 "Aviation Safety - Essentials for Profitable Operations" - Ken S. Lewis, feneral manager, Safety and Environment, QANTAS Airways

0900~0930 "An Airline's View of Aviation Safety Management" - Capt. Colin Sharples, director, Flight Safety, Britannia Airways

0930~1000 "Making Positive Returns of Incidents" - Pierre Mouton, chief consulting engineer, Flight Safety, Societe Nationale d'Etude et de Construction de Moteurs d'Aviation (SNECMA)

1000~1030 Refreshments (Cascade Ballroom Foyer)
Sponsored by Flight

參、主要心得

一、1959-1994年民航機失事之統計與分析

研討會中由波音公司飛機安全部門首席工程師Paul Russell講述「1959年至1994年全球商用噴射機失事統計分析」專題。

依據波音公司所提出之國際民航自1959年至1994年重大事故統計，概分為(1)飛機全毀事故(Hull Loss Accidents)與(2)死亡事故(Fatal Accidents)兩類。該公司所作之事故統計係以世界商用噴射機其最大總重為60,000磅以上者之飛航事故，並不包括渦輪螺旋槳推進之飛機；亦不包括蘇聯製造之飛機。

該事故資料之來源為各國政府公報、民航業者、飛機製造商等；該事故不包括因氣流不穩導致之人員受傷，乘客上、下飛機之意外，亦不包括因破壞、軍事行動、試驗飛行發生之事故。有關死亡事故則包括乘客以外之人員死亡事件，至於死亡人數統計則以乘客為主。以下分別針對各類重大事故肇事因素進行分析:

1.所有之重大事故及其肇因分析:

所有之重大事故(All Accidents)之定義為飛機具有實質之毀損(Substantial damage)、或人員死亡、或嚴重傷害(Serious injury)之事故。其中嚴重傷害包括(1)須住院48小時、或至少須7天之醫療者、(2)導致骨折、(3)裂傷導致出血、肌肉、神經損傷、(4)體內器官受傷、(5)二、三級燒傷或表皮5%灼傷等。

在近36年內發生之1,017件所有重大事故中，以可歸究於人為因素者最多計569件，約佔56%；其次為飛機本身之因素計138件，約佔13.6%；原因不明或等候調查報告者計133件，約佔13%；至於其他如維修、氣象、機場設備、航管等因素所佔比率則較低；而1985年至1994年共計310件重大事故中，亦以可歸究於人為因素者最多計136件，約佔43.9%；其次為原因不明或等候調查報告者計76件，約佔24.5%，而飛機本身之因素計32件，與其他因素計33件相當，約各佔10.3%與10.6%；其他如維修、氣象、機場航管等因素所佔比率則頗低，詳細件數與所佔比率如表1.所示。

表1. 1959年至1994年國際民航重大事故肇因分析

主要原因	所有事故				全毀事故			
	1959-1994	比率	1985-1994	比率	1959-1994	比率	1985-1994	比率
飛行組員	569	56%	136	43.9%	327	61%	92	49.5%
飛機	138	13.6%	32	10.3%	49	9.1%	15	8.1%
維修	31	3%	13	4.2%	14	2.6%	9	4.8%
氣象	41	4%	9	2.9%	22	4.1%	5	2.7%
機場/航管	43	4.3%	11	3.6%	19	3.6%	6	3.2%
其他原因	62	6.1%	33	10.6%	15	2.8%	5	2.7%
原因不明或等候報告中	133	13%	76	24.5%	90	16.8%	54	29%
總計	1,017	100%	310	100%	536	100%	186	100%

若依飛機係在何種情況下發生事故之統計，則以降落(Landing)時與最後進場(Final approach)為最多，分別為降落時208件，約佔20.5%；最後進場時為200件，約佔19.8%；以起飛(Take-off)與仰轉(Initial climb)次之，分別為130件與77

件，約各佔12.8%與7.5%；其餘如初期進場(Initial approach)、爬升(Climb)、巡航(Cruise)、下降(Descent)則所佔比率則較低，詳細件數與所佔比率如表2.所示。

表2.1959年至1994年國際民航重大事故飛行情況分析

主要原因	飛行組員	飛機	維修	氣象	機場航管	其他	不明	合計	比率
起飛	57	30	6	1	4	13	19	130	12.8%
初期爬升	41	15	2	4	3	3	9	77	7.5%
爬升	13	29	7	4	2	4	6	65	6.3%
巡航	14	13	5	5	5	7	9	58	5.7%
下降	39	5	1	2	3	8	5	63	6.2%
初期進場	54	0	0	1	1	1	10	67	6.5%
最後進場	169	3	1	8	4	1	14	200	19.7%
降落	174	34	8	15	16	6	55	208	20.5%
滑行	8	9	1	1	5	19	6	49	4.8%
合計	569	138	31	41	43	62	133	1017	100%
比率	43.9%	10.3%	4.2%	2.9%	3.6%	10.6%	24.5%	100%	

2.全毀事故(Hull Loss Accidents)及其肇因分析

近36年來所發生之536件全毀事故中，仍以人爲因素者最多計327件，約佔61%；其次爲原因不明或等候調查報告者計90件，約佔16.8%；飛機本身之因素計49件又次之，約佔9.1%；至於其他因素所佔比率則較低；而1985年至1994年共計186件全毀事故中，亦以可歸究於人爲因素者最多計92件，約佔49.5%；其次爲原因不明或等候調查報告者計54件，約佔29%，而飛機本身之因素計15件又次之，

約佔8.1%；至於其他因素所佔比率則頗低，詳細件數與所佔比率亦如表1.所示。

而民航機全毀事故案件中，飛機亦以最後進場與降落爲最多，分別爲最後進場時130件，約佔24.2%；降落時爲108件，約佔20.1%；以起飛與初期進場次之，分別爲76件與61件，約各佔14.2%與11.4%；其餘如仰轉、爬升、巡航、下降則所佔比率則較低，其件數與比率詳如表3所示。

表3. 1959年至1990年國際民航全毀事故飛行情況分析

主要原因	飛行組員	飛機	維修	氣象	機場航管	其他	不明	合計	比率
起飛	31	18	4	0	3	4	16	76	14.2%
初期爬升	35	3	1	3	1	2	9	54	10.1%
爬升	10	10	4	4	2	2	6	36	6.7%
巡航	6	3	2	2	2	2	7	24	4.5%
下降	26	2	0	1	2	2	4	37	6.9%
初期進場	49	0	0	1	1	0	10	61	11.4%
最後進場	106	3	1	7	2	1	10	130	24.2%
降落	62	8	1	6	5	0	26	108	20.1%
滑行	2	2	1	0	1	2	2	10	1.9%
合計	327	49	14	22	19	15	90	536	100%
比率	61%	9.1%	2.6%	4.1%	3.6%	2.8%	16.8%	100%	

依據國外民航事故之肇因分析知，約有六成爲人爲因素所致，故世界各國航空公司均以加強組員資源管理(Crew Resource Management，簡稱CRM)課程之訓練，即是加強飛航組員間之溝通、協調與合作，期能藉分工合作之效益，以減少人爲疏失之發生，並於緊急情況發生時，能共同面對解決。

再依事故發生之時機多在起飛、降落的情況而言，該段時期所佔飛行時間之百分率僅爲1%，惟所佔事故之比率卻高達一至三成，故該時段已被稱爲危險之窗(Hazardous Window)，有關所有事故與全毀事故之發生情況比率詳如圖1.與2.所示。(本篇論文內容請參閱附件一)

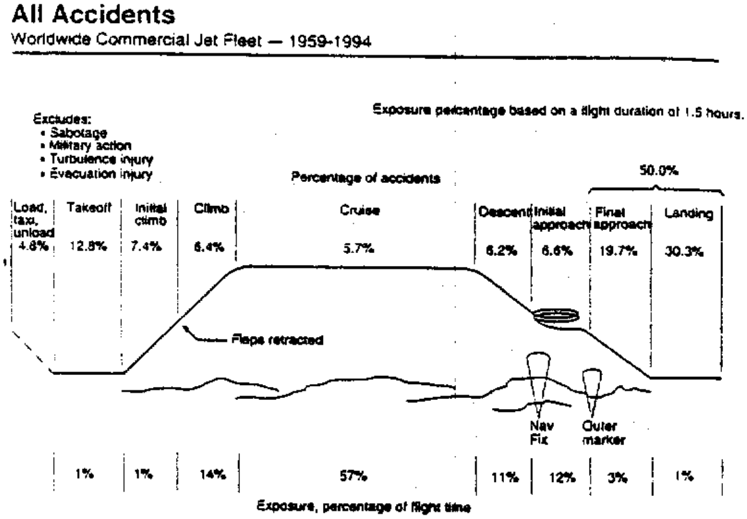


圖1. 1959年至1994年全球民航所有事故與發生時段之比率對照圖

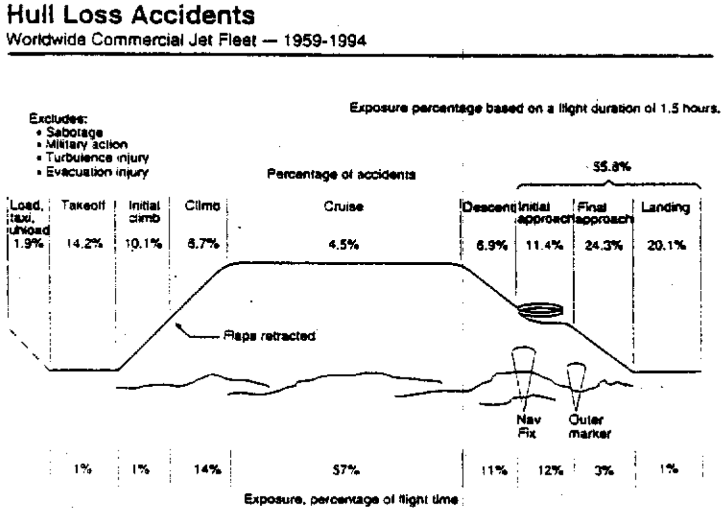


圖2. 1959年至1994年全球民航全毀事故與發生時段之比率對照圖

二、在航員操控下撞山與降落事故之預防

本篇論文係由波音公司系統工程部門首席工程師Earl Weener博士講述，他首先提到自1994年11月至1995年11月止計發生四次在航員操控下撞山(Controlled Flight Into Terrain，簡稱CFIT)事故，造成178人死亡之慘劇。而自1959年至1994年全球各地區依發生(CFIT)事故佔每百萬飛行次數之比率統計，則以非洲2.04爲最高，亞太地區與拉丁美洲地區次之，分別爲1.09與1.08，歐洲0.42又次之，北美洲爲0.03，而澳洲與中東均爲零事故。

自1988年7月至1995年11月近七年所發生之(CFIT)30次事故中，若依其儀器程序型態(Type of Instrument Procedure)統計，以遞降進場時計發生15次爲最高，其次爲最初進場計發生8次，有關各種儀器程序型態之統計詳如表4.所示。

表4. 近七年CFIT事故依儀器程序型態之統計一覽表

儀器程序型態	明細內容	小計
遞降進場	. 12 VOR-DME . 2 LOC-DME . 1 ASR	15
最初進場	. 1 ATC vector . 2 NDB to ILS . 1 VOR to ILS . 3 VOR-DME to ILS . 1 VOR-DME	8
ILS 進場	. 1 glide slop receiver 可能失效 . 1 flight director可能未能攔截 . 1 auto-pilot 可能未能結合	3
單一助航進場	. 2 NDB . 1 VOR	3
離場		1

有鑑於CFIT事故之嚴重性，世界各國努力之目標為期望在未來五年即至1998年能將降落時該事故率減少一半，故而成立「減少CFIT、進場與降落事故任務小組」(CFIT and Approach and Landing Accident Reduction Task Force)，並積極進行相關課題之研討，計有1992年4月召開IAC Workshop，9月IASS召開「國際標準之挑戰」研討會，10月召開初期推動小組會議，11月接受IAC在長島會議之計畫，1993年11月在吉隆坡召開IASS會議，1994年11月在里斯本召開IASS會議，1995年11月在西雅圖召開IASS會議。該任務編組之組織架構如圖3.所示。

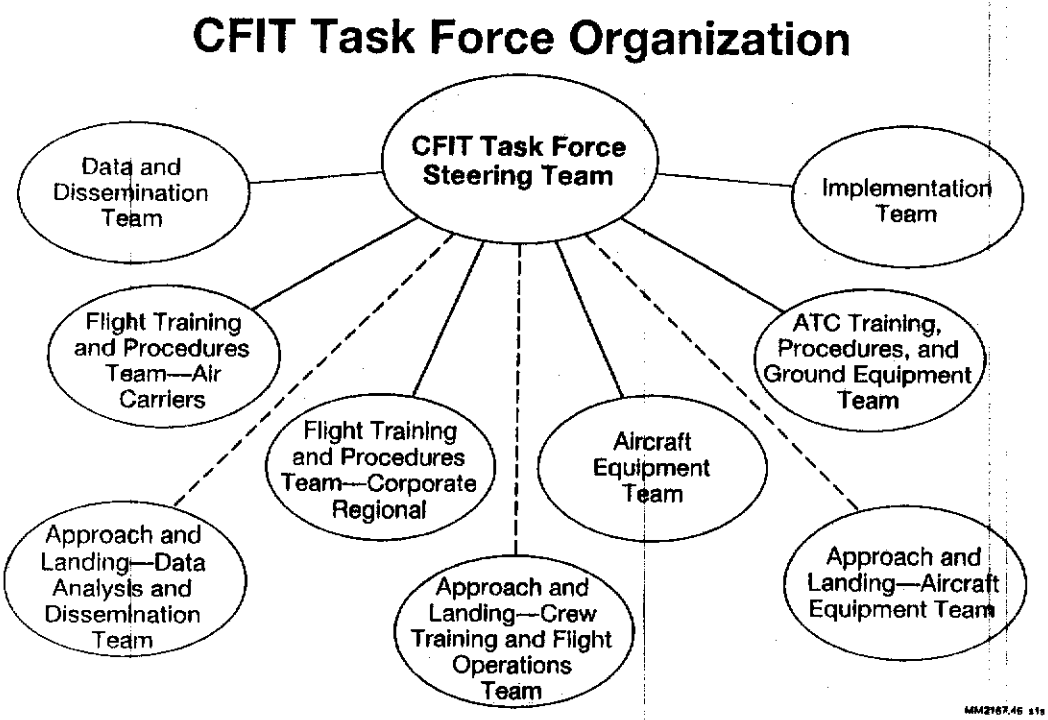


圖3. CFIT任務編組之組織架構

該小組所提之建議爲：(該文內容請參閱附件二)

1. 各地區之決策與管制單位、航空營運部門與媒體彼此間應適當保持接觸。
2. 利用上述團體其人員間之會議、簡報與書信，傳遞執行CFIT進場與降落事故預防措施之相關信息。
3. 將該計畫之成果與知識提供前述團體參考。
4. 促成前述團體對其所負責之部分方案付諸執行。

三、建立人因與資源管理組織架構之功能形式

由於舉世均認同將營運、管制與財務部門和人因與資源管理結合之原則，可應用於航空營運方面之重要性，這可由一些航空公司的營運部門提出之「進階資格計畫」(Advanced Qualification Program)以及美國航空總署(FAA)提出人員須加強資源管理訓練之規定得知。惟業者對於應於何種層次來結合人因與資源管理之功能產生疑慮，故由Delta航空公司飛安部門副總裁John Lauber博士與人因部門主任 Ray Justinic共同提出之論文即爲探討在1995年推出之「全國人因計畫」(Human Factors National Plan)其組織架構、程序與功能。

該文根據國際民航組織(ICAO)人因文摘第十期對「全國人因計畫」之解說，來強調如何結合人因與資源管理計畫。其內容包括二者結合之特性與挑戰、一套完整結合的系統方法、人因部門之態度、定義人因部門之功能、建立結合之形式與功能基礎、將原則化爲行動等。

該文提到政府部門、學術機構與航空公司之訓練計畫在機制上欠缺將研究上所發現的人因知識移

轉至實務上而加以改進飛航安全。在工作地點可利用以下四種作法以獲致最大之人因訓練計畫效益：

1.建立與執行必要之政策與程序以促使環境改變。
2.在各階層訂定各種人因教育與訓練計畫。
3.增加人因工程研究方面之人員，與添置現代化之裝備與技術。
4.建立與維持人因研究成果之移轉制度，以引導整個企業之人性化管理走向。

該文首先闡明企業內各部門間整合上之挑戰，由於每個成員之態度、行爲與文化背景之不同，其對企業文化之形成具有重大之影響。接著論及在確定公司之人因計畫時應考量以下之要素：

1.須有足夠之資源以因應潛在之改變。
2.須與公司之政策、程序與文書表件保持一致性。
3.須涵蓋適當之各階層人員。
4.須具有跨組織與部門之性質。

在談及航公公司人因部門所扮演的腳色時，該文係以Delta航空之人因部門運作哲學爲例，指出該公司之人因部門目標爲「在營運上產生人爲績效之極致，以改進飛航安全並增進企業效率」。而其任務爲分析人之行爲對有關「人、政策/程序、機、營運結構」四個資源要素產生之績效；利用心理學、生理學、社會心理學、生化技術、系統科學與管理科學等多重學術訓練，以達到管理上之控制與改進績效之目的，詳如圖4.5.6.所示。

該公司並依照以下六項步驟：溝通、人員協調、規劃、工作負荷管理、決策、狀況認知管理來進行資源管理工作。結論爲惟有在實務上建立一個完整的組織架構、確定問題並謀求解決之道、化爲

在營運上之作法、並建立一套回饋系統，方能將人因計畫成功的施行於各航空公司。(詳請參閱附件三)

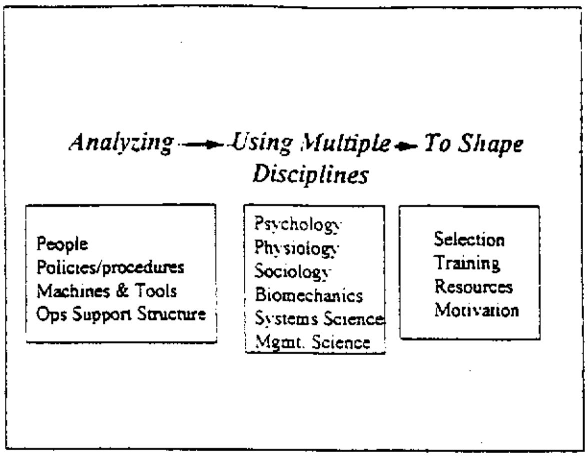


圖4. Delta航空之人因部門自分析至執行之任務

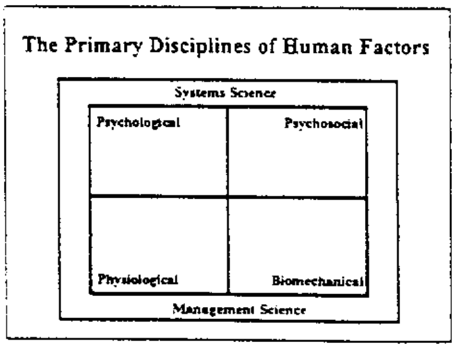


圖5. 主要人因之學術領域

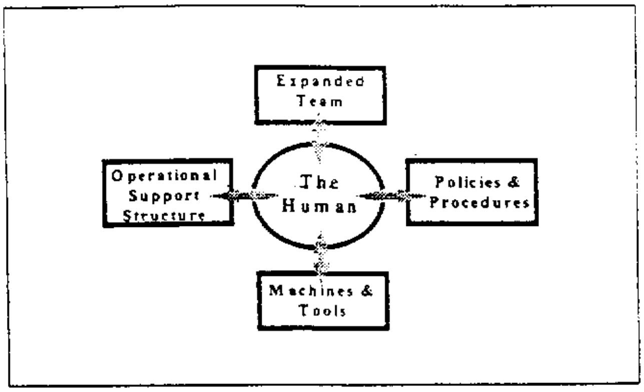


圖6. Delta航空之基本人因模式

四、開發中地區之空中交通管理

本文係由Aeronautical Radio Inc.公司(ARINC)總裁James L. Pierce提出之報告，文中有鑑於國際民航組織(ICAO)在「未來航空導航系統(Future Air Navigation System,簡稱FANS)」報告中，談到對全球民航業執行FANS計畫中之通訊、導航與監控(Communication、Navigation、Surveillance,簡稱CNS)方式之空中交通管理(Air Traffic Management,簡稱ATM)合稱為CNS/ATM系統的規劃程序概念。雖然許多大國多年來已利用傳統之系統如雷達作為監控航機飛行之用，並投資極多之人力物力於未來之發展策略。不過亦有許多國家由於欠缺詳細的現有CNS建設，致無法與其地面科技相結合，故在規劃上面臨許多困難。惟對許多開發中地區而言，其所管制之飛航情報區雖較小，但卻不如大國那樣具有足夠之規劃、研究與發展之資源或經費。同時因為其空中交通量較低，其營收或稅捐不足以支付其在空域改善上之投資。故該文特別針對開發中地區之民航主管機關提供其發展CNS/ATM之替代性作法與概念。

1. 在通訊方面，傳統的航管為以語音來通訊，而在CNS/ATM則所有的通訊均利用資料鏈(Data link)作為機師與管制員間之連繫。例如美國正規劃以Mode S資料鏈系統作為航管資料鏈通訊之用。對於開發中地區，該文建議可利用現有企業所提供之通訊資料鏈方式來共同使用，以節省該建設之投資。例如牙買加政府則以資料鏈通訊供應者(ARINC)身份來提供資料鏈通訊服務，而依「使用者付費」方式收費，不僅對其投資共同使用之建設僅須給付小部分之費用，並可從中獲利與減少風險。

2.在導航方面，傳統的導航系統有許多限制，導航之無線電標識在裝設與維護上極昂貴，且通訊範圍有限，且無法裝設於如沙漠、海洋等地點。而CNS/ATM系統概念係以極低之費用來引進衛星導航系統，故ICAO所規劃之全球導航衛星系統(Global Navigation Satellite Ssytem,簡稱GNSS)將在未來佔有極重要之地位。而美國所實施之全球衛星定位系統(Global Positioning System,簡稱GPS)已可作爲GNSS之應用矣。目前利用GPS系統接收訊號並未收費，在機場或進場時之導航即可多加利用。由於單一跑道之第一類儀器降落系統可能需100萬美金投資，而若投資於GPS在跑道50哩範圍內之設備則遠低於500美金。在斐濟(Fiji)已採用衛星導航系統，該國政府選用GPS後對其NDB與VOR等助航設施之維修成本均獲得節省，估計每年約可節省200萬美金之助航設備替換與維修費用。

3.在監控方面，傳統的監控方式計有由機師按時以語音來通報航機位置，這會產生訊號上的延遲與人爲上之疏誤，致使航機間之隔離必須加大。使用空域雷達監控後，管制員僅須利用航機上之雷達訊號接收器在螢幕上顯示其位置而進行飛航監控，藉助其高精確度與減少人爲判斷上之失誤，既能縮短航機間隔，又能提高飛航安全。開發中地區由於無法投資昂貴之雷達監控系統，尤其在其空域涵蓋範圍遼闊，而其空中交通量卻較低、且多高山沙漠海洋等無法通行之地形時亦是。惟利用前述之資料鏈通訊系統以及衛星導航等科技，可以較經濟有效的達到監控之目的。航機祇要以衛星定位導航，再將其相關資訊經由資料鏈傳輸，航管上即可快速、精

確、有效的掌握其動態。這種經由航機自動回報位置，而不必透過機師或管制員之自動相依監控(Automatic Independent Surveillance)為ICAO研發FANS之CNS/ATM系統概念上另一重要之環節。

4.在空中交通管理方面，傳統之空域管理是以「合約」(Contract)方式稱之為飛行計畫來進行，航機之安全隔離是規定航機必須航行於特定空域，故對空域之使用上極不經濟。較現代且有效率之作法為透過前述之通訊、導航與監控，經由電腦計算後使得航機不會太過接近。在亞太地區1995年9月第一套FANS1系統已應用於飛越遠東蘇俄地區。這套由ARINC公司研發之ATM工作站與VHF資料鏈系統可將航機位置、資料顯示於管制螢幕上。

5.在空域使用者觀點言，開發中地區須配合未來航機發展上之兩大型態來作業，一種是由已開發地區飛來之大型現代化航機，具有複雜的ICAO所研發之FANS CNS/ATM概念之特性；另一種則為老式的、小型的航機使用傳統的語音通訊，利用INS、Loran-C、VOR、NDB與ILS導航，與利用語音報位、初級雷達或二級雷達監控裝備之航機。惟後者可利用加裝空用電子儀器以發揮執行資料鏈、衛星導航與自動監控之功能。

該文中結論談到開發中地區可利用共同投資於資料鏈服務方式，採取VHF資料鏈系統來進行航機空對地之通訊；並可利用全球衛星導航系統進行航路上之定位與進場之導航與監控，以免除投資於昂貴之雷達費用支出；其空中交通管理則以加強地面必要之自動化設備投資改善，例如以電腦工作站方式來處理機師與管制員間資料，俾對航機作精確隔

離。業者亦可在其老舊之航機上加裝空用電子儀器以發揮執行資料鏈、衛星導航與自動監控之功能。(該文內容詳請參閱附件四所示)

五、由航空公司觀點來談航空安全管理

本文係由英國Britannia航空公司飛安部主任Colin Sgarples在會中提出的報告。他從1966年該公司所發生之僅有的死亡事故說起，該事故爲航機在Yugoslavia的Ljubljana機場進場時撞毀，帶給公司極大之震撼。如今該公司爲世界上最大之包機公司，在1994年載客達到800萬人，且爲英國第二大航空公司。其1996年之機隊包括18架B757型、8架B767-200型與4架B767-300型客機，每年每架飛機飛行約4,500小時，故其對機師、飛行組員與工程人員之要求標準極高。

在該公司內之安全管理系統講究的是各階層擁有飛安共識，形成安全的企業文化。該公司典型的航空營運人員分配爲總人數2,550人中機師有430人佔17%、飛行組員有1430人佔56%、工程人員有690人佔27%。故其中約有44%的人員具有飛安上的認知，而56%的人員僅部分具有飛安上的認知。若再依1,430位飛行組員中細分，則約16%爲極有飛安經驗與認知、30%爲具有合理的經驗與認知、28%爲部分具有經驗與認知、26%爲對飛安無經驗與認知。而航空公司的安全管理目標爲祇要飛行組員一加入公司行列，即須具有「安全第一」之體認。

企業文化爲公司內部人員對飛安之態度與行爲表示。藉由公司在任務說明上強調「安全第一」之政策，每四至六週召集相關部門聚會研商飛安事件

發生之原因與對策，並要求人員對飛安相關課題表示意見以回饋，則可加強各階層對飛安之瞭解。

他認爲公司應在資源與預算上著重飛安相關之設備投資，例如在航機上加裝地面接近警告系統(Ground Proximity Warning System, 簡稱GPWS)、避免交通碰撞系統(Traffic Collision Avoidance System, 簡稱TCAS)，以儀器輔助飛安之確保，將有助於對外界凸顯企業對飛安之重視。

另外公司亦應加強員工之飛安訓練，無論對機師進行模擬機之教育訓練、航線飛行訓練(Line Oriented Flight Training, 簡稱LOFT)，飛行組員資源管理(Cockpit Resource Management, 簡稱CRM)與工程人員之訓練等，均有助營運上飛安之確保。

文中提出典型的航空安全管理系統如圖7.所示。其中決策階層係由資深之經理主導，直接向營運主管報告，並擬定公司之飛安標準作業程序或手冊。在地面稽查方面，公司內部應組成一稽核小組(Internal Audit Team)以稽查工程部門對前述飛安標準作業程序或手冊之執行與相關之飛安稽核，利用跨部門間之協調與溝通，必能化解潛在之飛安危機。而完整之稽查修正流程各環節除包括公司內部之稽查外，尚有外部環境如法規之配合、與須符合飛機製造商之維修規範等，其流程詳如圖8.所示。

該文最後談到飛安是企業內全體人員之責任，發展航空安全管理目標是確保飛安之持續，每位人員須認知其在中斷事故鏈中所扮演的腳色。(該文內容請參閱附件五所示)

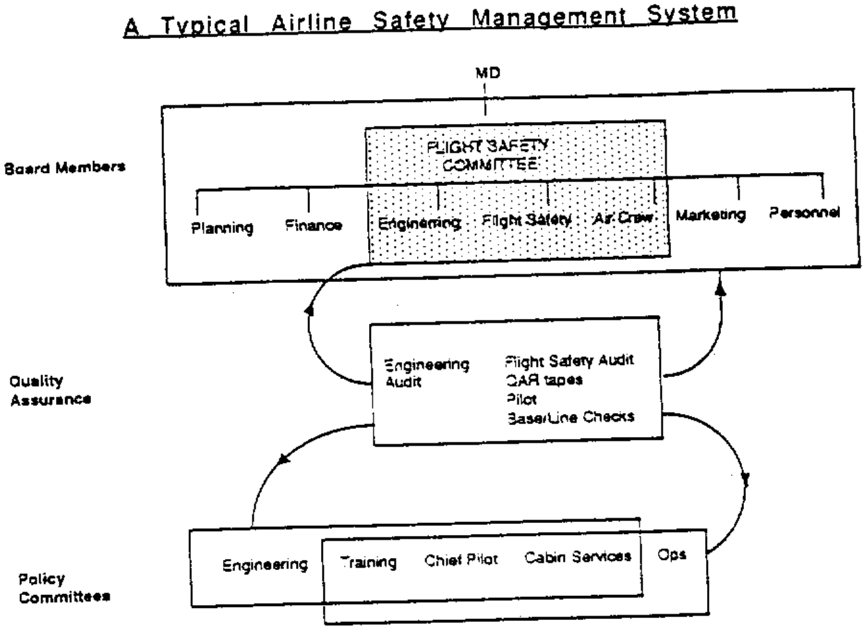


圖7.典型之航空安全管理系統架構

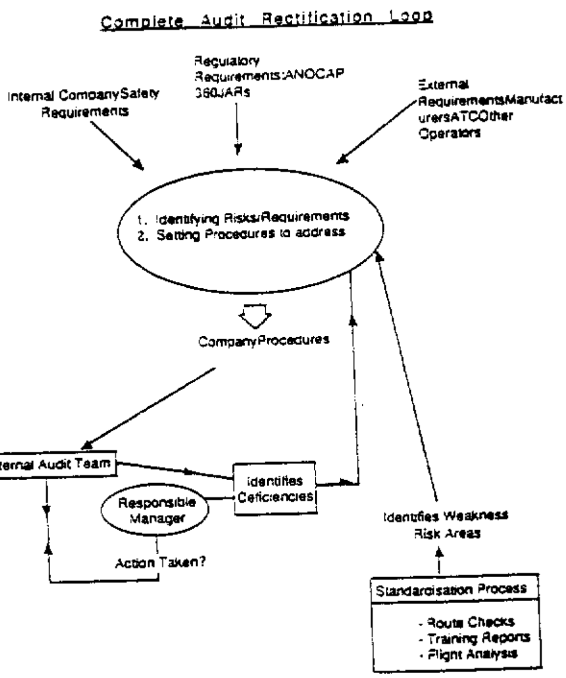


圖8. 航空公司完整的稽查修正流程圖

六、抵抗疲勞生理及藥物上的對策

本文係由 MedAir.Inc.公司總裁 Joan Sullivan Garrett 提出之報告。由於對於 24 小時運作的航空事業而言，因為疲勞與失事間可能具有直接且高的相關性，故疲勞因素會對業者產生立即且實際的影響。該篇論文主要在調查因時差及睡眠不足所產生的疲勞其影響若何，並研擬減輕這種影響的對策。

由於航空業者對於疲勞產生的問題常常是因飛航組員使用製造品質及劑量不可控制的藥物，作為自療(self-medicate)的工具所引起的。一般研究發現顯示，沒有一種生理及藥物的控制是能完全取代正常且定時的睡眠。

該文首先提出疲勞自人類生理學而言，是一種正常運作上的改變，主要有兩種來源：累積睡眠的損失及生理週期的混亂(生物的行為以 24 小時為計)。疲勞這一個字描述的是一種倦怠(weariness)、衰弱(weakness)或是睡眠，導致對外在刺激或壓力暫時失去反應的能力。睡眠對於決策、警戒、反應時間、記憶、座標、方位及資料的處理，所有在飛航情境中需要時間及合適判斷力及行動的反應都產生了缺口。

另一方面在不需要立即做作判斷的飛航環境中，不充份的睡眠也可能會產生嚴重且負面的影響。依據Rosekind與Gander 等人最近的研究(1994)指出甚至只要比需要的睡眠少上一個小時也會產生倦意。而欠缺睡眠累積得越多，則越會進入不自覺的睡眠狀態(Spontaness episodes of sleep)。在該狀態中睡眠者"會從外在環境中跳脫其五官知覺，而變成對外在消息的傳遞毫無反應"，這樣突顯出飛航組員在飛航情境中若有此狀態會導致立即的危險，因為他

不論在航路操作設定中或緊急狀況下，都不可能作出敏銳且迅速的判斷。

疲勞除了會因睡眠不足而產生，也可以從生理週期(circadian 指以 24 小時爲週期的生活習慣爲主)的混淆中產生。 circadian 指的是每天清醒或睡眠中的循環、體溫的高低及消化活動的快慢等日常身體的運作程序或既定的生存模式。如果一個人被強迫在他正常睡眠期間保持清醒，這種對生理循環上的破壞將導致疲勞的產生。

對航空業者而言，不論是累積性睡眠的喪失、或是生理週期上的混亂，所產生的疲勞造成的影響是一種毀滅性的:包括警覺性、反應時間及判斷力的喪失及減弱。研究指出一個人要達成合理的警覺狀態，有充足時間的睡眠是必要的。

該文接著提及應如何減輕疲勞的對策，在以往研擬減輕疲勞的對策上，常以兩種方法來減少疲勞:生理上及藥物上。較早期減少疲勞的對策著重在生理上的方法，爲尋求如何管理睡眠，將睡眠的時數最大化，並促進生理週期的調整而不僅是假裝無睡眠上之損失，這是預防性、非治標性的對策。

睡眠包含兩種階段:非迅速眼球活動期(Non rapid eye movement,簡稱 NREM)、迅速眼球活動期(rapid eye movement,簡稱 REM)。在前者之睡眠期間心跳呼吸和新陳代謝緩慢，所分的四個階段中，較深的睡眠係發生在第三及第四個階段;而後者則起因於做夢，由於大腦的活動造成眼球的迅速活動，此時身體及肌肉均呈現麻痹的狀態。

以一個典型的夜晚爲例， NREM 及 REM 會重覆每九十分鐘爲一個循環， REM 發生在前三十分鐘，

NREM 發生在後六十分鐘。大部份的深度睡眠(NREM 的第三個及第四個階段)發生在夜晚的三分之一；REM 若發生得早一點的夜晚，其期間則較短；若發生在晚一點的夜晚，則期間會較長(Rosekind,NASA Technical Memorandum,1994)。

研究睡眠的人員發現,假如有人在深睡期間被喚醒,這個人可能需要花較長的時間以保持清醒,同時也會覺得昏昏沉沉，這種不規律的狀態可能需要 10 到 15 分鐘才能回復。這種打盹狀態，對在非正常工作時間操作飛機,以及在不應睡眠的錯誤時間而睡眠產生關連,並和累積性睡眠上的損失產生同一種混淆的效果。生理學家已在尋求對策,即對睡眠的時間及期間加以管理以求得最大利益。

這種對策不同於真正的睡眠週期,而是將睡眠時間加以改變或延遲。通常這樣的方法適用於旅行前或中途休息時。

- 人們應在旅行前獲得充分的休息,而不是進行一連串欠缺睡眠的行程，這將會有個糟糕的旅程。
- 在旅程中途應保持和正常睡眠循環同等份量的睡眠。
- 若有睡意產生且情況允許時，應小睡片刻；但若自動清醒後且經過 15 至 30 分鐘仍不能再度入睡，此時則應起床。
- 小睡片刻確能有效提高注意力。若在執勤前休息，則最好睡眠時間少於 45 分鐘較平常小睡時間短些,以避免進入深睡期。(若是超過 2 小時之小睡，則可使睡眠者獲得至少一次 NREM/REM 的週期)。
- 在旅途中若有休息時間，則應充分獲得主力睡眠(anchor sleep)時間，該種睡眠是指一般正常睡眠

所需之時間。

- 睡眠環境應該是黑暗的、安靜的、適當且舒服的。
- 人們應該作規律的運動，惟因激烈的運動使人很難入睡，故運動時間不應距上床時間太近，。
- 在長途旅行的前 24 小時，能有合理的睡眠時間表是迫切的。且人們應安排距自己平常睡眠時間較近的時段，不要設法調整至一個新的時段。

除了生理對策之外，由於藥物亦可減少疲勞反應，故從藥物治療上可獲得改善，這些藥物包括下列數項：

(1)燈光：

燈光是一種環境因素，研究指出燈光可以扮演重新設定生理內部時鐘的角色，據了解明暗循環和生理內部時鐘是內部循環的最重要指標，這種動因是暫時性的並不能解除累積睡眠的損失。

(2)興奮劑：

興奮劑如咖啡因、安非他命、嗎啡等，一般而言醫學上因其附帶作用較小，故被鼓勵使用在減輕疲勞上。較常使用的刺激物爲咖啡因，由於其隨處可得故使全世界都可利用它的性能來減輕睡眠損失的效果。然而一般人對咖啡因產品若懺生忍受力後，即需要加強劑量才能保持清醒如常；惟若劑量增加至相當程度，伴隨而來的是焦燥不安、顫抖及心脈血管疾病的可能性。雖然安非他命能抗拒疲勞，但常伴隨心脈血管的疾病、顫動、高血壓及中樞神經系統的不停歇、抖動、亢奮、易怒、失眠和病痛的發作；還有胃腸方面的作嘔、嘔吐、抽筋，若長期使用安非他明，則深度沮喪的發生是可以預期的。雖然安非他命可

以使人清醒，但卻是種被動的清醒，會影響方向性及判斷力，故並非可靠的一種清醒狀態。

另一種興奮劑"modafinil"可增加人們在缺乏睡眠狀態下的警覺性，而且沒有安非他命破壞性的副作用，最初的研究將"modafinil"用來治療不規律睡眠及酒精症狀，其方式類以副腎上腺素的作用，可以改善白天的警覺性，且不干擾到夜間的睡眠，但是就長時期而言，它對生理週期規律的影響是模糊的。

(3)鎮定劑：

鎮定劑如酒精、苯柯鹼、仿苯柯鹼等是指那些藥物具有鎮定的功能，包括酒精，"benzodiaeepiner"(催化減輕倦意)，"imideeopyridiner"(催化使生睡意)。鎮定劑可壓制焦慮及導致睡眠，除了會減輕身體的警覺性外，亦會產生和疲勞完全相同的反應。

酒精會產生醉意，減少腦部對氧的需求，減少快速反應的能力及睡眠的品質。

"benzodiaeepiner"是催化減輕中樞神經系統產生睡意，常被用於治療回復失眠症方面，治療恐慌的發作，壓制激動與減少倦意，但卻會產生記憶力的喪失、失眠、缺乏方向感及迷惘。

Zolpidem 是一種"imideeopyridiner"，能夠產生較弱的反痙攣效果及較弱的肌肉鬆弛作用，且能使人們維持在較深度的睡眠狀態，當人們需要深度睡眠以補充維持身體活動所需的睡眠時，具有重要的療效：但是這種藥物會導致記憶力的喪失。

(4)Melatonine：

當夜晚來臨時，人們的松腺體開始分泌神祕的 melatonine ，所以 melatonine 基本上是種黑夜的訊號，它會欺騙腦部使其認爲現在是晚上(Sack Lewy 1993)，口服的 melatonine 被認爲可以減輕因旅行而必須穿越不同時區產生的時差及疲勞的症狀。

最近的研究指出 melatonine 可以強化免疫系統及延緩老化的作用。在過去的六個月中 melatonine 顯示出它可以延遲因老年引起的疾病，且能預防癌症，故使 melatonine 的價格因而水漲船高。由於祇要 1/10 毫克的用量便可促進睡眠，一份報告並指出在研究睡眠的情緒和行爲各方面， melatonine 能針對警察夜間值勤後改善其睡眠品質及增加工作時間中的警覺性;但其對記憶掃描的速度及精神負荷的程度反而會受到影響。因此，專家建議直到未來相關之研究足以證明其藥效，以及其在製造上受到嚴格之規範，否則人們應避免自行服藥治療。

最後該文談及和航空業者的關聯性，由於睡眠、生理週期的破壞及疲倦的關係是複雜的，但研究指出必要之睡眠仍須維持，由Nicholson and Stone(1987)之研究認爲可藉由工作時間的安排來作爲有效管理的基礎，在睡眠不能減少的情況下，工作分派者必須主控營運的工作時程及環境因素;藥物的介入雖能暫時欺騙人體使其保持清醒的狀況，但是藥物本身與其可能會產生危險的副作用，亦會產生類似疲勞的反應現象。

該文之結論認爲對抗疲勞的對策在生理上的管理是較爲有效及自然的方法，若借助藥物的幫助，其時效性極短暫且副作用大。有鑑於人爲因素在飛安事

故的肇事原因中約佔七至八成，因此航空醫學對疲倦產生的飛安事故研究之應用，對藥物副作用所產生心理及生理的變化，值得吾人警惕與重視。(詳細內容請參閱附件六所示)

七、主要複合結構的維修程序與設計之判定

由 Aerospatial 公司複合結構強化部門的 ALain Tropis 針對判定航機主要複合結構的維修程序的改善，維護設計及判定提出報告。

該文首先指出對於航機之主要複合結構檢查程序之定義、內涵、要求，以及由該公司彙整出可能的方法應用在 ATR-72 的主翼上。在 1989 年 ATR-72 進入正常營運後，使得該公司針對複合機翼維修程序的確定及維護的設計判定上研擬改善的方針。在 1989 年所研發的維修程序，主要針對 ATR-72 的 CFRP 機翼的認證及應用於 A330/A340 的襟翼及起落架門，這樣的程序旨在定義檢視的程序、以及決定可預見撞擊損害的剩餘強度，所採用的趨近方法是爲機率法則。在採用這種方法時，所考慮意外的損害除了因元件穩定強度的減少而導致的損害外，也包括其發生的機率及偵測率。根據適航認證單位提出的要求，失敗的機率爲航空器所遭受損害結構之剩餘強度超過負荷的機率，准許值爲 10^{-9}/飛時。因此這種檢視的程序能夠控制失敗的機率低於該值。由於碳纖材料的主翼並不須在基本維修情況下額外增加特別困難的維護，故維護理論已被定義成法規所要求包括雷擊、腐蝕、機械強度及航空公司的規定。

該文提及航機在維護過程中主要須符合許多適航認證上對大結構的要求，其要求係爲了重建結構組

件的完整性，以達到所要求的機械強度、防止碰撞及雷擊，在一般的維修過程中這是嚴格要求航空公司必須達成的。(詳細內容如附件七所示)

八、 MEDA 對商用航空業者的使用及影響

本文由人因維修部門的 Jerry p. Allen,Jr 與人因工程部門的 William L. Rankin 博士針對錯誤維修決策支援（ Maintenance Error Decision Aid,簡稱 MEDA)提出報告。

有鑑於人爲錯誤實所難免，人因工程便成爲解決以人爲主的相關工作如飛行員之選擇及訓練、人因空間環境的安排、資訊的顯示等方面之考量。例如 Fittes and Jente （ 1947 ）對於空軍 460 名飛行員錯誤造成的意外事故提出人爲因素之研究即是。在 1992 年英國民航局(UKCAA)對於重量大於 5700 kg的飛機進行之研究顯示，下列八項維修問題影響飛安至鉅：

1.不正確的組件裝置方式
2.錯誤零件的設置
3.電子配線的錯誤
4.將工具及其他物體殘留在飛機內
5.不適合的加注潤滑劑
6.整流罩，面路鑲板，及整流片未固定
7.汽油機油及空中加油片未固定
8.出發前沒有將起落架輪栓移出

依據 Swarn and Guttman 在 1983 年所提出的績效形成因素理論(Performance Shaping factors,簡稱 PSFS)，指出“外部 PSFs”包括情境特徵(熱、燈光、監督..等)、職業及工作指令(程序及車間練習)、工

作及裝備特徵(工作的複雜性及人機介面)；而"內部PSF"則包括職前經驗及訓練、整合與活力；至於"壓力下的PSFs"則包括心理壓力(如工作速度，單調及分心)、以及生理壓力(如疲勞，疼痛及生理週期的改變)。

Swain 強調 1990 年 Lorenzo 的研究指出只有15~20%的工作錯誤是由"內部 PSFs"產生，剩下的80~85%則是由"外部 PSFs"及"壓力 PSFs"所產生的。

由於對於人爲因素發生在維修過程錯誤方面的研究仍在萌芽中，有必要蒐集人爲因素所產生維修錯誤上的各種型態，並將他們歸納在 PSFs 研究中，錯誤維修決策支援(MEDA)理論乃應運而生。

目前 MEDA 理論已由波音公司維修人因小組發展達二年之久，其內涵包括下列各項:

- 增進航空業維修部門對於人員素質與維修錯誤間之關連的瞭解。
- 提供維修部門一個標準的方法去分析維修上之錯誤。
- 表現出維修系統的錯誤發生之可能性及減低系統效率的傾向。
- 提供航空業者錯誤傾向之分析方法。

MEDA 理論提供了以下思考模式：(1)通則(General)、(2)事故(Events)、(3)維修錯誤(Maintenance Error)、(4)造成因素(Cotributing Factors)、(5)修正行動(Corrective)；並建議採取實地測試(Field Test)的方法去評估 MEDA 及其改善策略。

由美國飛航總署(FAA)在 1994 年 11 月及 1995 年 7 月間和 8 家國內與國際航線業者以及一家修理廠

合作完成實地測試的工作。該文之圖 1.爲波音公司小組針對 74 件操作性事件完成的分類報告，其中 22 件造成飛機延誤、17 件造成航空器的損毀、11 件空中回場，這些取樣爲 MEDA 的調查引起動機，惟該數據未指出錯誤所造成事故的比例。圖 2.則爲維修錯誤的型式分布，其中以裝設不當佔 26 件爲最高，最值得警惕；不適當或錯誤之拆解/檢查/測試爲 11 項佔第二位，服務不當佔九項，其他原因爲 17 項其中 8 項曾造成地面損壞。

至於肇致之原因分布則如圖 3.所示，以資訊爲 37 項佔 50%爲最多、溝通與工作/任務次之，分別爲 32 項與 31 項，各佔 43%與 42%、環境/設備爲 28 項佔 38%又次之、影響個人運作的因素爲 26 項佔 35%、資歷/技巧爲 23 項佔 31%、飛機設計/構造爲 22 項佔 30%、裝備/工具/零件爲 20 項佔 27%、組織環境爲 19 項佔 26%、監督則爲 12 項佔 16%。依排名的狀況我們可以瞭解到，一般航空公司較重視監督及資歷/技巧，而輕視環境/設備及影響個人運作的因素是應該加以改正的。波音公司目前將 MEDA 方法應用於一般航空公司以改善其維修行爲，該公司的維修暨地面操作系統小組(MGOS)亦提供 MEDA 對客户的服務。

該文最後提到 MEDA 的工具及調查過程，確實能提供維修部門一種容易運用的標準與調查方法給。這種工具不僅可發掘出維修系統方面的不足，而藉教育訓練的過程亦有助於瞭解人的行爲對組織影響的程度。因此航空業者應該繼續發展以人因模組爲基礎的訓練計畫與程序，藉著科技的協助進行事故肇因分析，以促進業者對錯誤因素之瞭解及團隊工作在錯誤管理的重要性。(詳細內容請參閱附件八所示)

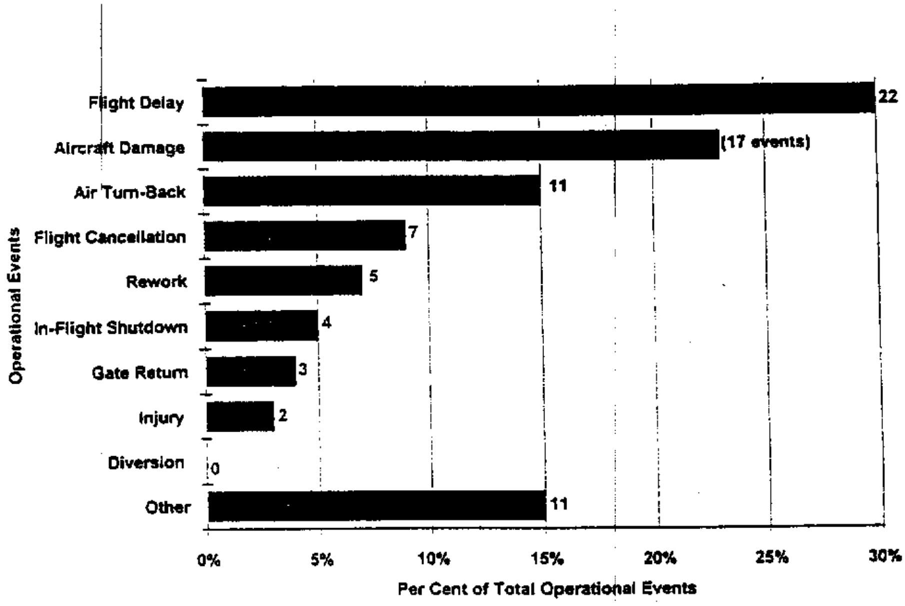


圖 1.操作性事件之分類統計

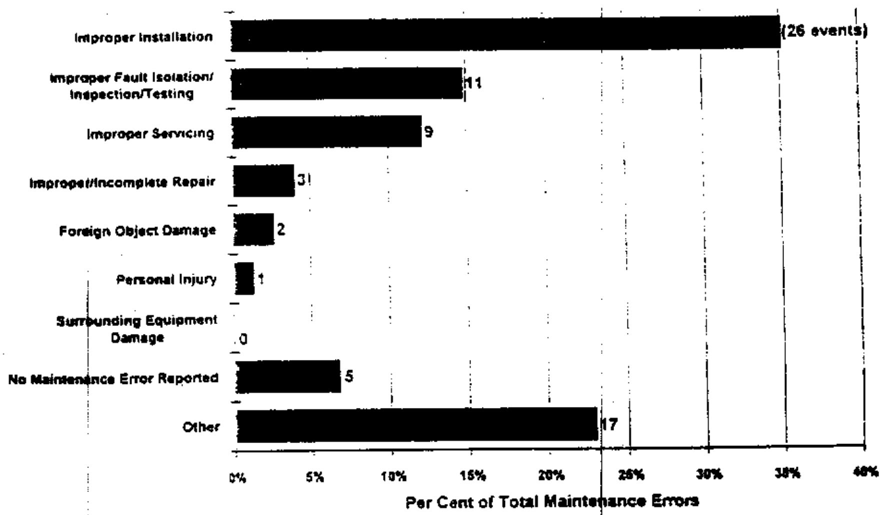


圖 2. 維修錯誤之分類統計

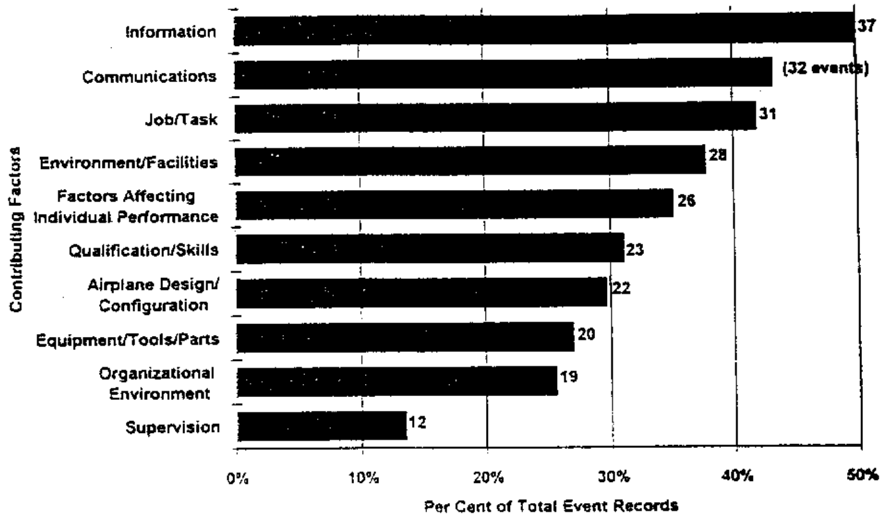


圖 3. 操作性事件肇致之原因分布

九、航空器/跑道性能研究

本論文爲美國航空太空總署(NASA)的 Langley 研究中心資深工程師 Thomas J.Yager 針對該中心正進行之飛機輪胎及跑道摩擦的介面研究計畫提出報告。飛機輪胎的摩擦參數如鋪面的質地狀況、輪胎的操作方式、膨脹壓力、飛行器速度的相關性皆在討論之列。

目前已知吾人可以地面摩擦力去評估跑道摩擦性能，以計算載具的能力。一種新的珠擊表面處理也被採用去改善表面質地、摩擦力、行駛品質及輪胎摩損效能。許多機關諸如美國飛航總署(FAA)、加拿大運輸部(Transport Canada)、美國航空(U.S.Air)以

及航空業者皆加入此項測試的計畫,據該中心指出該計畫有助於瞭解未來飛機飛航地面之操作將與輪胎及跑道摩擦介面間之關聯。

一個飛行員能成功的起飛及降落,大部份係依賴飛機落地時翼輪及鼻輪系統相對於機場跑道面之作用。摩損的輪胎及煞車、加上惡劣的天候狀況,很明顯的會減少飛機在地面操作之性能,使得飛行員很難達到落地之要求,而使得飛機可能會產生衝出跑道或轉向不足。新的輪胎設計、改善煞車元件、以及防滑控制,再加上改善後的高摩擦力、跑道表面除膠方法、及其控制污染的新科技,已能協助飛機超越其在跑道操作的限制,及滑動意外的最小發生率。

這一篇文章中說明該中心正在研究的數項影響輪胎鋪面與介面之因素。藉著兩架裝備具地面測試功能的飛機,利用各自獨立的測試裝備而獲得一些最新的測試結果, NASA 的 Wallops Flight Facility 測試工作站嘗試在其輪胎/跑道摩擦研究站以最新式的珠擊機(shot peening machine)去改善跑道表面織構(texture)摩擦力、行駛品質及輪胎摩損。

該中心所使用的數種相關性能測試機具及裝備中包括飛機落地動力裝置(Aircraft Landing Dynamic Facility,簡稱 ALDF),是一個大型的測試載具,利用高壓水彈射到一定程度後來測試速度,載具則被限制在一個 594m(1800feet)的鋼製軌道中自由滾動,然後遭遇 5 個粗大的捕捉線,使載具在 180m (600feet)的距離中停止。這樣的裝置在五 0 年代中期即被用來測試飛機落地輪軸系統和機具(包括太空梭)在一同跑道表面的性能。八 0 年代早期這樣的裝置則被加以更新,提供一個新的測試機具有較大的水

力噴射推進系統及較長的測試段，一個新的停止輪軸系統及較高測試速度(200 & 100 knots)及較重的輪軸落地負載能力。從 3 至 12 月當周遭空氣溫度超過 0 ℃時，載具就以每二小時運轉的方式，一天可測試 4 至 6 小時。The ALDF 不僅有能力針對不同的動態輪胎/舖面性能測試加以評估，亦能對靜態輪胎機械特性進行測試，故大部份的現有飛機以及各種等級的輪胎負荷狀況與膨脹壓力值的性能都能測知。

該中心進行裝備輪胎測試的載具(Insturmented Tire Test Vehical,簡稱 ITTV)被設計用來評估輪胎的許多參數包括正面滾動、左右滾動(yawed rolling)、彎度滾動(Cambered rolling)以及定滑煞車測試(fixed-slip braking test)。這些測試主要以最大速度 105km/h(65mph)及最大測試輪胎負荷 22.2KN(5000lb)進行測試。在輪軸支架上我們裝置一些應變儀(Strain gages)來對輪胎垂直量、阻力及側邊負荷加以了解；接著將測試後的輸出值接上電腦，再以終端機來顯示多項測試數據。測試時係利用一個充氣的系統來降低及舉升測試胎。定滑模擬的煞車系統則藉由具備可調式鋼支架的測試輪胎來組成，它穿過多向接頭而連接到一個可調式扣鍊齒輪上，換句話說，就是將左前輪驅動軸鎖住，接著再鬆開、移動測試輪胎的驅動支架以評估自由滾行、左右滾行、及彎度操作模式。就一個未煞車而左右滾動的輪胎進行測試，係以其支架未加鎖定且旋轉到事先選定的角度，以及固定在某個角度來進行。接著以彎度效應來評估輪胎的摩擦及磨損的性能狀況，輪胎測試支架能將彎度 1 度提升到 4 度，在這種彎度下測試胎也可以在被用來在左右變化角度的固定滑度下作煞車測試。

該中心所採用的對角煞車載具(Diagonal-Braked Vehicle,簡稱DBV)具有高性能的引擎，能迅速加速到正常測試速度96km/h(60mph)，以特殊的對角煞車組件爲主，提供一組對角線鎖死的輪胎與兩個自由滾動的輪胎，當輪胎在高速煞車鎖死狀態時，這個煞車能提供足夠的載具穩定性及方向控制。這種對角煞車輪胎是符合美國測試及材料協會載具的光滑輪胎，而另一組對角胎則裝設正常的標準輪胎，以提供所需之載具速度、加速度及停止距離。載具的速度及停止距離顯示在飛機載具的儀表板上，減速資料用來測試速度的大小及鎖死的輪子或滑動磨擦係數加以計算，相關資料請參考DBV提供的參考文獻。

該中心在維吉尼亞洲的東部Wallops Flight Facility(WFF)具有一個三條跑道的機場，作爲測試飛機地面操作性能及地面載具測試的變化上一個很理想的場所。跑道4/22爲一個46m(150feet)寬及2667m(8750 feet)長的落地測試跑道，其中有16米(52feet)乘以1128m(3700feet)的特殊測試跑道，包含數種不同的溝狀，非溝狀，水泥道，柏油道的測試跑道。溝狀跑道爲寬6mm(0.25in)及深25到51mm(1 and 2 in)的間距，一個6mm(0.25in)寬及25mm(1in)深的管道環繞每一個跑道的中心線測試表面及提供橡膠栓塞以控制水深。一個無溝狀3.7x2.4m(12by 900 feet)的水泥測試段靠近跑道側間肩擁有珠擊器修訂的不同跑道織紋。相同的裝備也使用在佛羅理達甘迺迪太空中心中的太空梭跑道上。

該中心將研究計畫及測試結果召開了數次的輪胎與跑道摩擦研討會，第二次的年度研討會於1995年15日-19日於NASA Wallops Flight Faility 舉

行，超過60個工程師與科學家參與研討活動，他們分別代表來自11個國家的35個組織。12個摩擦量測裝置在一星期内蒐集了超過500組資料，6種織紋技術用來收集超過200組於15種不同介面的測量資料，呈現在研討會成員前面的藍、紅、白三種畫板是特別被構建的參考畫板相對應於高、中、低的紋理。未來測試計畫就是將這些參考畫板成爲磨擦的及織紋量測設備的標準參考值。有關研討會期間被用來評估的裝置以及一典型摩擦/速度梯度曲線請參閱附件九，研討會中最有價值的資料庫所建議摩擦/速度梯度的斜率是 macro-texture 的函數，其大小爲 micro-texture 的函數。

現階段計有六種連續性摩擦量測裝置被 FAA 與 ICAO 認定合格使用於機場跑道，這些裝置包括設計、維修計畫及最小可接收度並在 65km/h ～ 90 km/h 時跑道摩擦等級的標準。

該文接著提出飛機輪胎磨損結果，認爲改進角磨損性能可由 ALDF 軌跡試驗獲得，我們使用 40 × 14 飛機輪胎來比較相同大小的 bias-ply 輪胎在最大速度 160 節時於一條乾且沒有溝條的水泥跑道的測試資料，結果顯示由2個輪胎於相同膨脹壓力與6度左右轉動角的磨損/能量等級，摩擦/能量參數簡單的説是胎紋厚度摩損平均量，這個量在測試距離中由煞車及角力的平均等級形成。磨損資料中顯示 radial belted 輪胎構造改善角磨損性能百分之 20 。

舖面表面紋路經由 ITTV 試驗對於 20 × 4.4 Bias-Ply 輪胎摩損效果用於3種不同表面的評估，結果顯示輪胎紋磨損率及平均紋理的深度在煞車(14 %滑度)及角(8 degrees) 操作模式下織紋深度

增加的趨勢。這些表面都是在 65km/h 乾燥測試。

有關太空梭易降跑道修正方面， Kennedy 太空中心整合各方面的努力設定跑道表面修正使太空梭的降落由 15 節的速度容許增加到 20 節。由研磨、旋珠擊(rotopeening)、射珠擊(shot peening)及特殊外裝所造成 18 種不同的表面處理，第一次被用來評估 ITTV 輪胎摩損與摩擦試驗。由這資料庫，三種表面處理被選擇用來填充全長 4572 公尺的水泥跑道，而每種材質各佔 3.7 公尺寬度，全尺寸的 crosswind 降落模擬使用來自該中心的降落系統研究機。這經特別修改及特別儀裝的 CV-990 噴射運輸機配備--電腦控制、機身中心線起落架。這起落架專門設計符合太空梭主起落架輪胎， Kennedy 太空中心由 CV-990 試驗所得的太空梭輪胎磨損試驗結果顯示，其跑道表面用 Skidabrads shot peening method 做修改，明顯的可提供最佳磨損性能，因此於 1994 年 9 月跑道 91m 至 4572m 的表面都採 skidabraden 裝備做修改，由該中心進行三次的太空梭降落輪胎磨損資料顯示，自從跑道修正過後，的確有較佳的磨損性能。

NASA DBV 摩擦量測試驗基於美空軍 C-17 系統計劃室的要求，在北卡羅來那州 Pope 空軍基地 Holland Landing Zone 進行短(1097 公尺土壤)跑道測試，這些測試計畫主要爲 C-17 在乾地起飛降落操作。 DBV 資料顯示土壤跑道提供幾近乾鋪面跑道磨擦性能以及 C-17 飛機成功的操作其上。 Bowmark Skidman 組件爲一電子減速量測器提供載具加速或減速到 1g 的永久性時間歷史紀錄。 Tapley 減速量測器之右邊是一手工操作的儀器能顯示載具煞車後的高峰減速度大小。兩種減速器均被 DBV 所採用，所得數據均相

似，而 Skidman 組件內建於 C-17 上，經其紀錄之值和 C-17 飛機資料取得系統的值相似。

至於冬天跑道磨擦聯合測試計畫(Joint Winter Runway Friction Test Program)該中心與美聯邦航空局 FAA 及加拿大運輸部及數個團體支持這項計畫，計畫內容包括飛行器及地面載具摩擦的相互關係，航空器/跑道化學除冰及航空器遭遇水/泥漿/雪的衝擊阻力的研究，這些研究提供的資料將成爲國家及產業在冬季考量下的跑道摩擦力計算及報告的最佳材料。

十、“共同飛航需求”的手法

本篇論文係由共同飛航機構(Joint Aviation Authorities,簡稱 JAA) 秘書長 Klaus Koplin 在會中針對「共同飛航需求」(The Implementation of Joint Aviation Requirement)所提出之報告。由於 JAA 的機體引擎及螺旋槳的規定數年前偏重於大型飛機，現今已擴展到小型機及直昇機方面。 JAR-145 已被近 1400 個組織所採用。其操作的要求（ TAR-OPS ）已在 1995 年 3 月被採用，而人員檢定執照部份將於 1996 年中完成。該文即是介紹 JAA 今日及未來的發展。

該文首先說明什麼是共同飛航機構(JAA)， JAA 是一個歐洲民航會議(European Civil Aviation Conference,簡稱 ECAC)下的綜合體，這 ECAC 代表一些歐洲國家的民航主管當局，他們同意爲發展及改善大眾飛安的標準及程序而共同合作。這樣的合作傾向於執行嚴格的安全標準，許多和美國一樣的強調重點均被放在一致的 JAA 準則中。

JAA 的會員國成員於 1990 年在所簽定的協定 JAA(JAA Arrangement) 中，基於協定及相關會議，將 JAA 的目標及功能定義如下：

1.JAA 之目標爲

- 在會員國中確定藉合作前提，在法規中提出高的飛安標準要求。
- 在同一安全標準的環境中，提供會員國公正且平等的競爭條件。
- 以有效成本安全(cost-effective Safety)及最小法律責任，來提供會員國在全世界的競爭力。

2.JAA 之功能爲

- 在飛機設計、製造、操作、維修及人員檢定發展採用供同飛航之要求(Joint Aviation Requirement，簡稱 JAR)。
- 發展行政及科技上的程序以改善 JAR 。
- 一致且協調的去發展行政及科技上的程序。
- JAA 安全的目的在於不論何時都不會沒有理由的破壞競爭力。
- 提供歐洲專家系統的理論中心，以達成飛安法規的一致性。
- 建立共同的產品及服務程序，並考慮頒發共同證書。
- 在需求和程序上和其他飛航安全組織特別是 FAA 求得一致性。
- 和其他國外組織特別是 FAA 在產品和服務的執照核發上合作。

JAA 之會員資格係開放給屬於 ECAC 的成員，ECAC 現有 32 個會員國，而 JAA 是 ECAC 的關連組織。會員資格生效於 1990 年協定的簽署，今天 JAA 共有

23個會員國。

兩階段(two-stage)的會員資格系統使國家加入必須有詳盡的評估程序，才能由資格候選會員轉成完全會員國資格，現今共有18個完全會員及5個資格候選國(Cyprus、Malta、Monaco、Poland、Slovenia)有幾個國家正開始進入資格候候選國的程序(Czech Republic、Slovak Republic、Hungarg、Turkey)。

JAA透過JAA Commitee (JAAC)委員會來運作，委員會由各個會員國的一位代表所組成，通常這位代表負責當事國駐在JAA反應該國所有安全法規的代表。日常的事務由執行委員會所決定，而執行委員會有6個從JAA committee中選出的成員，委員會決定政策以及最終預算的審查。

JAA Board 包含各成員國的民航機構領導人，基金委員會則負責基金事務，爲JAA總部負責事業管理角色，此委員會並不包括制定JAA技術策略。

JAA的總部幕僚係以主任秘書爲首(Secretay General)下設有認證、法規、維修、營運、發照與行政六個部門。1995年有30個幕僚被約聘到總部，計劃到1997幕僚將增至36員。1995總部預算爲2.7百萬ECUS(US$4.1m)，預計1996年將增至3.1百萬ECUS，1997年則增至3.6百萬ECUS。若JAA總部持續現在的活動，長期幕僚與成本不致會改變很大。

該文提及JAA在認證方面之內容涵蓋大飛機(JAR-25)、小飛機(JAR-23)、直升機(JAR-27and-29)、引擎(JAR-E)、輔助動力系統APU(JAR-APU)、螺旋槳(JAR-P)及裝備(JAR-TSO)進行認證。

JAA及FAA同意合作訂定共同認證的程序，目前正在蒐集所需的工作項目並在未來用在B777、 Learjet45，B737-600、700及800，MD95-30及其他未來研發的飛機上。

以直升機而言，JAA則使用源於1994年早期Euro-copter EC120的JAR-27爲準則，目前尚有三種FAA認證的直升機目前正在審議中。

JAR-21"飛機相關產品及零件的認證程序"在1993年11月被採用，1995年1月1號正式生效，JAR-21包括JAA及FAA航空業者對於產品認證、設計、核准製造的政策和協定。

至於維修方面，JAR-145規定所有組織內的飛機維修都需經過JAR-145的標準，核準維修的責任在各國家的民航當局，大約1200個美國維修機構及90個加拿大維修機構正在申請JAA的JAR-145的核可，其中920個美國維修單位及57個加拿大維修組織已被核可。JAS-65規定認證人員將負責簽放飛機的認證進入正常營運。

JAA常召開會議，其意圖是對JAA提供更爲正式的法律地位，嚴謹的會員國成員規範、促進JAA的發展、加強JAA組織，以及去除JAA進步的障礙。

JAA於1992年6月成立條約工作群(Treaty Working Group)，完成其草約會議，並呈約給JAA委員會。

1995年3月JAA Board總結草約會議的討論，雖然有一些議題必須定案，但是最後協定已經決定，最後草約被傳送到所有會員國成員，內容提供JAA會員國有關貿易考慮及立法的方向。JAA會議並不預期快速改變JAA的型態，會議的目地在於促使JAA各會員國的民航局成爲事實上的單一民航局，因會議的進行促使會員國一步進步是可預期的。

肆、結論與建議

綜合而言，出席本屆飛航安全年會瞭解全球飛安事故之統計分析、各國航空公司安全計畫管理、空中交通管理新科技之發展、人因研究對於疲勞之對策、對維修作業程序之設計與判定、航空器與跑道性能之研究、歐洲共同飛航需求之啓示等方面，計獲得以下結論與建議：

1. 政府部門應積極籌設或輔導民航界培訓航空技術人才。

   由國外飛安事故統計資料顯示，約有七成係人爲因素肇致，而由我國近二、三十年來之重大事故資料分析，約達四成肇事原因爲人的因素。究其背景則爲我國自民國七十六年底交通部推動「開放天空政策」後，促成國內民航蓬勃發展，新航空公司先後成立，機隊亦不斷擴充，致飛航及維修人才需求孔急。惟因國內該類人才多自軍方釋出，若由民間培訓，則因須耗費二至三年之久而緩不濟急，且其投資龐大非一般中小型航空公司所能負荷；然而軍方由於國防建軍計畫之需，可能轉役民航之人員大幅縮減，故短期內形成航空技術人才之青黃不接景象，致造成部分須仰賴外籍機師之局面，故政府應積極籌設或輔導民航界培訓航空技術人才，例如結合現有訓練資源加以利用，給予有志航空飛航與維修之青年基礎培訓，再依各航空公司需要，進一步甄選人才赴國外實施飛航課程之訓練，除可充分利用現有之訓練設備外，並可補足中小航空公司飛安培訓之不足。

2.加強飛安管理各層級及其所屬人員之專業素養。

由於飛航安全管理計畫是民航界推動飛安之手段，對航空公司而言，必須由上至下均能支持飛安工作之推動，而飛安之改進措施亦應由下而上方能回饋貫徹，這是一項全面性且持久性之工作，故在高層管理者須有口頭承諾與政策之支持外，亦應隨時加強吸收最新之飛安管理資訊與觀念，方能帶動公司上下注重安全第一。而管理各階層人員則須對現階段之飛航安全計畫有所瞭解，以擬訂安全管理、緊急應變和安全檢查計畫、以及失事預防策略等，飛安督導階層人員亦應以專業理念推動合作與分工，使飛安工作與理念能一致，以發揮確保銷費者安全之實效。

3.政府應加強未來航管自動化作業之規劃與推動，以更新我國空中交通管理之技術與設備。

由於我國航管自動化系統甫完成驗收作業，而國內各航站之跑道容量已無法因應快速成長之空中交通量，故有時須實施「流量管制」策略，而造成班機之延誤；同時部分離島機場因受限於地形無法裝設導航設施、或氣候導致無法降落，均使航機飛行受到影響，故為配合國外「未來航空導航系統」(FANS)之發展，政府實應儘速推動成立專案小組，謀求在現階段採取替代性之通訊、導航、監視功能之技術與設備投資，以發揮強化我國民航飛安之功效。

4.政府應推動建立「航空安全報告系統」(Aviation Safety Report System,簡稱 ASRS)以預防飛安事故之發生。

有鑑於歐美等先進國家均建立有「航空安全

報告系統」，針對日常作業中有異常或突發之狀況加以敘述，可透過事後之分析找出問題之癥結所在，進而謀求改善之策略，實爲杜絕類似事件發生之最佳措施。而由於我國文化背景與國人之傳統心態認爲多一事不如少一事、或意圖遮掩事實之眞象，往往使得飛航組員未能提高警覺，錯失預防良機，故建議民航主管機關應成立「異常狀況事件報告系統」，以電腦與各航空公司連線，受理相關飛安異常狀況之報告，並給予報告人保密與不處罰之待遇，以有效做好失事預防工作。

5.政府應儘速成立航機失事調查專責機構以確實掌握失事原因防止事故再度發生。

由於我國多年以來之失事調查作業多仰賴國外專家之協助，未積極培育本國調查人才以謀求技術生根；且無專業之機構對相關之調查報告亦未加以整理分析，以瞭解事故之肇因與改善之對策。故因應現階段國內航空事故頻傳，立法委員要求成立「航空器失事調查委員會」之便，儘速規劃成立專責失事調查機構，並進行專業人才培育計畫之研擬，以掌握我國飛安事故之確切原因，謀求改善因應之道。

6.民航主管機關應研議飛行員值勤標準，並加強各航空公司對飛航組員工時之管理，以避免員工產生疲勞之影響。

目前各航空公司雖訂定有其內部員工服勤工時之規定，但依國內航空現況分析，業者是否會因成本及效率之考量，飛行員是否因本身自信及薪資的多寡而遊走於法律邊緣，將法定休息時數縮短，或是以邊界值繼續值勤，值得重視。建議

政府主管機關應研議飛行員值勤標準，其內涵融合新醫學科技，將生理時鐘、管理手段、疲勞因素、睡眠、行車用餐因素、藥物使用、藥物管理、併發症管理等，溶入法規中考慮，在業者、飛航組員、政府、乘客協調間達到最安全的飛航環境。

7.在航機維修方面建議航空業者及主管當局應及早引進維修新科技，以求得最大效率與最佳安全度。

由於複合材料的應用已經普遍使用在飛機結構的主系統，包括飛機主翼、襟翼及副翼的蒙皮及結構上，因此如何在瞭解其設計原理的條件下檢修及維護機翼，並在成本的考量下以較少影響現階段全鋁合金結構維修的方向，以及保持在失敗機率准許值之下，為航空業者及主管當局當務之急。故建議業者及政府應配合新科技的發展趨勢，引進最新維修技術以求得航機之最大效率與最佳安全度。

8.政府應針對國外航空研究機構提出的研究報告中值得借鏡之資料加以重視，藉此通路進行類似及前瞻性的研究，以研擬改善國內飛安之策略。

依據美國航空太空總署(NASA)的 Langely Programs 對於影響航空器/跑道介面變化的數項成因進行之研究，顯示數種特殊的測試機具的裝備如航機降落動態裝置(Aircraft Landing Dynamics Facility)與 Wallops flight 裝置，在甘迺迪太空中心與 Pope 空軍基地的操作下分別完成其測試結果，這提供未來航空器在惡劣天候下的地面管理性能資料，可供國內航太研究機構借鏡，所謂它山之石可以攻錯。有助於加以應用於研擬適合國情的飛航安全改善方案。

9.政府與民間應加強與區域性飛安組織之相關規範資料交換與蒐集，以增進彼此之瞭解與相護承認。

由歐洲共同飛航機構(JAA)之會員形成歷史、發展型態、組織結構、功能執行以及未來發展方向，值得我們作爲與國際間民航主管當局合作分工的參考資料。由其在發展區域合作及人員、航務操作、維修認證等方面，在制訂其規範過程中如何制訂其標準值得我們注意及借鏡。

10.政府除加強國內外相關飛安資訊之交流外，亦應加強各航空公司間之飛安資訊交流。

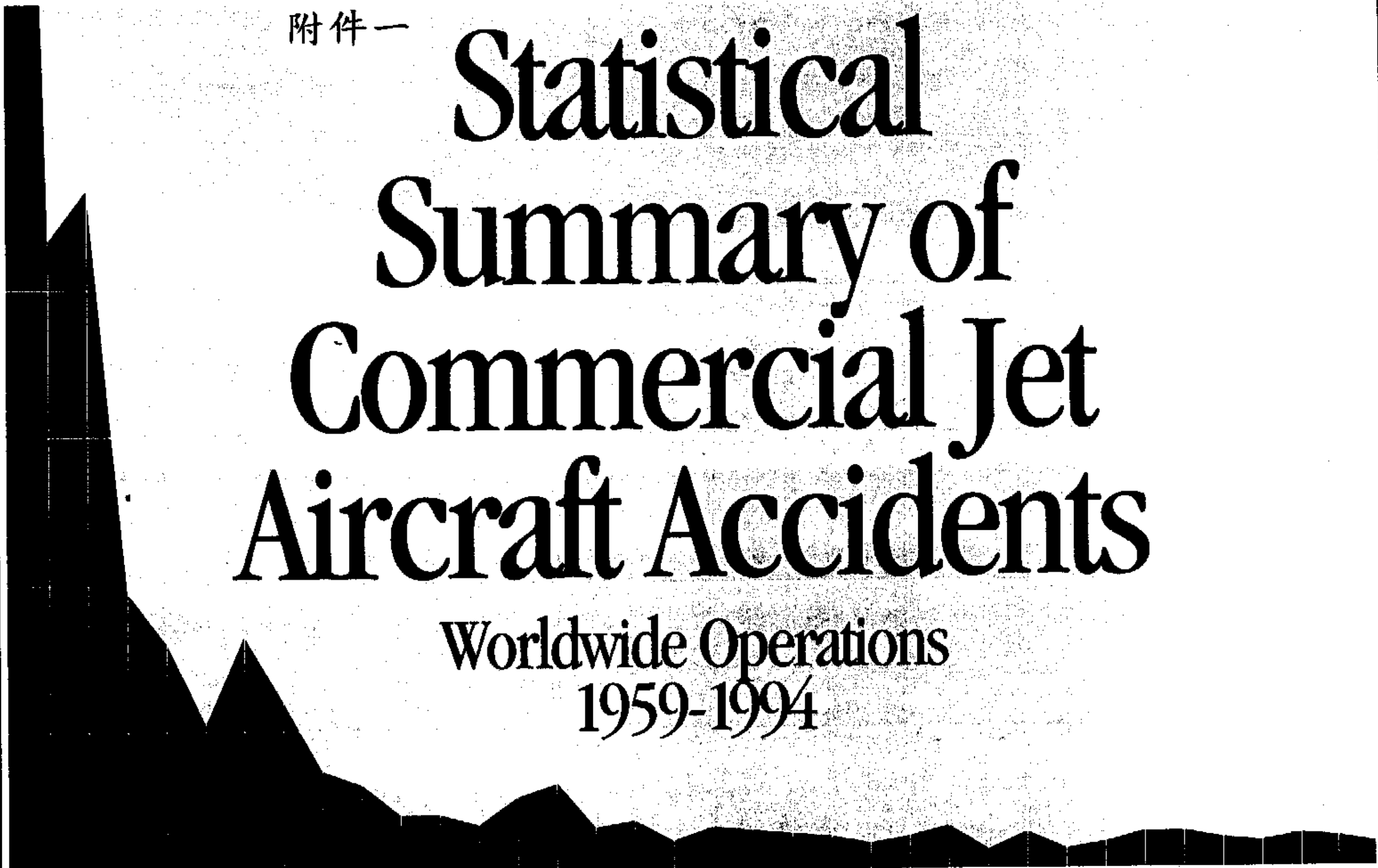
政府應扮演橋樑腳色，除積極引進國外最新相關飛挨資訊外，在業界間亦能公開分享飛航安全相關資訊，以共同致力於國內飛安之改進。

附錄

附件一

Statistical Summary of Commercial Jet Aircraft Accidents

Worldwide Operations 1959-1994



1994

Contents

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Introduction

The accident statistics presented in this document apply to commercial jet aircraft, worldwide, and heavier than 60,000 pounds maximum gross weight, but do not include turboprop powered aircraft. CIS (former USSR) manufactured aircraft are also not included because complete operational data is not available. Military operators of commercial type aircraft are, for similar reasons, also excluded.

Accident data are obtained, when available, from government accident reports; otherwise, information is solicited from operators, manufacturers, and various government and private information services. The accident selection essentially corresponds to the U.S. National Transportation Safety Board's accident definition; however, events are excluded which involve non-fatal injuries resulting from maneuvering, atmospheric turbulence, loose objects, boarding or disembarking, or airplane servicing activities. All accidents resulting from sabotage, hijacking, suicide, military action, or experimental test flying are also omitted. Midair collisions of civil aircraft involving military aircraft proceeding in accordance with civil air traffic rules are included.

Fatal accidents include those where persons other than airplane occupants are fatally injured; however, the number of fatalities for a given accident includes only those who were occupants of the aircraft.

Death or injury of a stowaway, and death of a passenger or crew member from natural causes (including heart failure), does not in itself constitute an accident and is not counted as a fatality.

Aircraft flight time and flight cycles are primarily obtained from compilations maintained by aircraft and engine manufacturers; these being gathered from the operators' aircraft and engine logs. Flight operations data for non-Boeing airplanes are derived from the ACAS electronic database which is published by Aviation Research & Support (AR&S), Limited of Rugby, England. Year end 1994 operations figures were extrapolated from available data as of publication date.

Accident Definitions

- "Aircraft accident" means an occurrence associated with the operation of an aircraft that takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, in which any person suffers death or serious injury as a result of being in or upon the aircraft or by direct contact with the aircraft or anything attached thereto, or the aircraft receives substantial damage.

- "Serious injury" means any injury that (1) requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received; (2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose); (3) involves lacerations that cause severe hemorrhages, nerve, muscle, or tendon damage; (4) involves injury to any internal organ; or (5) involves second or third degree burns affecting more than 5 percent of the body surface.

- "Fatal injury" is defined as an injury that results in death within 30 days of the accident.

- "Substantial damage" means damage or failure that adversely affects the structural strength, performance, or flight characteristics of the aircraft, and that would normally require major repair or replacement of the affected component. (Not considered substantial damage are engine failure or damage limited to one engine, bent fairings or cowling, dented skin, small punctured holes in the skin or fabric, damage to landing gear, wheels, tires, flaps, engine accessories, brakes, or wing tips. Generally, if the aircraft can be repaired in a 48 hour period to allow a ferry flight to a repair base, the damage is not considered substantial.)

Summary

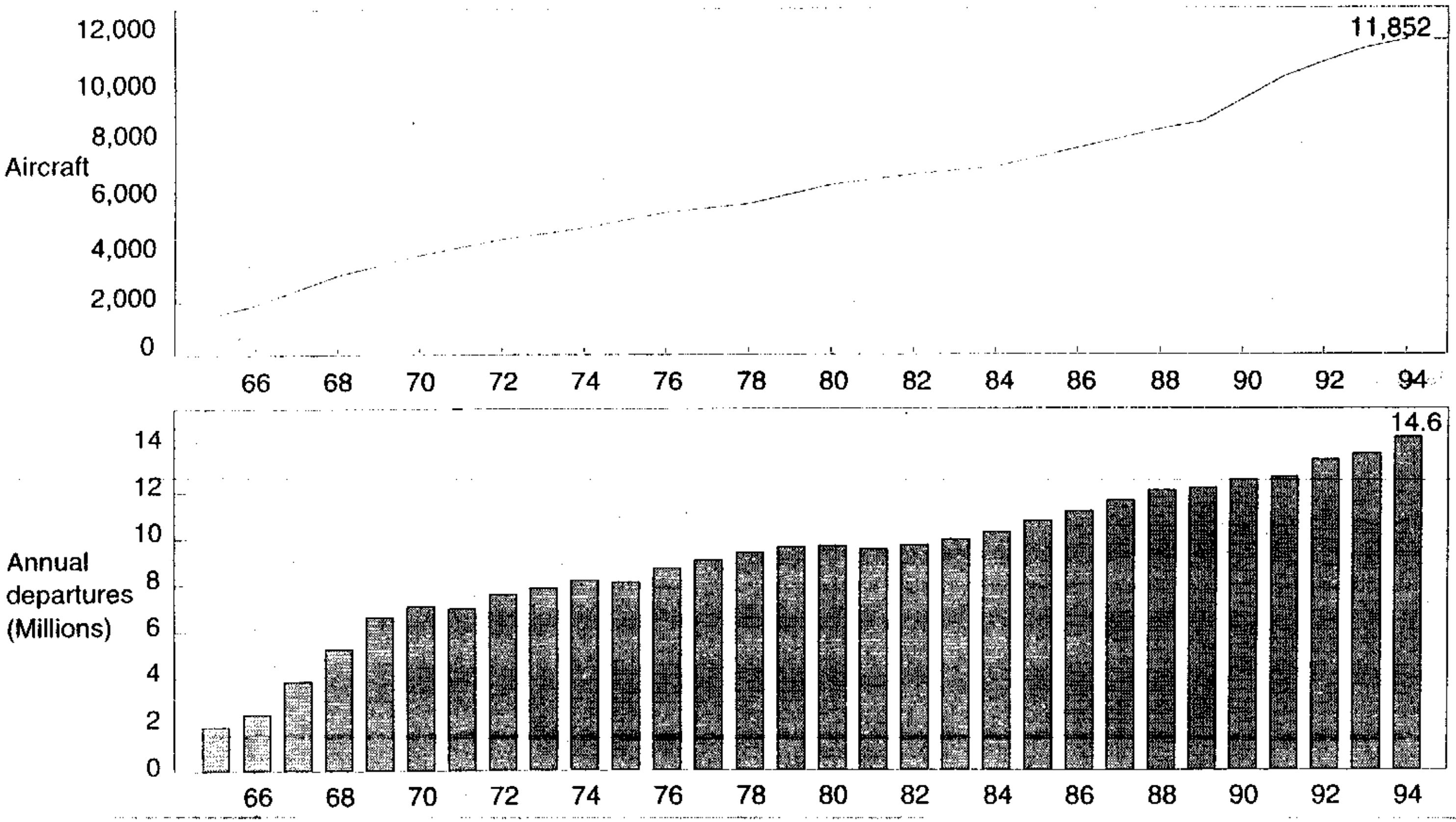
Worldwide Commercial Jet Operations* — 1959 Through December 31, 1994

- 9 manufacturers - 30 significant types (8 Boeing)
- 11,852 aircraft in service as of 12/31/94 (6,646 Boeing)
- 433 million flight hours (253 million on Boeing aircraft)
- 286 million departures (157 million on Boeing aircraft)

* Certified jet aircraft greater than 60,000 pounds maximum gross weight, including those in temporary nonflying status and those in use by nonairline operators, but excluding military operations and CIS manufactured airplanes.

Jet Aircraft in Service and Annual Departures

Worldwide Operations 1965 — 1994



All Accidents

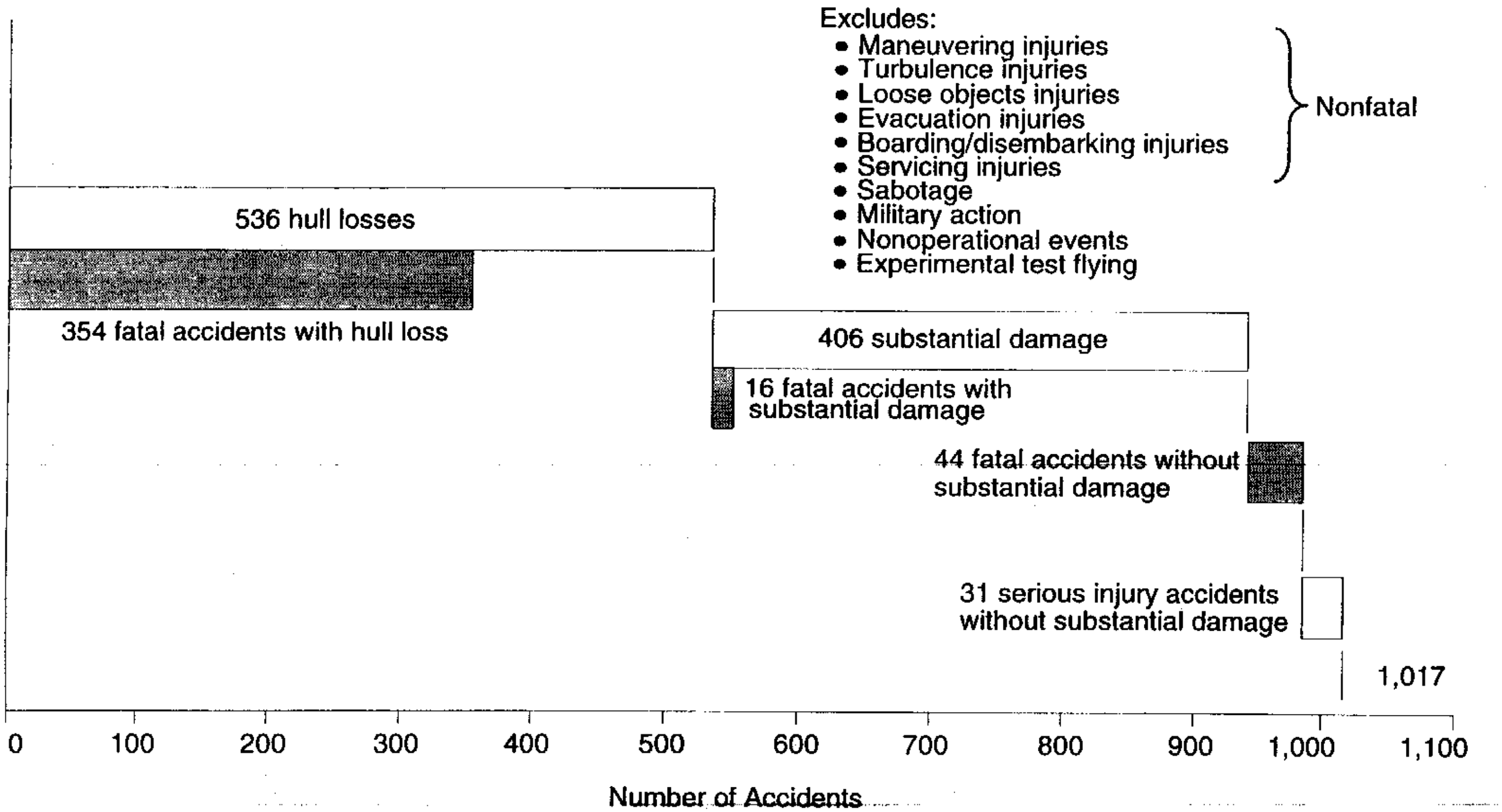
Definition:
Substantial damage to the aircraft and/or death or serious injury to any person in, or in direct contact with, the aircraft.

Excludes:

- Maneuvering injuries (Nonfatal)
- Turbulence injuries (Nonfatal)
- Loose objects injuries (Nonfatal)
- Evacuation injuries (Nonfatal)
- Boarding/disembarking injuries (Nonfatal)
- Servicing injuries (Nonfatal)
- Sabotage
- Military action
- Nonoperational events
- Experimental test flying

All Accidents

Worldwide Commercial Jet Fleet — 1959-1994



All Accidents

All Aircraft — Worldwide Commercial Jet Fleet

1959-1994

1,017 total accidents

- Accidents - U.S. operators
  - 270 during passenger operations
  - 45 during all-cargo operations
  - 33 during test, training, demonstration, or ferry
- Accidents - non-U.S. operators
  - 544 during passenger operations
  - 66 during all-cargo operations
  - 59 during test, training, demonstration, or ferry

1985-1994

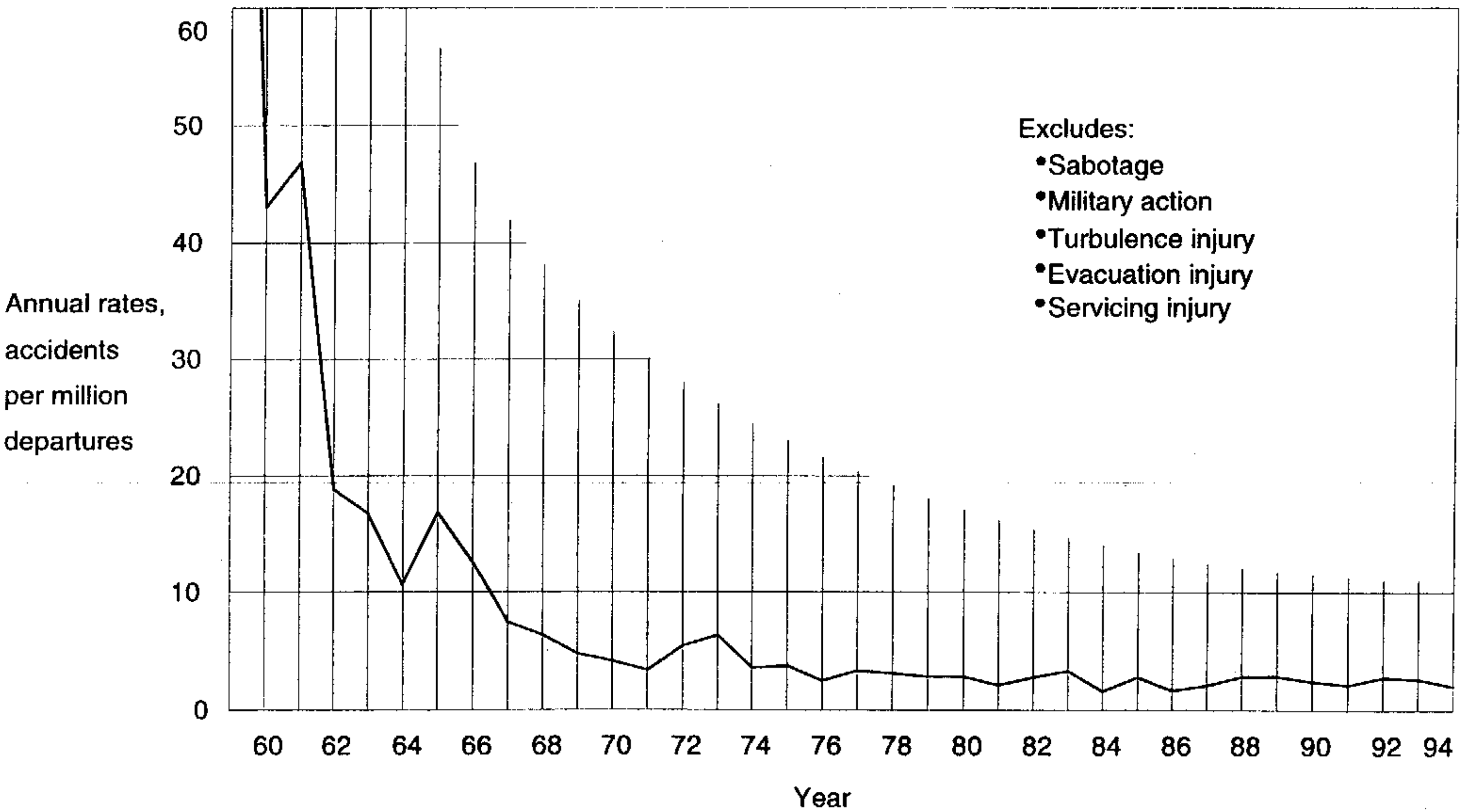
311 accidents (last 10 years)

- Accidents - U.S. operators
  - 56 during passenger operations
  - 15 during all-cargo operations
  - 3 during test, training, demonstration, or ferry
- Accidents - non-U.S. operators
  - 192 during passenger operations
  - 34 during all-cargo operations
  - 11 during test, training, demonstration, or ferry

Excludes:
- Turbulence injuries
- Emergency evacuation injuries
- Sabotage/Military action (35 inflight hull losses, 44 hull losses on the ground, 3566 fatalities since 1959)
- Non-operational events

All Accidents

All Aircraft — Worldwide Commercial Jet Fleet



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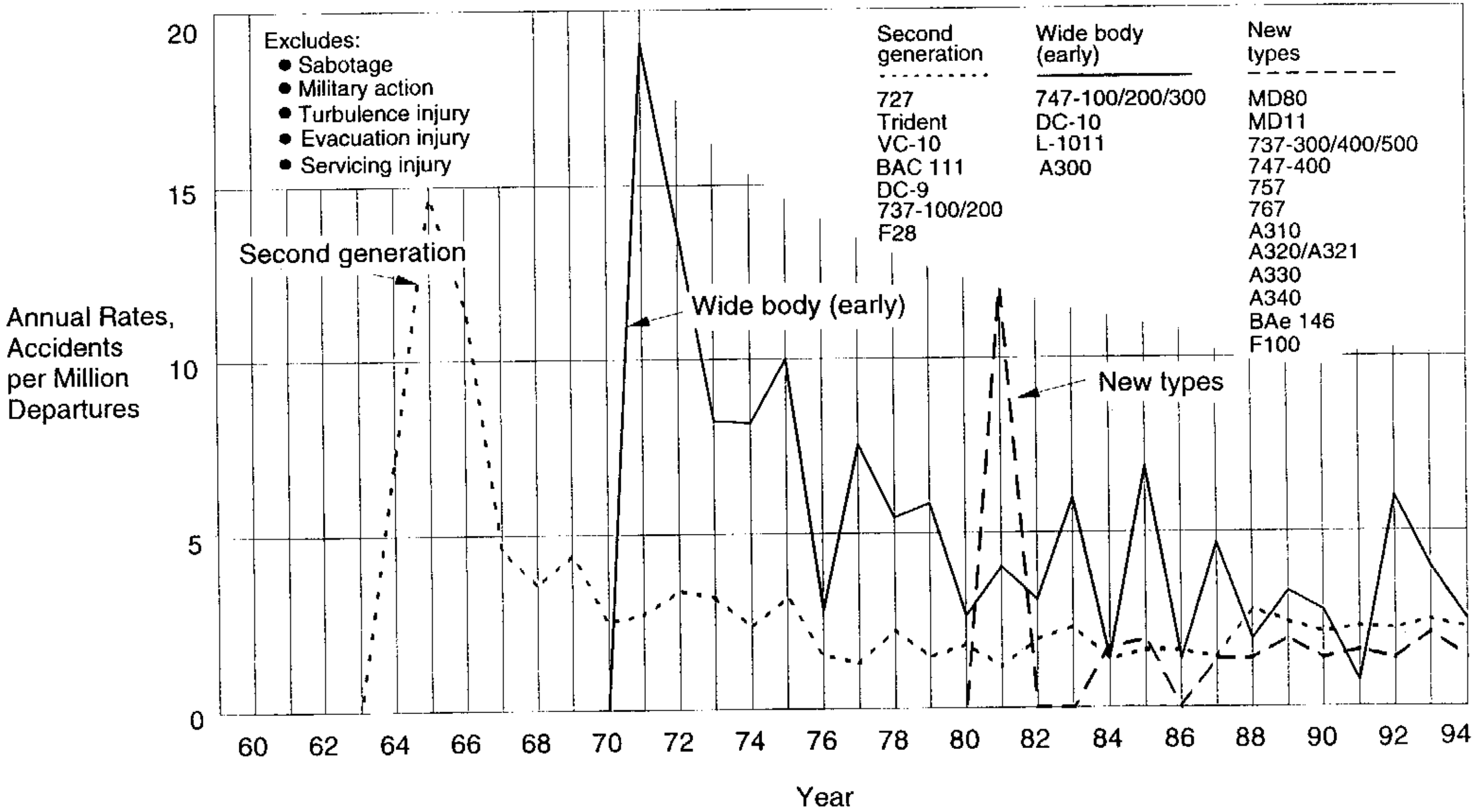
All Accidents

Worldwide Commercial Jet Fleet — By Generic Group



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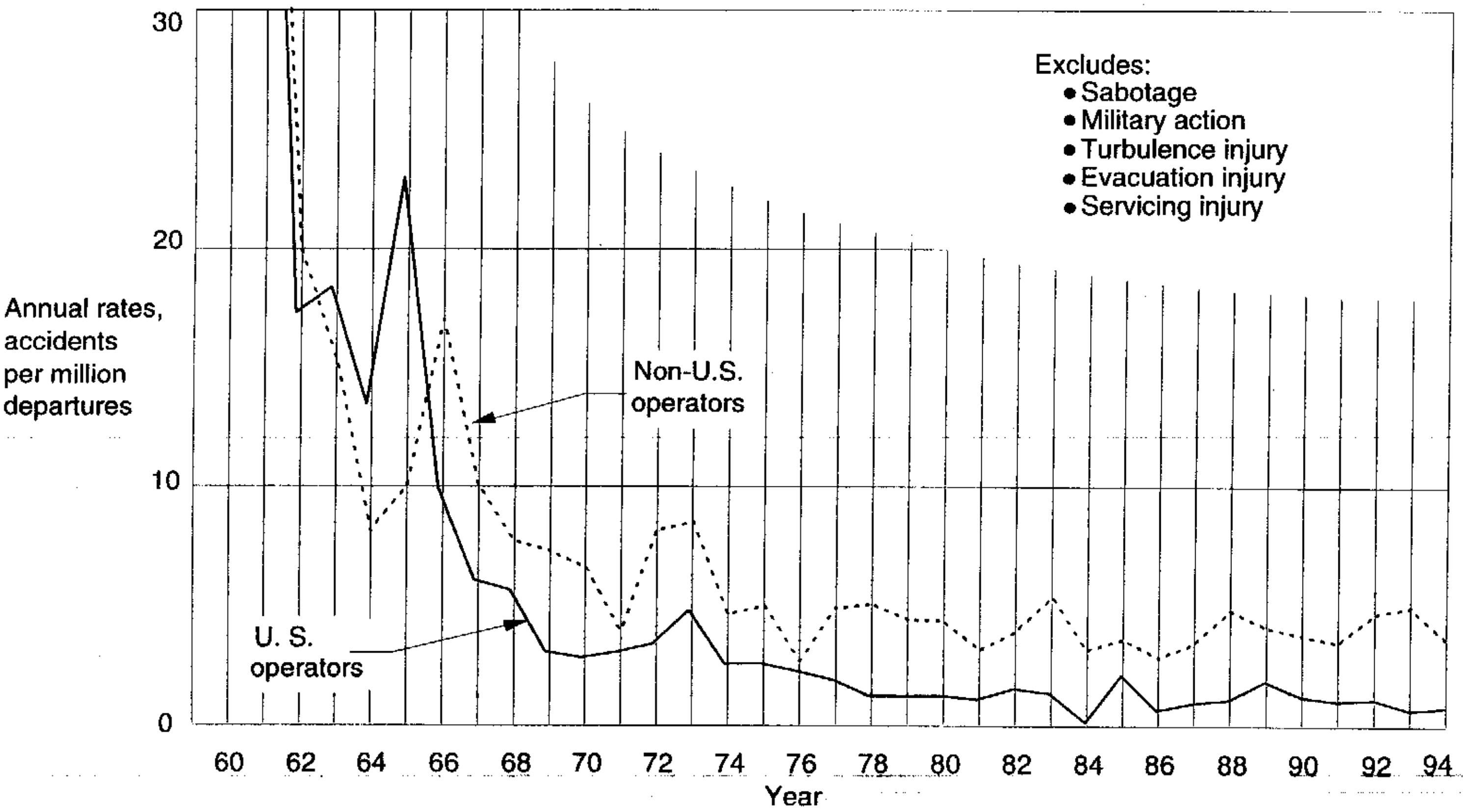
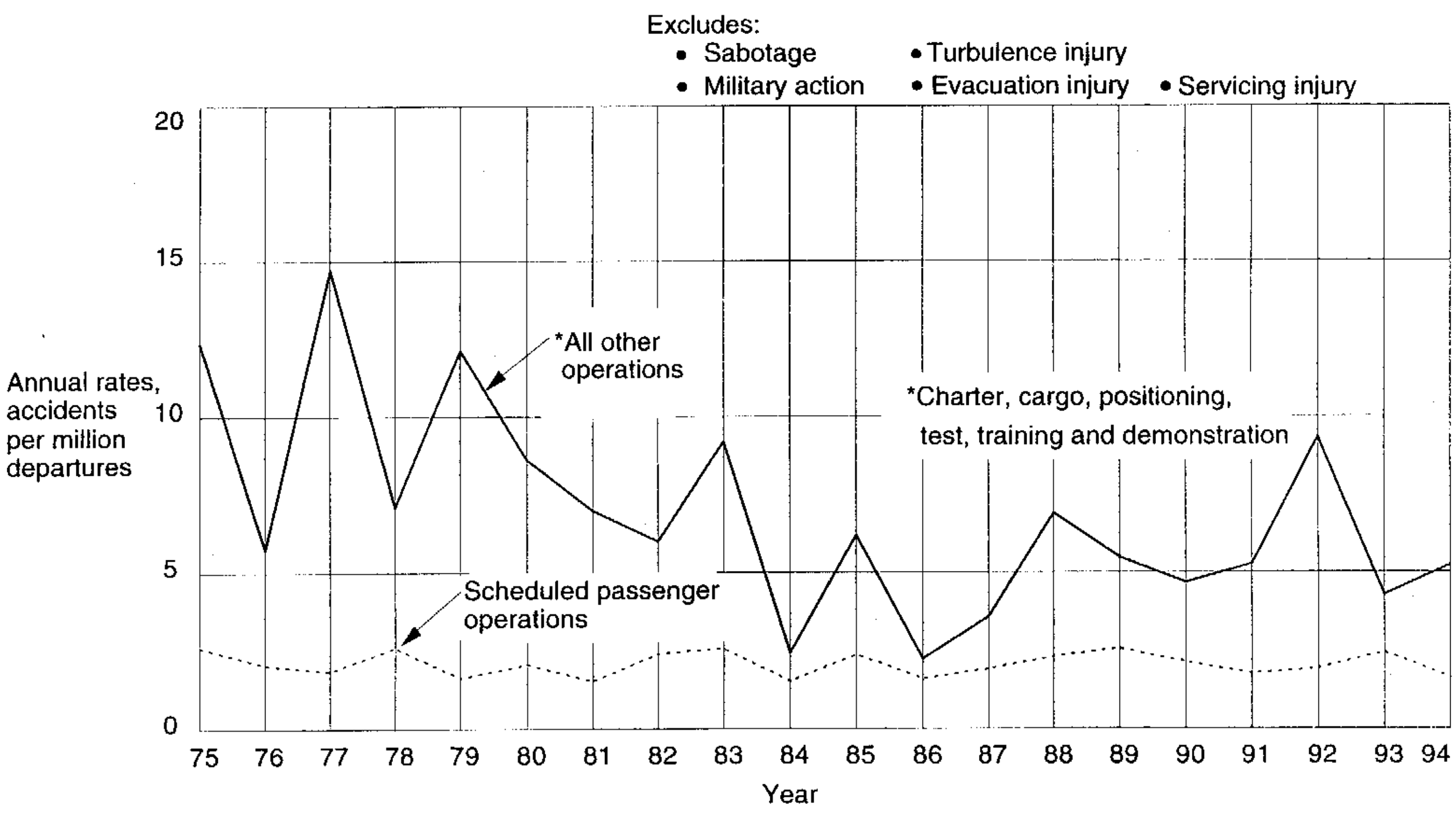
All Accidents

U.S. and Non-U.S. — Worldwide Commercial Jet Fleet



All Accidents

Worldwide Commercial Jet Fleet



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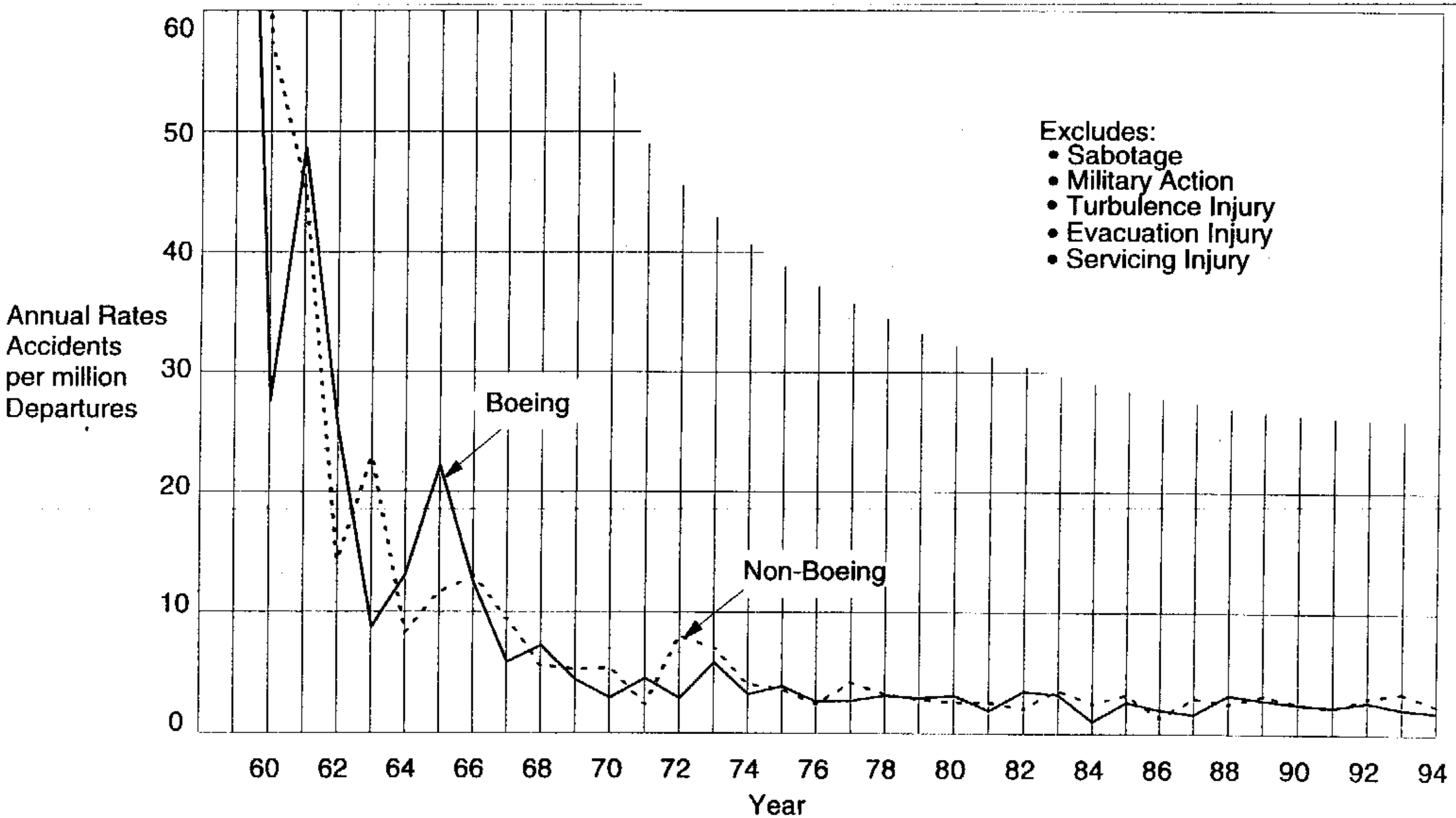
All Accidents

Worldwide Commercial Jet Fleet



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All Accidents

Worldwide Commercial Jet Fleet — 1959-1994

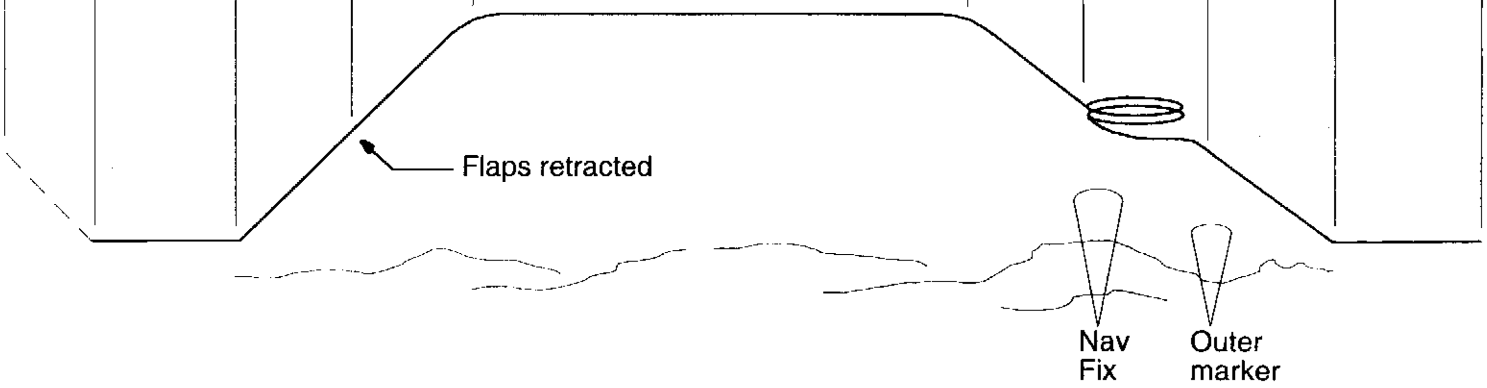
Excludes:
- Sabotage
- Military action
- Turbulence injury
- Evacuation injury

Exposure percentage based on a flight duration of 1.5 hours.

Percentage of accidents

	Load, taxi, unload	Takeoff	Initial climb	Climb	Cruise	Descent	Initial approach	Final approach	Landing
Percentage of accidents	4.8%	12.8%	7.4%	6.4%	5.7%	6.2%	6.6%	19.7%	30.3%
Exposure, percentage of flight time		1%	1%	14%	57%	11%	12%	3%	1%

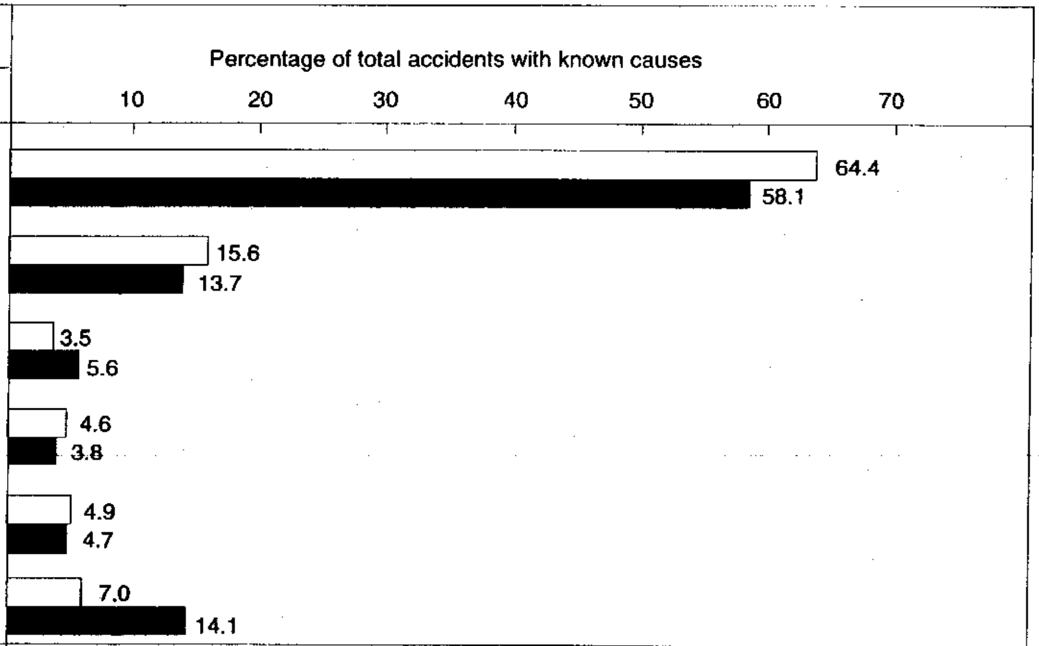
Final approach + Landing: 50.0%



Exposure, percentage of flight time

Primary Cause Factors – All Accidents
Worldwide Commercial Jet Fleet

Primary factor	Number of accidents: Total	Number of accidents: Last 10 years
Flightcrew	569	136
Airplane *	138	32
Maintenance	31	13
Weather	41	9
Airport/ATC	43	11
Miscellaneous/other	62	33
Total with known causes	884	234
Unknown or awaiting reports	133	76
Total	1,017	310



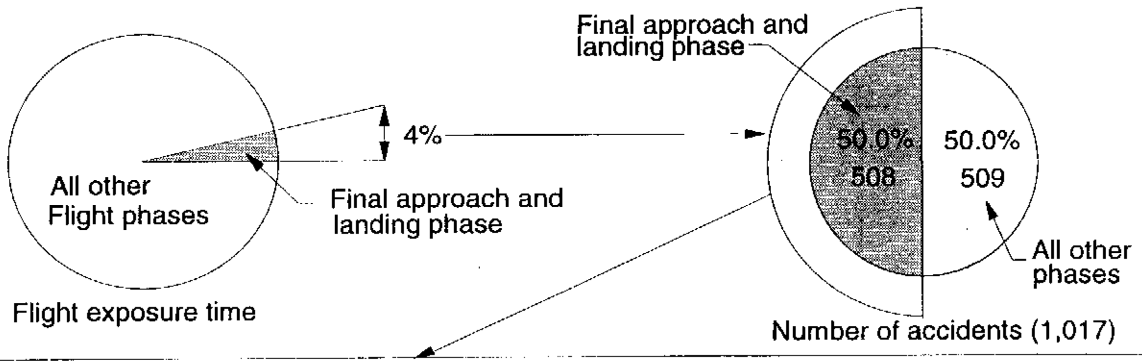
Excludes:
- Sabotage
- Military action
- Turbulence injury
- Evacuation injury
- Servicing injury

* Includes:
- Airframe
- Aircraft systems
- Powerplant

Legend:
- 1959 - 1994
- Last 10 years (1985 - 1994)

All Accidents – 1959-1994

Critical Time and Cause — Final Approach and Landing



Final approach and landing phases

Primary factor	Number of accidents	Percentage of the 439 accidents with known causes
Flightcrew	343	78.1%
Airplane	37	8.4%
Maintenance	9	2.1%
Weather	23	5.2%
Airport/ATC	20	4.6%
Miscellaneous/other	7	1.6%
Total with known causes	439	
Unknown or awaiting reports	69	
Total	508	

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All Accidents

Primary Cause Factors Versus Flight Phase — Worldwide Commercial Jet Fleet — 1959-1994

Primary factor	Total (Boeing / Non-Boeing)	Takeoff	Initial Climb	Climb	Cruise	Descent	Initial approach	Final approach	Landing	Taxi Load
Flightcrew	306 / 263	31 / 26	17 / 24	9 / 4	9 / 5	19 / 20	28 / 26	83 / 86	108 / 66	2 / 6
Airplane	62 / 76	12 / 18	7 / 8	12 / 17	6 / 7	2 / 3	0 / 0	3 / 0	16 / 18	4 / 5
Maintenance	15 / 16	1 / 5	1 / 1	2 / 5	4 / 1	0 / 1	0 / 0	0 / 1	6 / 2	1 / 0
Weather	22 / 19	1 / 0	2 / 2	4 / 0	2 / 3	1 / 1	0 / 1	4 / 4	7 / 8	1 / 0
Airport/ATC	19 / 24	3 / 1	2 / 1	1 / 1	0 / 5	1 / 2	0 / 1	0 / 4	9 / 7	3 / 2
~~Miscellaneous~~	39 / 23	5 / 8	1 / 2	3 / 1	4 / 3	7 / 1	1 / 0	1 / 0	5 / 1	12 / 7
Unknown	52 / 81	5 / 14	6 / 3	3 / 3	6 / 3	2 / 3	4 / 6	7 / 7	15 / 40	4 / 2
Total 1,017	515 / 502	58 / 72	36 / 41	34 / 31	31 / 27	32 / 31	33 / 34	98 / 102	166 / 142	27 / 22

Excludes:
- Sabotage
- Military action
- Turbulence injury
- Evacuation injury
- ~~Servicing injury~~

	Accidents	Flight time	Departures
Boeing	51%	58%	55%
Non-Boeing	49%	42%	45%

Hull Loss Accidents

Definition:
Airplane damage which is substantial and beyond economic repair.

Excludes:

- Sabotage
- Military Action
- Non-operational events
- Experimental test flying

Hull Loss Accidents

All Aircraft — Worldwide Commercial Jet Fleet

1959-1994

536 hull losses

- U.S. operators
  - 101 during passenger operations
  - 27 during all-cargo operations
  - 15 during test, training, demonstration, or ferry
- Non-U.S. operators
  - 309 during passenger operations
  - 49 during all-cargo operations
  - 35 during test, training, demonstration, or ferry

1985-1994

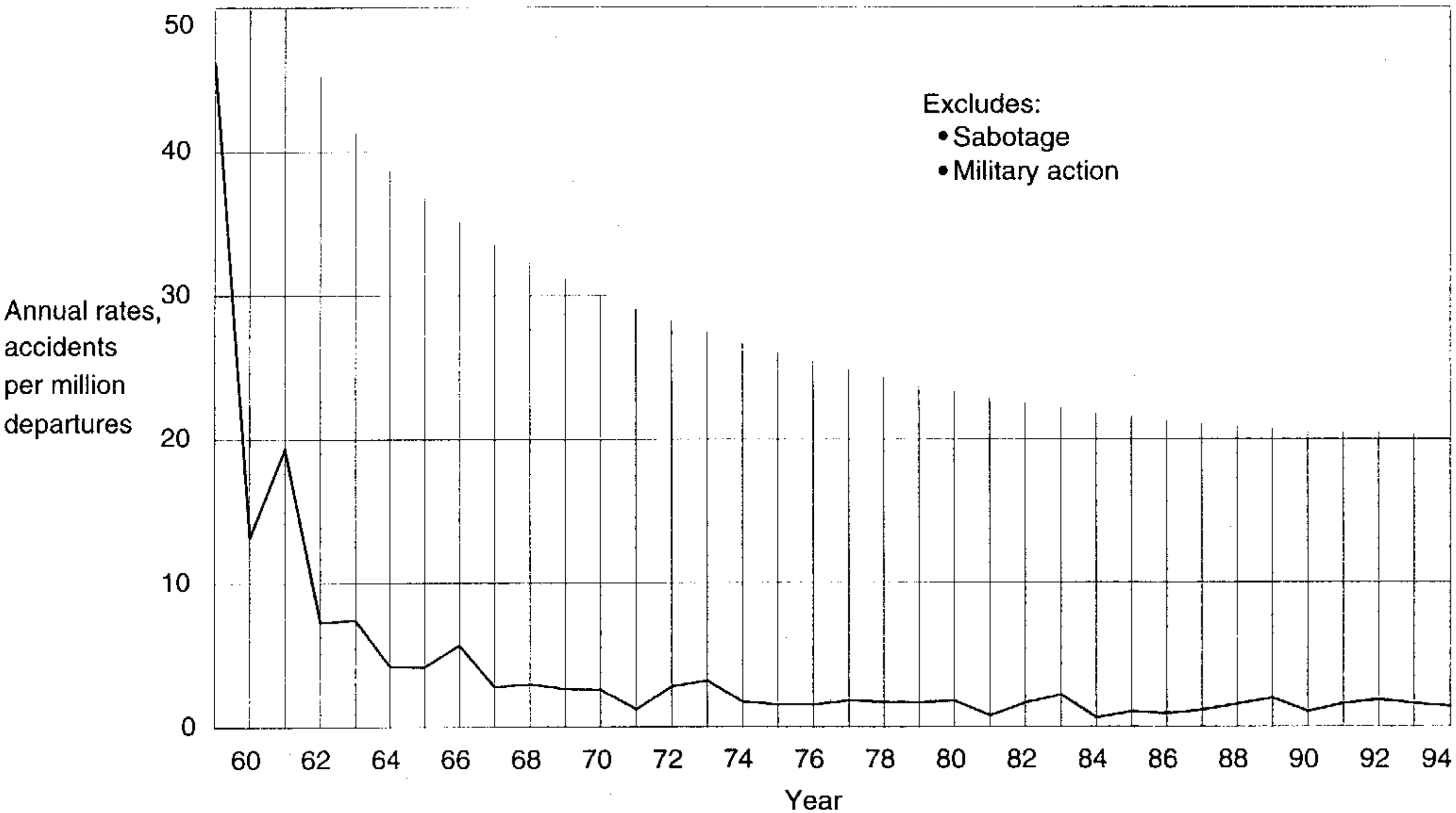
187 hull losses

- U.S. operators
  - 26 during passenger operations
  - 9 during all-cargo operations
  - 2 during test, training, demonstration, or ferry
- Non-U.S. operators
  - 111 during passenger operations
  - 29 during all-cargo operations
  - 10 during test, training, demonstration, or ferry

Excludes:
- Sabotage
- Military action and military operations
- Non-operational events

Hull Loss Accidents

All Aircraft — Worldwide Commercial Jet Fleet



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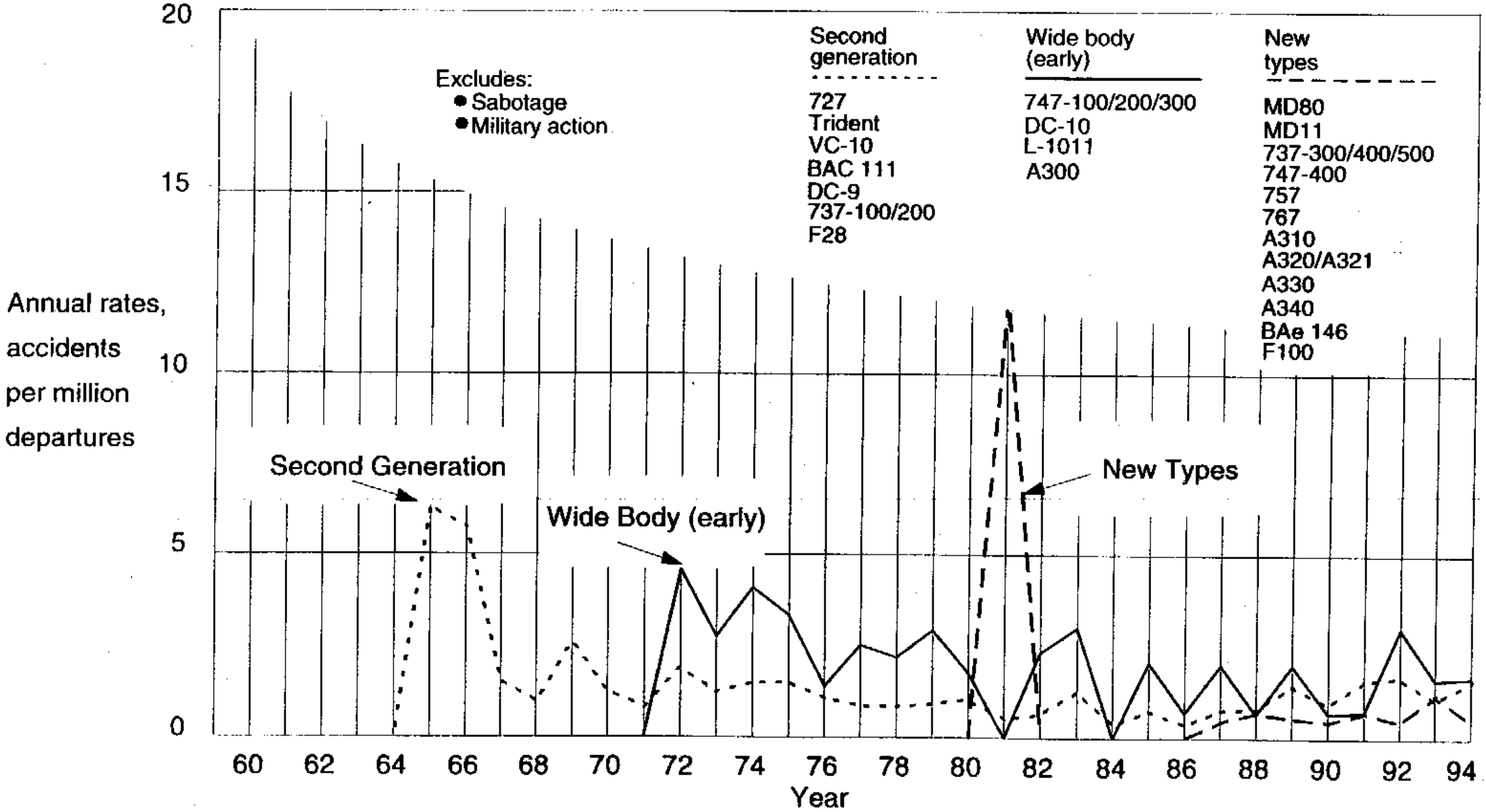
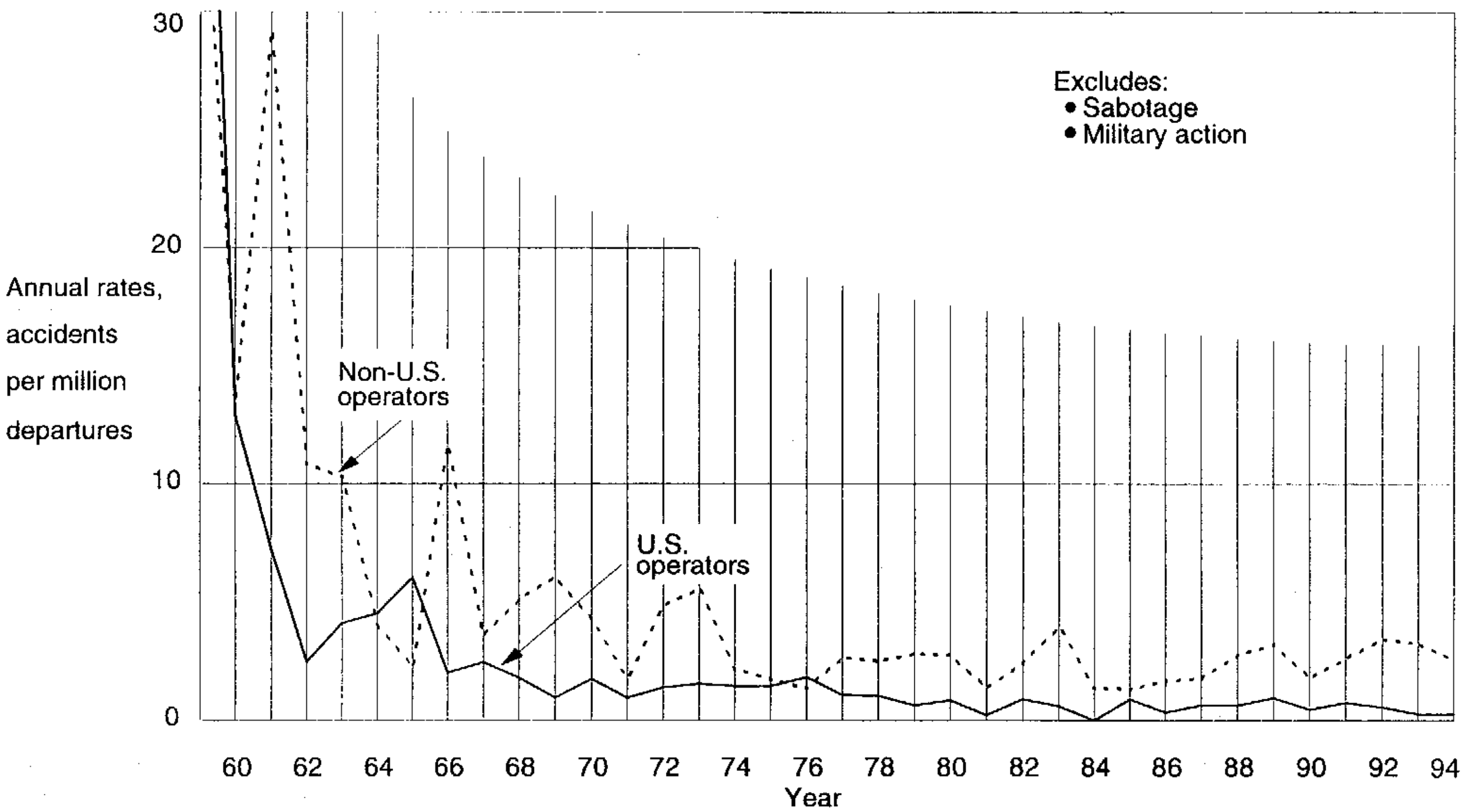
Hull Loss Accidents

Worldwide Commercial Jet Fleet — By Generic Group



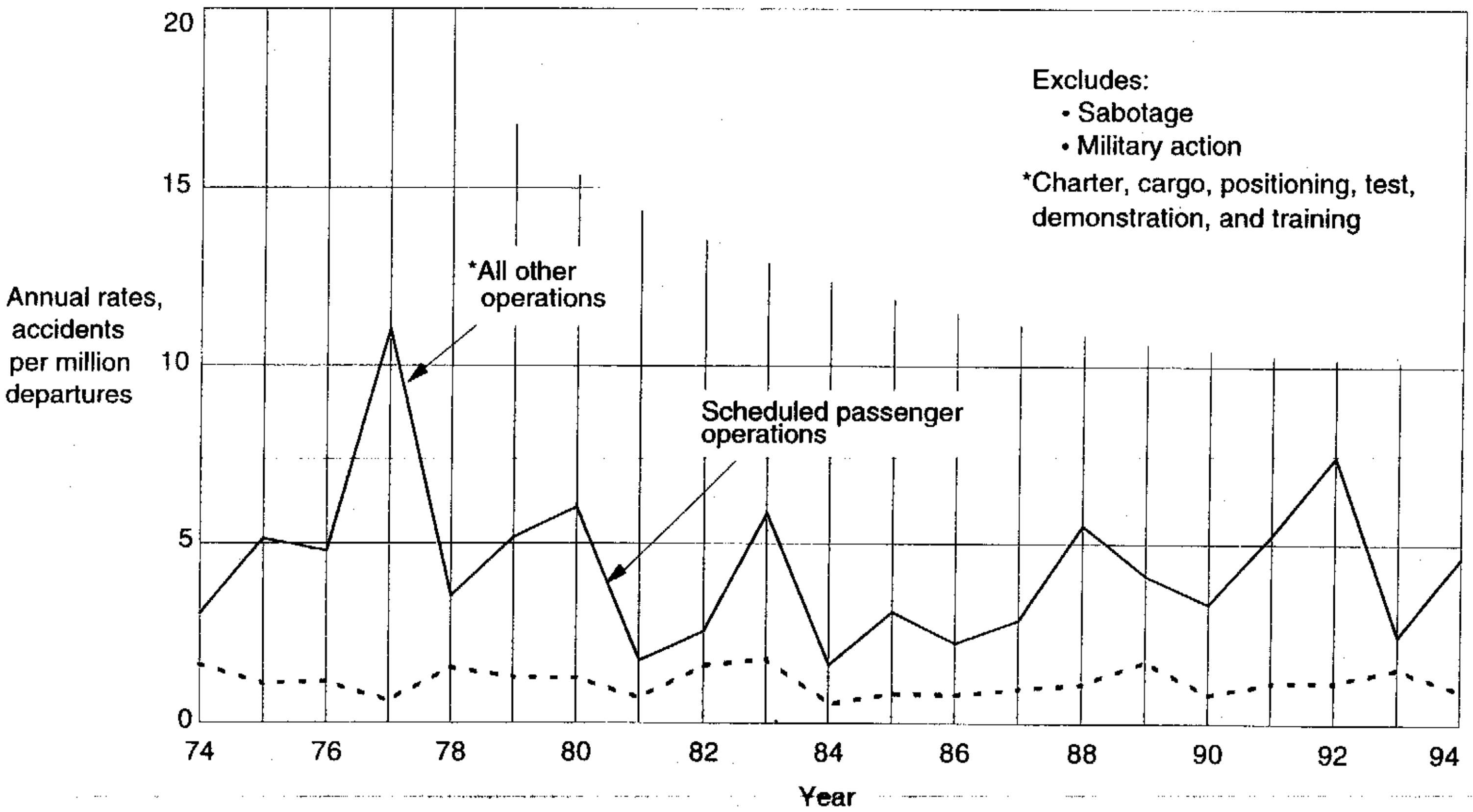
Hull Loss Accidents

U.S. and Non-U.S. — Worldwide Commercial Jet Fleet



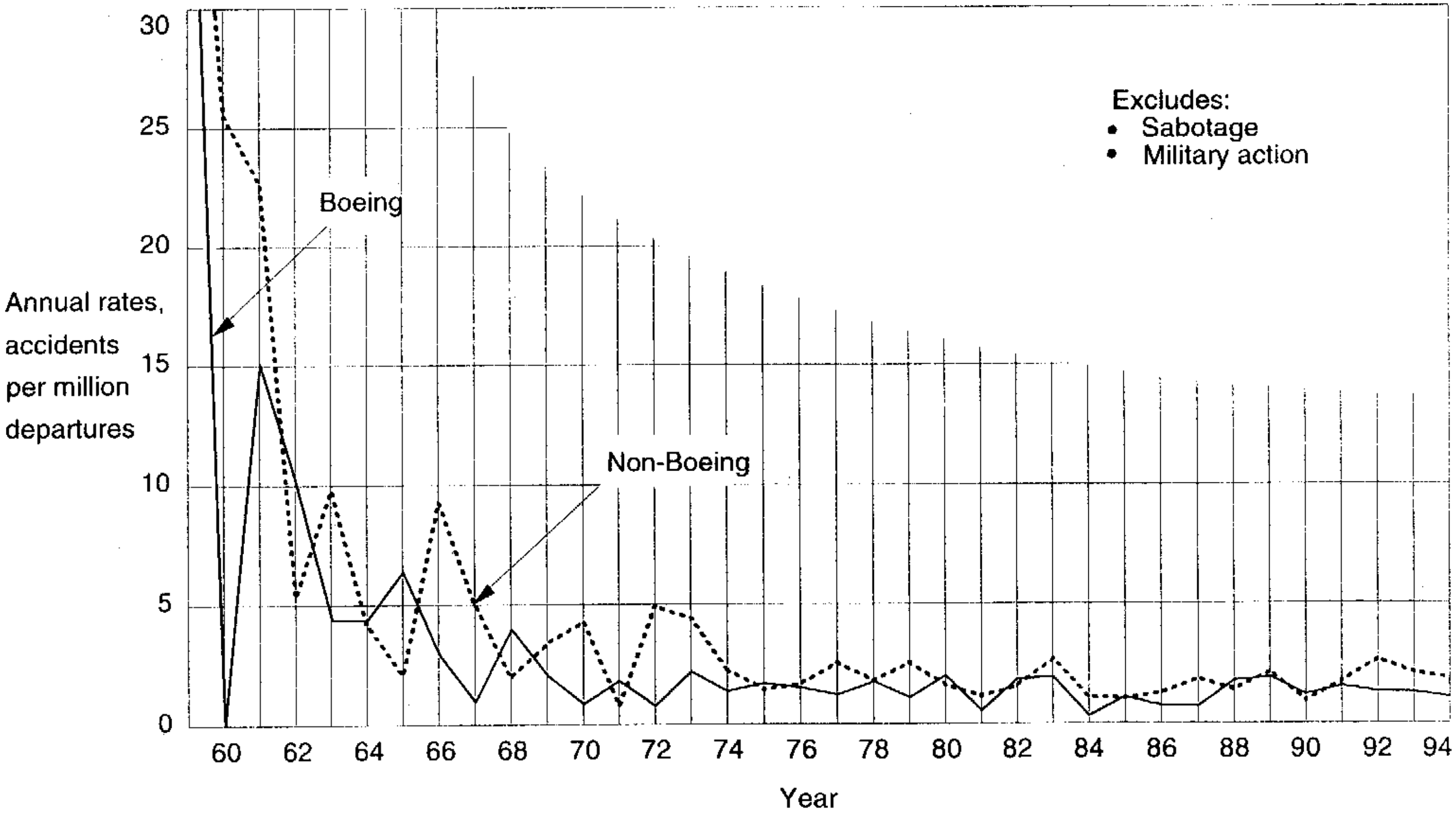
Hull Loss Accidents

Worldwide Commercial Jet Fleet



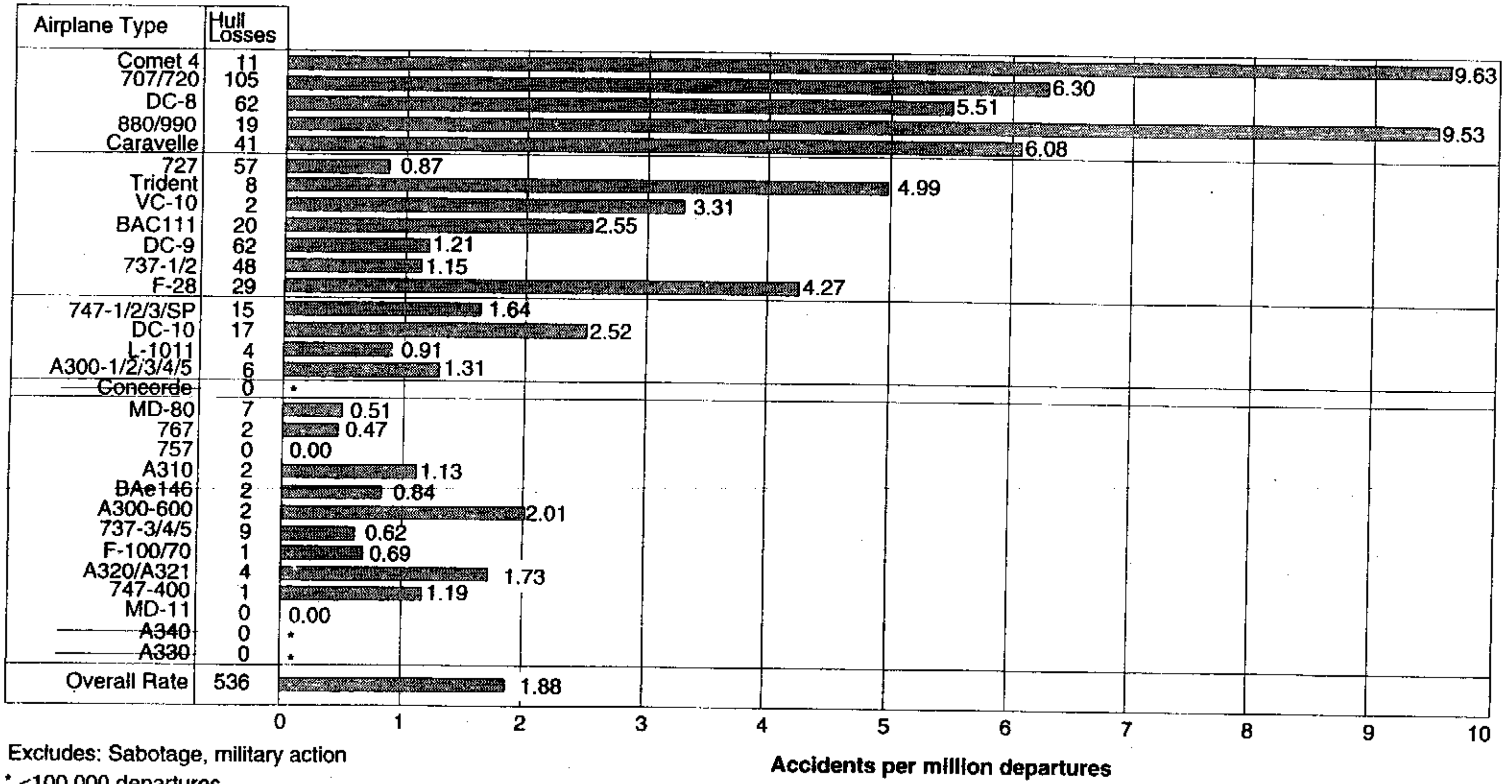
Hull Loss Accidents

Boeing and Non-Boeing — Worldwide Commercial Jet Fleet



Hull Loss Accidents Rates

Worldwide Commercial Jet Fleet — 1959 -1994



Excludes: Sabotage, military action

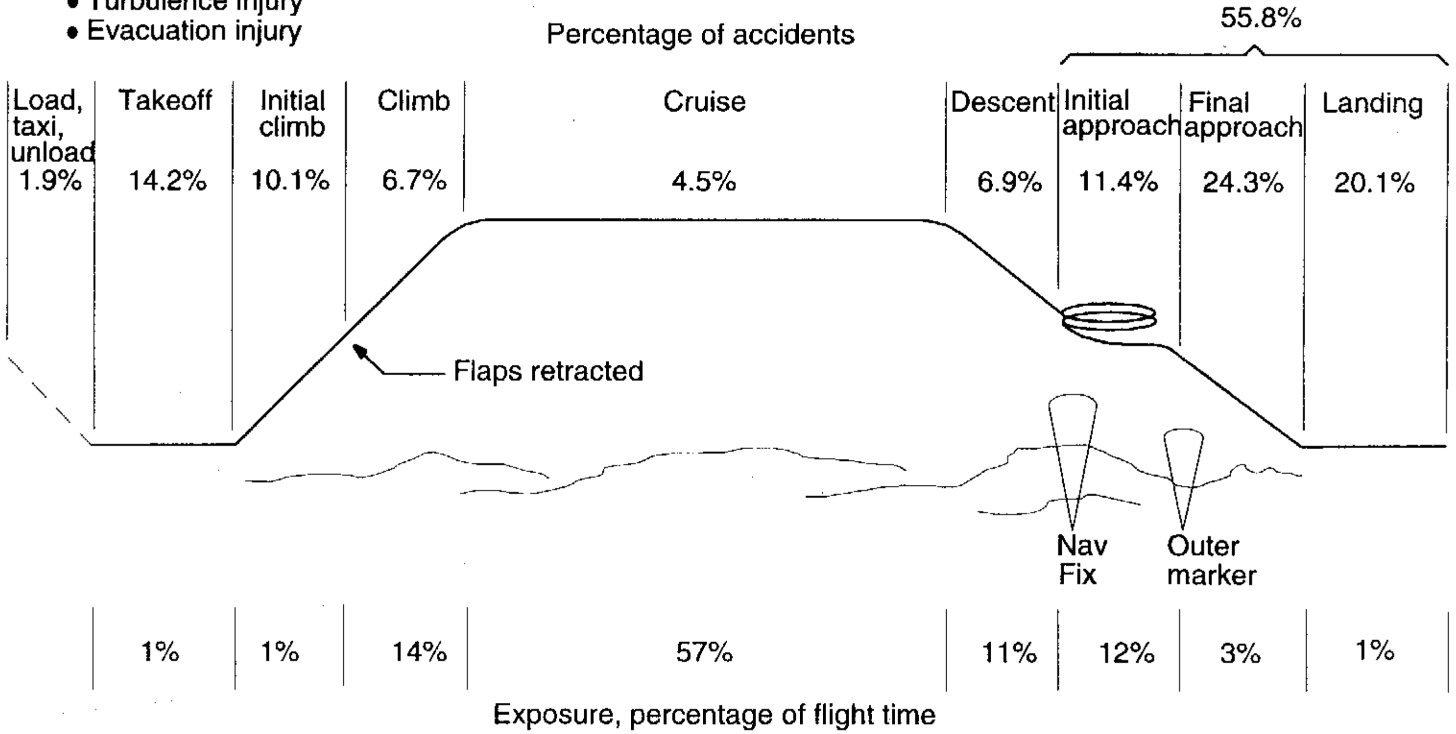
* <100,000 departures

Hull Loss Accidents

Worldwide Commercial Jet Fleet — 1959-1994

Excludes:
- Sabotage
- Military action
- Turbulence injury
- Evacuation injury

Exposure percentage based on a flight duration of 1.5 hours.



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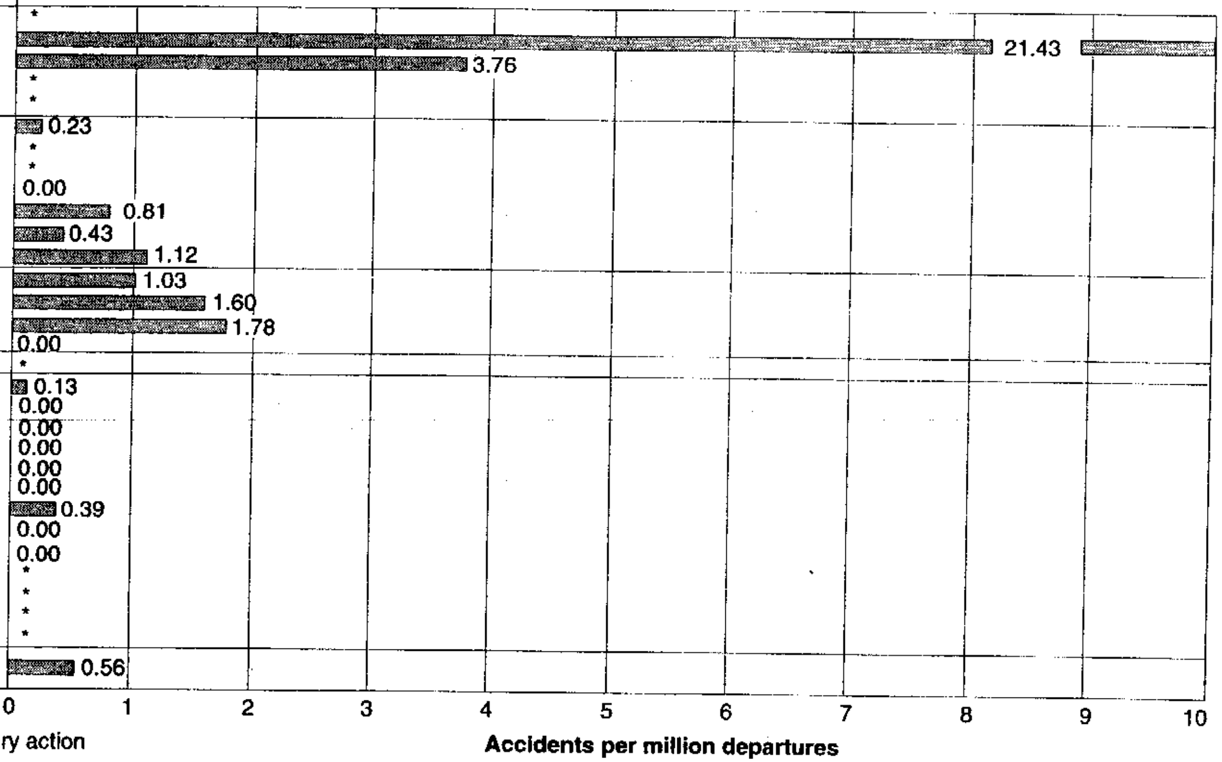
Hull Loss Accident Rates

U. S. Commercial Jet Fleet 1985-1994

Airplane Type	Hull Losses	Accidents per million departures
~~Comet 4~~	0	*
707/720	3	21.43
DC-8	5	3.76
~~880/990~~	1	*
~~Caravelle~~	0	*
727	4	0.23
~~Trident~~	0	*
~~VC-10~~	0	*
BAC111	0	0.00
DC-9	9	0.81
737-1/2	4	0.43
F-28	1	1.12
747-1/2/3/SP	1	1.03
DC-10	3	1.60
L-1011	2	1.78
A300-1/2/3/4/5	0	0.00
~~Concorde~~	0	*
MD-80	1	0.13
767	0	0.00
757	0	0.00
A310	0	0.00
BAe146	0	0.00
A300-600	0	0.00
737-3/4/5	3	0.39
F-100/70	0	0.00
A320/A321	0	0.00
~~747-400~~	0	*
~~MD-11~~	0	*
~~A340~~	0	*
~~A330~~	0	*
Overall Rate	37	0.56

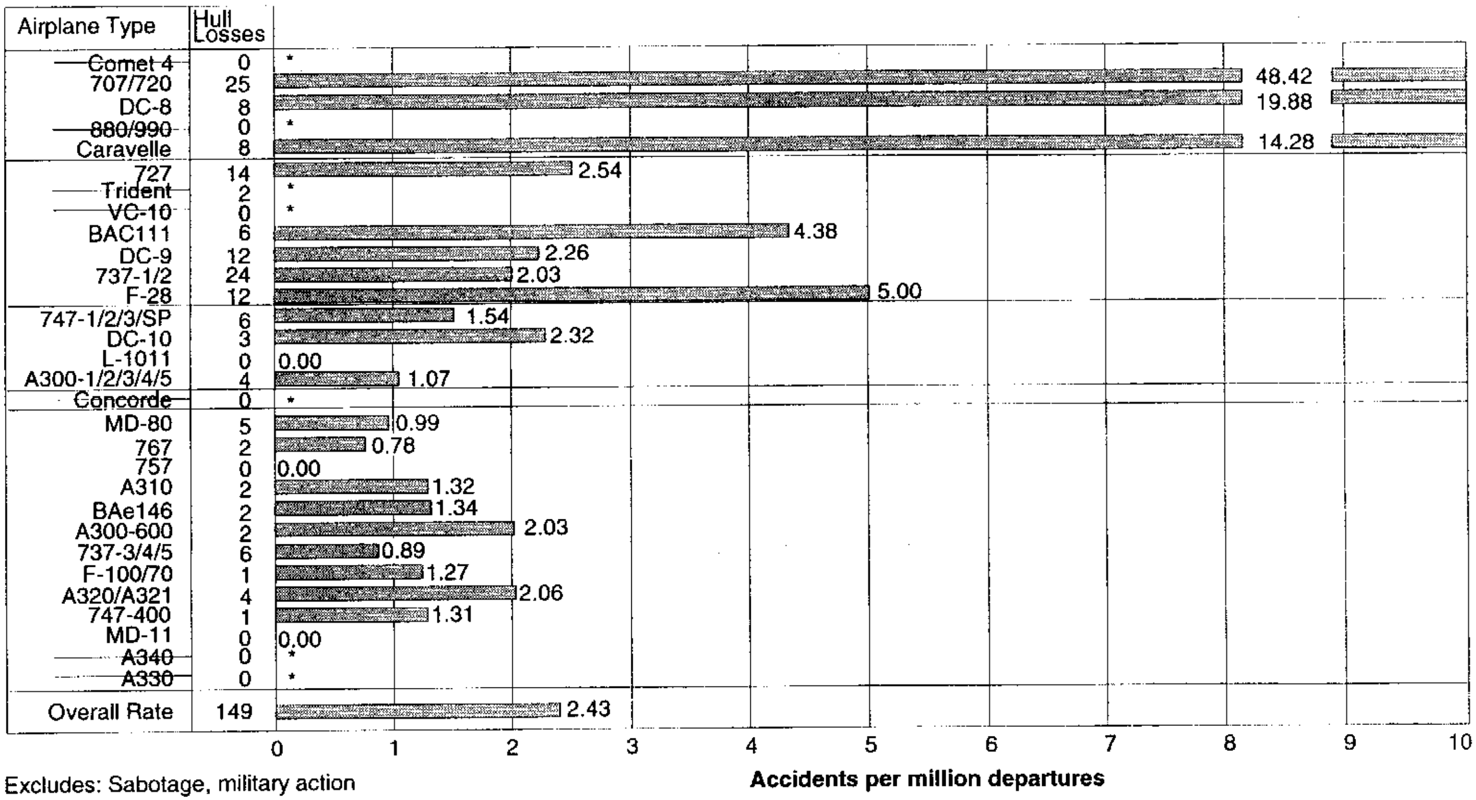


Excludes: Sabotage, military action

* <100,000 departures

Hull Loss Accident Rates

Non-U. S. Commercial Jet Fleet 1985-1994



Excludes: Sabotage, military action

* <100,000 departures

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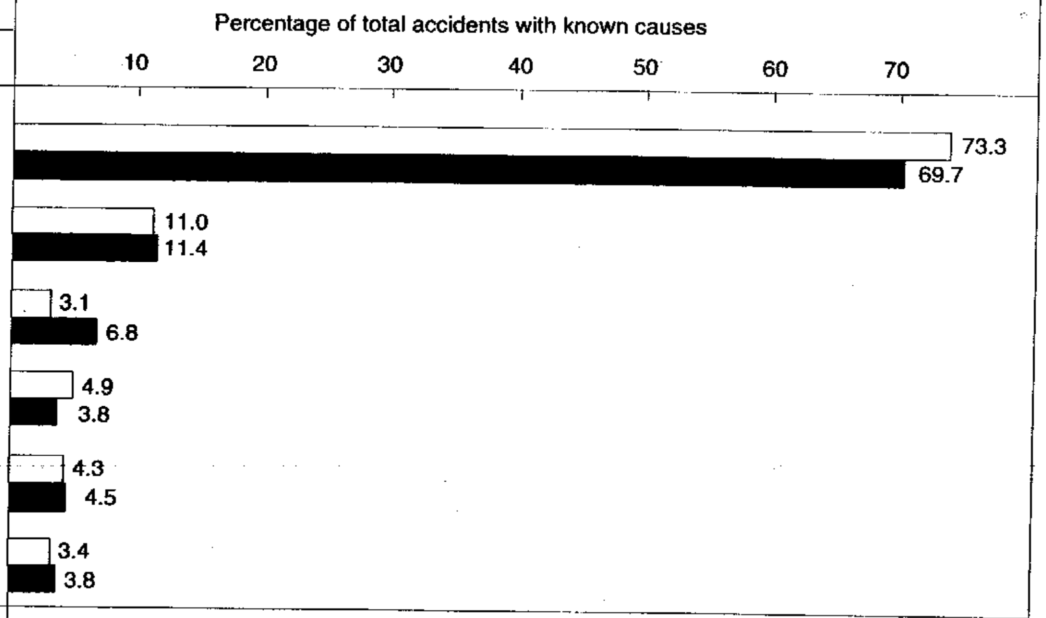
Primary Cause Factors – Hull Loss Accidents

Worldwide Commercial Jet Fleet

Primary factor	Number of accidents: Total	Number of accidents: Last 10 years
Flightcrew	327	92
Airplane	49	15
Maintenance	14	9
Weather	22	5
Airport/ATC	19	6
Miscellaneous/other	15	5
Total with known causes	446	132
Unknown or awaiting reports	90	54
Total	536	186



Excludes:

- Sabotage
- Military action

Legend:

- 1959 - 1994
- Last 10 years (1985 - 1994)

Hull Loss Accidents

Primary Cause Factors Versus Flight Phase — Worldwide Commercial Jet Fleet — 1959-1994

Primary factor	Total (Boeing / Non-Boeing)	Takeoff	Initial Climb	Climb	Cruise	Descent	Initial approach	Final approach	Landing	Taxi Load
Flightcrew	157 / 170	16 / 15	13 / 22	7 / 3	4 / 2	13 / 13	25 / 24	48 / 58	31 / 31	0 / 2
Airplane	17 / 32	6 / 12	0 / 3	4 / 6	0 / 3	1 / 1	0 / 0	3 / 0	2 / 6	1 / 1
Maintenance	5 / 9	0 / 4	0 / 1	2 / 2	2 / 0	0 / 0	0 / 0	0 / 1	0 / 1	1 / 0
Weather	8 / 14	0 / 0	2 / 1	2 / 0	0 / 2	0 / 1	0 / 1	3 / 4	1 / 5	0 / 0
Airport/ATC	6 / 13	3 / 0	0 / 1	1 / 1	0 / 2	0 / 2	1 / 1	0 / 2	2 / 3	0 / 1
Miscellaneous	9 / 6	1 / 3	0 / 2	2 / 0	2 / 0	1 / 1	0 / 0	1 / 0	0 / 0	2 / 0
Unknown	35 / 55	4 / 12	6 / 3	3 / 3	6 / 1	1 / 3	4 / 6	4 / 6	5 / 21	2 / 0
Total 536	237 / 299	30 / 46	21 / 33	21 / 15	14 / 10	16 / 21	29 / 32	59 / 71	41 / 67	6 / 4

Excludes:
- Sabotage
- Military action

	Hull Losses	Flight time	Departures
Boeing	44%	58%	55%
Non-Boeing	56%	42%	45%

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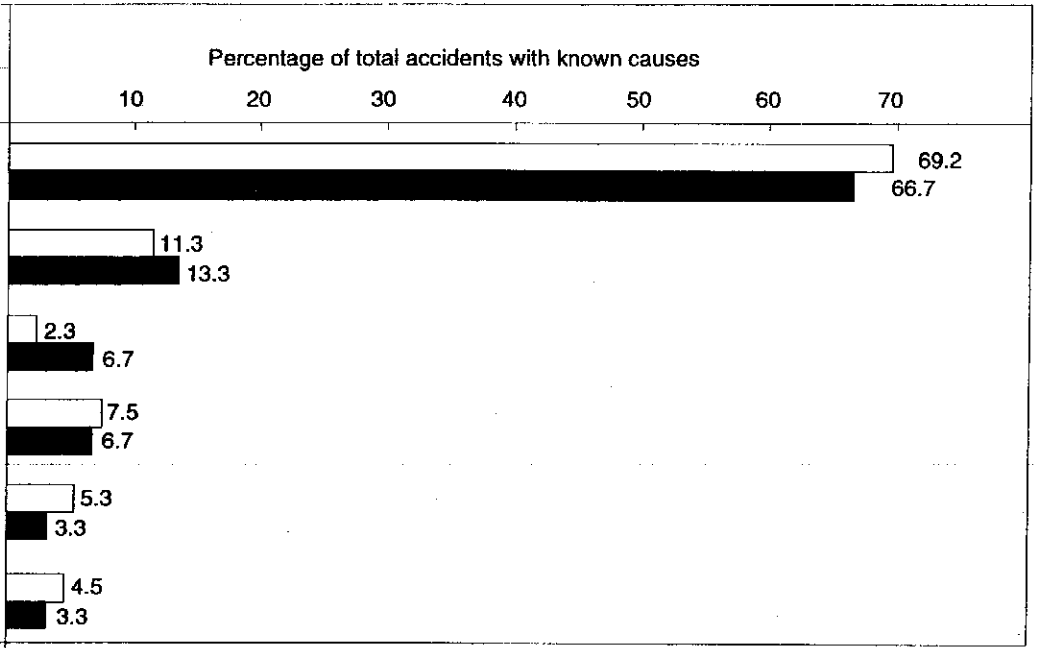
Primary Cause Factors – Hull Loss Accidents

U. S. Commercial Jet Fleet

Primary factor	Number of accidents	
	Total	Last 10 years
Flightcrew	92	20
Airplane	15	4
Maintenance	3	2
Weather	10	2
Airport/ATC	7	1
Miscellaneous/other	6	1
Total with known causes	133	30
Unknown or awaiting reports	11	7
Total	144	37



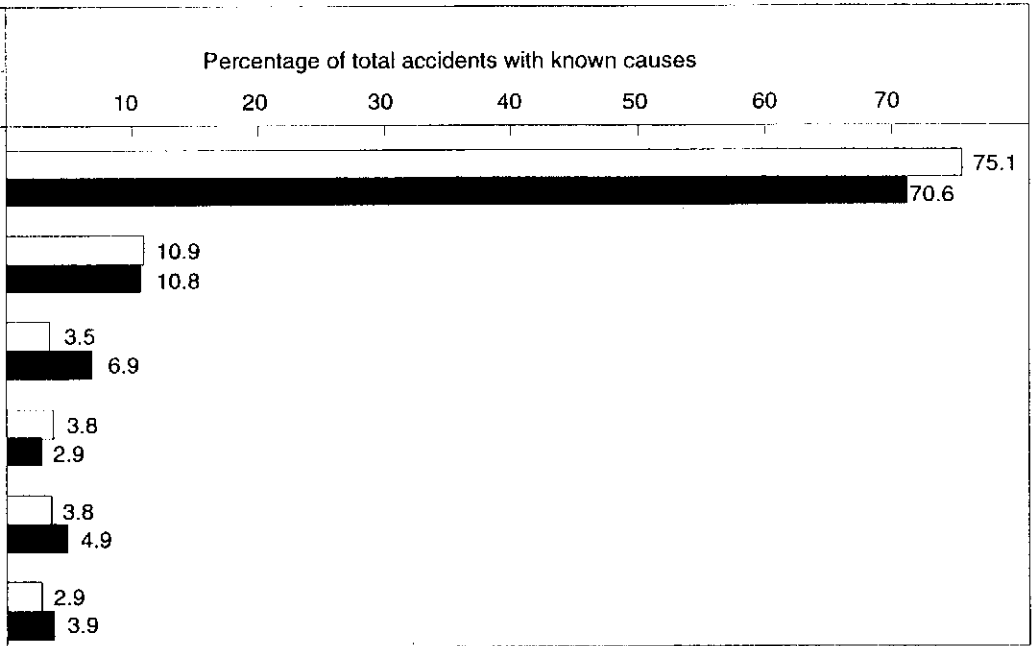
Excludes:
- Sabotage
- Military action

Legend:
- 1959 - 1994 (white)
- Last 10 years (1985 - 1994) (black)

Primary Cause Factors – Hull Loss Accidents

Non-U. S. Commercial Jet Fleet

Primary factor	Number of accidents: Total	Number of accidents: Last 10 years
Flightcrew	235	72
Airplane	34	11
Maintenance	11	7
Weather	12	3
Airport/ATC	12	5
Miscellaneous/other	9	4
Total with known causes	313	102
Unknown or awaiting reports	79	47
Total	392	149



Excludes:
- Sabotage
- Military action

Legend:
- 1959 - 1994
- Last 10 years (1985 - 1994)

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Hull Loss Accidents

Airplane Systems Cause Factors — Worldwide Commercial Jet Fleet — 1959-1994

System	Total	Per-centage	Number of accidents								
			Takeoff	Initial climb	Climb	Cruise	Descent	Initial approach	Final approach	Landing	Load taxi
Flight controls	8	17.0%	1		2				3	2	
Power plant or thrust reversers	14	29.8%	8	2	1	1				1	1
Hydraulics	2	4.3%								2	
Landing gear, brakes and tires	13	27.7%	6		3					3	1
Auxiliary power unit	1	2.1%			1						
Fuel systems	1	2.1%					1				
Electrical systems and instruments	6	12.8%	3	1	1	1					
Passenger accommodations	2	4.3%				1	1				
Total	47	100%	18	3	8	3	2	0	3	8	2

Fatal Accidents

Definition:
Accidents with on-board fatality or those where persons other than aircraft occupants are fatally injured. However, the number of fatalities includes only aircraft occupants.

Excludes:

- Sabotage
- Military Action
- Nonoperational events
- Experimental test flying

Fatal Accidents

Worldwide Commercial Jet Fleet

1959-1994

414 fatal accidents

- Passenger operation
  - 331 fatal accidents
  - 19,646 fatalities*
- All-cargo operations
  - 47 fatal accidents
  - 182 fatalities*
- Test, training, demonstration, and positioning
  - 36 fatal accidents
  - 172 fatalities*

1985-1994

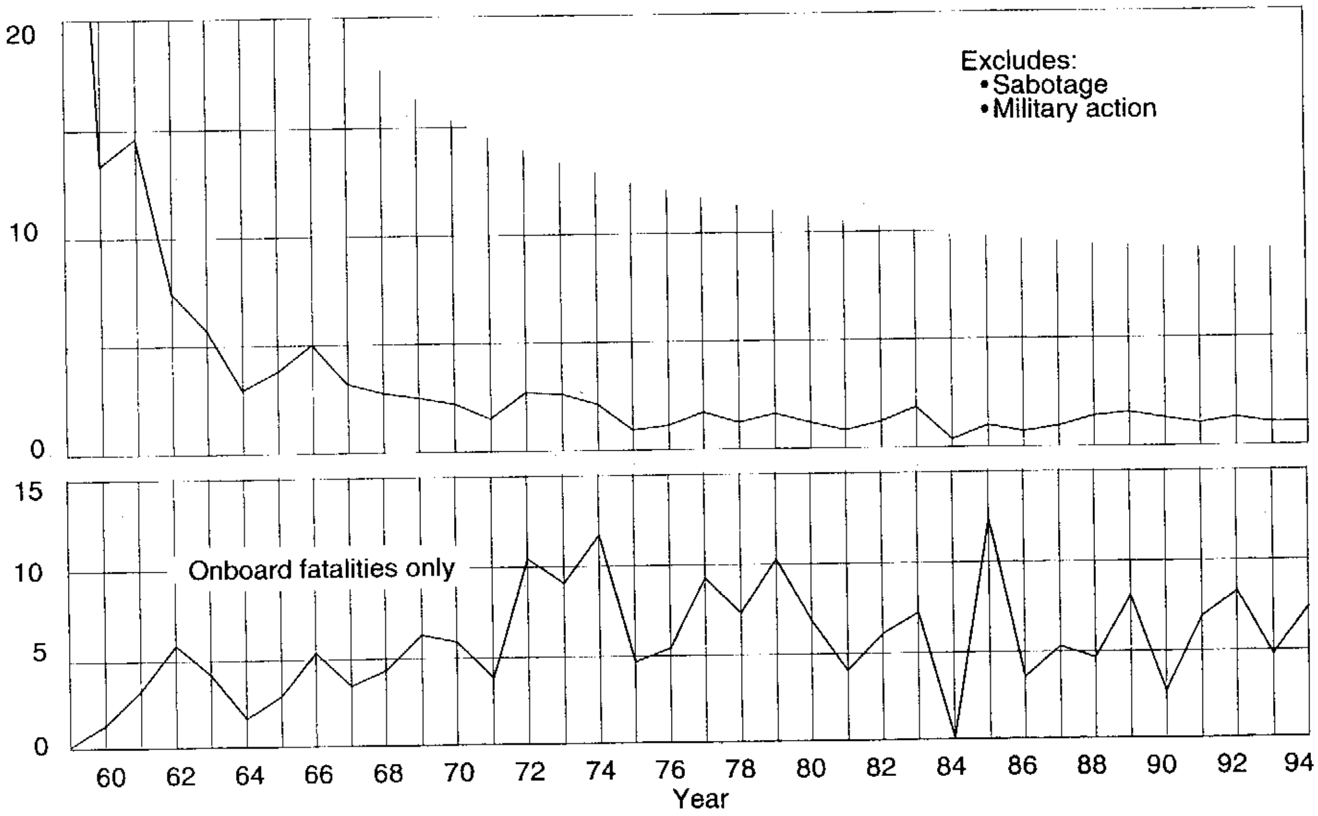
132 fatal accidents

- Passenger operation
  - 105 fatal accidents
  - 6,112 fatalities*
- All-cargo operations
  - 20 fatal accidents
  - 80 fatalities*
- Test, training, demonstration, and positioning
  - 7 fatal accidents
  - 57 fatalities*

*Onboard fatalities only

Fatal Accidents

Worldwide Commercial Jet Fleet



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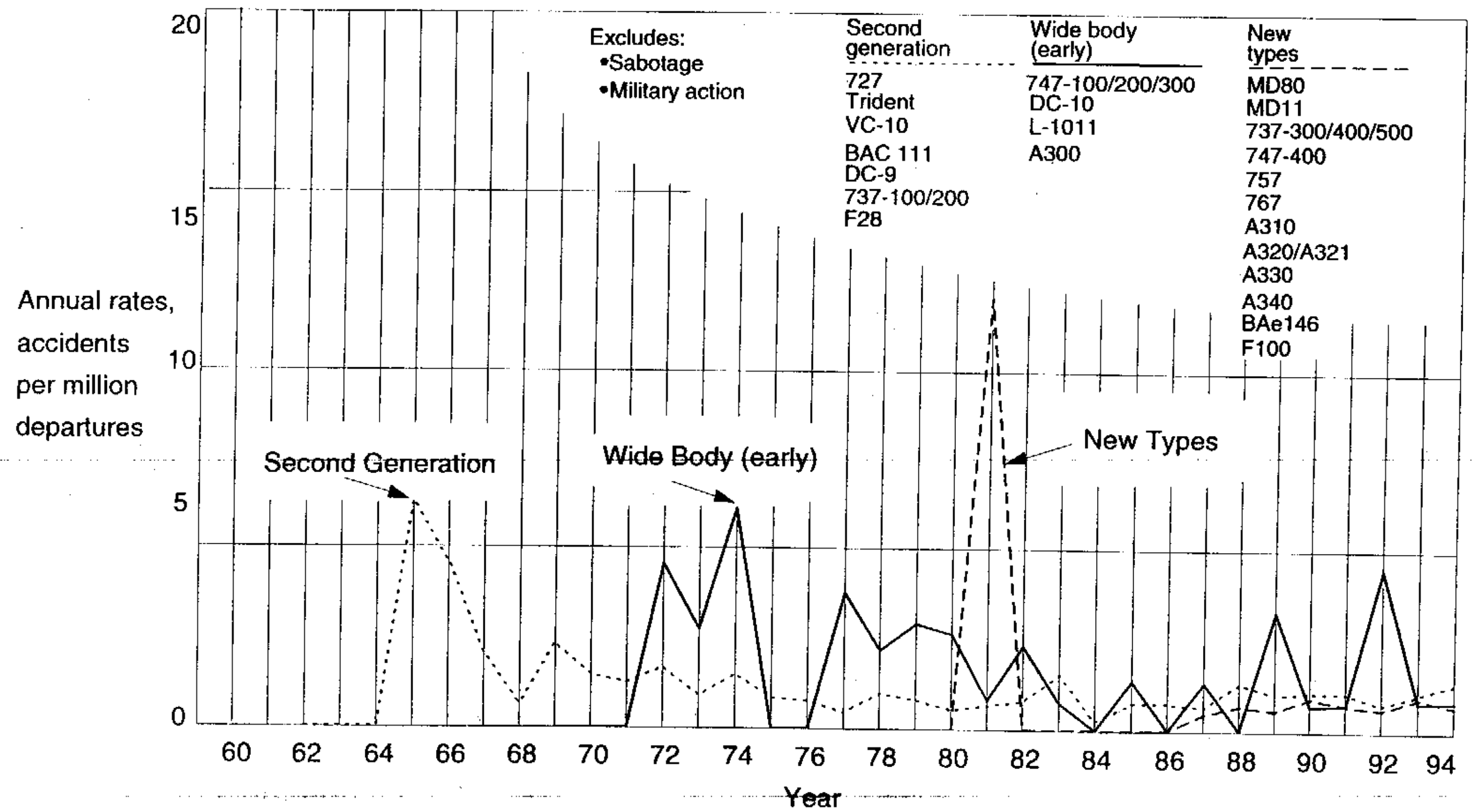
Fatal Accidents

Worldwide Commercial Jet Fleet —By Generic Group



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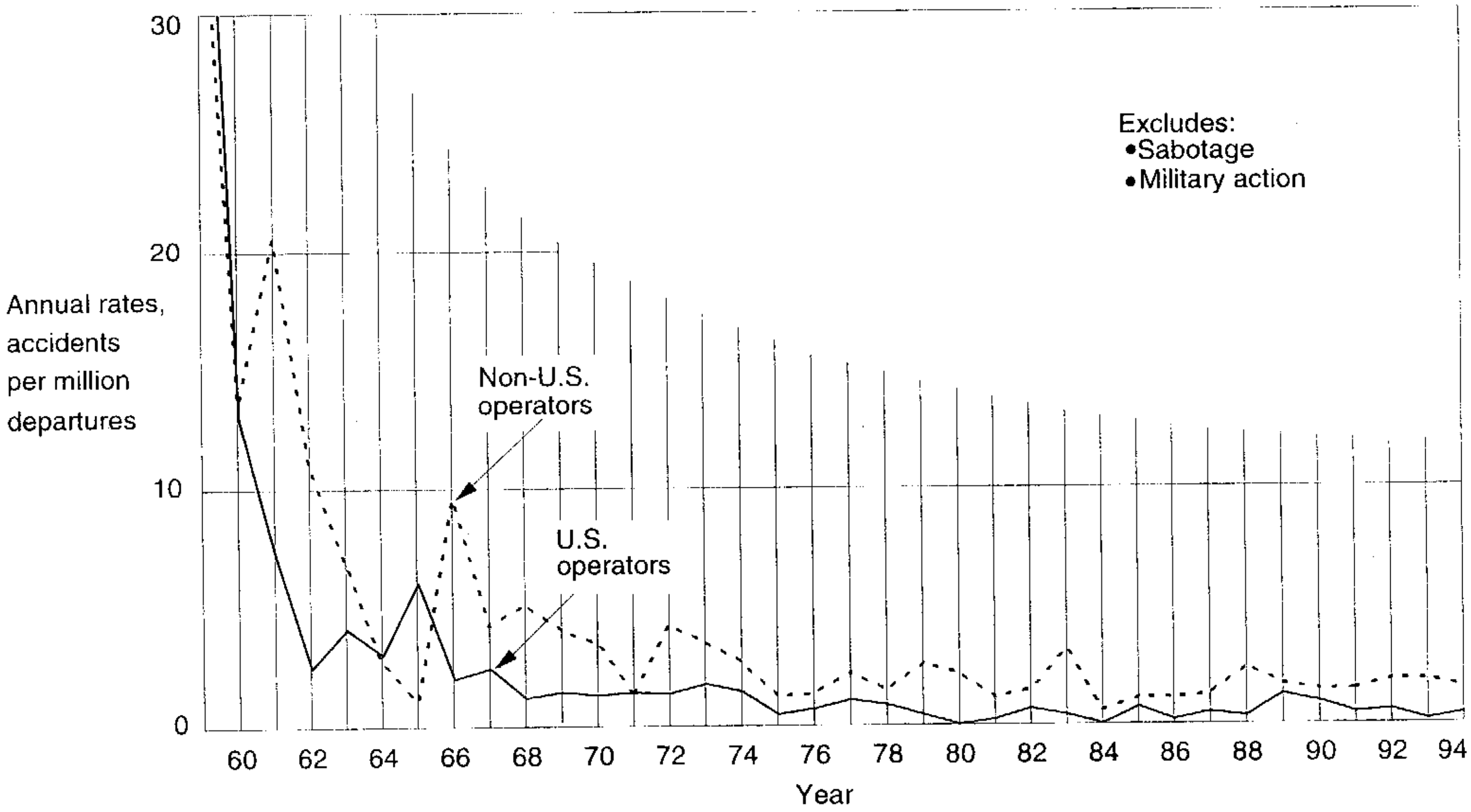
Fatal Accidents

U.S. and Non-U.S. — Worldwide Commercial Jet Fleet



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Fatal Accidents

Worldwide Commercial Jet Fleet — 1959-1994

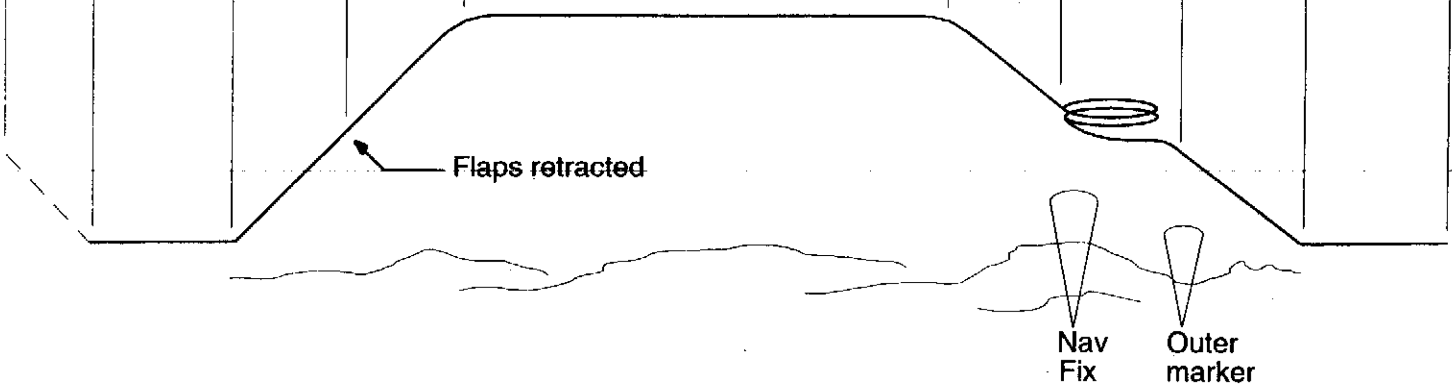
Exposure percentage based on a flight duration of 1.5 hours.

Excludes:
- Sabotage
- Military action
- Turbulence injury
- Evacuation injury

Percentage of accidents

48.3% (Descent, Initial approach, Final approach)

Load, taxi, unload	Takeoff	Initial climb	Climb	Cruise	Descent	Initial approach	Final approach	Landing
5.3%	10.9%	10.6%	8.5%	8.5%	10.1%	14.5%	23.2%	8.5%
	1%	1%	14%	57%	11%	12%	3%	1%

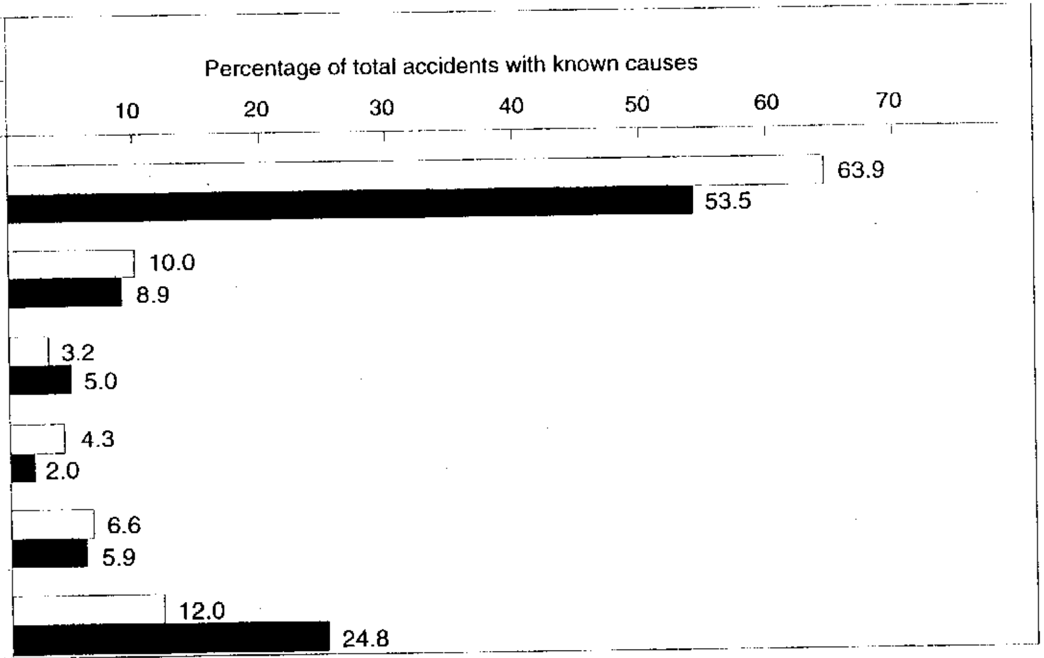


Exposure, percentage of flight time

Primary Cause Factors – Fatal Accidents

Worldwide Commercial Jet Fleet

Primary factor	Number of accidents: Total	Number of accidents: Last 10 years
Flightcrew	223	54
Airplane **	35	9
Maintenance	11	5
Weather	15	2
Airport/ATC	23	6
Miscellaneous/other	42	25
Total with known causes	349	101
Unknown or awaiting reports	65	31
Total	414	132



Excludes:
- Sabotage
- Military action

** Includes -
- Airframe
- Aircraft systems
- Powerplant

Legend:
- 1959 - 1994
- Last 10 years (1985 - 1994)

Fatal Accidents and Fatalities

Primary Cause Factors Versus Flight Phase — Worldwide Commercial Jet Fleet — 1959-1994

Primary factor	Accidents / Fatalities* Total	Number of Accidents: Takeoff	Initial Climb	Climb	Cruise	Descent	Initial approach	Final approach	Landing	Taxi Load
Flightcrew	223 / 11,855	18 / 720	27 / 1,481	10 / 615	9 / 371	29 / 1,768	47 / 3,266	73 / 3,184	8 / 400	2 / 50
Airplane	35 / 1,532	4 / 107	3 / 124	10 / 569	7 / 172	3 / 177	0 / 0	3 / 83	3 / 283	2 / 17
Maintenance	11 / 1,789	3 / 575	1 / 22	3 / 1,033	3 / 113	0 / 0	0 / 0	1 / 46	0 / 0	0 / 0
Weather	15 / 829	0 / 0	2 / 176	2 / 167	2 / 59	2 / 64	1 / 63	5 / 270	1 / 30	0 / 0
Airport/ATC	23 / 620	3 / 51	1 / 10	2 / 116	2 / 131	2 / 194	1 / 64	4 / 15	6 / 28	2 / 11
Miscellaneous	42 / 951	10 / 42	2 / 7	2 / 114	5 / 325	2 / 122	1 / 0	1 / 3	5 / 0	14 / 338
Unknown	65 / 2,424	7 / 80	8 / 495	6 / 258	7 / 291	4 / 213	10 / 667	9 / 201	12 / 211	2 / 8
Total	414 / 20,000	45 / 1,575	44 / 2,315	35 / 2,872	35 / 1,462	42 / 2,538	60 / 4,060	96 / 3,802	35 / 952	22 / 424

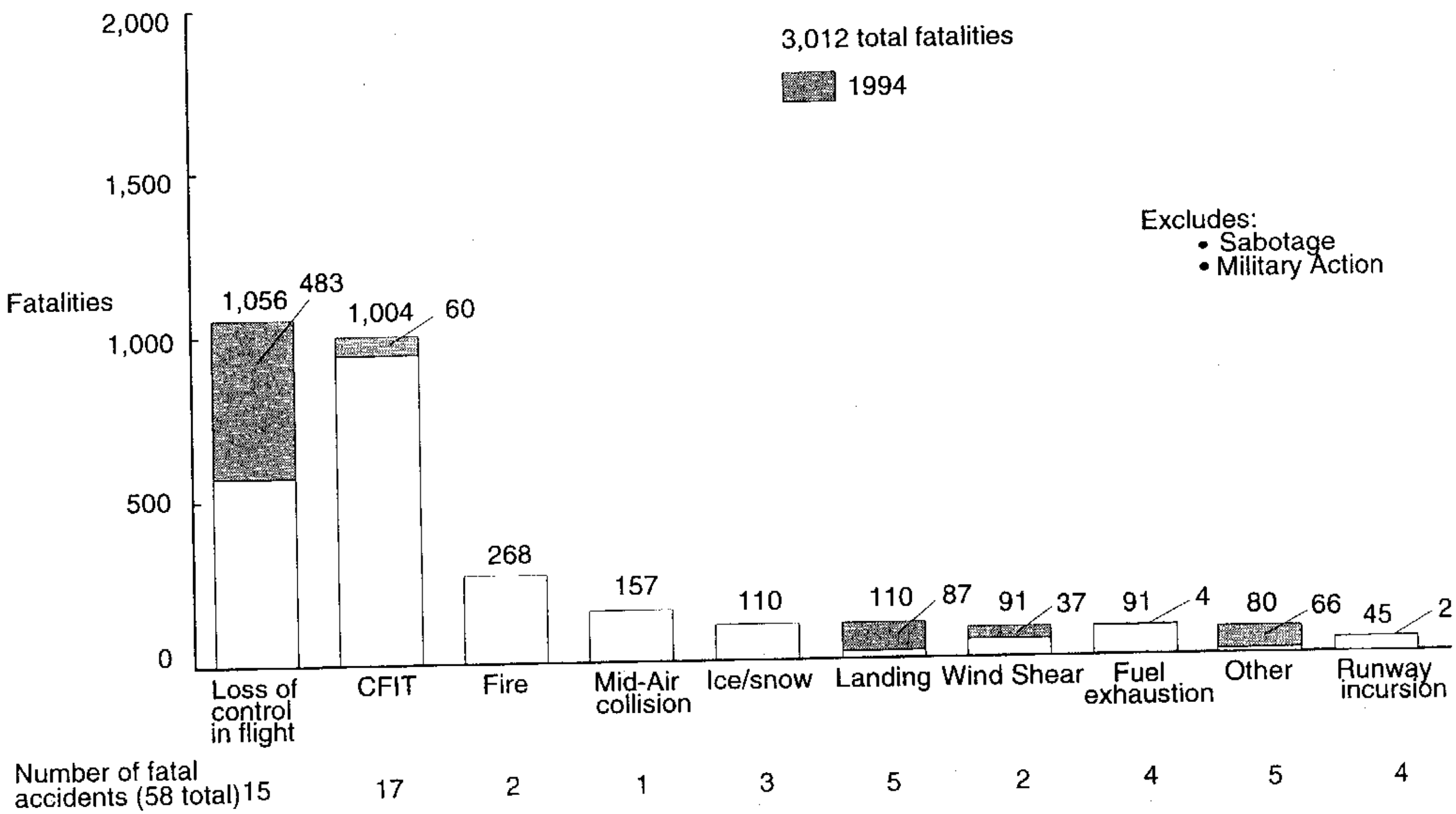
Excludes:
- Sabotage
- Military action

* Onboard fatalities only

	Fatal Accidents	Fatalities	Flight time	Departures
Boeing	46%	48%	58%	55%
Non-Boeing	54%	52%	42%	45%

Worldwide Airline Fatalities

Classified by Type of Accident — 1990-1994



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附件二

FSF/IFA/IATA 48th International Air Safety Symposium

Controlled Flight Into Terrain and Approach and Landing Accident Prevention

Steering Team Leader
Earl F. Weener

MM2167.40 s

Since November 1, 1994

To November 1, 1995

- Controlled flight into terrain
  - 4 accidents
  - 178 fatalities

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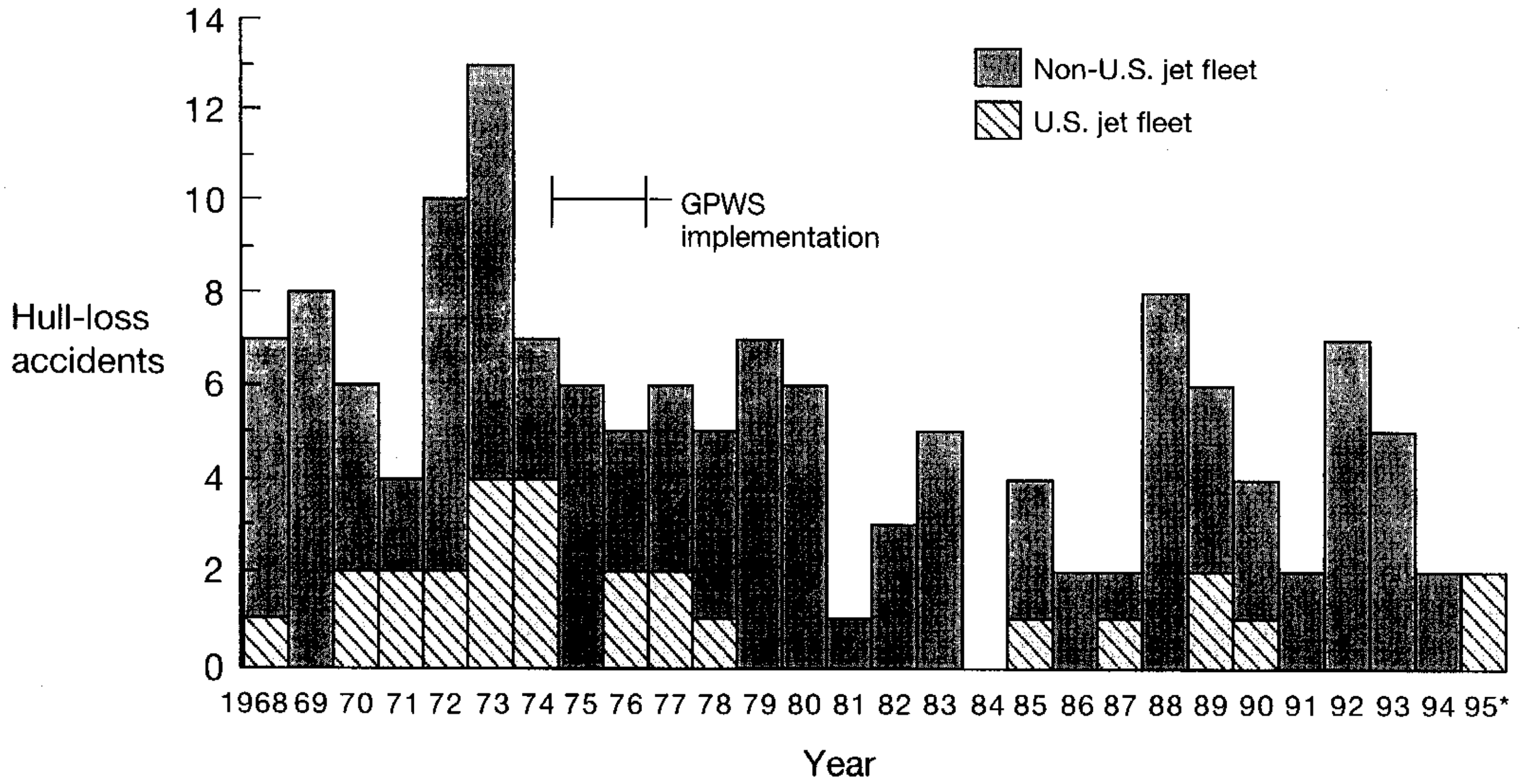
Jet Transport Controlled Flight Into Terrain



* To November 1, 1995.

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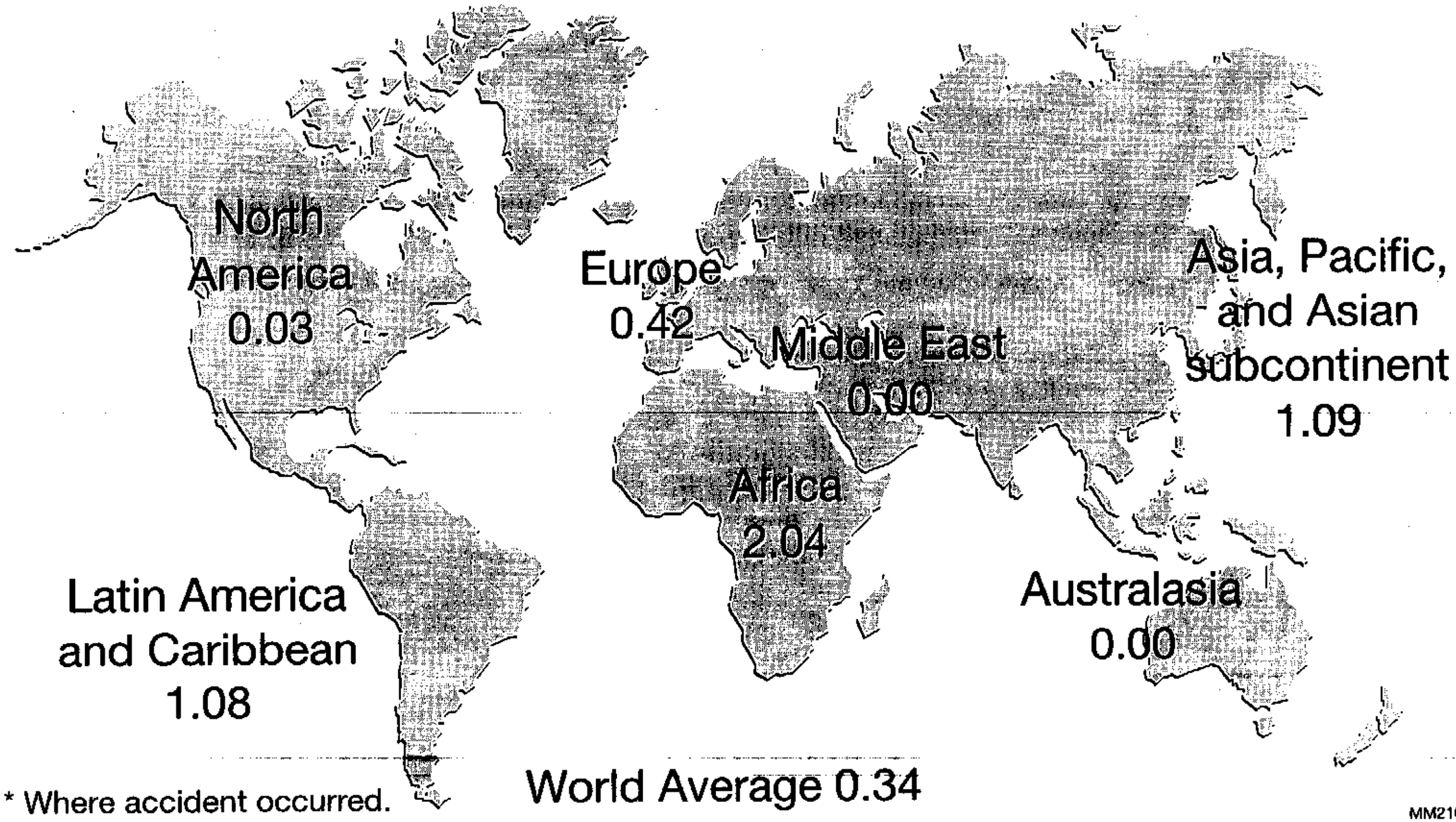
Worldwide Jet Transport Aircraft

CFIT Accident Rates per Million Flights by Region*

1985 Through 1994



World Average 0.34

* Where accident occurred.

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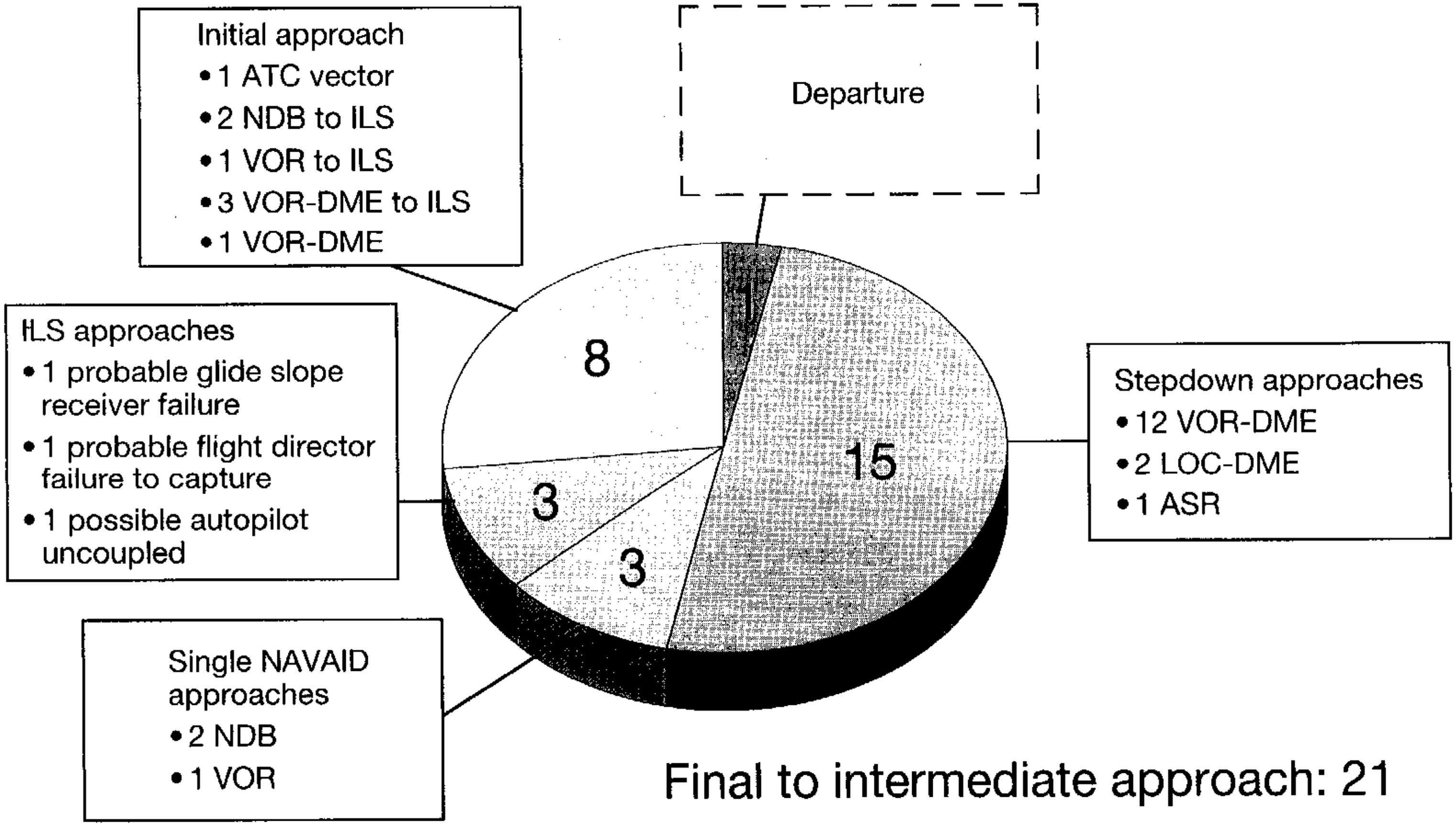
CFIT Accidents by Type of Instrument Procedure

Commercial Jet Aircraft—Last 7 Years, July 1988–November 1995



Final to intermediate approach: 21

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Overall Goals

- Reduce CFIT and approach and landing accident rate by 50% in 5 years (1998).
- Limit worldwide accident rate in either category to no more than twice the rate in the lowest geographic region.

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History—CFIT and Approach and Landing Accident Reduction Task Force

- April 1992—IAC Workshop
- September 1992—1993 IASS Agenda Development Team sets international standards challenge
- October 1992—Initial steering team meeting
- November 1992—Acceptance of plan by IAC—Long Beach
- November 1993—IASS Kuala Lumpur
- November 1994—IASS Lisbon
- November 1995—IASS Seattle

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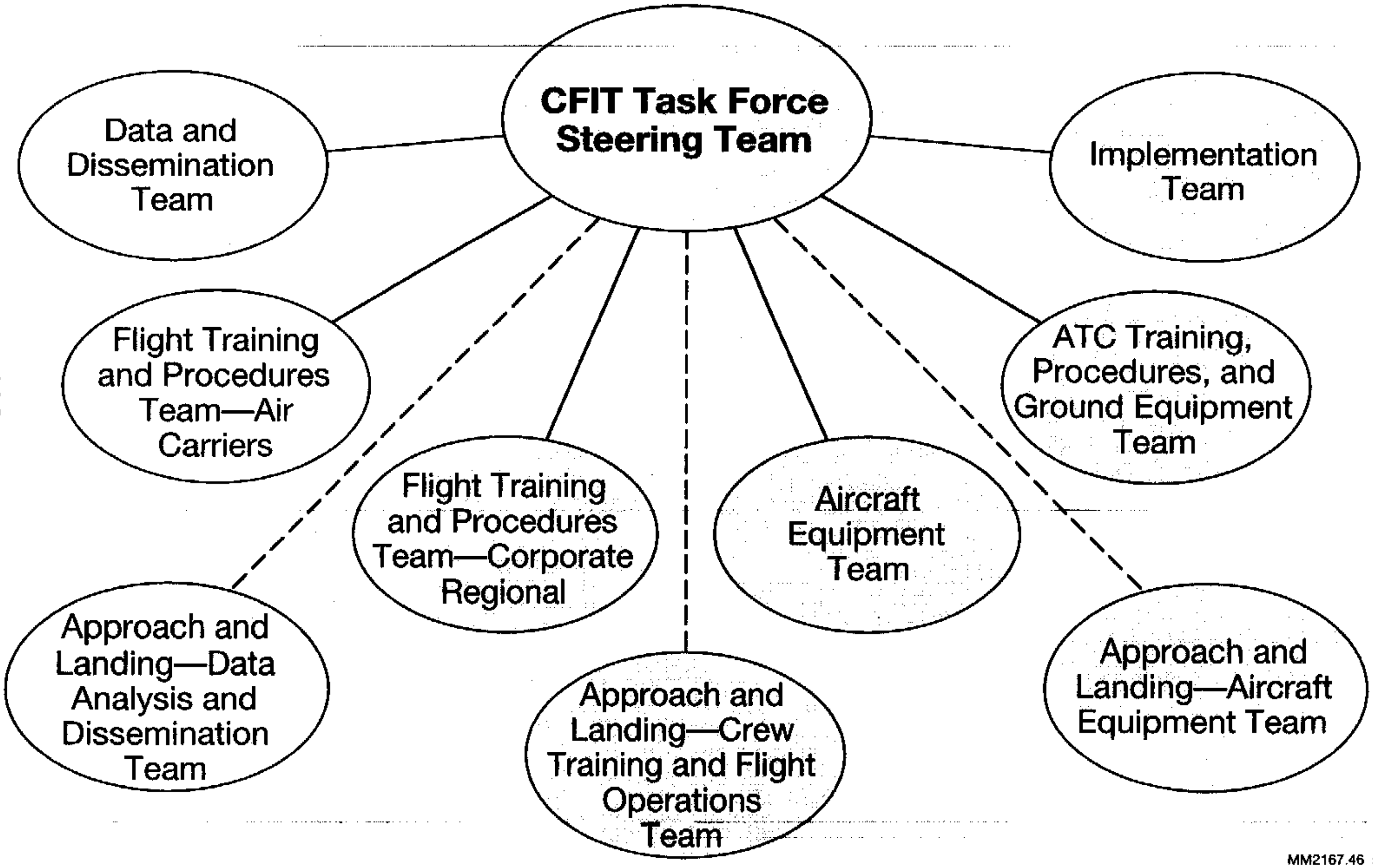
CFIT Task Force Organization



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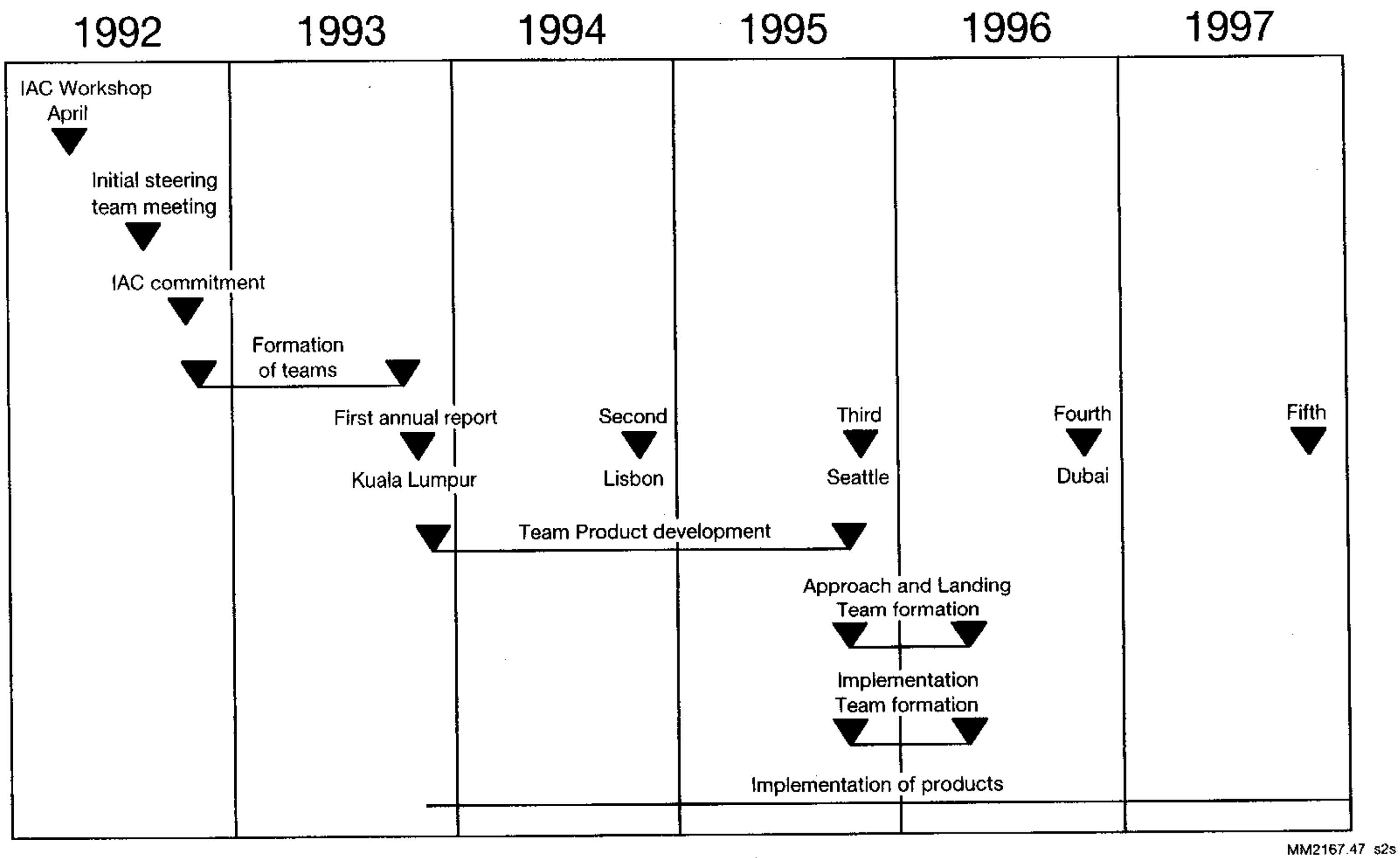
Overall Plan



Implementation Team Scope

- Distribute products developed by product development teams.
- Lead and facilitate implementation activities.
- Prioritize distribution and implementation based on accident history.
- Focus messages and activities.
- Identify leverage points.
- Develop organization structure for subteams as required.
- Identify and recruit subteam members as required.

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Implementation Team Participation

- Core Implementation Team will provide overall direction to the entire implementation team.
- Core Implementation Team's membership (10 to 15 members) will represent a cross section of at least the following:
  - Air carriers
  - Corporate and regional carriers (both turboprop and jet)
  - Airframe manufacturers
  - Standards (e.g., regulatory authorities and ICAO)
  - Geographical regions
  - Trade associations
  - Insurers

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Recommended Action

- Make appropriate contact by industry segment on a regional basis with:
  - Politicians
  - Regulators
  - CEOs
  - Flight Operations Department
  - Media
- Carry CFIT/approach and landing accident prevention message to above listed groups through:
  - Personal meetings
  - Presentations
  - Correspondence
- Provide products or knowledge of products produced by CFIT and Approach and Landing program to the above listed groups.
- Influence above listed groups to take actions, appropriate to their respective areas of responsibility.

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附件三

Function Follows Form: Building Organizational Structures and Processes to Accommodate Human Factors and Resource Management

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Steve Predmore

Introduction:

There is widespread agreement throughout the operational, regulatory, and fiscal communities that integrating human factors and resource management principles into operations is a wise course of action. Increased interest in human factors integration has been fueled by operational successes in the Advanced Qualification Program (AQP), the publishing of the Human Factors National Plan, and the proposed FAA regulations requiring resource management training. For the airline manager it has become more a question of ***how*** to integrate rather than ***if*** an organization should integrate human factors and resource management. If the organizational managers are still asking "Should we integrate human factors at the corporate level?" then there is a fundamental issue of education and commitment that must be addressed before issues of human factors and resource management function and form can be addressed.

The Human Factors National Plan (1995) provides a useful framework for guiding human factors integration. In fact, the application of human performance principles into operations is one of two primary agenda items contained in the National Plan. The Plan calls for "improving the application of research results to planned and ongoing programs." The importance of translating principles into operational programs is detailed in the following National Plan excerpt.

> Too often, government, academic, and industry programs lack the mechanisms to effect the transfer of the human factors knowledge contained in research products. Implementation of the following four management actions is essential to institutionalize human factors activities in the workplace and to maximize the benefit of a national human factors program.
>
> - Establish and implement the policies and processes necessary to create an environment for change
> - Develop human factors education and training programs at all levels
> - Equip personnel and facilities with modern tools and techniques of the human factors engineering discipline
> - Develop and maintain the infrastructure to translate and disseminate human factors products, and guide the organization's functions involving the human component

This report will focus primarily on how to integrate human factors and resource management structures and processes into an organization. Using the guidance from the Human Factors National Plan and the ICAO Human Factors Digest No. 10, we highlight how human factors and resource management can be integrated. This report will focus on several aspects of integration to include the nature of the integration challenge, a systems approach, human factors department attributes, human factors department functionality and conclude with suggestions for moving from principle to action.

Terms and Conventions

Several derivatives of Crew Resource Management (CRM) have emerged in recent years. Maintenance Resource Management (MRM), Dispatch Resource Management (DRM), and Team Resource Management (TRM) are a few acronyms used to describe tailored variations of basic resource management programs. Since this report is directed to the corporate level, all variations of Resource Management will simply be grouped together and labeled "Resource Management."

Most organizations use different labels for functional groups. For our purposes, the entity designed to perform human factors functions will be referred to as a department. The reference to a "department" is not a mandate to elevate or subordinate the functions of human factors to match a hierarchical label. Each organization will have to determine where in the organizational chart the Human Factors functionality should reside and what it should be labeled.

The Nature of the Integration Challenge

Operational solutions to human performance challenges must acknowledge the influence and interdependence of organizational variables in shaping attitudes, behaviors and culture. A human factors integration effort that focuses exclusively on the individual or the organization ignores this influence and interdependence. Individual as well as organizational level issues must be addressed to correct human performance challenges. The interdependence of systemic factors and individual performance is not a new issue. Dr. Richard Hackman (1993), for example, details the interdependence of organizational process, structure, and context in his discussion of factors that influence crew behavior.

Attitudes, behaviors, and culture are shaped on an individual as well as organizational level. One of the most powerful shaping influences on corporate culture is individual and small group accountability. The ultimate measure of successfully internalized norms is observed when someone violates the norms. The following excerpt from the ICAO Human Factors Digest No. 10 (1993) highlights the importance of individual and small group attitude, behavior and culture.

> "Culture defines the values and predisposed attitudes, exerting a final influence on the behaviour of a particular group. Norms are enforced by expressing disapproval of wrongdoers; how strongly a culture sanctions those who violate norms is an indication of the importance attached to those norms." (p. 11).

This internalization on an individual and small group level is critical to ensure that sound human factors practices become reflexive and expected. Human Factors Department form and function must be designed to affect individual and small group performance. To affect individual and small group attitudes, behavior, and culture, there must be a corporate commitment to systemic integration of human factors. If the human factors principles are not internalized both individually and organizationally, the likelihood of their sustained practice is significantly reduced. Each individual must internalize and subsequently attach importance to human factors-oriented organizational norms. The human factors department must have the breadth and depth of reach to affect the attitudes, behaviors, and culture. This reach simply cannot be realized without a commitment to systemic integration.

Avoiding the "Quick Fix" Trap

Corrections to human performance deficiencies too often focus on individual or crew remediation (punishment or additional training). Administering discipline or training the individual or crew is usually the quickest, easiest, and most familiar response to a deficiency. While there are times when discipline and/or training may be the correct response to a human performance deficiency, an accident or incident, too often these "quick fixes" are used as bandages that do not correct the systemic or root causes of the problem.

> "Focusing remedial action around improved performance by [a] particular crew would enhance safety at the individual level, that is, only as far as this crew is concerned. However, the door would remain open for many other [individuals] operating in the same unimproved system to make errors invited by imperfect system design. the major contribution must then originate at the decision-making levels, those who have the ultimate power to introduce radical changes and modify - system-wide - the architecture, design and operation of the system." (ICAO, 1993, p. 6)

It does very little good to spend a lot of effort building "training vaccinations" or sending memos to change individual performance without considering the departmental and organizational components that contribute to individual performance. A quick fix (a memo, a briefing, etc.) may change behavior for a short time but the underlying habit patterns of the individual, the department, and the organization will generally drive behaviors back to the original state unless the underlying system is also fixed.

To look beyond individual performance, it is important to identify and assess the systemic and organizational factors that shape individual performance. A simple "fix-the-operator" approach to human performance neglects the reality and influence of other systemic contributors. To have a sustained affect on individual performance, the human factors programs must also address the organizational structures and processes affect the attitude, behavior, and culture.

A Whole Systems Approach to Integration

There is little disagreement that underlying systemic factors shape individual and organizational performance. To address individual and organizational performance, one must look at systemic factors that enhance or detract from performance.

> "Contemporary safety views argue for a broadened perspective which focuses on safety deficiencies in the system rather than in individual performance. Evidence provided by analysis from this perspective has allowed the identification of managerial deficiencies at the design and operating stages of the aviation system as important contributing factors to accidents and incidents." (ICAO, 1993, p. 1)

Senior management commitment to improving human performance through the application of human factors and resource management is a fundamental requisite to success. Senior managers have a tremendous shaping influence on individual and organizational attitudes, behaviors, and culture. The orientation toward increased safety and efficiency through a commitment to improved human performance will be as good as senior management desires or as bad as they will allow. There is a huge spectrum of possible performance that is largely determined by senior management proactivity and support.

Human Factors Department Attributes

Before designing function and form, it will be important to identify the necessary attributes of a corporate human factors program. This section highlights some of the attributes that should be integral attributes of a human factors department form and function.

Sufficient Resources to Sustain Change

One of the important attributes of a human factors department will be sufficient resources (staff, budget, equipment, commitment) to sustain integration of the department and the programs. Many books have been written about individual and organizational behavior. Integrating human factors into an organization's culture is like planting a tree in an arid climate; it must be nurtured and supported until it has deep enough roots to reach ground water after which time it will continue to survive on its own. This concept applies equally to the entire department as it does for individual projects.

If the integration of human factors is not systemic and does not reach individual and organizational attitude, behavior, and culture the entire system will tend to revert to its original state. The end result of a "quick fix" approach is that the organization ends up where it started without the benefit of the money and time spent on the quick fix.

Consistency

Many organizations have elements of human performance-oriented programs, policies, procedures, documents, and training scattered throughout the organization. The challenge of the human factors manager is to bring some coherency and unity to the human performance programs that exist and to fill in the gaps where they do not exist. As the Human Factors Manager begins to scan existing programs, he or she will invariably identify gaps and duplications. The dissociated nature of departmental programs is the genesis of many of these gaps and duplications in human performance programs. A manager must ask "Is it possible that our organization has outstanding technical merit and performance as individual departments, yet on an organizational level we are inefficient?"

> "Investigation of well-publicized, major catastrophes in sociotechnical systems clearly suggested that it is quite possible to correctly design individual components of the organizational structure (departments, sections, etc.) so that they can achieve their assigned objectives safely and efficiently, and yet fail to secure over-all organizational safety and effectiveness because of inattention to the way those individual components interact when integrated." (ICAO, 1993, p.14)

While it is important that human performance programs be tailored in language and function to each area of the company, it is equally important that there is a corporate-level focal point for core human performance related development. This focal point ensures consistency while identifying and reducing duplication of effort. The human factors department should placed organizationally to be able to assess and coordinate all departmental and operational interactions (contractors included). At Delta, The Corporate Safety and Compliance Department is in such a position.

Placement at the Corporate Level

An early challenge for the senior manager who oversees the human factors department will be to create an organizational structure (form) that will allow for sufficient human factors breadth and depth to be able to shape attitudes, behaviors, and culture across organizational and operational boundaries. To accomplish this, the human factors manager must have the authority, both perceived and real, to reach across the whole operation. The manager must also be able to assemble and coordinate resources and people across organizational and operational boundaries. Placing the human factors department inside another operational department with their inherent silo-oriented structure and limitations would seriously impair the functionality of corporate human factors. The Human Factors Department should be placed organizationally to be able to assess and coordinate all departmental and operational interactions (contractors included). At Delta, the Corporate Safety and

Compliance Department is in such a position. The Corporate Human Factors Department has been placed as a department within Corporate Safety and Compliance.

Cross-Organizational and Cross-Departmental Reach

Many systemic difficulties that lead to human performance deficiencies are born from insufficient communications across departmental or operational boundaries. In many cases, the individuals who shape operational policies and procedures, for example, are not the same individuals who develop the documentation and training. It is not reasonable to assume that all the individuals who affect the organizational structures and processes will have a comprehensive awareness of human performance science to be able to identify and incorporate these tenets. Without some common corporate focal point, it is even more unlikely that different departments (or operators in the case of contracts) will integrate these principles consistently. There must be an entity that assists with the integration of sound human factors principles consistently across departmental and operational lines.

Optimum human factors integration would include most parts of the company. In the same way a chain is only as strong as it's weakest link, the company's weakest human performance link may be where the integration is not happening. A company exposes itself to higher risk and lower safety margins if only isolated parts of the operation consistently integrate human factors while other parts remain untouched. As carriers move toward more contract servicing, more operational personnel will not fall under the carrier's umbrella. Extending sound human factors principles outside the organizational structure to contractors is an important issue that must be addressed. To address this challenge, a human factors department will need to assist the contract liaisons to develop of mechanisms and standards for human factors integration and practice.

Defining Human Factors Department Functionality

Human factors functionality must support existing core corporate programs while incorporating all the basic tenets of a sound safety orientation. ICAO Human Factors Digest No. 10: Human Factors Management and Organization (1993), offers several attributes inherent in a safety-oriented organization. A safety manager must look at these objectives and structure the human factors department as well as the programs to enhance these goals.

In general terms, safe organizations:

- Pursue safety as one of the objective of the organization and regard safety as a major contributor in achieving production goals;
- Have developed appropriate risk management structures, which allow for an appropriate balance between production management and risk management;
- Enjoy an open, good and healthy safety corporate culture;
- Possess a structure which as been designed with a suitable degree of complexity, standardized procedures and centralized decision-making which is consistent with the objectives of the organization and the characteristics of the surrounding environment;
- Rely on internal responsibility rather than regulatory compliance to achieve safety objectives; and
- Respond to observed safety deficiencies with long-term measures in response to latent failures as well as short-term, localized actions in response to active failures.

Defining a Philosophy to Focus and Prioritize Human Factors Efforts

A philosophy is a useful tool for determining program and department direction as well as prioritization. The field of potential applications and projects is so large that the human factors manager cannot possibly address them all. Prioritizing human factors departmental efforts will be important. The progression highlighted by Wiener and Degani (1991) in their publication, "Philosophy, Policies, procedures and Practices: The Four P's of Flight Deck Operations," provides a useful backdrop for developing human factors programs and priorities within your organization. From this philosophy, a coherent and consisten set of policies, procedures, and practices can be derived. Weiner and Degani (1991) state:

> "... by establishing a philosophy of operations, management states how it wants the organization to function. Such philosophy can only be established by the highest corporate level. From philosophy, policies can be developed. Policies are broad specifications of the manner in which management expects tasks to be accomplished..."

Delta's Human Factors Department Operating Philosophy:

To be the guardians of safe human performance standards and the champions of human performance excellence

A Closer Look at the Human Factors Department Operating Philosophy

There is a huge variation between minimum regulatory compliance and optimum (or even acceptable) operational performance. Safety and human factors must be more than goal line defense programs for minimum acceptable compliance standards. Programs should focus on excellence yet excellence cannot be mandated; It must be internalized at the individual level. While minimum compliance standards should be respected as inviolate, they should not become the benchmark for optimum system or individual performance. Both common sense and competitive forces would suggest that organizational goals must focus on excellence that is well above the minimum standards. Increased safety margins through improved human performance are best realized by focusing on excellence rather than aspiring to minimum compliance.

Clearly Defining the Goal, Mission, and Roles of Human Factors

The outcome of human performance programs has a direct impact on the safety and efficiency that our customers, employees, and stakeholders enjoy. Defining the goal, mission, and roles helps us direct, prioritize, and utilize our limited resources to their maximum effect. As we move from philosophy to practice the verbiage becomes less abstract and more action oriented.

Delta's Human Factors Department Goal

To improve the safety and efficiency of Delta operations by creating and supporting excellence in human performance.

Delta's Human Factors Department Mission

To analyze human performance with respect to all four resource quadrants (people, policies / procedures, machines, operational support structure) using multiple disciplines (psychological, physiological, psychosocial, biomechanical, systems science, and management science, etc.) to arrive at adjustments and improvements in the four areas a manager controls to shape job performance (selection, training, resources, and motivation). See Figures 1, 3, 4, & 5.

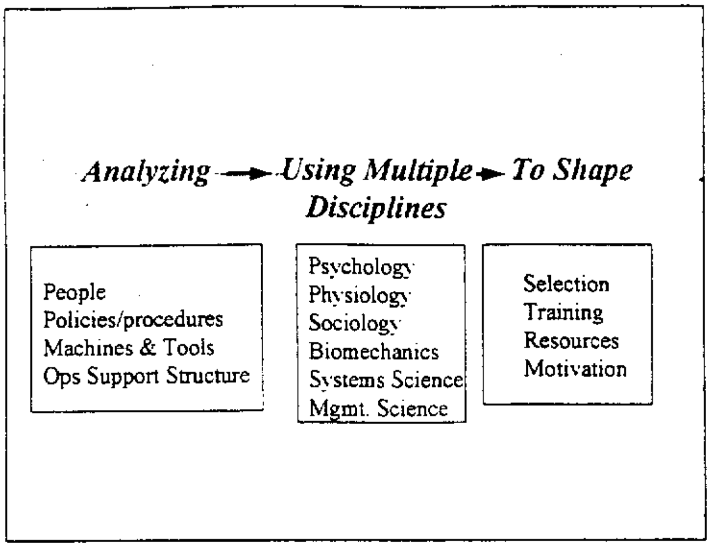

Figure 1: Delta's Human Factors Department Mission: Moving from Analysis to Action

The Human Factors Department Role

The role of the Delta Human Factors Department is to be a service entity providing guidance and insight to operational managers (internal customers) across departmental boundaries for integrating human factors principles in a systemic manner. The goal is to provide operational managers the awareness and tools to strengthen human performance themselves. It is not the goal of the Human Factors Department to become an oversight authority that regulates human performance programs. The role of the human factors managers is serve as internal consultants to help operational managers improve systems, structures, and processes. The human factors manager helps operational managers translate the latest human factors science into action with programs directed at improving human performance through optimized selection, training, resource, and motivation systems, processes and structures. Figure 2 highlights the services offered to internal customers by Delta Air Lines' Human Factors Department:

- conducting human performance audits on new and existing programs to identify opportunities for performance enhancement,
- assisting in the development of Team Resource Management training programs and performance evaluation tools,
- human factors accident and incident investigation,
- matching human performance challenges with experts inside and outside the company,
- assisting in the development of performance-oriented recruitment, selection, and personal development programs.

Figure 2: Delta Human Factors Service to Internal Customers

Building Form and Function with the Basics

Many of the basic principles of human factors, resource management, and training are timeless and provide a useful foundation for building human factors form and function. This section highlights some of the basic principles and models used to shape Delta's Human Factors form and function.

To build realistic boundaries for your Human Factors department and programs it will be useful to establish definitions for both Human Factors and Resource Management. While this may seem basic, without a common definition, a common vision of program form and function will be elusive. The human factors manager will likely find himself or herself creating a program without limits while chasing amorphous and ill-defined expectations.

Human Factors Definition:

Human factors can be defined as the comprehensive, multi-disciplinary science focusing on systematic and comprehensive assessment and improvement of human performance.

The Primary Disciplines of Human Factors

There are many disciplines associated with human performance. To be a credible human performance resource, the human factors department should have the capability to address the primary disciplines (Psychology, Physiology, Sociology, Biomechanics, Systems Science, & Management Science) integral to human factors (See Figure 3).

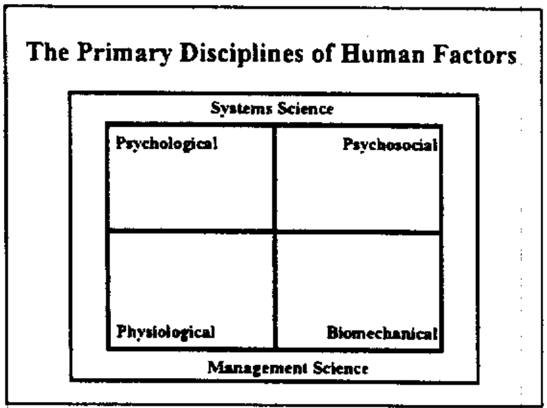

Figure 3: The Primary Disciplines of Human Factors

Delta's Core Human Factors Model

At Delta, we use an adaptation of the Edward's SHEL model, illustrated in Figure 4, as a core framework for human factors. The human function is analyzed in four different contexts: hardware, software, liveware, and environment.

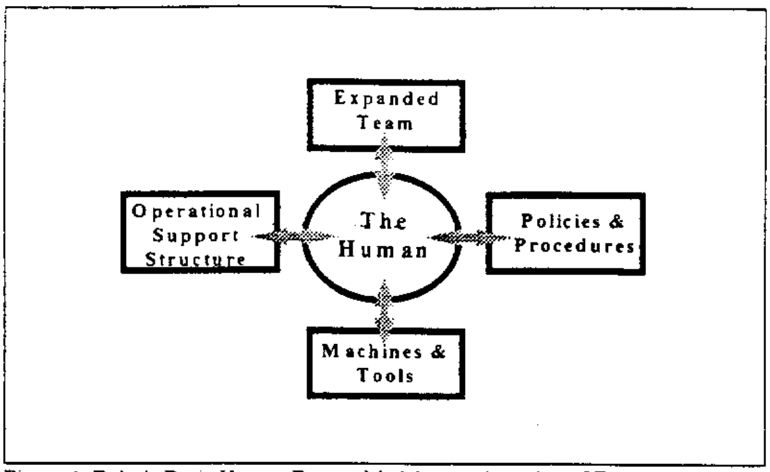

Figure 4: Delta's Basic Human Factors Model (An adaptation of Edward's SHEL model)

Human (Liveware): The human who interacts with the system

Expanded Team (Liveware): The other individuals, crew members, or expanded team members with whom the human in the center of the model interacts.

Policies and Procedures (Software): The guidelines, standards, norms (written and unwritten) that highlight how the system works

Machines and Tools (Hardware): The equipment, machines, tools, and other devices that the human uses to accomplish work.

Operational Support Structure (Environment): The support structure (organizational, operational, functional, etc.) within which the human performs. (Examples might include the Air Traffic Control infrastructure, the company scheduling structure, etc.)

Four Contributing Factors to Job Performance a Manager Controls

To shape human performance, it is important to assess the factors that are within the control of an operational manager. The Jones (1993) model highlighted in Figure 5 highlights the four components of job performance a manager controls.

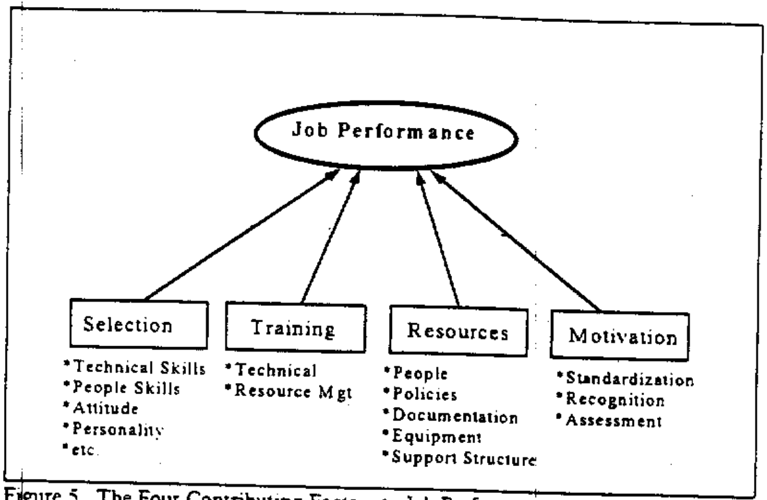

Figure 5. The Four Contributing Factors to Job Performance a Manager Controls (An adaptation of the Jones Model)

Resource Management Definition

Within the discipline of Human Factors, Resource Management training programs will be one of the most useful tools available to managers throughout the organization for shaping performance. A clear definition of Resource Management will help define the scope and focus of departmental and program efforts. Recent definitions of Resource Management have begun to encompass a much broader scope and have been coined as Corporate Resource Management. It will be important for the manager to determine the scope of resource management efforts to establish a focus and boundaries for program development. We found it useful to break down (C)RM into individual components, define each separately, then offer a collective definition. The following is Delta's definition of (C)RM:

* <u>Crew / Team / Maintenance / Dispatch / Corporate:</u> The scope of extended group that collectively contributes to the operation

* <u>Resource:</u> The people, policies, machines and operational structure that the group can call upon during the flight or mission.

* <u>Management:</u> The knowledge, skills, and roles used to direct, control, and coordinate resources

<u>The Collective Definition of Resource Management:</u>

The knowledge, skills and roles used to direct, control, and coordinate all available resources toward safe and effective operations.

Delta's Six Resource Management Categories

To systematically integrate the resource management skill set into documents, standards, policies, procedures, training and evaluations, it will be important to further identify, define, and categorize resource management. The categories collectively represent the skill set an individual uses to manage resources. Many organizations slice the Resource Management pie in different ways. How an airline categorizes resource management is less important than the fact that they have established a categorization scheme. Figure 6 highlights Delta's six resource management categories.

It is important to note that the categories should be is stated in terms of skills and not abstractions or concepts. For example, Delta uses "Situational Awareness Management" instead of "Situational Awareness." Situational Awareness is an outcome, while Situational Awareness Management is a skill.

<u>Delta's Six Resource Management Categories</u>

Communication
Crew Coordination
Planning
Workload Management
Decision Making
Situational Awareness Management

Figure 6. Delta's Six Resource Management Categories

A Framework for Basic Learning Progression

One of the most effective tools available to the corporate manager to shape behavior is training. To be effective, however, the training programs must be built on sound Instructional Systems Design (ISD) and human factors principles. Curricula must systematically lead individuals from Knowledge to Skill to the fulfillment of a Role (KSR). This systemic KSR learning progression (Mancuso & Kirijan, 1995) has proven to be most successful in aircrew human factors and resource management training (See Figure 7). The wisdom of structuring the learning progression to systematically shape behavior applies equally on the flight deck as it does anywhere else in the organization.

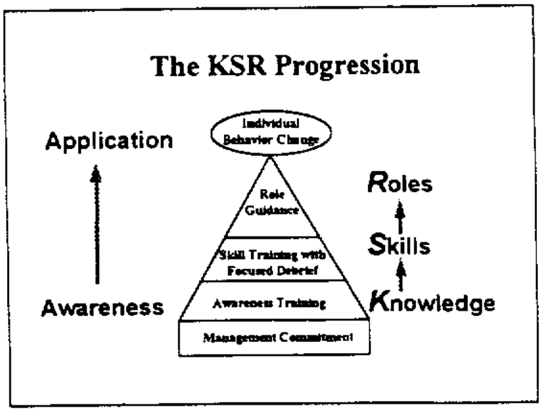

Figure 7. The KSR Learning Progression (Mancuso & Kirijan)

Moving from Principle to Action

The principles of good human performance are relatively simple. Translating these simple concepts into (selection criteria, policies, procedures, documents, training, etc.) practice is the challenge. Most airlines would not be in business if they did not have a cursory understanding of how to harness human performance. In many cases it could be considered just good common sense. As the industry increasingly puts voice to the tenets of human performance, the airline manager can objectively and overtly weave these principles part of the corporate style and put them into action. To create excellence in human performance the airline, the managers, and the personnel will have to extend the understanding and integration beyond a cursory awareness. The first challenge is to put these sound human factors and resource management principles into an organizational language that can be understood by everyone. The next challenge is to weave these concepts into policies, procedures, documents, company structures, training, etc. in a coherent and unified manner from top to bottom.

Proactively Develop a Departmental Structure Rather Than Letting One Emerge

Two approaches might be taken in the development of a human factors department. The first option would include building an organizational structure (form) designed to perform human factors functions. The second option would be to allow the emerging human performance functionality determine the shape of the organizational structure. In reality, the way that human factors emerged at Delta was a mix of both approaches. The successes of Human Factors in flight operations were recognized as equally applicable and beneficial to other areas of the company. As other departments within the company recognized this benefit, they began approaching Flight Operations Human Factors for assistance. Once Flight Operations began exporting their programs to other parts of the company, the benefits became apparent to other non-flight operational managers. The evolution to the current structure is not a process that every organization will have to go through if they choose to adopt the form rather than let one emerge. There simply is no reason to "recreate the wheel" for human factors integration in every organization.

There are a few significant problems associated with waiting for a function to emerge. The systemic nature of human factors integration suggests a cross-departmental and cross organizational approach. If the department responsible for human factors integration resides many levels down within the organizational chart, it may not have the real or perceived authority or responsibility to accomplish cross-departmental and cross-operational coordination functions. Any integration that requires action outside of the departmental silo within which the human factors department resides may not occur due to competing political and economic inter- and intra- departmental interests. By taking a function first approach, the human factors department and programs may not have the fertile ground to develop deep enough roots to self-sustain or affect the corporate attitudes, behavior, and culture. It will be very difficult to shape human performance in a meaningful way by taking a pure "function first" approach.

Two Options: Fix the System or Accommodate the Limitations

A system fix is almost always more desirable. There will be times, however, when an immediate fix is not practical or possible. In this case it will be important to identify, accommodate and manage the limitations. When changing the infrastructure or processes is not appropriate, the human factors managers can assist in the development of accommodations to inherent system limitations.

Accommodate the Reality of Limited Resources

In a perfect world, we would have unlimited time and financial resources to gain peak human performance in all operational aspects. In reality, operational managers will not have unlimited time and financial resources to address human performance issues. It is important for the manager to keep one eye on fiscal as well as time constraints. One of the cautions and concerns of senior management is misallocation of effort and resources. The problem is not whether there are sufficient high value human performance initiatives to address; there are plenty. The challenge is to direct limited resources to the projects that have the highest impact. As performance measures (individual and organizational) are refined, the ability of a manager to identify, track, measure, report organizational factors (process, structure, and outcome) will improve. The manager will be able to more objectively assemble these measures for fiscal justifications or project prioritization. The bottom line is that there are plenty of productive human performance projects but there is a shortage of hard data to drive and support human performance oriented program decisions.

Identify and Leverage Existing Company Programs and Resources

The most efficient operational impact will be realized when the Human Factors Manager is able to harness the existing company programs and resources. As we reviewed the nature of shaping human performance within the corporation, two distinct activities emerged; problem identification and problem solving. The manager may find it useful to group existing resources into these two different categories.

Identify and Leverage "Problem Identification" Resources

There will be many existing departments, programs, and people within the organization that are charged with identifying problems. Many entities will be charged with an audit and analysis function. These groups may include safety review teams, continuous improvement teams, audit teams, etc. It will be important to work with the problem identifiers to help them build their knowledge and skill as well as their tools and protocols for identifying individual and systemic human performance issues. If there are gaps in the company's existing identification resources it will be the human factors manager's challenge to fill in those existing problem identification gaps.

Identify and Leverage "Problem Solving" Resources

Once the problem is identified it is time to select and complete a course of action. While many of the program identifiers may also be involved with solving the problem, the Human Factors Manager will likely find a whole new set of existing company resources that are designed to solve problems. Training program developers are one of the more common resources. It will be important for the Human Factors Manager to work with the problem solvers to help build their knowledge and skill as well as their tools and protocols for solving individual and systemic human performance issues. Similar to the problem identifying group, it will be inevitable that the Human Factors Manager will find gaps in the existing problem solving programs. When these gaps are identified, the managers will need to build or augment programs to address the gap in problem solving capability.

Identify and Assess Human Performance Issues

To improve human performance, an organization must have the capability to identify and put voice to human performance issues. This organizational self-awareness is a developed skill that includes manager education. The ability to take a giant step back from the operation and look at it with an eye toward human factors issues is not a skill that everyone in the organization possesses. The challenge for the Human Factors Manager will be to build this capability by systematically educating managers and employees to identify human performance issues.

Bring the Sciences to Bear on the Problems

There is a wealth of talent and resources available throughout the scientific community directly beneficial to the airline industry. However, there is often a gap between human factors research and the operational needs. It will be important for human factors managers to collectively work with government to shape and direct research and development activities to address the needs of the users.

Another challenge inherent in bringing the sciences to bear on the problem is the ability to translate research language into operational language. If the Human Factors Manager hopes to harness the tremendous insights in existing human factors research and literature, he or she must be able to speak both operational and research language. The bridge will not be built between the two communities unless the capability to translate between the two domains exists.

Generate Operational Solutions

The ability to generate operational human factors solutions (structures and processes) will be an important capability that the manager must develop to ensure success. Even if the problem is identified and the appropriate theories and research findings are identified, the most significant challenge often lies in translating these theories and findings into action (programs, policies, procedures, documents, etc.). This is probably the most important skill in the Human Factors Manager's toolbox. It will be important to find and/or develop methods, tools, strategies and protocols for applying human factors within an operational airline setting. The challenges will be unique throughout the organization. The application of human factors in selection, training, resources and motivation systems will represent a challenge to each department and organization. Currently, AQP continues to lead the industry in the sound and systemic integration of human factors and resource management into an organizational system. While AQP focuses primarily on training, it provides an example of a "whole systems approach" that can be applied to other departments, and programs.

Develop and Use Feedback Systems

Any complete system requires accurate and timely feedback. As the operational community becomes more savvy in applying human factors in operational settings there is an increasing need for developing metrics to track performance. To assess the fitness of individual performance and the systemic contributors to human performance, it will be important to have appropriate and accurate metrics. There are several challenges that face the manager when trying to develop appropriate metrics. The first challenge is to identify measurable processes and outcomes that are a reflection of individual and systemic performance. The second challenge is to develop methods for collecting and assessing the data. The third challenge is to develop methods for reporting these findings in operationally relevant ways. The final challenge is to use the findings to initiate and shape change within the organization. Individual and systemic human performance feedback systems are an integral component of an organization's human factors integration.

Conclusion

There have been some notable successes in applied human factors within airline organizations. There are, however, many human performance challenges and opportunities that remain undeveloped. Through an orientation toward action, a foundation in Human Factors and Resource Management basics, a clear understanding of system attributes and functionality, all tied together in a systems approach, human performance improvements can become an integral part of an airline's form and function.

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附件四

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Air Traffic Management in Developing Regions

Presented by: James L. Pierce, CEO and Chairman of ARINC

Summary

Worldwide growth of aviation cannot be sustained without improvements in the air traffic infrastructure. The air navigation system in which aircraft fly must be safe, and must be economical for air traffic service providers and airspace users. Aviation growth and economic operations can only be achieved by utilizing modern technology for communications, navigation, surveillance, and automation. While developing nations may have difficulty in affording traditional technology for air navigation, the new concept of automatic dependent surveillance (ADS) and low-cost controller work stations should be affordable by all nations. ADS can take advantage of current avionics in many of the world's commercial aircraft, and new low-cost avionics can provide much of the needed functionality in older aircraft, smaller aircraft, or fleets of aircraft where costs are otherwise prohibitive.

1. Background

ICAO's Future Air Navigation System (FANS) reports outline a planning process for Civil Aviation Authorities (CAAs) to implement the FANS Communications, Navigation, and Surveillance/Air Traffic Management (CNS/ATM) systems concept. Many large countries have already implemented conventional systems (e.g., radar for surveillance) and have already invested significant effort in determining an optimum future implementation strategy. However, for many of the world's nations the planning task is much more difficult; they do not have a comprehensive existing CNS infrastructure and cannot afford to implement existing ground-based technology. Although many developing regions control relatively small Flight Information Regions (FIRs), they do not have the planning, research and development resources or procurement budgets of larger countries. Also, with lower volumes of air traffic there are fewer revenue or tax opportunities to offset the financial investment required for airspace improvements.

For civil aviation authorities and aircraft operators in developing regions it may be useful to consider the alternative approaches offered by implementing the CNS/ATM systems concept.

2. Roles and Options for Aviation Organizations

ICAO has identified several different types of organizations and how they can work together to implement a viable action program:

- States and Regions
- Airspace Users
- ICAO
- Aviation Manufacturers
- Communications Service Providers

This paper presents options from the perspectives of the developing states and regions, the airspace users, and the communications service providers.

3. The Developing States' and Regions' Perspective

The "developed" states are characterized by having well established aviation infrastructure systems already in place, well established plans for the future, and well established funding mechanisms to make a transition viable. They also have well established national airlines and other airspace users who can articulate their needs and, through taxes or fee structures, can directly or indirectly fund the investment needed for the future.

The developing states are characterized by having either no or only very limited aviation infrastructure systems, and thus are not well equipped to develop plans for the future. With no baseline systems in place there is usually no existing funding mechanism for future infrastructure investment, and usually a relatively low source of government funds available for such projects. The airspace users consist of domestic airlines that are sometimes solvent only because of government funding, foreign carriers who transit or only overfly the state, and usually there is no body of general aviation users.

Some developing states have very large areas of land and airspace, some have only small areas. A common thread is that the utilization of airspace is relatively sparse. This creates several dilemmas. Low airspace usage means that user fees will produce little revenue. Large land areas mean that extensive coverage is required. Low density of traffic also means that air traffic controllers get little experience in handling aircraft, and cannot afford sophisticated tools to optimize the control of aircraft. In extreme cases, air traffic control is virtually abandoned as an impossible task of no benefit to the country concerned.

There are several factors that are acting as the catalyst for change.

The demand for air travel is continuing to grow; well over 10% annually in the Pacific rim, and about 5% in the areas of least growth.

Aircraft operators are seeking optimum routing for their aircraft. This will result in air traffic being more distributed than ever before, as each flight seeks to take advantage of the wind of the day. Some areas that are used to higher volumes of traffic will see less traffic, and other areas that see no traffic today will be requested to accept new overflights.

New technology allows much lower cost methods for implementing communications, navigation, and surveillance and the resulting air traffic management.

Communications:

Traditionally, air traffic control communications is accomplished by voice. In the CNS/ATM concept, all routine communications will be done via data link. The "developed" nations of the world are already making plans for the communications infrastructures they will use for data link communications between controllers and pilots. Other nations, with less ability to fund such systems, can take advantage of the development and investment made collectively by the industry by using an established communications service provider. The US FAA is planning to implement a Mode S data link system for ATC data link communications. The government of Jamaica offers data link communications through an arrangement with a communications service provider, ARINC. Jamaica has not had to fund any research, development, construction, implementation, or future upgrades for the data link technology. Instead, Jamaica benefits from the shared investment in a common system on a "pay as you go" basis, only paying for its small share of a large system. Thus, Jamaica avoids the financial, schedule, and technical risk associated with technology that matures and changes very quickly.

Jamaica is one example of a developing region where line of sight VHF communications can be accomplished throughout the nation's entire airspace. With VHF data link communications, the added expense of satellite communications need not be required.

Navigation:

Conventional navigation systems have many limitations. Navigation radio beacons often are expensive to install and maintain, have limited range, and cannot be installed in difficult locations (e.g., deserts, oceans).

The CNS/ATM systems concept introduces satellite navigation as a universally available and low cost navigation system. The ICAO Global Navigation Satellite System (GNSS) will address most, if not all, of the institutional issues of such a system. In the near term, until a full GNSS is implemented, the US Global Positioning System (GPS) is already available for use as a GNSS system.

For en route navigation GPS can be used as-is. There are no user charges for receiving the GPS signals.

For terminal area and approach navigation, augmentation of GPS may be required. Such augmentation can likely be achieved at a cost well below the cost of conventional navigation aids. A single runway Category I Instrument Landing System might cost $1M. A GPS augmentation system, allowing Category I approaches at all runways within 50 miles might cost less than $500K.

In all cases where GNSS is used for navigation, the are almost no costs associated with ongoing maintenance!

One country to adopt satellite navigation is Fiji. GPS is the official navigation system accepted by the government. At minimal cost they can start to reduce the maintenance costs associated with NDBs and VORs. Fiji calculates it will save $2M per year in avoided NAVAID replacement/maintenance costs.[1]

Surveillance:

Conventional surveillance is achieved by several methods. Procedural airspace is addressed by requiring pilots to make periodic position reports by voice communications. This is prone to delays in reporting and human error. Consequently, the separation of aircraft required to maintain safety is relatively large. Radar airspace is addressed by requiring participating aircraft to carry a transponder that will allow an air traffic controller to monitor aircraft flight details on a radar screen. Higher reliability and reduction of human error allows much closer separation of aircraft while maintaining a high level of safety. Both methods have relatively high costs.

Developing regions cannot afford the cost of traditional radar systems, especially when the territory to be covered is large, the volume of air traffic is low, and the terrain is difficult or impossible to access (e.g. mountains, deserts, oceans).

With the improvements mentioned previously for communications by data link, and navigation using satellites or inertial systems, a totally new method of surveillance becomes technically and economically feasible. Aircraft using satellite navigation have constant access to very accurate position information. Aircraft using data link communications can very quickly, accurately, and economically communicate position reports to air traffic control authorities. Modest automation in aircraft can accomplish this position reporting automatically, without intervention by either the pilot or the air traffic controller. This method of automatic dependent surveillance (ADS) is another cornerstone of the ICAO FANS CNS/ATM system concept.

Air Traffic Management:

Conventional management of airspace is via a "contract" called a flight plan. Safe separation of traffic is assured by authorizing an aircraft to fly in specific airspace. All other aircraft are kept out of airspace reserved for other aircraft. Achieving safety in this way is a non-efficient use of airspace.

A more efficient means of managing airspace is by providing tools that ensure that aircraft never get too close to each other. With improved tools for monitoring the location and intent of aircraft, air traffic controllers can be automatically alerted if aircraft are likely to get too close to each other. Such as system will require the improved communications, navigation, and surveillance mentioned previously, but it will also require some computational capability for the air traffic controllers. In airspace with only modest densities of traffic, a simple work station (e.g. a personal computer) with appropriate software can accomplish this function. An ATM work station can display composite position

[1] Air Traffic Management, pg 31 (May/June 1995)

information, including radar reports, ADS reports, and even transcribed voice position reports. The same or an auxiliary work station can also be used to allow pilots and controllers to communicate using data link.

In September 1995 a milestone was achieved in the Asia-Pacific Region with the first FANS1 flight over Far East Russia. In cooperation with Rosaeronavigatsia, ARINC has installed a prototype ATM work station and VHF data link system at the Magadan Area Control Center in Far East Russia in support of Magadan Aerocontrol. This system provides Magadan's air traffic controllers with a situation display showing aircraft positions. The position reports are ADS reports constructed by the aircraft's flight management system, and delivered to Magadan ACC by ARINC's GLOBALink satellite data link system, or ARINC's VHF ACARS data link ground station at Magadan, and using the ARINC Data Network Service (ADNS) for international terrestrial communications. The work station ensemble displays aircraft positions, aircraft data, and provides the controllers with the data link messaging capability to use industry-standard defined text or free text.

4. The Airspace Users' Perspective

Developing regions must cope with two distinctly different types of aircraft. Large, modern aircraft from "developed" regions will have complex, modern avionics with full capabilities for all the ICAO FANS CNS/ATM concepts. Aircraft that are older, smaller, or from financially strapped operators will have conventional systems for communications, navigation, and surveillance. Communications will be by voice; navigation will be by INS, Loran-C, VOR, NDB, and ILS; surveillance will be by procedural voice position reporting, primary radar, or secondary radar.

Many of the world's largest international carriers have already made the investment decisions to equip with avionics to accomplish data link communications, satellite communications, satellite navigation, area navigation, and automatic dependant surveillance.

However, the cost of equipage can be high; $100K for VHF data link avionics, $500K for satellite communications; $150K to upgrade an existing flight management system, or up to $1M if the aircraft does not have an existing flight management system.

There are well over 5,000 aircraft in the world already equipped with VHF data link avionics. These aircraft already have much of the avionics required to participate in the airspace of the future.

For other aircraft there remain some attractive options.

Resulting from the large popularity in the US of general aviation and commuter aircraft, there is a significant demand for a less expensive suite of avionics. With such a large market demand it is economically feasible to develop, design, and build a modest avionics set that is small in size, light in weight, low in cost, and still able to perform all the basic functions required to operate in the airspace of the future.

One such implementation of this type of avionics is the CNS-12 produced by Magellan. This unit is priced below $10,000, fits into the instrument panel in a cockpit, and includes VHF data link and GPS navigation; coupled together these two functions permit automatic dependant surveillance.

5. The Communications Service Providers' Perspective

ICAO has identified the role of communications service providers as:

- Develop and install the necessary infrastructure
- Participate in standards setting
- Be involved in research, development, testing and demonstration
- Cooperate with each other and with air traffic services

Suites of systems, products and services for CNS/ATM can be a viable alternative to developing in-country solutions. Each CAA can fully customize each system element to achieve an implementation that fully addresses local needs, but without the full technical and financial risk and investment associated with original development.

Communications:

ICAO recommends that all routine communications should be achieved through data link instead of voice. ICAO recommends that VHF voice should be complemented with satellite voice, and that HF voice should be phased out.

Air/ground communications and ground/ground communications must both be considered.

Implementing Air/Ground VHF Data Link: To implement air/ground data link a CAA has several options, including Mode S, VHF, and Satellite. While Mode S data link is still being developed and implemented, the airline industry has been using VHF data link since 1977. To keep costs at a minimum, functionality high, and risks low - a VHF data link solution can be used. Once again, several alternatives exist.

- Use a commercial data link service with no changes
- Use a commercial data link service, with in-country processing
- Operate a joint-venture (CAA and commercial communications provider)
- Buy a turn-key data link service
- Develop, build, and operate a data link service

1) Use a commercial service provider. Established VHF data link services are routinely used by airlines around the world. Airlines transmit data between aircraft and ground systems reliably and economically. In some states these systems are being used to for early implementation of new CNS/ATM services, often as an interim measure until the states' own Mode S services are completed and ready for use. The advantage is that airspace users can get immediate safety and financial benefits. An example of this is the successful program implemented by Transport Canada for delivery of oceanic clearances to east bound transatlantic flights. Oceanic clearances from Gander are delivered to aircraft via two commercial data link systems, operated by Air Canada and ARINC. Trials of this system were successful and the trial has been continued as an operational service.

2) Use a commercial service provider, with in-country processing: Some states have asked commercial service providers to initially implement data link services using a commercial network, but with the proviso that the system should ultimately be controlled by a local in-country host processor. This minimizes the cost and time taken for start-up, and as the use of the service grows it offers a greater degree of control for the host CAA. As the CAA gains familiarity with using data link it will develop expertise and benefits needed to support ongoing operation. Several states are currently considering proposals such as this.

3) Operate a joint venture: One Caribbean nation, Jamaica, has chosen a variation of the above by entering into a joint venture with a commercial service provider, with a sharing of the revenues obtained from providing commercial data link services. This provides the CAA with a large measure of control, without the burden of owning or operating the data link system. This program has now been operating successfully for two years, allowing the state of Jamaica to offer its own data link service.

4) States with a requirement for ownership of data link services can request communications service providers to offer a turn-key operation. This option allows a state to acquire a fully functional system with no technical risk. States can make various arrangements for initial or ongoing operation, and for maintenance and upgrades to remain compatible with future changes in data link standards. One state that has proceeded this way is Japan (AVICOM Japan Ltd.)

5) States with a self-sufficient capability to design, build, and implement their own data link systems can choose from a wider variety of data link standards, although it should be recognized that many airlines will need to maintain VHF data link connectivity for airline communications needed to support CNS/ATM operations when flying in countries who do not plan to implement Mode S data link.

Implementing Ground/Ground Communications: To put the required ground communications in place, a CAA has several options. Today the AFTN provides some of this functionality. However, for future system there will be higher requirements for availability, integrity, transit time, and capacity. In "developed" countries, robust networks are in place or are being implemented. In developing regions, the same capabilities can be achieved by using the networks of communications service providers. Using a service provider, a CAA can avoid the need for dedicated resources and the capital investment needed.

6. Conclusions and Recommendations

In developing regions it is possible to implement all the appropriate elements of ICAO's FANS CNS/ATM systems concept by taking advantage of the shared investment provided by service providers.

VHF data link systems can be implemented to provide inexpensive air/ground data communications for pilots, controllers, and the automation systems in aircraft and on the ground.

GNSS navigation can be used en route with little or no augmentation; modest augmentation systems can provide very cost-effective terminal area and approach navigation. GNSS can allow decommissioning of conventional navaids.

Data link and GNSS can allow aircraft to participate in automatic dependent surveillance, thus allowing full surveillance without the expense of installing radar.

Air traffic management can be improved by using ground automation tools, that may require no more than a work station to allow an air traffic controller to be automatically warned of potential aircraft conflicts. The same work station can be used to allow pilots and controllers to communicate via data link.

Aircraft operators can equip older and smaller aircraft with avionics to perform data link, satellite navigation, and automatic dependant surveillance in an inexpensive way.

Civil aviation authorities and aircraft operators in developing regions are recommended to begin implementation of these ground and aircraft systems immediately. By using a service provider, CAAs can implement these systems inexpensively can avoid or minimize initial capital investment and the technical risk normally associated with implementing new technology.

附件五

An Airlines View of Airline Safety Management

Captain Colin Sharples, Director of Flight Safety, Britannia Airways.

Introduction

With the advent of reliable, turbine powered aircraft a degree of complacency has probably developed within the Management of the worlds airlines.

Airline accidents within the Western world are now extremely rare. However, when things do go wrong the consequences are dire, with the media requiring immediate explanations, and - after the formal investigation - the lawyers demanding unlimited compensation.

Back in 1987 a Townsend Thoresen Roll on/Roll off passenger and freight ferry capsized four minutes after leaving Zeebrugge harbour bound for Dover. A total of 187 passengers and crew lost their lives. The subsequent enquiry found 'the Board of Directors did not appreciate their responsibility for the safe management of their ships............and they must accept a heavy responsibility for their lamentable lack of direction'.[1]

In 1993 the Managing Director of an outdoor leisure company was jailed by an English Crown Court for 'failing to devise, institute, enforce and maintain a safe system for the execution of an outdoor leisure activity'.[2]

Of course airlines in the UK, and many other parts of the world, are highly regulated and are frequently inspected by their civil aviation authority so they must be safe and well managed. But is that so? Every accident can be traced back to a chain of events, a chain that can be broken by a number of people provided they recognise the potential consequences of neglect.

Back in 1966 Britannia suffered its only fatal accident. A Bristol Britannia crashed during an approach to Ljubljana in Yugoslavia. The cause was attributed to pilot error. The shock of that accident reinforced our resolve to be a very safety conscious airline.

[1] Department of Transport Formal Investigation MV Herald of Free Enterprise pg. 14 & 15

[2] The Crown v Peter Baylis Kite - Winchester Crown Court.,1993.

Today, Britannia Airways is the largest charter airline in the world in terms of passengers carried - 8 million in 1994 - and the second largest airline in the UK. Our 1996 fleet will consist of 18 x B757's, 8 x B767-200's and 4 x B767-300's which we will fly on a world-wide route system with an annual aircraft utilisation of 4500 hours per aircraft. We require the highest standards from our pilots, cabin staff and engineers.

However we also recognise that more is required and this paper sets out thoughts of how an Airline Safety Management system can be developed for the future.

Safety Management System

Perhaps the first thing for airline managers to do is to ensure that they are all speaking the same language. Within all airlines there is 'pilot speak' and 'engineering speak' and effective communication can sometimes be very difficult when these two groups meet. Just as a very simple example the word 'visibility' has a totally different meaning for a pilot, than for an engineer. A pilot thinks of visibility as a measurement of distance, whereas the engineer is talking about the clarity and understanding of a procedure. Maybe the word 'audit' is simpler but within our airline I believe it has a multitude of meanings depending on whether you are aircrew, engineering or administration.

Once this small obstacle is over, the serious business of deciding what a safety management system is can really begin. Described by the UK Health and Safety Executive (HSE), it is composed of four elements:

1 A safety case
2 Internal audit process
3 A deficiency rectification loop
4 A safety culture

It could be argued that the industry already has a safety management system. The Operations Manual within an airline must be one very important product of a safety case. Arguably that safety case might not have been developed in a formal manner, but generally the development of the Operations Manual procedures does require an operator to consider which parts of the operation are at risk and how best they can be handled in order to operate the aircraft in as safe a manner as possible.

It might also be thought the internal audit process already takes place in the form of pilot base and line checks, and engineering internal audit quality checks. The deficiency rectification loop is surely retraining a pilot if he fails to achieve a sufficiently high standard in his base or line check.

Finally the safety culture must already be with us because pilots and engineers don't willingly put themselves at risk. However, to believe that simplistic approach would today be foolhardy.

Accidents in years gone by were so often blamed on 'pilot error' with the real culprit of neglect hiding behind this convenient banner. However, with the social changes that have taken place over the past ten years, this is no longer good enough. Investigative journalism and the 'wiser public' have conspired to 'lift every stone' and identify the people ultimately responsible for the way a company runs.

To my mind the most important of the four elements is 'a safety culture' and I'd like to take a few moments to explain why. During the past year we have had two flights land without the fasten seat belt signs being illuminated, one flight take off without the seat belt sign being illuminated and one aircraft land with cabin staff not being seated. However, I'd argue that we are a very safety conscious airline and all the crew members involved were bright and intelligent individuals, the problem, I believe, is a lack of safety awareness. During years of intensive pilot and engineering training many actions become second nature and we develop a situational awareness regarding safety. This has to be continually topped up with safety related feedback but a solid foundation is to be found in every professional pilot and engineer.

When we consider cabin staff we are dealing with crew members who only have five to eight weeks initial training, a large proportion of which is not concentrated on safety related issues. With time and experience in the role a degree of safety awareness begins to form.

A typical Airline operational profile of staff could be:

Pilots	430	17%
Cabin Staff	1430	56%
Engineers	690	27%
	2550	100%

So 44% of operational staff I would argue are very safety aware whereas 56% are only partially aware, and if we then consider the 1430 or 56% in greater detail, we find:

16%	No: 1's are very experienced and aware
30%	No: 2's are reasonably experienced
28%	permanent 3/4's becoming experienced and aware
26%	are inexperienced and unaware.

The objective of airline management must be to ensure that from the moment any member of staff but especially cabin staff join an airline they realise that safety is the Number One priority.

If safety awareness is stressed and promoted enough throughout an Airline, it eventually becomes the culture and the risks from the large proportion of inexperienced staff are reduced.

So let us now look at each of the four elements in turn to see if we can improve on our present situation.

<u>A Safety Culture</u>

Removing the jargon safety culture is about people, people understanding safety, people caring, taking responsibility and being aware of safety.

The accountability for safety must rest at the highest level within the Company with the Chief Executive obviously being involved in setting the tone and clearly specifying the level of safety required.

There should be a reference to safety in a company's mission statement, in fact it should be the number one statement. I believe that the very minimum a Company should have to oversee Safety is a flight safety committee that meets regularly, i.e.: every 4-6 weeks. At least one board member should sit on the committee and I would suggest that ideally this should be the Chief Executive, because at the end of the day he is the accountable manager. All companies should have a flight safety officer who sits on the flight safety committee and has direct access to the Chief Executive should he need it. A method of feedback of safety related issues needs to be established so that all members of the Company can learn from the misfortune of others.

Whereas the flight safety committee should be empowered to investigate all in house incidents and accidents as well as reviewing safety related material from external sources, it must ensure that where problems are identified that the department responsible for that area have ownership and involvement in carrying out the committee's recommendations; follow up action should rest with the appropriate Director.

To establish a safety culture that is apparent to all the workforce requires spending money. Perhaps one of the easiest ways to do this is in aircraft maintenance. Aircraft Maintenance should not be reactive, it should be preventive. Our business has been built on high utilisation - as I already stated that is 4500 hour per aircraft with an average sector length of 3.2 hours.

To achieve this level of utilisation requires a high degree of serviceability and therefore preventive maintenance is vital. With the introduction of ETOPS into our flying in 1988 a decision was taken to upgrade all line replaceable units (LRU's) to ETOPS standard, that is 45 LRU's per aircraft. The benefits of this are the enhanced procedures and equipment standards demanded by ETOPS which give improved reliability and safety. Arguably in the long run this extra maintenance saves money, it also sends out a powerful message to the staff.

Money should also be spent on safety related equipment. I am very concerned to hear that there are still aircraft flying around without Ground Proximity Warning Systems (GPWS). Traffic Collision Avoidance System (TCAS) is the latest piece of safety equipment available. If Airline Managements are serious about safety, TCAS should be fitted into their fleets now. Such investment in safety related equipment, especially when it is not mandatory, sends a clear message to internal and external audiences that a company is serious about safety. Of course one cannot just buy safety "off the shelf" and any equipment must be properly introduced and supported. Industry should lead the regulators. Flight analysis equipment is now affordable due to the development of micro-computers. This is currently the only piece of equipment that can actually tell us how safe our airlines are and I'll come back to this later in the paper.

Other examples where the culture can be established and visible are in the efforts spent by the Company in the training of all their staff.

The Pilot training department needs to encourage a training culture as against a checking culture. Modern aircraft are highly complex especially in the non normal situation and the only way for crews to become confident in dealing with them is in the simulator. Therefore, it is vital that simulator time is used in a realistic manner, for example on Line Orientated Flight Training (LOFT) exercises, and on practising responses to malfunctions on a rolling schedule.

The regulatory authorities may need to review their requirements in this area, to move away from the box ticking certificate of test to a minimum time training that has to encompass the regulatory requirements. Training staff may well have to be more judgmental especially with the extension to the retirement age from 60 to 65 now taking place in many parts of the world. They will need to be prepared to remove from flying duties any crew member who has difficulty in maintaining an acceptable standard.

Crew training in it's most realistic form should be encouraged. Cockpit Resource Management (CRM) courses for pilots have won universal acclaim. The process must continue with integrated training for the whole crew followed by the involvement of engineers, dispatchers, etc. No one knows which link will break the accident chain but it is vital that everyone knows they have the power.

On first inspection there could be no compelling reason to give training to staff other than flight crew or engineering personnel. However the vast majority of our accidents each year are ramp accidents caused by either loading or catering trucks. Even though in our situation these workers are employed by a third party, it is our responsibility to ensure they are adequately trained. If they were exposed when recruited to a 2 or 3 day induction course which covered ramp safety, personal safety and aircraft operational safety as it can be affected by his and related staff activities, then I believe a positive safety message would spread amongst all the staff who work on or near to aircraft.

Within the UK the CAA is taking the issue of airside safety very seriously. Guidance on airside safety management has been issued in the form of CAP 642 which has been very well received by the industry. Following a very successful ramp safety seminar in November 1994, the UK Flight Safety Committee are also progressing the matter through a working group.

If we look at our own ramp damage statistics over the past 5 years it could be said that they are fairly constant apart from 1994.

Ramp Damage

Year	Total	Per 1,000 Sectors
1990	6	.10
1991	2	.04
1992	7	.14
1993	6	.12
1994	13	.34

It is ironic that 1994 was the year we phased out our small aircraft and standardised on large aircraft and the increase in accidents reflects the greater numbers of vehicles required for larger aircraft. However what is not told by these statistics is the days out of service suffered by these accidents. One incident alone caused the aircraft to be grounded for 2 weeks.

I have used loading and catering trucks in this example because the results are very apparent both in terms of damage and cost. However all staff in the Company should have safety training. It will cost money but it should be seen as an investment rather than an unnecessary overhead.

Above all there needs to be openness, honesty and trust between management and staff. This can be established if a non disciplinary approach is developed wherever possible when dealing with flight safety issues.

A Safety Case

Again, removing the jargon, what we are talking about are procedures and processes. The Company's safety case should meet a number of requirements. Firstly it should satisfy the regulatory authority's requirements. Within the UK these are presently specified in the Air Navigation Order, Civil Aviation Publication's and Joint Airworthiness Requirements. (Figure 1).

A Safety Case

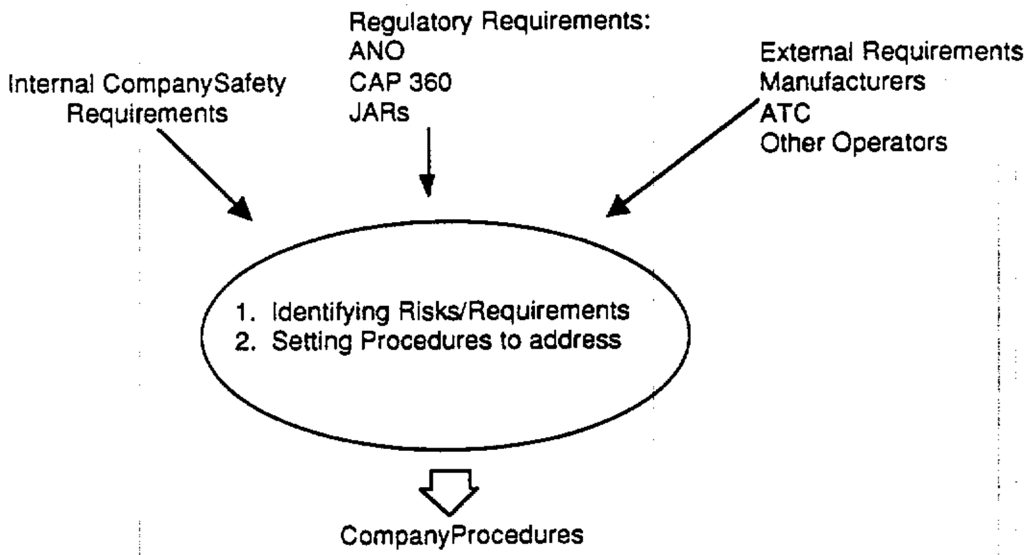

Figure 1

In Europe with the forthcoming Joint Aviation Requirement known as JAR-OPS 1 we are all being required to re-write our operations manuals in the desired format. This I would suggest is a good thing. Pilots are not generally the worlds best manual writers and in even a short period of time manuals become out of date with discrepancies and errors creeping in. JAR-OPS requires us to methodically write down procedures and state individual responsibilities and accountabilities. Clearly written manuals with the appropriate indexing and cross referencing should immediately highlight inconsistencies between the various divisions of a Company. The sheer act of completing this administrative exercise should give clarity and understanding.

Historically operators have considered themselves safe provided they have met the minimum requirements specified in the regulations. In other words there exists a compliance culture. 'We must be safe since we meet all CAA's requirements'. For the future a safety management system will require the company to determine at board level safety objectives as mentioned earlier . This higher level of safety objectives will also need to be addressed during the production of the Operations Manual.

A Typical Airline Safety Management System

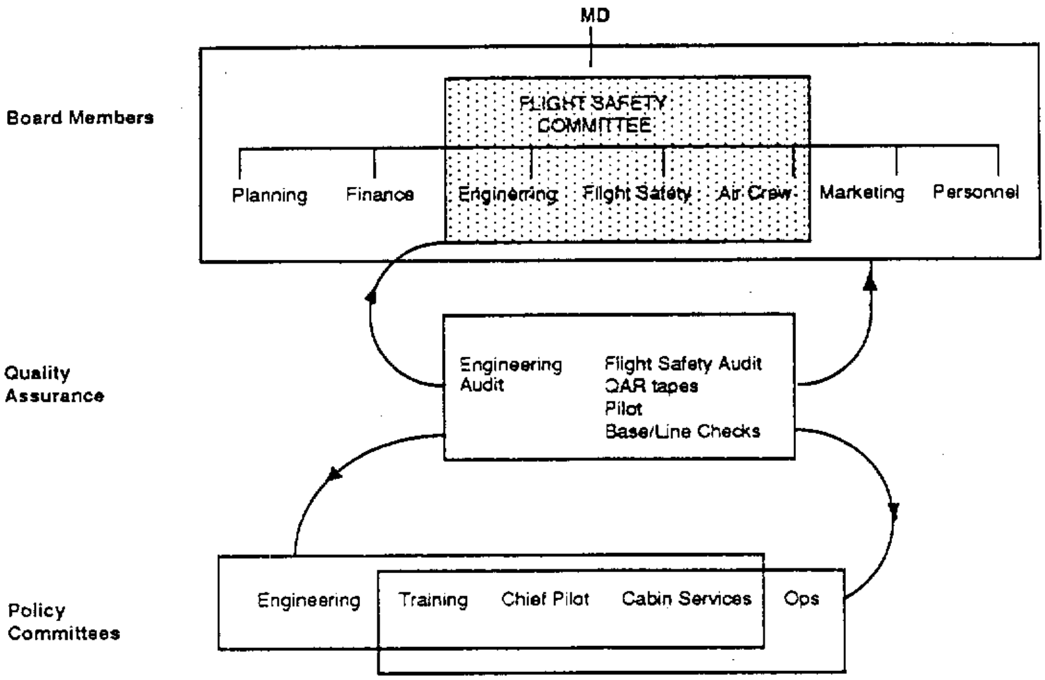

Figure 2

In practical terms it is anticipated that a company would need a Policy Committee chaired by a senior manager, reporting directly to the Operations Director, and responsible for the safety case deliberations and for developing company operating procedures which meet both the regulatory as well as the company's safety requirements. The end result is the Operations Manual for use by the flight operations crew and all the various other procedural manuals that exist within an airline. The Policy Committee should have inputs from all the senior fleet managers and other senior managers of other departments, they should be aware of the regulatory requirements, the safety objectives of the company, recommendations made by the Safety Committee, and be aware of standards being achieved as a result of feedback from training courses, results from route checks, fleet audits and from Flight Monitoring and Analysis systems (see Figure 2).

There comes a point in any company's development where its size makes it impracticable to have just one Policy Committee overseeing all the requirements and procedures for that company. For the larger operators it is envisaged that the Policy Committee would be split into a number of separate units, which deal with Flight Operations, Engineering and with Ground operations. Other than having cross-fertilisation by placing members of one committee onto other committees it will more importantly, be necessary for the Managing Director to hold overall accountability for the decisions made in each of those Policy Committees; as otherwise inter-divisional strife may develop.

Internal Audit System

Whereas for some time quality systems have existed amongst maintenance organisations, self auditing in flight operations is something new and will initially be seen as a threat. For the audit team to have credibility it should consist of multi-skilled members who have the desired personal attributes and are respected by their peers. Auditors should be thoroughly trained in the required skills. By being objective, and taking a common sense view, the team will gain respect and eventually be seen as an asset and not as an unnecessary evil. (Figure 3).

A rolling comprehensive audit programme should be developed based on assessed risks and strategic need but the flexibility should be maintained to allow extra audits to be called for whenever procedures or systems change.

A Deficiency Rectification Loop

However, no audit is of value unless the corrective actions called for are carried out. Deficiencies should be brought to the attention of the appropriate manager and a realistic timescale for the rectification

Ground Audit Rectification Loop

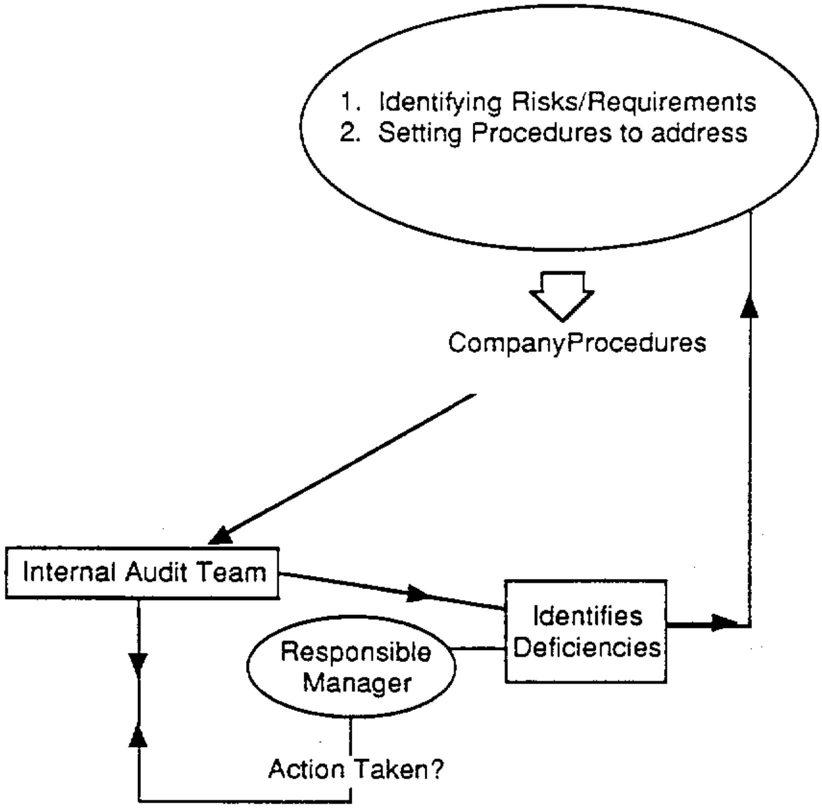

Figure 3

should be agreed. This closing of the loop is vital and would be one of the important roles of the Quality Manager, a position that will have to be established under JAR-OPS requirements. A second loop should also feed into the Policy committee in order to advise them of where procedures have failed and to determine whether a change in the written procedures is required.

The Airborne Situation

The process is fine as far as it goes but we can do more. An airline can have it's culture, procedures, audits and rectification loop but we are dealing with an absent workforce who are flying expensive aeroplanes.

Previously we have had no cost effective means of knowing what safety level is actually being achieved once those aircraft become airborne, except for the small number of training Captain route check reports.

Complete Audit Rectification Loop

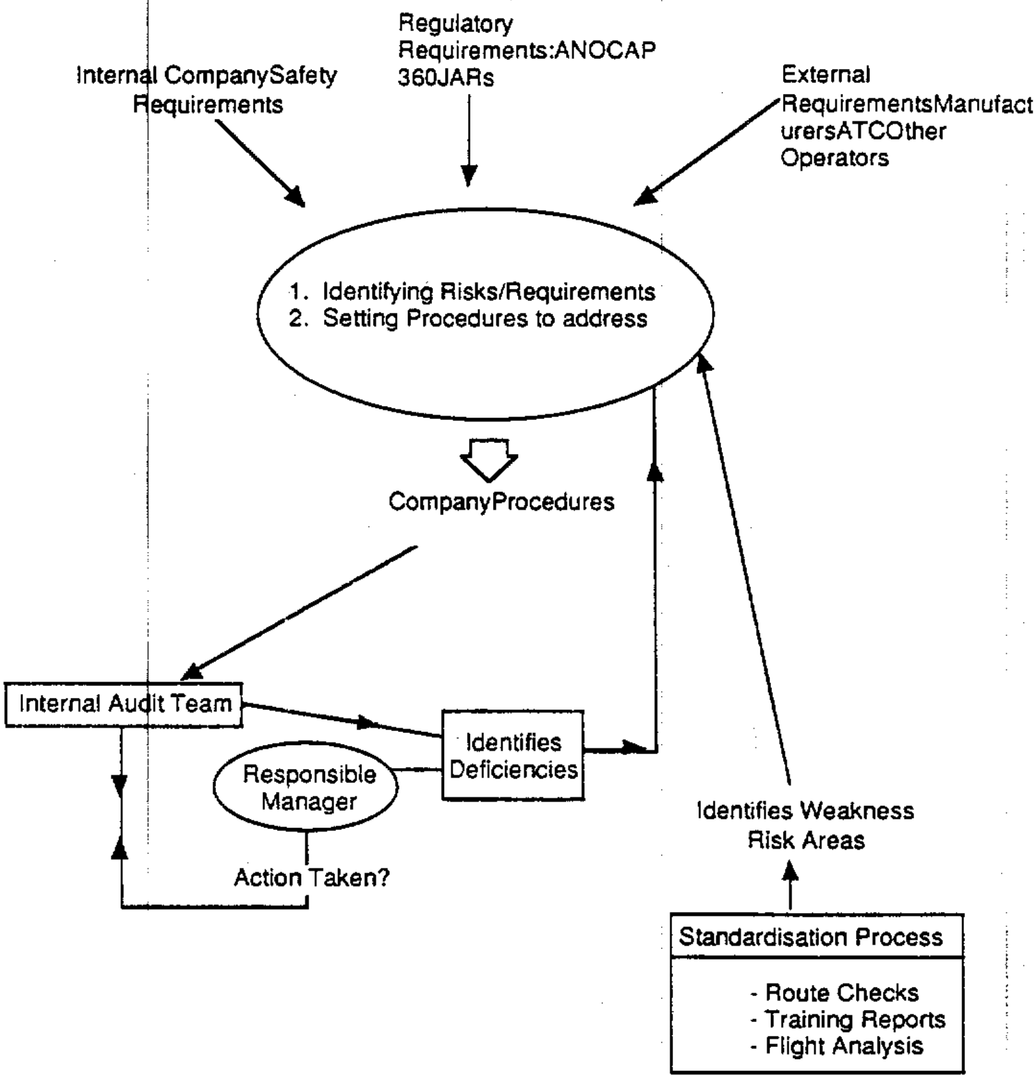

Figure 4

However, the technology is now available in micro computer form that allows flights to be analysed in a cost effective manner. By means of a quick access recorder (QAR), flight data information can be replayed through the micro computer and the flight profiles compared with the ideal. By setting tolerances at important phases of flight, actual performance can be measured, and a true picture of the airline's safety can be assessed. Again, with a feedback system to the crews an airborne audit system can be established. (Figure 4).

I believe this is currently the ultimate tool of airline safety management and with trend analysis data available to management and crews, proactive steps can be taken to amend procedures or to address deficiencies with improved training in order to seek operating standards of the highest order.

However, such tools need to be used and managed in a very responsible manner. To remove suspicion amongst the crews the contact point should ideally be a respected line pilot. We call him the pilots representative or 'honest broker'. He or she should analyse the QAR tapes and talk to the pilots concerned. Management need not become involved unless the 'honest broker' considers that the crew would benefit from extra training. Transparent procedures must be in place to ensure that management achieve all the benefits from the information provided by Quick Access Recorders without causing suspicion or antagonism amongst the operating crew. I believe that by not using union, training or management pilots in this role does develop the trust of the pilots.

So to visualise simplistically what I have been talking about

1 We develop a safety culture for all our staff

2 Ensure the safety case - ie: procedures are comprehensive and complete.

3 Audit the safety case frequently from different perspectives.

4 Ensure the rectification loop is completed.

thus achieving a virtuous Safety circle.

Adoption of safety management systems by the airline industry is one means to seek an improvement long term in the standards of operation world-wide. There are obvious benefits, Namely:

Benefits

- The responsibility for safety will rest with the most senior Airlines managers and cascade down.

- When individuals know they are responsible they are thorough and conscientious.

- Regular audits will engender a continuous improvement ethic within the organisation.

But also difficulties that will need to be addressed.

Disadvantages

- Some operators will do the minimum

- Initially many will be unwilling to invest money into safety related training and systems - a carefully controlled education programme will have to be developed.

- Many organisations in Europe will not have the resources necessary until implementation of JAR-OPS is complete.

- Quick Access Recorder technology will not be available to the smaller aircraft operations.

Conclusion

Over the past twenty years there has been a significant shift in society's attitude to life. In the everyday matters of drinking, driving and smoking, unbelievable changes have been made, are now accepted and indeed expected.

Today Aviation incidents of even a minor nature generate letters to senior airline executives copied to the CAA and the local MP. Unsatisfactory responses are not accepted by our passengers.

Safety is demanded and it is the responsibility of airlines Managers to deliver. The development of Airline Safety Management is required to ensure safety levels continue to improve. Everyone involved in the airline business must realise that they have a part to play, because they might be the link that can break the accident chain.

Acknowledgement

This paper has been produced in with the help and advice of Captain John Mimpriss, UK CAA, and Captain Jock Lowe, British Airways.

附件六

Physiological and Pharmacological Countermeasures to Fatigue

Flight Safety Foundation
48th Annual International Air Safety Seminar

—

International Federation of Airworthiness
25th International Conference

—

International Air Transport Association

November 9, 1995

By:
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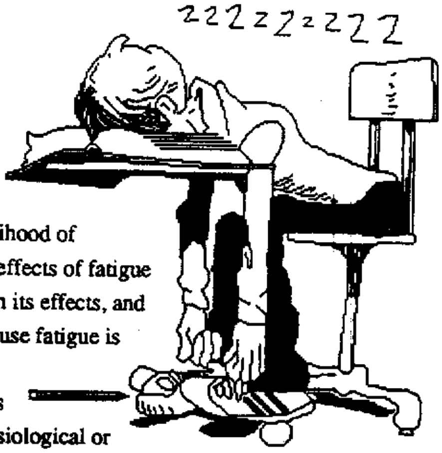
MedAire provides the aviation industry with MedLink - a worldwide emergency medical advisory service, medical training for flight crews and ground personnel and emergency first aid kits. Questions concerning this paper can be addressed to Ms. Garrett at 602.263.7971 or fax 602.252.8404

Fatigue



The effects of fatigue are of immediate practical interest in the aviation industry, which depends upon round-the-clock (24 hour) operations, for fatigue contributes substantially to the likelihood of accident. The purpose of this paper is to survey current research into the effects of fatigue resulting from jet-lag and loss of sleep, to analyze strategies used to lessen its effects, and to analyze implications of this research for the aviation community. Because fatigue is problematic in the aviation industry, aviation employees frequently self-medicate, often with substances whose manufacturing quality and dosages are uncontrolled. The general finding of research, however is that no physiological or pharmacological measure substitutes for regular, timely sleep, which is biologically set.

Sources of Fatigue

In human physiology, fatigue is a general disruption of well-being that has two sources: cumulative sleep loss and disturbance of circadian rhythms (biological activity measured in 24-hour cycles). The word "fatigue" describes weariness, weakness, or sleepiness that produces a temporary loss of power to respond to stimulus or stress. Sleepiness produces defects in decision-making, vigilance, reaction time, memory, coordination, and information - processing, all responses needed for timely and appropriate judgment and action in the aviation environment.

An insufficiency of sleep that may be critical in the aviation environment may have adverse effects in work environments that do not rely so heavily upon split-second judgment. Recent studies (Rosekind, Gander, et al., 1994) indicate that obtaining even one hour less than required sleep can affect waking levels of sleepiness. There are degrees of sleepiness, and the greater the cumulative sleep debt, the more rapid and frequent are intrusions of sleep (called spontaneous episodes of sleep) into wakefulness. Spontaneous episodes of sleep may be very brief, perhaps only seconds, or they may be extended, lasting minutes (Rosekind, 1991). During sleep, the sleeper "disengages perceptually from the external environment, becoming unresponsive to outside information" (Rosekind, 1991). And so spontaneous episodes of sleep, whether brief or extended, pose immediate danger in the aviation environment, making impossible the acuity or rapidity of judgment needed in routine operational settings or during emergency.

Fatigue ensues from disruption of circadian rhythms as well as from loss of sleep. The term "circadian" describes the body's programming for daily cycles of waking and sleep, high and low body temperature, and high and low digestive activity. Cycles of sleep-wakefulness, motor activity, hormonal processes, and body temperature peculiar to each person are biologically set, and so, for example, if one is forced to stay awake during the time normally allotted to sleep, the disruption of the circadian cycle will produce the effects of fatigue.

To perform with optimal alertness, one needs both a sufficiency of sleep and synchrony of sleep: enough sleep at the right time.

For the aviation industry, the critical finding is that no matter the source, cumulative sleep loss or disrupted circadian rhythms, the effects of fatigue remain uniformly destructive: decreased alertness and reaction time and impaired judgment. Research findings indicate that in order to perform with optimal alertness, one needs both a sufficiency of sleep and synchrony of sleep: enough sleep at the right time.

In an article addressed to aviation management, Dinges (1991) comprehensively sets out irreducible principles concerning the relationship between sleep and fatigue in aviation safety:

- The need for sleep appears to be biologically set; it is not easily reduced for any sustained period of time, nor can another activity (such as exercise) substitute for it.
- The amount of sleep obtained will vary with the time of day during which one attempts to sleep and with the amount of accumulated sleep debt. Attempting to sleep during one's biological day (for example, after a night flight) is usually more difficult than attempting to sleep at the preferred circadian phase (during one's regular biological night) for sleep.
- Fatigue that originates in disruption of circadian rhythms degrades one's ability to sustain attention to a task and slows reactions to key signals.
- Fatigue causes accidents. It is a major factor in catastrophes in many industries, including commercial and corporate aviation.

Strategies for Lessening Fatigue: Physiological and Pharmacological

In the history of treatment of fatigue, one can identify two major kinds of strategies for lessening fatigue: physiological and pharmacological. Since physiological mechanisms underlie fatigue, early research in reducing fatigue focused on physiological countermeasures that sought to manage sleep, maximizing time and hours of sleep and promoting circadian adjustment rather than masking effects of sleep debt. These countermeasures are preventive rather than palliative.

Sleep comprises two stages. The first is NREM, for non-rapid eye movement, and the second is called REM, for rapid eye movement. During NREM sleep, heart rate, breathing, and other bodily processes slow. NREM sleep is measured in four stages, with the deeper sleep occurring during stages 3 and 4. REM sleep, however, is associated with an active, dreaming brain and with bursts of rapid eye movements; during REM sleep, the major motor muscles of the body are paralyzed. Over the course of a typical night, NREM and REM sleep repeat a 90-minute cycle, in which 60 minutes of NREM sleep are followed by 30 minutes of REM sleep. Most deep sleep (NREM sleep stages 3 and 4) occurs in the first third of the night; REM periods are shorter early in the night and become longer later in the sleep period (Rosekind, NASA Technical Memorandum, 1994).

Sleeping at the wrong time may be as disruptive as cumulative sleep loss.

Sleep researchers have found that if one is awakened during deep sleep, one may take an extended time to wake up and may continue to feel groggy, perhaps disoriented, for 10 to 15 minutes. This finding has relevance for the timing and duration of naps, for during flight operations that involve irregular work hours, sleeping at the wrong time may be as disruptive as cumulative sleep loss. Adapting to this finding, research physiologists have sought to manage timing and hours of sleep in order to maximize its benefits. The strategies below accommodate physiological realities of the sleep cycle in order to conceal or delay sleepiness. They are to be used at home before a trip or during a layover.

- At home, one should fully rest before a trip so as not to begin a schedule with a sleep debt, which will worsen during the trip.
- During a trip, one should obtain as much sleep during a layover as one would obtain during a normal sleep cycle.
- If one feels sleepy and circumstances permit, one should sleep; if one wakes spontaneously and is unable to return to sleep within 15-30 minutes, one should get out of bed.
- A nap can acutely improve alertness. If one sleeps immediately before a duty period, one should limit sleep to 45 minutes or fewer so that sleep does not reach the period of deep sleep. At other times, one may nap longer. (A nap longer than two hours is likely to take the sleeper through at least one NREM/REM cycle.)
- One should obtain "anchor sleep" during a portion of layover. Anchor sleep is sleep during one's usual home sleep time.
- The sleep environment should be darkened, quiet, of comfortable temperature. Sleep surface should be comfortable.
- One should exercise regularly but not too near bed-

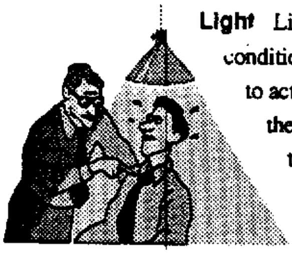
time, for exercise is stimulating, and it is difficult to fall asleep immediately after exercise.

During the first 24 hours of a long trip, proper sleep scheduling is most critical. As a result, one should schedule sleep during this period to conform as closely as possible to the time of one's usual home sleep time, not try to adjust one's sleep to the new time zone.

In addition to physiological strategies, several pharmacological agents that promise to lessen the effects of fatigue have been studied extensively. These agents are:

- light;
- stimulants (caffeine, amphetamines, modafinil);
- depressants (alcohol, benzodiazepines, and imidezopyridines):
- melatonin.

Of these, current interest in melatonin is greatest.

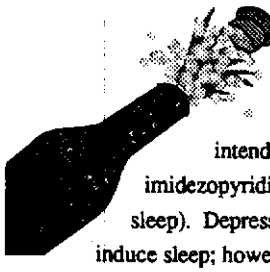


Light Light is an environmental condition that can be manipulated to act as a drug. Research into the role of light in resetting the internal clock arose from the recognition that light/dark cycles are the single most important environmental cue for synchronizing the body's internal clock to the earth's 24-hour cycle (Sack & Lewy, 1993). Research indicates that exposure to bright light produces phase-shifting effects in humans, perhaps tricking the body to believe that night is day. Beneficial effects of this agent are temporary, for this strategy does not address the underlying problem of cumulative sleep debt.

Stimulants. In general, stimulants produce such serious side effects that their use as countermeasures to fatigue should be discouraged. The most commonly used stimulant is caffeine. Familiar and readily available, it is used worldwide to enhance performance and to alleviate effects of sleep loss. However, it has disadvantages. Many persons develop a tolerance to its stimulant effects and require ever larger doses to produce wakefulness, and larger doses are accompanied by anxiety and tremor and have been implicated in the development of cardiovascular disease.

Although amphetamines can counteract fatigue, their unacceptable side effects are well known. Among them are cardiovascular effects such as palpitations and hypertension; central nervous system effects such as restlessness, tremor, hyperactivity, irritability, insomnia, and seizure; and gastrointestinal effects such as nausea, vomiting, and cramps. With prolonged use, acute rebound depression may ensure. Further, although amphetamines clearly produce wakefulness, it is an agitated wakefulness that interferes with coordination and judgment, not a reliable, productive wakefulness.

The stimulant modafinil enhances alertness in persons deprived of sleep without producing the destructive side effects of amphetamines. Originally studied as a treatment for sleep disorders and alcoholic brain syndrome, modafinil works by adrenergic (resembling adrenaline) action. It has been shown to improve daytime vigilance while not interfering with nocturnal sleep. However, its role in the regulation of the circadian cycle is unclear, as are long-term effects.

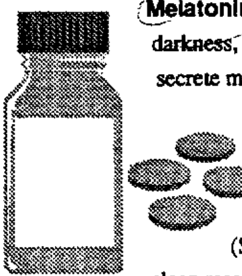


Depressants Depressants are substances that have a sedative action. They include alcohol, benzodiazepines (hypnotics intended to relieve anxiety), and imidezopyridines (hypnotics that induce sleep). Depressants calm anxiety and induce sleep; however, they also suppress mental alertness, and for this reason their use is discouraged among employees in 24-hour operations who must maintain vigilant alertness. In their correct action, they produce the selfsame effects of fatigue that cause accidents in the workplace.

Alcohol produces drunkenness as well as aftereffects that severely impair performance. In any use, it reduces the capability of the brain to use oxygen, impairing the ability to process information quickly. And instead of productively regulating sleep it actually reduces the quality of sleep.

The benzodiazepines (Restoril and Halcion are familiar brand names) are hypnotics that depress the central nervous system to produce drowsiness. They are prescribed to relive insomnia, to treat panic attack, to suppress convulsions, and to reduce anxiety. Shift workers and flight personnel frequently use these agents to produce sleep. The disappointing finding, however, is that they produce sleep but at intolerable cost, for they induce memory loss, rebound insomnia, impaired coordination, and confusionóthe very deficits of performance produced by fatigue.

Zolpidem (Ambien) is an imidezopyridine, a hypnotic that produces weaker anti-convulsant effects and weaker muscle relaxant activity than the benzodiazepines but preserves the deep sleep stages in humans. This fact is important, for it is the deep sleep that is the restorative phase of sleep necessary for the maintenance of many bodily processes. However, this drug can produce memory loss if one wakes up before the effect of the medicine is gone. Other adverse effects may include rebound insomnia, dependence on the drug, and withdrawal symptoms.



Melatonin. At the first falling of darkness, the pineal gland begins to secrete melatonin. "[M]elatonin is essentially a "dark signal" and...melatonin administration can "trick the brain" into thinking it is nighttime" (Sack & Lewy, 1993). Among sleep researchers, it is hoped that melatonin might alleviate winter depression and other major affective (emotional) disorders that are related to asynchrony of the body with the dark/light cycle. Currently, it is believed that controlled oral administration of melatonin can alleviate symptoms of jet-lag and fatigue and help the body readjust when shift work or travel through multiple time zones has disrupted the sleep cycle.

Recent research finds that melatonin may strengthen the immune system and retard aging. Within the past six months, preliminary results in studies of melatonin have suggested that melatonin may delay age-related degenerative diseases and perhaps even prevent cancer, causing sales of melatonin to skyrocket. Early findings indicate that minute doses of melatonin (one-tenth of one milligram) may promote sleep, but consumers who are hoping to benefit from its advertised ability to increase longevity are taking it in megadoses. At present, melatonin is available in over-the-counter packaging of uncertain dosage and uncontrolled manufacturing quality. According to a recent report, researchers analyzed a substance sold by a health food store as melatonin and found that the primary substance was rat dung. A controlled study of sleep, mood, and behavior among police officers working successive night shifts indicates that melatonin does improve sleep and increase alertness during working hours; however, memory scanning speed and perception of mental load are adversely affected. Until further controlled studies yield definitive information and until quality of manufacturing is regulated, consumers should avoid self-medication with over-the-counter formulations of melatonin, no matter how enthusiastically the media portray its benefits.

Implication for the Commercial Aviation Community

The relationship between sleep loss and disrupted circadian cycles and fatigue is a complex one. The consistent finding of sleep research that sleep must be preserved makes it clear that points of entry into the problem of fatigue must take into account this irreducible condition. The way to accommodate this condition and to manage operational task and environment at the same time is to design duty schedules in order to manage duty hours. One might well accept as axiomatic the inference of Nicholson and Stone (1987) in this matter: "Arrangement of the hours of duty provides the foundation of effective management."

What this means is that careful consideration must be given to the interaction of length of duty and time of day. Since the irreducible condition that sleep must be preserved does not change, schedulers must manipulate operational tasks and environmental factors in promoting restedness and alertness. Pharmacological intervention can temporarily trick the body into wakefulness, but the drugs intended to avert or control fatigue produce the same deficits of behavior of fatigue that they were designed to manage and some dangerous side effects as well.

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附件七

DETERMINATION OF MAINTENANCE PROGRAM, DESIGN AND JUSTIFICATION OF REPAIRS FOR PRIMARY COMPOSITE STRUCTURES

by Alain TROPIS
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AEROSPATIALE

ABSTRACT :

The introduction into service of primary composite structure led Aérospatiale to develop improved method for the determination of maintenance program and for design and justification of repairs.

This paper presents :

- the requirements concerning the definition and substantiation of the inspection program for composite structures and Aérospatiale associated probabilistic method used for the ATR72 outer wing. In this method, accidental damages are considered in relation not only with the static strength reduction of the element consecutive to this damage, but also with its probability of occurence and its probability of detection. Thus, the inspection program can be determined in order to limit the probability of failure to a value lower than 10^{-9} per flight hour.
- the repair processes developped for monolithic primary structures which fulfill Airworthiness requirements that is, reestablish the structural integrity of the component which, in addition to required mechanical strength, protection against corrosion and lightning strikes, must be achievable by the airlines in typical maintenance conditions.

I - INTRODUCTION

The ATR72 is the first civil transport aircraft of such a size, equipped in its basic definition with a C.F.R.P outer wing (figure 1), to have been certified by the French D.G.A.C. and the American F.A.A.
This document presents the requirements concerning the selection of inspection intervals for a composite structure and the Aerospatiale associated approach. This method developped in 1989 for the certification of the outer wing of the ATR72 (reference 1) allows to define the inspection program and to determine the residual strength to be demonstrated in case of a visible impact damage .

Furthermore, its entry into service in 1989 led Aerospatiale to develop, with the ATR product support, repair procedures fo the carbon primary structure that met the regulatory requirements and could be performed by the airlines in typical maintenace conditions.

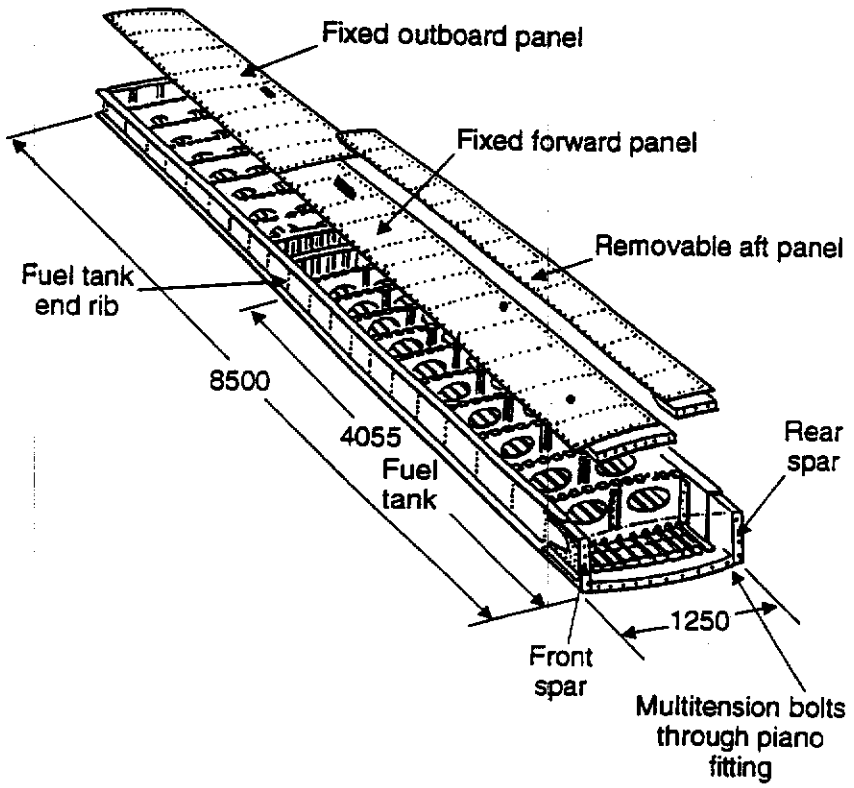


Figure 1 : ATR72 outer wing box

II - DETERMINATION OF MAINTENANCE PROGRAM

II - 1 REQUIREMENTS

AC20.107A and ACJ 25603 in paragraph 6.2.4 requires :
"An inspection program should be developed consisting of frequency, extent, and methods of inspection for inclusion in the maintenance plan. Inspection intervals should be established such that the damage will be detected between the time it becomes detectable and the time at which the extent of damages reaches the limit for required residual strength capability. For the case of no-growth concept, inspection intervals should be established as part of the maintenance programme. In selecting such intervals the residual strength level associated with the assumed damage should be considered".
The reason of this requirement is well explained in reference 2 document. In fact, if no damage propagates and if its size never reachs a critical size, the damage tolerance assumption is always met. However the figure 2 (issued from reference 2) shows that with such an assumption the composite structure without particular inspection interval analysis should be less safe than metallic ones.

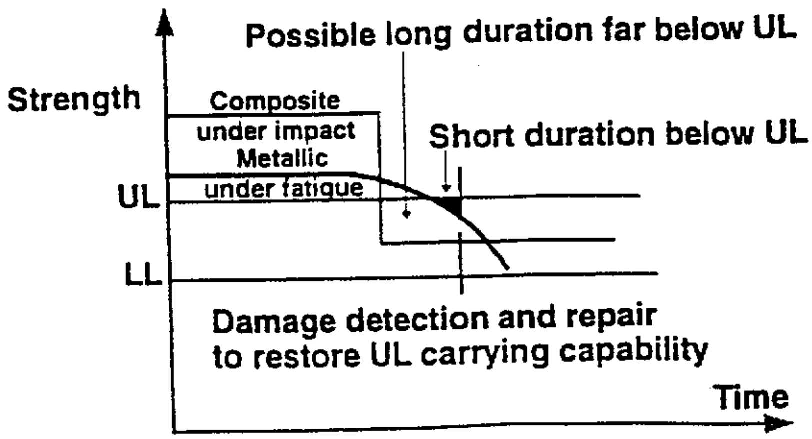


Figure 2 : Damage tolerance philosophy

To perform this analysis, three sources of damages should be taken into account :

- fatigue
- corrosion
- accidental damage

For fatigue damage, even if composite materials with thermoset resin system are insensitive to fatigue (for in plane stresses and spectrum representative of a civil aircraft), a substantiation by a full-scale test is required particularly in Europe to demonstrate that with the selected design, the structure does not contain any "perverse design defect" i.e design details which, associated with selected materials, would favour the development of fatigue damage. In case of previous experience with the same design and the same level of strain, the substantiation can be made by analysis and comparison with the previously substantiated element.
For corrosion, if special care has been taken during design to prevent galvanic corrosion, this kind of damage does not need special inspection task.
Remain only accidental damage such as low velocity impacts that can occur and induce a reduction of the structure strength capability during the aircraft life. To determine the inspection interval, accidental damages have to be considered in relation not only with the static strength reduction of the element consecutive to this damage, but also with its probability of occurrence (for example the upper skin has not the same probability of tool drop occurrence than the lower skin) .
This approach induces the knowledge of the probability of occurrence of each accidental damage source.

Two main approaches are then workable :

- one, agreed by the Airworthiness Authorities, with a classification of the probability of occurrence of damages associated with the inspection interval and the level of load to be sustained.

DAMAGE	PROBABILITY OF OCCURENCE /FLIGHT HOURS	DETECTION	LEVEL OF LOAD TO BE SUBSTANTIATED
Non visible up to barely visible impact damage	1	NO	Ultimate loads
Visible impact damage	$10^{-5}<p<1$	During 1C/2C/4-5 years inspection	k x Limit loads $1<k<1,5$
Obvious damage	$p< 10^{-5}$	Prior to the next flight	>0,7 Limit loads

- the second approach, developed by Aerospatiale for the ATR72 outer wing box certification in 1989 (in accordance with Airworthiness Authorities who require "a probabilistic approach for the definition of the inspection program.."), is a probabilistic analysis for which the failure probability (allowable value equal to 10^{-9} per flight hour) is the probability of the aircraft to encounter loads exceeding the residual strength capability of the damaged structure.

II - 2 HYPOTHESES AND PRINCIPLE OF AEROSPATIALE METHOD

The hypotheses and the mathematical principle of Aerospatiale method are :

- The damages are the results of impact occuring during the aircraft use and maintenance operations ;
- According to the material used, the fatigue load level and the design, no propagation of damage (manufacturing or accidental damages) is contemplated ;
- The risk of failure is a function of (cf sheet 1) :
  * The probability of occurence of a damage size "at" (Pat)
  * The probability to encounter a load exceeding the residual strength capability with this damage size "at" (Pr at)
  * The probability to detect the damage (Pd at)

This function is calculated with all the values of the distribution

$$\int \text{Pat} \times \text{Prat} \times (1 - \text{Pdat})$$

- The methods and intervals of inspection are selected in order to limit this probability of failure to a value lower than 10-9 per flight hour (by cumulating all the damages types considered in the analysis)

Each part of this risk formula are now being detailed.

II - 2 - 1 Probability of occurence of a damage of size "at" : Pat

The determination of this probability is the main difficulty of this study because of the lack of data. The Aerospatiale method is based on an approach proposed by SIKORSKY (reference 3).

In this document, probabilities of occurence of damages have been defined for an helicopter considering that the impacts are the results of in service or maintenance actions.

In the Sikorsky study, these probabilities are defined as a function of :

- the exposure rate : i.e. in case of maintenance impact : exposure rate = maintenance interval/10,000 flight hours;

- the impact/exposure ratio i.e. the sensibiliy of an area to a source of damage. Four families have been defined :

* low risk	rate = 1 impact for 100 exposures
* moderate risk	rate = 1 impact for 50 exposures
* moderately high risk	rate = 1 impact for 25 exposures
* high risk	rate = 1 impact for 10 exposures

- the damage severity i.e. the energy and its associated probability.

Eleven impact hazards have been selected (cf sheet 2) such as dropped tool impact, foot traffic impact, edge and corner impact (dropped pannel, etc...

For each source of damage, a maximum energy level that should not be exceeded in 99% of the cases (E_{99}) has been estimated according to realistic incident in service.

Two others hypotheses have been made by Sikorsky :

- the distribution of impact energy is assumed to be a log normal law ;

- The energy E_1 of an impact that will be exceeded in 99% of the cases is assumed to be 10% E_{99} (energy exceeded in 1% of the case).

Aerospatiale application of this study has been the following:

The previously described analysis is specific for the type of aircraft, the concerned part (fuselage, wing,..) and to the in service/maintenance actions planned.

So, a specific analysis has to be performed for each new component with the Product Support, in order to define a "remote event" . By analogy with the system failure rate, this damage is assumed to have a probability (including the impact/exposure rate) of 10^{-5} per flight hour (frontier between reasonably probable and remote).

For exemple, for the ATR72 outer wing (reference 5), four impact hazards have been selected, tool drop, removable element drop, man on the wing and impact to a corner or an edge due to maintenance equipment.

To define the statistical law of these events, a constant standard deviation (0,217-based on the Sikorsky hypothesis) has been choosen.

Since the aim is to determine the probability of occurence of a size of damage rather than of an energy, the relationship between the energy level (E) and the associated damage size (Sd) has been defined with conservative assumptions. This has been obtained through tests, at various levels from coupons up to the full scale specimen, with considerations like thickness (t), rib, stiffener pitches (a, b), modulus (E), etc… .

$$Sd = f(E, t, a, b)$$

These tests have also allowed to relate the damage size (and the energy) to an associated indentation parameter (f) (relevant parameter for the detectability of the damage)

$$f = g(E, t, a, b)$$

II - 2 - 2 Probability of occurence of a load level higher than the residual strength capability of the structure with a damage "at"

* Residual strength/damage size relationship

Tests have been performed on coupons, elementary specimens and integrally stiffened panels in order to define the curve "B value compressive strain versus delaminated area" :

$$\varepsilon = f \text{ (delaminated area)}$$

From tests performed in compression/shear and pure shear, a curve has been plotted and allows to define a coefficient applied to the pure compression characteristics in order to simulate the realistic behaviour of compression/shear residual strength versus the delamination size.

* Probability of occurence of a load level

For gusts, the probability of having limit loads is 2.10^{-5} per flight hour (fh).

The probability of having ultimate loads is 2.10^{-9}/fh .

On the basis of these 2 values, a law of probability of occurence of a load level per flight has been defined by its mean value and its standard deviation.

By combination of the above informations, knowing the size of a damage "at", the probability of a load higher than the residual strength capability of the inspected structure can be defined : Prat.

II- 2 - 3 Probability to detect a damage of a size "at" : Pdat

For composite structures, Aérospatiale elected not to use complex non destructive testing method, so the 3 considered methods of inspection are :

	VALUE OF DETECTABLE INDENTATION	
Inspection method	Mean value	"A*" value
Visual (at a distance of 2 meters)	2 mm	= panel thickness
External detailed visual (at around 0,5 meter on a cleaned structure)	0,3 mm **	0,5 mm
Internal detailed visual (inspection during panel removal)	0,1 mm***	0,2 mm

These values and the statistical distribution have been defined on the basis of experimental evidence and with the use of a high safety factor (for the external detailed inspection, tests have been performed with 13 operators, 82 panels painted or not and 120 impacts of different indentation - reference 4).

Note :

* "A" value : value with a probability of 99% and a confidence of 95%

** Due to the evolution of dent depth during the aircraft life due to ageing, fatigue loading, viscoelasticity of the resin, the initial dent depth at the time of impact for the materials used by Aérospatiale must be 1 mm to get 0,3 mm at the end of the aircraft life.

*** Internal detection is linked to fiber breakage on the inner side of the impacted panel

II - 3 APPLICATION TO THE ATR72 OUTER WING (reference 5)

Different areas of the wing have been defined in order to perform a specific analysis of risk of failure for each area damaged by an impact. This sharing allows to have different parameters between areas such as ultimate strain, inspection methods and intervals, probability of occurence of the damage, etc…

For the ATR72 outer wing, the upper panel is divided in 3 areas, the lower one in 2 areas at the front and the rear spars.

The risk obtained in each zone for one type of hazard is added to the ones obtained for the other hazards in order to define an overall risk for the structure.

The failure risk for one source of damage has the following general form :

$$\mathbf{Pfailure} = \int_{Acp}^{Acq} \mathbf{Pat} \times \mathbf{Prat} \times \sum_{m=1}^{ERL} f(1 - \mathbf{Pdat}, \mathbf{It})\, dt$$

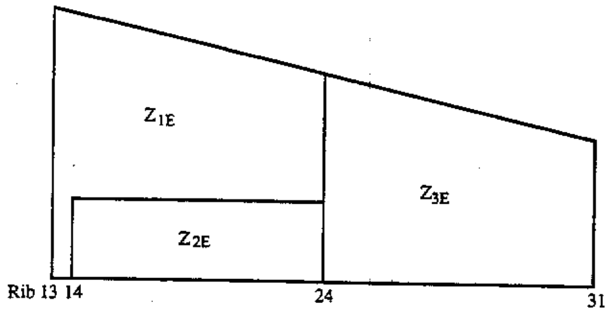
↑ Summation along various damage sizes contributing to the risk

↑ Probability to not detect the damage

↑ Inspection intervals along the Economic Repair life

Applied for example to ATR72 outer wing upper skin this lead to the following inspection programm (only based on visual inspection) and risk associated :

	Rapid visual	External detailed	Internal detailed
Z_{1E}	1250 fh	8000 fh	16 000 fh
Z_{2E}	1250 fh	8000 fh	16 000 fh
Z_{3E}	2000 fh	16 000 fh	/



Considering tool drop, drop of removable parts, foot traffic impact and maintenance component impact, the cumulated risk of failure in area Z1E which is the most critical of the ATR72 outer wing is $1.35.10^{-10}$ per flight hour which is lower than the required level of 1.10^{-9}/fh. This demonstrate that the methods and inspection intervals defined are acceptable.

Note : Due to the lack of data on the different scenario of impacts, Aiworthiness Authorities have required to increase the mean energy value and its probability by a coefficient 2 to determine its sensitivity on the cumulated risk of failure and hence the "permissible error" on this data.

II - 4 - DETERMINATION OF THE LOAD LEVEL TO BE SUSTAINED BY THE STRUCTURE DAMAGED BY A VISIBLE IMPACT DAMAGE

On an other hand, the load level to be substantiated with a V.I.D (Visible Impact Damage) could be obtained through a special use of this probabilistic method as follow :

- Identification of the critical zone for the visible impact damage, i.e most critical area of the panel which could be perforated in the range of the energy considered (E maximum equal to cut-off energy).
- Calculation of the cumulative risk obtained in this area taking into account the methods of inspections and the inspection interval.
- The risk is then "brought back" to the objective value (Prisk object = 10^{-9}/fh) by modification of Prat.

As it has been defined above :

$$Re = Pat \times Prat \times f\,(1 - Pdat)$$

with

Pat : Probability of occurence of a damage At

Pdat : Probability to detect the damage At

Prat : Probability of occurence of load higher than the residual strength with a damage "at"

Pat is fixed by the considered part and its defined damage scenari, Pdat by the method and inspection program. Hence it will be Prat value that will allow to increase the failure risk.

The following relation can be written :

$$p_k/Robj = P_{U.L}/Re$$

with :

p_k = probability to have a load level equal to k x L.L

R obj = objective risk = 10-9/fh

$P_{U.L}$= probability of having ultimate load = 10-9/fh

Re = calculated risk for the considered area (Re ≤ 1 X 10-9/fh)

This formula defines the relation between the risk obtained in the area damaged by a visible impact damage and the load level to be sustained. The results are shown in the figure 3.

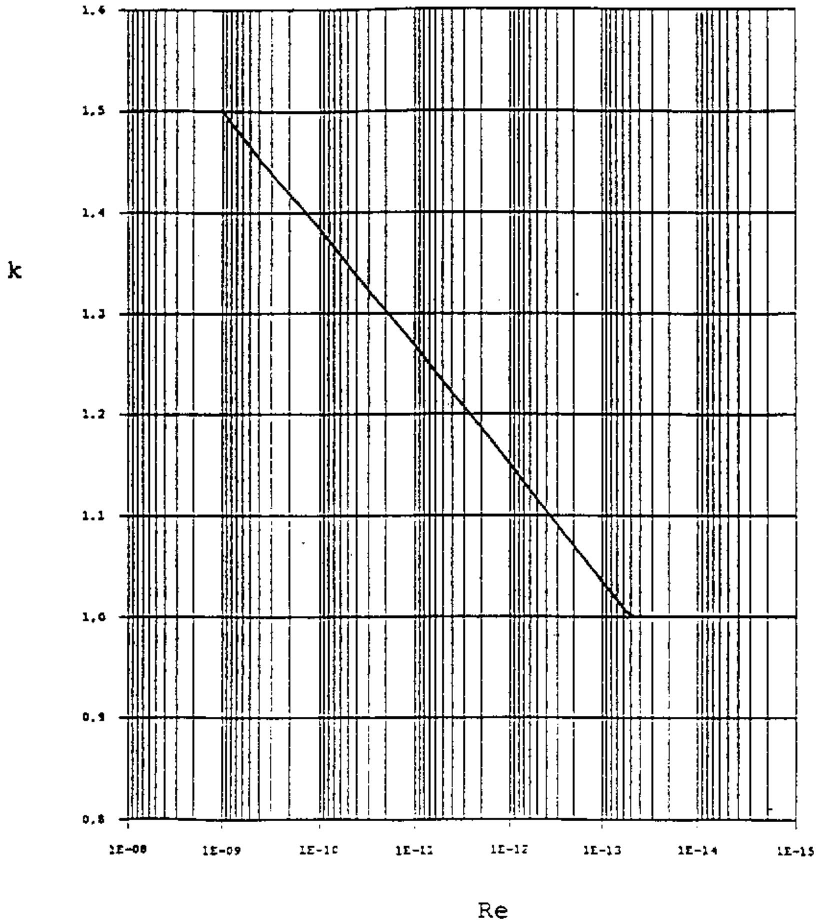


Figure 3 : Level of load to be substantiated with a V.I.D.

For example for a calculated risk of 2×10^{-11} per flight hour, the level to be sustained with a visible impact damage (V.I.D) is 1.30 Limit load.

III - REPAIR DEFINITION AND JUSTIFICATION PRINCIPLE

The entry into service of monolithic primary structure which acts as fuel tank, such as the ATR72 outer wing in 1989, led Aérospatiale to define repairs that meet the regulatory requirements, i.e reestablish the structural integrity of the repaired component in terms of mechanical strength, protection against corrosion and lightning strikes,and that must be achievable in typical maintenance conditions.

The following principle was therefore applied :

Damage with residual strength greater or equal than ultimate loads	"Cosmetic" repair : - sealing (resin), - bonded wet lay-up repair.
Damage with residual strength lower than ultimate loads	Structural repair : * Damage to skin : - temporary repair by bolted metalic plate ; - definitive repair by riveted carbon patches. * Damage to skin + stiffener : - dual-face doubler made of aluminium sheet. This repair imposing panel removal is outside the scope of the Structural Repair Manual.

This document will therefore deal with the structural repairs included in the ATR72 Structural Repair Manual, and their justification by means of corrosion, lightning strike and mechanical tests and calculations.

III - 1 CORROSION

In order to define a corrosion-proof repair principle, various types of doubler (aluminium, stainless steel, carbon) associated with several protection methods (glass fabric, alodine, bronze mesh, painting, etc...) were tested on detail specimens subjected to salt spray tests and natural adverse weather conditions in an urban environment. In addition, an electrical bonding check was conducted between the repair and the basic carbon panel for all configurations tested.

On the basis of these findings, two structural repair principles were selected :

- for temporary repair, the solution consists of a light alloy doubler protected by alodine . This definition allows to have an acceptable compromize between correct electrical bonding and protection of the metal against galvanic corrosion.

- for definitive repair, a solution consisting of riveted precured carbon patches was chosen. As, in this case, the material of the original panel and the doubler are the same, there will be no galvanic coupling problems.

III - 2 LIGHTNING

Justification tests on the lightning behaviour of the repair principles, both cosmetic (wet lay-up) and structural (solutions within and outside the scope of the Structural Repair Manual), were conducted on a test box structure representative of the ATR72 outer wing thus allowing a realistic assessment of the damage and the sparking associated with the lightning stike to be obtained.

The tests were conducted in compliance with the regulatory requirements of Advisory Circular AC20.53 A dated 12.04.85 and a complete check was performed during and after lightning strike.
The fuel area repair solutions selected subsequent to the corrosion tests (anodized aluminium alloy doubler with inserted bronze mesh, carbon modules covered by bronze mesh) use exterior doublers attached to the wing box panel by blind rivets. Although the rivet tails are not protected, the results demonstrate the validity of the principles retained to the direct and indirect effects of lightning as no sparking or damage to the repairs or the panels occured.

III - 3 CALCULATION METHOD

The mechanical validation of the structural repair solutions retained was achieved via tests on subassemblies with the aim of validating the chosen calculation methods then by making two typical repairs on the fatigue and damage tolerance test wing, one temporary (metalic doubler), the other definitive (precured carbon module doubler cf figure 4) as described in the Structural Repair Manual.

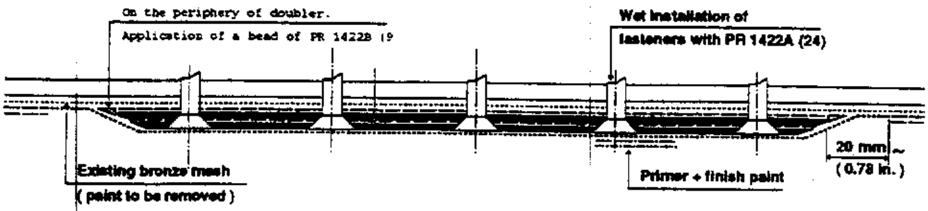


Figure 4 : Definitive repair by precured carbon modules

III - 3 - 1 Calculation method

In order to meet the dimensioning criteria for a wing-type primary structure bolted repair, the calculation method developed and programmed on the microcomputer allows :

- the mechanical loads passing through each repair fastener and, therefore, the doubler, to be determined considering the normal load and shear load contributions and, for metallic repair cases, the thermal effects ;
- the mechanical strength of the wing panel and the repair to be calculated (strength a fastener holes and bearing strength) ;
- the shear strength of the rivets to be checked ;
- the strain at location of damage after repair to be determined ;
- the buckling strength of the structure thus repaired to be determined taking possible local buckling of the panel, variations in rigidity and offset of the neutral line due to the repair, into account ;

and therefore to validate the repair by finding the minimum margin after repair.

III - 3 - 2 Validation of the analytical approach by tests

Mechanical tests on sub-components (integrally-stiffened panels) were conducted in tension and compression. This specimens were tested under the following conditons :

- a wet aging phase,
- ondulating fatigue,
- a residual test at hot temperature.

Comparison between the test results and the values forecast by calculations validates the analytical program. This program was used to determine the rupture mode and the failure level. Also, these tests validate the definition of the principles selected both for the temporary repairs and for the definitive repairs .

Furthermore, a fatigue-damage tolerance justification test was conducted on a complete outer wing with damages and repairs corresponding to those identified in the Structural Repair Manual.
All these tests on the fatigue-damage tolerance test wing were conducted without the least incident with good correlation between calculations and tests justifying, in addition to the subassembly test approach, the validity of the selected repair principles and the analytical microcomputer calculation program developed.

IV - STRUCTURAL REPAIR MANUAL

For the Structural Repair Manual, the approach consisted in making the type of repairs as consistent as possible so that each type of repair was applicable to the greatest possible number of wing areas. This led to the mapping of the wing defining the repair to be applied for a family of areas and size of damage. (Figures 5 and 6).

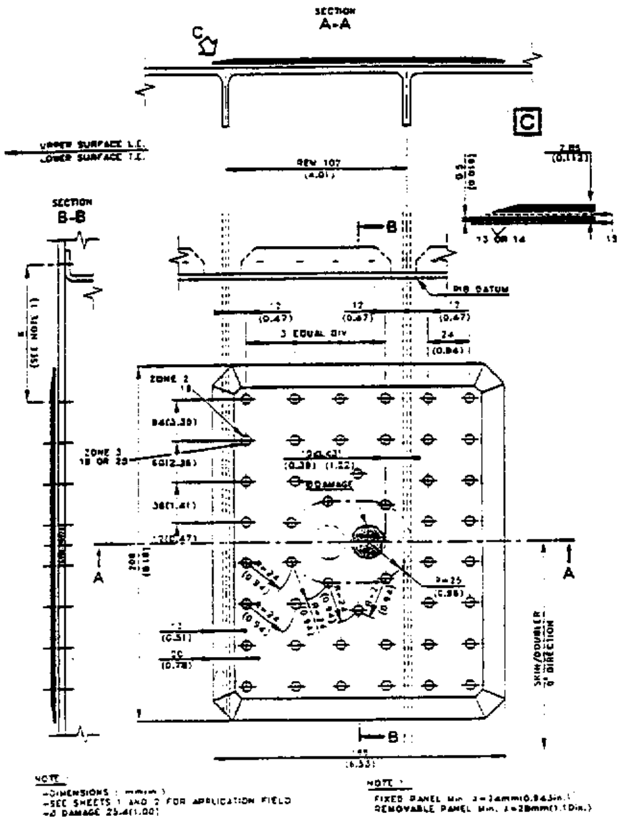


Figure 5: Definition of "D5" repair for damage of diameter lower than or equal to 1 inch

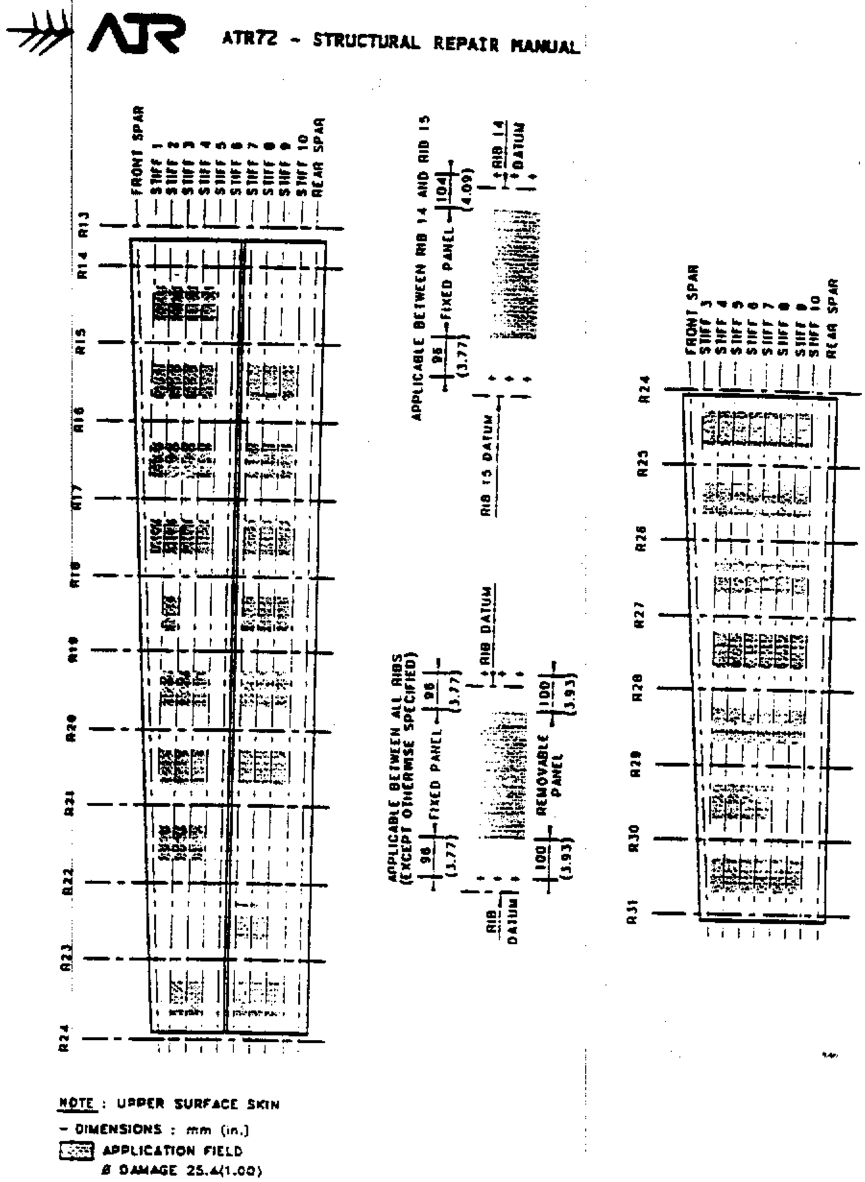


Figure 6 : "D5" repair application areas for upper panel

V - CONCLUSION

The entry into revenue service of the ATR72 in 1989 with a composite outer wing led Aerospatiale to develop improved method for the determination of maintenance program and for design and justification of the repairs.

The maintenance program method developped in 1989 for the certification of the CFRP outer wing of the ATR72 and used for the A330/A340 ailerons and landing gear doors allows to define the inspection program and to determine the residual strength to be demonstrated in case of a visible impact damage.
This approach is a probabilistic one, in accordance with Airworthiness Authorites requirement, for which the failure probability (allowable value equal to 10^{-9} per flight hour) is the probability for the aircraft to encounter loads exceeding the residual strength capability of the damaged structure.
Furthermore, repair principles have been defined meeting both the regulatory requirements in terms of lightning, corrosion and mechanical strength, and the requests made by the airlines to perform the repairs under typical maintenance conditions without inducing specific difficulties due to the introduction of a carbon primary structure.

VI - REFERENCES

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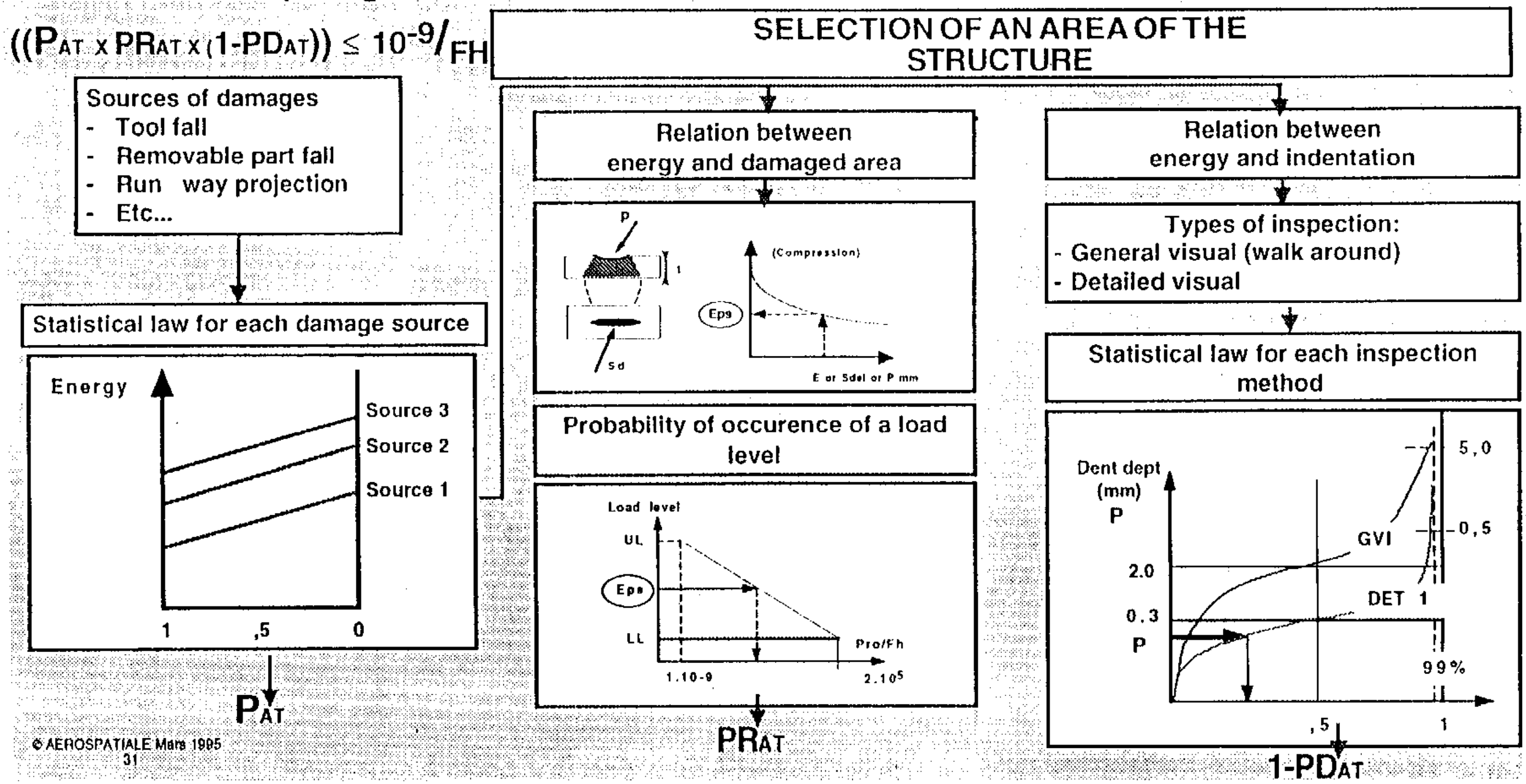
by Aerospatiale Aircraft Division dated 26th september 1991

5 : " Inspection program for the ATR72 outer wing"
by A. TROPIS
Aerospatiale dossier n°22//S.002.10508 issue 3

6 : "Composite or metallic bolted repairs on self-stiffened carbon wing panel of the commuter ATR72"
by A. TROPIS
A.G.A.R.D 1994 in Sevilla (Spain)

Statistical analysis based on the estimation of the risk of failure of a component damaged by an impact.
The interval inspection and check methods should be defined such that this cumulated failure risk be lower than 10^{-9} per flight hour

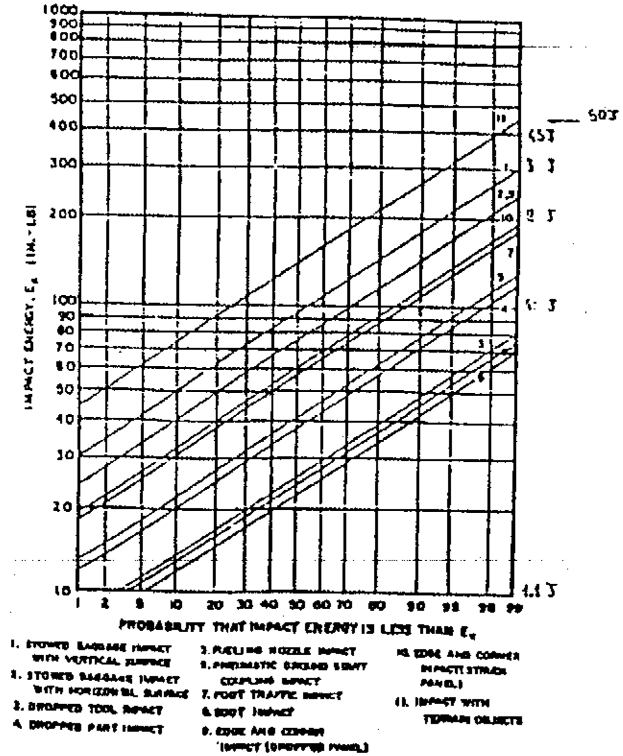
$$((P_{AT} \times PR_{AT} \times (1-PD_{AT})) \leq 10^{-9}/_{FH}$$



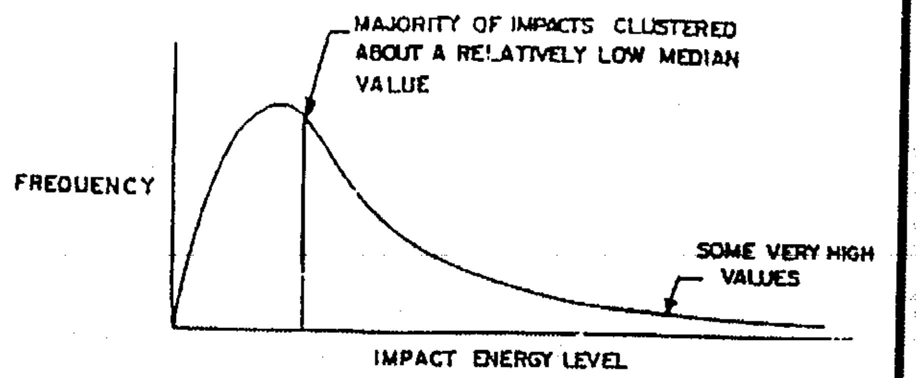
USA AVRAD COM TR80 D 16 AD A0877609

"Advanced Structures Maintenance concept"

Sikorsky Aircraft Division June 1980



Estimated Impact Energy Distributions for 11 Impact Hazards



Assumed Shape of Impact Energy Distributions

附件八

A Summary of the Use and Impact of the Maintenance Error Decision Aid (MEDA) on the Commercial Aviation Industry

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Introduction

While human error has existed since the beginning of mankind, only in the last 50 years has it been the subject of scientific inquiry. Concerns during and immediately following World War II regarding errors in human performance related to, among other things, pilot selection and training, information presentation and related control action, vigilance, and workspace arrangement served as the basis for the first studies in the field that was eventually called human factors. For example, Fitts and Jones (1947) examined 460 pilot error incidents for the Air Force. More recently, Singleton (1973) discussed theoretical approaches to examining human error.

However, major interest in the concept of human error began following the Three Mile Island (TMI) nuclear power plant accident in the spring of 1979. According to Woods et al. (1995), the cross-disciplinary national and international scrutiny of human error began with the "clambake" conference on human error in Columbia Falls, Maine, in 1980 and with the publications on slips and lapses by Norman (1981) and Reason and Mycielska (1982). In addition, work in the area of human reliability, for example, by Swain and Guttman (1983) and Swain (1987), began in the late 1970s and accelerated following TMI (see Gertman and Blackman, 1994). More recently, human error has been evaluated as to its relationship with commercial aircraft accidents (see Boeing, 1993).

Swain and Guttman (1983) define human error as "any member of a set of human actions that exceeds some limit of acceptability (page 2-7)." Similarly, Lorenzo (1990) defines human error as "any human action (or lack thereof) that exceeds the tolerances defined by the system with which the human interacts (page 3)." Reason (1990) says that "Error will be taken as a generic term to encompass all those occasions in which a planned sequence of mental or physical activities fails to achieve its intended outcome, and when these failures cannot be attributed to the intervention of some chance agency." For purposes of studying maintenance human error, we have defined maintenance error as an unexpected aircraft discrepancy (physical degradation or failure) attributable to, or facilitated by, the actions of an aircraft maintenance technician (Graeber and Marx, 1993).

Much of the work on human error since 1970 has focused on estimating the costs of human error, estimating the contribution of human error to accidents/incidents, cataloging types of human error, analyzing the factors that lead to errors, and developing strategies to prevent human error or minimize the effects of human error.

For example, in 1992, the United Kingdom Civil Aviation Authority (UK CAA, 1992) released a study on the top eight maintenance problems affecting aircraft over 5,700 kg. in weight. These problems were:

1. Incorrect installation of components
2. The fitting of wrong parts
3. Electrical wiring discrepancies
4. Loose objects (tools, etc.) left in the aircraft
5. Inadequate lubrication
6. Cowlings, access panels, and fairings not secured
7. Fuel/oil caps and refuel panels not secured
8. Landing gear ground lock pins not removed before departure

A more recent Boeing (1995) report, which analyzed in great detail the relationship of maintenance error to aircraft accidents, found that 15% (39 of 264) of accidents from 1982 through 1991 had maintenance as a contributing factor. More specifically, 23% of the 39 accidents had removal/installation as a contributing factor, 28% had the manufacturers or vendor maintenance or inspection program as a contributing factor, 49% had the airline's maintenance or inspection program policy as a contributing factor, and 49% had design as a contributing factor. Other important contributing factors included: manufacturer/vendor service bulletins and in-service communication (21%), airline service bulletin incorporation (21%), and missed discrepancy (15%).

Cataloging the different types of errors has also received much investigation. At a basic level there are two types of human errors--unintentional and intentional (Swain and Guttman, 1983; Lorenzo, 1990). Intentional errors are done "on purpose" because the operator believes that what he/she is doing is correct, so that when the action is taken, an error occurs. These would be called mistakes in Reason's (1990) terminology. Unintentional errors are committed without prior thought and are typically thought of as accidents, or, in Norman's (1981) terms, action slips.

Another common error dichotomy is classifying errors as errors of commission or errors of omission (see, for instance, Swain and Guttman, 1983). An error of commission is an act that is carried out incorrectly (e.g., incorrect reinstallation of a valve), while an error of omission is an act that should have been carried out, but was not (e.g., forgetting to install O-ring seals on a chip detector).

Reason (1990) has by far the most extensive categorization of types of errors. First, he distinguishes between failures of execution (slips, lapses, trips, and fumbles) and planning or problem-solving failures (mistakes). A second distinction that he makes is between errors and violations. Violations are typically intended deviations from safe operating practices, procedures, standards, or rules. Violations are typically due to motivational problems, occur in a regulated social context, and require motivational and/or organizational remedies. His third distinction is between active and latent failures. Active failures are unsafe acts that typically have immediate consequences. Latent failures are created as a result of organizational decisions (regarding, for instance, staffing levels, expectations regarding the use of procedures, and decisions regarding training) whose negative consequences typically lay dormant for some period of time and only become evident when combined with local environmental conditions. For example, understaffing is a latent failure when it contributes to a repair failure due to insufficient manpower.

Even with agreement that intentional malevolent behavior should not be included in the study of human error, the phrase "human error" still carries negative connotations - connotations that can hinder the in-depth study of the causes of error and error management (e.g., Woods et al., 1995; Reason, 1990; Lorenzo, 1990). This is because most people make attributions to the causes of human error, and those attributions most often are related to the person rather than to the environment. For example, most people believe that others make mistakes because they are (attributed to be) lazy, stupid, careless, etc. [Interestingly, however, most people would attribute the cause of an error they made to others or the environment--I was being rushed, the lighting was poor, etc.] Reason (1990) discusses this phenomenon as the "blame cycle." He believes that we attribute blame to people and not situations because of the Western culture's illusion of free will and ability to determine one's own destiny. He feels that we can only break out of the blame cycle if we:

- Recognize that human performance is shaped by the situation or environment
- Recognize that it is hard for people not to do something that they did not intend to do in the first place
- Recognize that errors have multiple contributing factors
- Recognize that situations are often more easy to change than people.

Woods et al. (1995) are also concerned about the prejudicial effect that comes from labeling a cause of an accident as human error. One reason is that saying that an accident was due to human error is often seen as the causal explanation for the accident. It can restrict the true investigation that should occur, which is to determine what the interaction was between the person, the equipment, and other situational variables that lead to the error.

These situational variables that contribute to the error have also received much investigation, especially by those working in the HRA (human reliability assessment) and PRA (probabilistic risk assessment) field. Thus, it is not surprising that Swain and Guttman (1983) have an in-depth list of these variables, which they call performance shaping factors (PSFs). They distinguish among these types of PSFs. External PSFs include situational characteristics (e.g., heat, lighting, supervision, and shift rotation), job and task instructions (e.g., procedures and shop practices), and task and equipment characteristics (e.g., task complexity and human machine interface issues). (Examples of internal PSFs include previous training/experience, intelligence, and motivation. Stressor PSFs include psychological stressors (e.g., task speed, monotony, and distraction), and physiological stressors (e.g., fatigue, pain, and disruption of circadian rhythm). Swain has estimated (see Lorenzo, 1990) that only 15-20% of workplace errors are caused by internal PSFs, while the remaining 80-85% are primarily caused by external PSFs and stressor PSFs, many of which are directly under management control.

The important thing about PSFs within the HRA/PRA framework is that they are seen as contributing to the cause of the human error. Thus, the concept of PSFs can be used to help break the "blame cycle" as discussed by Reason (1990). An obvious second important aspect of PSFs is that they help indicate where changes are needed to reduce human error.

Thus, it is not surprising that the concept of PSFs is used as a basis of error reduction programs. For instance, Lorenzo (1990) lists the Swain and Guttman (1983) PSFs, and then discusses many of them point-by-point as to how to enhance a PSF in order to minimize human error. As another example, McDonald and White (McDonald, 1995; White, 1995a; White, 1995b) looked at the PSFs that lead to airport ramp accidents/incidents and developed a ramp safety program based on changes to the PSFs that lead to the accidents/incidents.

As implied earlier, the study of human errors occurring in aircraft maintenance is still in its infancy. Data now exist to show that maintenance error is a contributing factor in aircraft accidents/incidents. There are also some data to indicate what types of errors are occurring. However, what is now needed with regard to maintenance human error is to collect empirical data on the types of errors that are occurring, their consequences, the PSFs that contribute to that error, and corrective action strategies for preventing future errors due to the same PSFs. That is the purpose of the Maintenance Error Decision Aid (MEDA).

<u>The MEDA Tool</u>

MEDA was developed over a two-year period by a team of airline representatives, regulators, and Boeing maintenance human factors personnel. The objectives of MEDA are to:

- Give commercial airline maintenance organizations a better understanding of how human performance issues contribute to maintenance error
- Provide line-level and organizational maintenance personnel a standardized methodology for analyzing maintenance error
- Identify maintenance system deficiencies that increase exposure to error and decrease system efficiency
- Provide a means of error trend analysis for the commercial airline maintenance organizations.

The MEDA tool consists of the Results Form (a paper tool used in the error investigation), a User's Guide to facilitate the investigation process, and Supplemental Assessment Information to facilitate the use of the Results Form. The Results Form consists of five major sections:
1) General, 2) Events, 3) Maintenance Error, 4) Contributing Factors, and 5) Corrective Actions.

The General section asks for information about the aircraft, the airline, the analyst, and where and when the incident occurred. The Event section asks for the type of event that triggered the MEDA investigations. Events include flight delay, flight cancellation, gate return, in-flight shut down, air-turn-back, aircraft damage, injury, diversion, and rework. The Maintenance Error sections asks the investigator to check the one type of maintenance error that caused the incident. The major categories of error, which are broken into sub-categories, include improper installation, improper servicing, improper/incomplete repair, improper fault isolation/inspection/testing, foreign object damage, surrounding equipment damage, and personal injury.

The Contributing Factors section is used to help guide the analyst to think about what factors affected technician performance resulting in a maintenance error. There are ten major categories of contributing factors, and each category has several examples in checklist format. The major categories include: information. equipment/tools/parts, airplane design/configuration, job/task, technical knowledge/skills, factors affecting individual performance, environment/facilities, organizational environment issues, leadership/supervision, and communication issues.

The Corrective Actions section includes three sub-sections. The first sub-section asks whether existing maintenance procedures, inspection or functional checks, maintenance documentation, supporting documentation, or company maintenance policies were intended to prevent the error but didn't, and how this could be resolved. The second and third sub-sections ask, respectively, for local corrective actions and other corrective actions that can be taken.

Field Test Evaluation

There was a desire to evaluate the MEDA tool and process before beginning full implementation at customer airlines. It was decided that the best method for evaluation was to have a subset of airlines use the tool and then provide feedback on how it might be improved. Eight domestic and international air carriers and one repair station agreed to participate in the Field Test. The Field Test training and evaluation were carried out under FAA contract over a period of eight months from November, 1994, to July, 1995 (see Allen and Rankin, 1995). Employees from these organizations were trained to use the MEDA process in a 3 to 8 hour training session, which included a case study exercise.

Three methods were used to collect Field Test evaluation data. First, five questionnaires were filled out by participating personnel regarding work environment, causes of maintenance error, and perception of error investigations. A Field Test Survey was filled out by MEDA trainees prior to the training class; a MEDA investigator filled out the Tool Survey after doing a case study in training or after doing their first MEDA investigation; the erring technician, if part of the investigation, filled out a Subject Survey following the MEDA investigation; a Management Survey was filled out by airline maintenance management at the end of the Field Test; and MEDA trained investigators filled out a Field Test Follow-up Survey at the end of the Field Test.

Second, the nine participating organizations used the MEDA Results Forms to investigate maintenance error event occurrences. Seventy-four completed Results Forms were sent to Boeing for analysis during the data collection period. Examples of the types of events included in-flight shutdowns (IFSDs), air-turn-backs, ground returns and significant delays. Data from completed Results Forms were analyzed to determine the types of events that were being investigated by the Field Test participants, what the error was that led to the event, what the contributing factors were to the error, and suggested corrective actions. In addition, the completed Results Forms were qualitatively analyzed to determine whether the forms were being filled out logically and consistently.

Third, meetings were held mid-point through the Field Test and approximately six weeks after the end of the Field Test to get feedback from representatives of the participating organizations.

In general, the Field Test found a wide variation in the manner in which MEDA was implemented in the participating organizations. Two of the organizations never fully implemented MEDA. The others implemented MEDA in various ways regarding which maintenance organization carried out the investigations, what types of events triggered an error investigation, and how corrective actions were implemented.

More specifically, the evaluation surveys found the following. Two hundred forty-eight respondents filled out the Field Test Survey before they took MEDA training. In general, these respondents agreed that poor communications is the biggest contributing factor to maintenance error. They also agreed that errors can be made by anyone, that they are made even on routine tasks, and that the factors that contribute to errors are largely controllable. The respondents believed that maintenance technicians have written materials available, as needed, and that lessons learned and problem areas are communicated to other technicians in order to prevent additional errors. However, support from other organizations is not seen as effective, feedback from supervisors is lacking, and satisfaction with the work environment is low. Punishment for errors is still used in some organizations, but it is not believed to be applied fairly, and it is not seen as being effective. There is general agreement that training is an effective way to reduce errors. Most agreed that their airline needs to reduce maintenance error, although about half believe that their airline (already) does a good, thorough job at maintenance error investigation.

The Tool Survey was filled out by 237 respondents following training, which included a case study, or after the first error investigation. The respondents generally agreed that the MEDA Results Form helped them with their error investigation and that it was easy to use. A large majority of the respondents believed that MEDA will have a positive impact on their maintenance organization, although they are much less certain that MEDA will reduce punishment for making errors or that MEDA will cause new corrective actions to be taken.

The Subject Survey was filled out by 17 technicians, who had been involved in the maintenance error and the subsequent MEDA investigation. In general, their experience of participation in the error investigation was positive. They did not feel intimidated during the investigation, they felt that the purpose and philosophy of the process was made clear to them, and they believed that MEDA would improve their work environment. However, they were not certain whether corrective actions would be taken.

The Management Survey was filled out by 13 managers in the maintenance functions of the participating organizations at the end of the Field Test. These managers agreed fully with the MEDA philosophy, understood how MEDA was being implemented at their airline, felt that there was strong acceptance of MEDA by airline management and technicians alike, strongly supported MEDA themselves, and felt that it was important for other airlines to adopt MEDA and to share MEDA data.

The Field Test Follow-up Survey was completed by 49 MEDA investigators at the end of the Field Test. Some of the questions were the same as used on the Field Test Survey. Comparison of the responses on these questions found that opinions had changed some since before MEDA training--there was less strong an opinion that carelessness caused error and that time pressure caused error. These respondents were less likely than managers to agree that their airline had done a good job in implementing MEDA, that technicians supported the process, and that they had seen positive benefits from the process. However, a majority of them strongly support the continued use of MEDA at their airline.

The Management Survey and the Field Test Survey also asked respondents to rank order the importance of eleven contributing factors to maintenance error. The managers and investigators differed very little in their rankings. Poor communications, inadequate supervision, and lack of information were seen as the top three contributing factors for both groups of respondents. These were followed (in order) by: qualification/skills, equipment/tools/parts, organizational factors, airplane design/configuration, job/task, environmental factors, factors affecting individual performance, and facility factors.

Seventy-four completed Results Forms were sent to the Boeing team members for analysis. Figure 1 graphs the operational events that triggered the MEDA investigations. Flight delays (22), aircraft damage (17), and air turn backs (11) were the major triggering events. The 11 "other" events included workshop errors, vendor problems, and a few events that probably could have been described by the existing event types in the Results Form but were coded "other" by the investigators. Note that these were the events selected by the participating organizations to trigger a MEDA investigation--therefore these numbers cannot be used to estimate the percentage of events that are due to maintenance error.

Given the types of events investigated, Figure 2 graphs the types of maintenance errors that caused the event. Improper installation (26 errors) was, by far, the major error type, which was followed distantly by improper fault isolation/inspection/testing (11 errors), and improper servicing (9 errors). Of the 17 "other" maintenance errors, eight were related to errors that caused ground damage.

Figure 3 graphs the factors that contributed to the errors. There was an average of 3.24 major categories of contributing factors selected per Results Form. Information was a contributing factor in 50% of the investigations, followed closely by communications (43%), job/task (42%), environment/facilities (38%), factors affecting individual performance (35%), qualification/skills (31%), airplane design/configuration (30%), equipment/tools/parts (27%), organizational environment (26%), and supervision (16%). It is interesting to compare these empirical data with the survey opinions of the managers and investigators about which of these factors were most likely to contribute to error. The managers and investigators correctly ranked information and communication as high in importance. However, they greatly overestimated the importance of supervision and qualification/skills, and they underestimated the importance of environment/facilities and factors affecting individual performance.

One additional methodology used to collect data on the tool effectiveness was to hold a Mid-Field Test meeting to review tool design, user experience, potential changes to the tool, and the MEDA software prototype created for the Field Test program. An End-of-Field Test meeting was held in Seattle on September 19-21, 1995. A small number of changes were suggested for the Results Form and the Supplemental Assessment Information. A major recommendation made regarding the presentations/training needed for implementation at other airlines was that three separate presentation/training packages be developed: the first to present the concept to senior management to gain their support and to lay out the organizational model required to implement MEDA successfully; the second to train the selected MEDA investigators; and the third to present the MEDA process to the maintenance technicians and their management to allay fears regarding punitive actions, to inform them about how the investigation process is carried out, and to discuss the benefits of MEDA.

Conclusions and Recommendations

In conclusion, the Field Test evaluation determined that the MEDA objectives were met. First, the MEDA tool and investigation process did provide an easy-to-use standardized investigation methodology to the maintenance organization. This was determined by the survey data and by the 74 completed Results Forms, which were judged generally to be filled out in a manner consistent with the intent of the MEDA process. One finding, which will prove invaluable to further MEDA implementation, is that it took the participating airlines longer to implement MEDA than first anticipated. Determining the events that will trigger a MEDA investigation, assigning MEDA administrative responsibility to an organization, selecting and training MEDA investigators, and (especially) setting up a corrective action process and feedback mechanism can be time consuming and are impacted by the organizational climate.

Second, the tool did help uncover maintenance system deficiencies. Although only 74 completed Results Forms were available before the cut-off to data collection, all of the participating airlines had successfully solved maintenance problems using MEDA.

Third, the educational process that was used for implementation did provide maintenance personnel with a better understanding of how human performance is influenced by local and organizational factors, as indicated by survey data and by anecdotal information discussed at the Field Test meetings. Finally, trend analyses were begun by the participating airlines, although more data is needed for these analyses to be more useful.

Several recommendations resulted from the Field Test.

It is recommended that air carriers continue to promote usage of event-driven analysis tools to foster error management within their organizations. MEDA Field Test participants should continue to use the MEDA tool in its present or customized form. Industry should also continue to develop modular human factors-based training programs (modeling successful CRM concepts) to complement the use of technology-enhanced, event-driven analysis tools and to promote organizational recognition of error producing factors and the importance of team work in error management. Also, issues that inhibit maintenance error reporting and analysis within individual organizations and industry-wide must be addressed by the individual organizations, where applicable, and within industry by its governing bodies. These issues include, but are not limited to:

- A uniformly accepted limited immunity policy governing U.S. technician participation in future event reporting and analysis programs, consistent with the standard established for similar flight operations programs
- Definition of an acceptable standard of disciplinary action that individual organizations can use as a model to complement the limited immunity policy and the use of event-driven analysis tools
- Potential for sharing the output of safety and information programs among operators and industry.

Boeing is now making the MEDA tool available to customer airlines to help them improve their maintenance operations and as a means to more efficiently communicate with Boeing about events that have design or manufacturing as a contributing factor. The Boeing Maintenance and Ground Operations Systems (MGOS) group, within Customer Services Division will assist customer airlines with training and implementation of the MEDA process. Air carriers interested in MEDA may contact MGOS through their Boeing Field Service Representative.

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Figure 1 Operational Events.

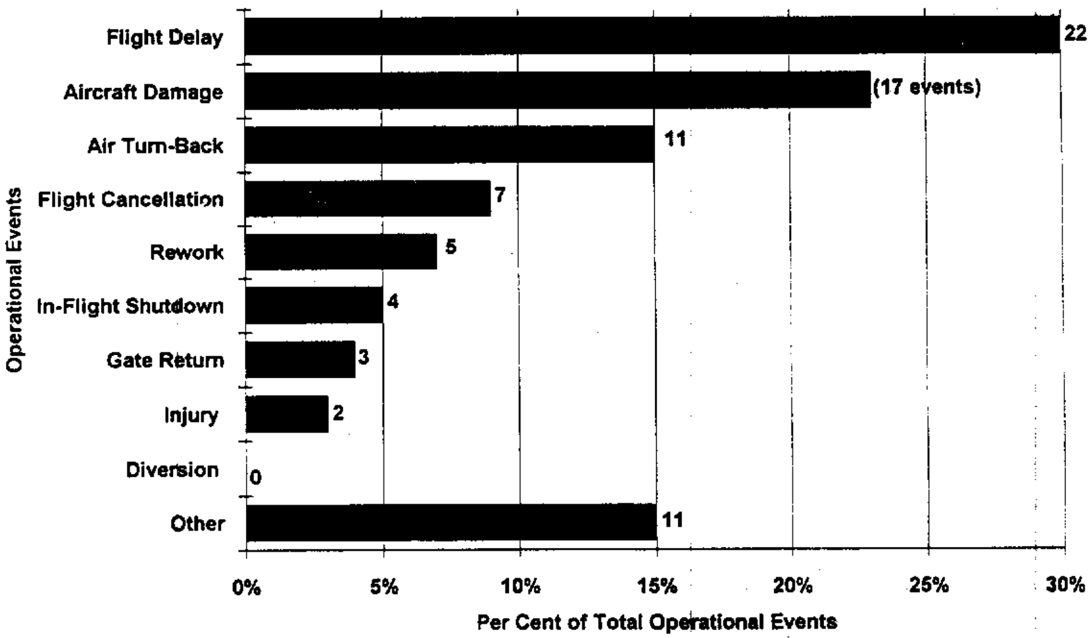


Figure 2 Maintenance Error Types.

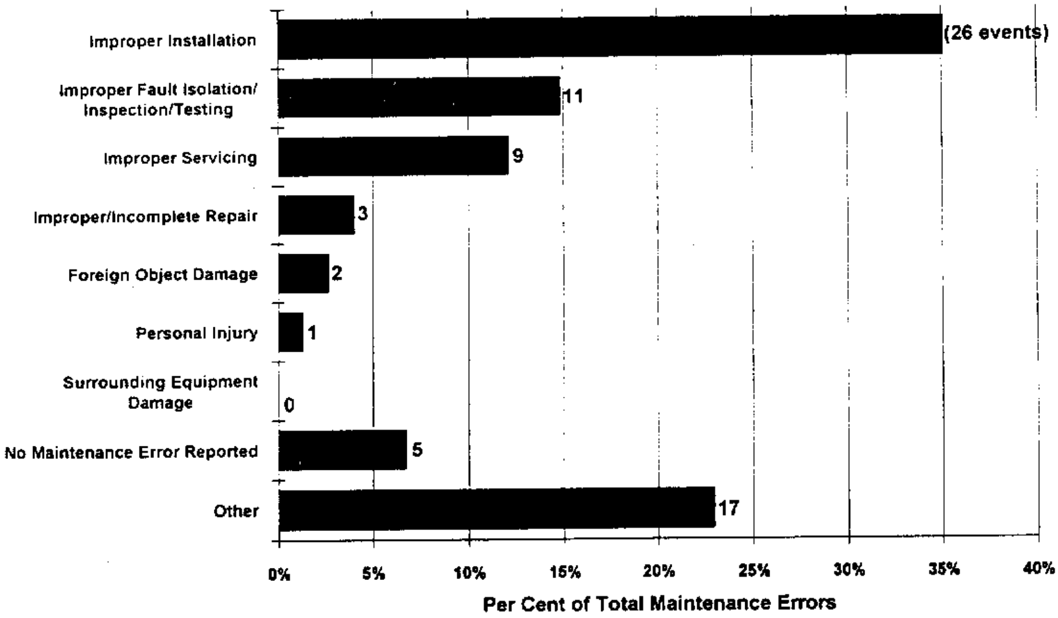
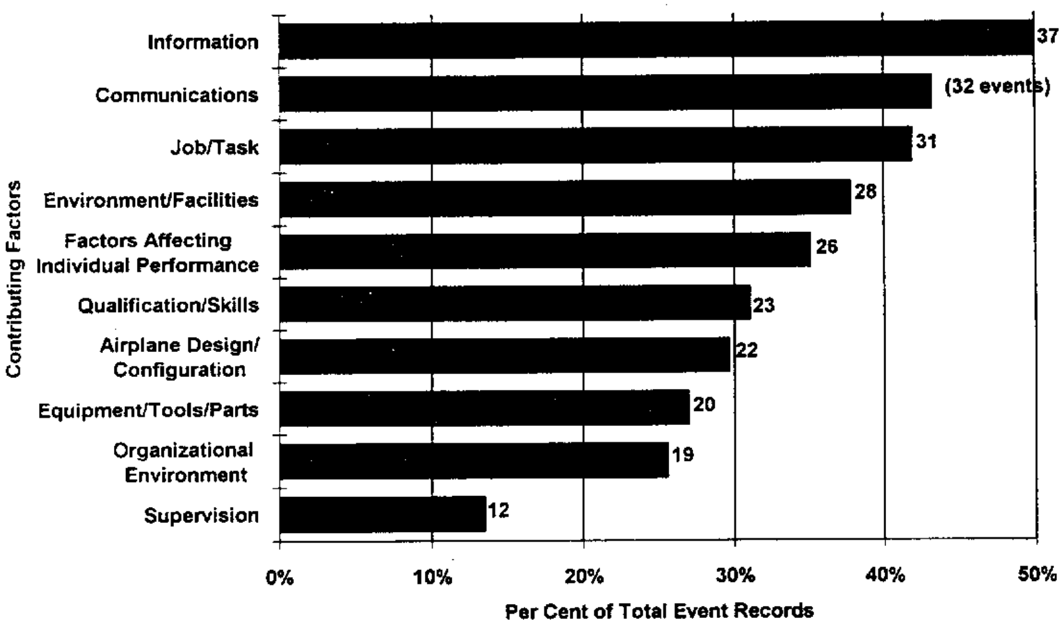


Figure 3 Contributing Factors.



附件九

Flight Safety Foundation's 48th Annual International Air Safety Seminar
Seattle, Washington
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Aircraft/Runway Performance Studies

by

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ABSTRACT

Gaining a better understanding of the many factors influencing the tire/runway friction interface is the aim of several ongoing NASA Langley research programs which are described in this paper. Results from studies conducted at the Langley Aircraft Landing Dynamics Facility (ALDF) and tests with instrumented aircraft and ground vehicles are summarized to indicate effects of different tire and runway properties. The effects on tire friction performance of parameters such as pavement surface texture and condition, tire operating mode and inflation pressure, and vehicle speed are discussed. An overview of current ground friction measuring vehicle capability for evaluating runway friction performance is given. A new, shot peening surface treatment is also described for improving surface texture, friction, ride quality, and tire wear. Several joint programs with the Federal Aviation Administration (FAA), Transport Canada, U.S. Air Force, and the aviation industry are described together with current test plans. The scope of future NASA Langley research directed towards solving aircraft ground operational problems related to the tire/runway friction interface is given.

INTRODUCTION

A pilot's ability to make a successful takeoff or landing operation is dependent, in large measure, on the condition of the aircraft landing gear system and the airport runway surface. Worn tires and brakes combined with adverse weather conditions can significantly reduce aircraft ground operational performance capability leaving little or no margin for delays in neccessary pilot inputs. When aircraft/runway conditions are such that pilot demands cannot be achieved, overrun or veeroff accidents are a very likely consequence. New tire designs, brake unit components, and antiskid control algorithms together with improved, high-friction, runway surfaces, rubber removal treatments, and other contaminant control/removal techniques have helped extend the aircraft/runway operational boundary limit and minimize occurence of skidding accidents.

Gaining a better understanding of the many factors influencing the tire/pavement interface is the aim of several ongoing NASA Langley research programs summarized in this paper. Langley's Aircraft Landing Dynamics Facility and two instrumented ground test vehicles are described and some recent test results obtained using these unique test facilities are discussed. An overview of current ground friction measuring vehicle capability for evaluating runway friction performance is given. The NASA Wallops Flight Facility test site, an annual tire/runway friction workshop, and a relatively new shot peening machine for improving surface texture, friction, ride quality, and tire wear are discussed. Several joint projects with other organizations are also described. The scope of future NASA Langley reasearch directed towards solving aircraft ground operational problems related to the tire/runway interface is given.

TEST FACILITIES AND EQUIPMENT

Aircraft Landing Dynamics Facility - An aerial view of the NASA Langley Aircraft Landing Dynamics Facility (ALDF) is shown in figure 1 together with the principal specifications and indentification of the main features. The large test carriage is catapulted to the desired test speed by means of pressurized water expelled through a quick acting valve. Once launched, the test carriage is constrained to free roll on level steel rails through the 549 m (1800 foot) runway test section and then encounters 5 arresting gear cables which bring it to a stop in the remaining 183 m (600 feet). This unique facility, described in references 1-3, has been in operation since the mid-1950's evaluating various aircraft landing gear systems and components, including the Space Shuttle, on a variety of runway surfaces. A facility upgrade project in the early 1980's provided a new test carriage, larger water jet propulsion system, a longer test section, a new arresting gear system, and most importantly, much higher test speed (220 vs 100 knots) and landing gear loading capability (34K vs 18K kg (75K vs 40K lb)). From March to December when daylight ambient air temperatures are usually above freezing, carriage test runs can be performed every 2 hours with as many as 4-6 per day. The ALDF not only has a unique capability to conduct a variety of dynamic tire/pavement performance tests but a range of static tire mechanical properties tests can be performed throughout most aircraft tire rated load and inflation pressure values. .

Instrumented Tire Test Vehicle - The NASA Langley Instrumented Tire Test Vehicle (ITTV) shown in figure 2 is designed to accommodate the evaluation of many tire performance parameters during straight ahead rolling, yawed rolling, cambered rolling, or fixed-slip braking test runs. Investigations can be performed at speeds up to 105 km/h (65 mph) and a maximum test tire loading of 22.2 kN (5000 lb). Tire vertical, drag, and side loads developed during test runs are measured by strain gages located above the wheel-axle support structure on the test fixture. Continuous time histories of the output from these strain gages are recorded on a computer in the vehicle cab compartment. Several test parameters can be selected for viewing on an onboard CRT during the test run or played back at a later time. A pneumatic system to lower or raise the test tire from the surface can be controlled from the cab compartment by the vehicle operator. Simulated braking at fixed slip is accomplished by driving the test wheel with an adjustable steel shaft connected through universal couplings to interchangeable sprocket gears, which in turn, are chain driven off one left rear driving wheel of the vehicle. Disengaging or removing this test tire drive shaft permits evaluation of free rolling, yawed rolling, or cambered operational modes. For unbraked, yawed tire tests, the fixture is manually unlocked, rotated to the preselected angle, and locked in place. For evaluation of camber effects on tire friction and wear performance, the tire test fixture is capable of producing camber angles of up to 4 degrees in 1 degree increments. Within this range of camber, the test tire can also be operated at various yaw angles or fixed-slip braking test modes. References 4 and 5 provide additional information on the ITTV.

Diagonal-Braked Vehicle - The NASA Langley Diagonal-Braked Vehicle (DBV), shown in the photograph in figure 3, is equipped with a high performance engine for rapid acceleration to the normal test speed of 96 km/h (60 mph). This vehicle has a specially modified braking system, shown schematically in figure 3, to provide locked-wheel braking on the diagonal wheel pair. With the remaining two freely rotating wheels, this braking configuration permits adequate vehicle stability and directional control when the diagonal wheels are locked at high speed. The diagonal-braked wheels are fitted with American Society for Testing and Materials (ASTM) smooth-tread test tires whereas the unbraked wheels are equipped with standard road tires that have good tread design. The key test parameters monitored by the onboard instrumentation and computer system are vehicle speed, acceleration, and stopping distance. A CRT display system is also available for viewing selected parameters during a test run or during playback at a later time. (Vehicle speed and stopping distance are displayed to the DBV operator by digital counters mounted on the vehicle dashboard.) (The deceleration data obtained with the DBV allows for computation of the locked-wheel or sliding friction coefficient over the range of test speed.) Additional information about the DBV is given in references 6 and 7.

NASA Wallops Flight Facility - Located on the eastern shore of Virginia, Wallops Flight Facility (WFF) has a three-runway airport with little transient air traffic and hence, it is an ideal facility for performing aircraft ground operational performance tests and a variety of ground vehicle tests. Runway 4/22 (see figure 4), also referred to as the landing research runway, is 46 m (150 feet) wide and 2667 m (8750 feet) long. The specially constructed level (no crown or cross slope) test section, 16 m (52 feet) by 1128 m (3700 feet), consists of several different grooved and ungrooved, concrete and asphalt test surfaces. The groove configurations, transversely cut into the pavement, are 6 mm (0.25 in.) wide and deep with spacings of 25 and 51 mm (1 and 2 in.). A channel cut 6 mm (0.25 in.) wide and 25 mm (1 in.) deep surrounds each runway centerline test surface and supports rubber-belt dams used to control water depth for instrumented aircraft and ground vehicle test runs. The texture of a 3.7 by 274 m (12 by 900 foot) nongrooved concrete section near the runway shoulder was modified with four different textures produced by a special shot peening treatment used in the Skidabrader machine shown in figure 5. This same equipment was also used to modify the Shuttle landing facility runway at Kennedy Space Center, FL which will be described later in this paper. Additional details concerning WFF runway test surfaces are given in references 7 - 9.

RESEARCH PROGRAMS AND TEST RESULTS

NASA Tire/Runway Friction Workshop - The second annual workshop was held at NASA Wallops Flight Facility on May 15-19, 1995 (see figure 6). Over 60 engineers and scientists participated in the workshop activities and they represented 35 organizations from 11 countries. Twelve friction measuring devices made over 500 data runs during the week and six texture techniques were used to collect over 200 data sets on 15 different test surfaces. The blue, red, and white panels shown in front of the workshop group in figure 6 are specially constructed reference panels with high, medium, and low texture finishes. Future test plans are to qualify these reference panels as calibration surfaces for both friction and texture measuring equipment. A list of these devices which have been evaluated during workshop sessions is given in figure 7 together with a typical friction/speed gradient curve. The available workshop data base suggests that the slope of this friction/speed gradient curve is a function of macro-texture and the magnitude is a function of micro-texture.

At the present time, there are six continuous friction measuring devices qualified for airport runway usage by both the U.S. Federal Aviation Administration (FAA) and the International Civil Aviation Organization (ICAO). These devices are listed in figure 8 together with three levels of runway friction classification - design, maintenance planning, and minimum acceptable at both 65 and 95 km/h (40 and 60 mph).

Aircraft Tire Wear Results - Improved cornering wear performance was obtained during ALDF track tests with radial-belted, 40 X 14 aircraft tires compared to similar size bias-ply tires at speeds up to 160 knots on a dry, nongrooved concrete runway. Figure 9 shows the level of wear/energy developed by both tires at similar inflation pressure and a yaw angle of 6 degrees. The wear/energy parameter is simply the average measured amount of tire tread thickness worn away due to the average level of braking and/or cornering force developed over a measured distance. This wear data indicates radial-belted tire construction improves cornering wear performance by nearly 20 percent.

The effect of pavement surface texture on 20 X 4.4 bias-ply tire wear rate evaluated during ITTV tests at NASA Wallops Flight Facility on three different surfaces is shown in figure 10. The tire tread wear rate variation with average texture depth indicates similar increasing trends with texture depth for both braking (14 % slip) and cornering (8 degrees) operational modes. These surfaces were dry when the test runs at 65 km/h (40 mph) were conducted.

Shuttle Landing Facility Runway Modification - Figure 11 gives the scope of the joint multi-faceted effort to identify a runway surface modification that would enable the Space Shuttle landing crosswind limitation at Kennedy Space Center, FL to be increased from 15 knots to 20 knots. A total of 18 different surface treatments produced by grinding, rotopeening, shot peening, and special coatings were first evaluated by comparative ITTV tire wear and friction tests. From this data base, three treatments were selected to be installed the entire length, 4572 m (15 000 ft) of the concrete runway at an individual width of 3.7 m (12 ft). Full-scale crosswind landing simulations were then performed using the Landing Systems Research Aircraft (LSRA) from NASA Dryden Flight Research Center. This specially modified and instrumented CV-990 jet transport aircraft is equipped with a unique, computer-controlled, centerline fuselage gear designed to accommodate a Space Shuttle Main landing gear tire. Figure 12 shows the range of shuttle tire wear test results obtained from the CV-990 aircraft tests at Kennedy Space Center and the runway surface modified by the Skidabrader shot peening method clearly offers the best wear performance. Consequently, the entire 91 by 4572 m (300 by 15 000 ft) runway surface was modified using Skidabrader equipment in September 1994. Tire wear data from three Space Shuttle landings at Kennedy Space Center since completion of this runway modification have indicated significantly better wear performance.

C-17 Transport Aircraft Soil Runway Tests - NASA DBV friction measurement tests were performed on a relatively short, 1097 m (3600 ft), soil runway at Holland Landing Zone near Pope Air Force Base, NC at the request of U. S. Air Force C-17 Systems Program Office. These tests were conducted under dry conditions prior to planned C-17 transport aircraft landing and take-off operations. The DBV friction data indicated the soil runway provided nearly dry paved runway friction performance and the C-17 aircraft operations were successfully carried out. The photograph in figure 13 shows a head-on view of the 4-engine, C-17 jet transport aircraft and figure 14 shows the somewhat unique (2 nose and

12 main gear tires) undercarriage configuration. Figure 15 shows the NASA DBV during a dry soil runway condition test run and the two portable decelerometer units used during both ground vehicle and aircraft tests are shown in figure 16. The Bowmonk Skidman unit is an electronic decelerometer which provides a permanent time history record of vehicle acceleration/deceleration up to 1.0 g's. The Tapley decelerometer unit shown on the right side of figure 16 is a manually operated decelerometer which can indicate the peak deceleration value obtained during a vehicle braking run. Both decelerometer units were used in the DBV and were found to measure similar values. The Skidman unit was also used onboard the C-17 aircraft and deceleration values recorded by the Skidman unit were similar to those measured by the C-17 aircraft data acquisition system.

Joint Winter Runway Friction Test Program - Planning and preparations are nearing completion for starting a proposed, 5-year, joint winter runway friction test program this coming winter season. The major participants include NASA, FAA, and Transport Canada with several aviation organizations and groups expressing keen interest in supporting this program. Testing will include instrumented aircraft and ground vehicles as well as Langley's Aircraft Landing Dynamics Facility. Program objectives include assessment of aircraft/ground vehicle friction correlation, effects of both aircraft and runway anti- and de-icing chemicals, and measurement of aircraft water/slush/snow impingement drag. As currently envisioned, this joint program will implement many of the recommendations from a white paper prepared by government/industry winter runway friction measurement and reporting working group.

CONCLUDING REMARKS

An overview of several NASA Langley programs aimed at gaining a better understanding of the many factors influencing the aircraft/runway interface has been given. Several unique test facilities and equipment have been described and test results from a variety of studies conducted at Langley's Aircraft Landing Dynamics Facility, Wallops Flight Facility, Kennedy Space Center, and Pope AFB have been discussed. The scope of some future NASA Langley research efforts directed towards improving aircraft ground handling performance under adverse weather conditions has also been given.

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AIRCRAFT LANDING DYNAMICS FACILITY

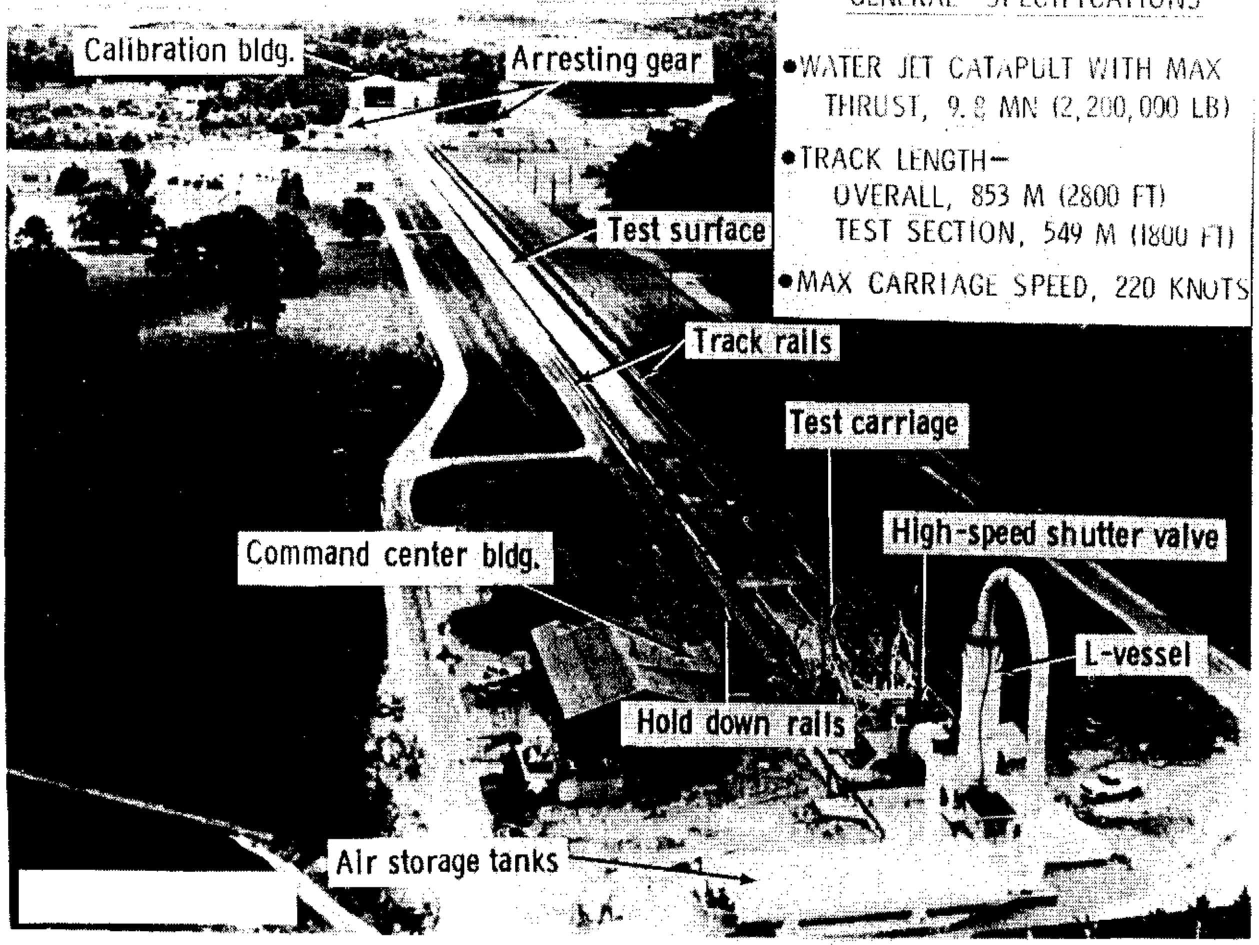


Figure 1

INSTRUMENTED TIRE TEST VEHICLE

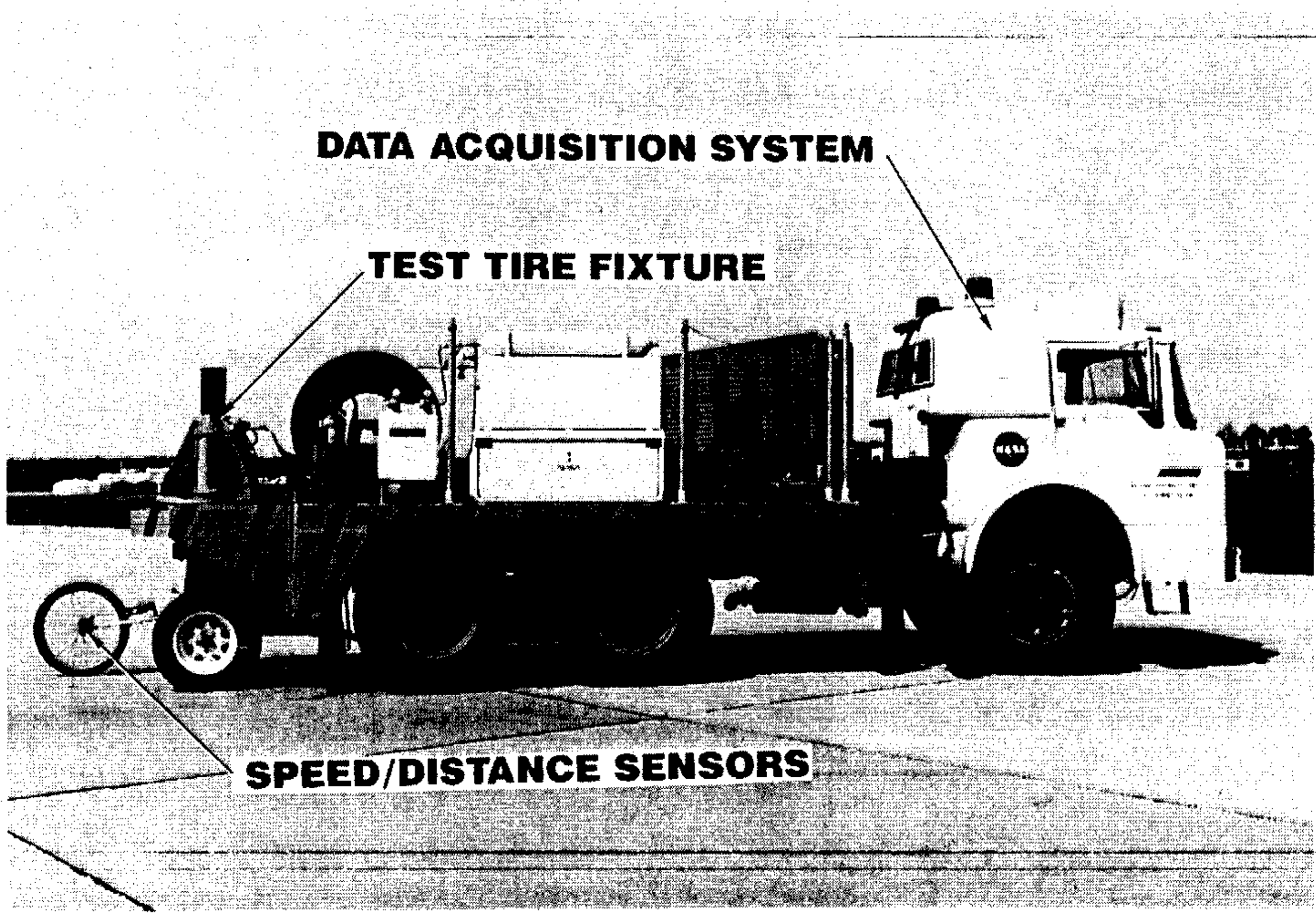
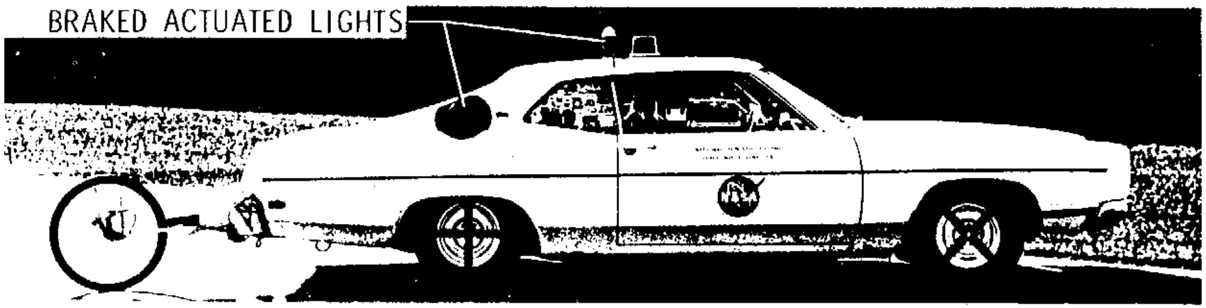
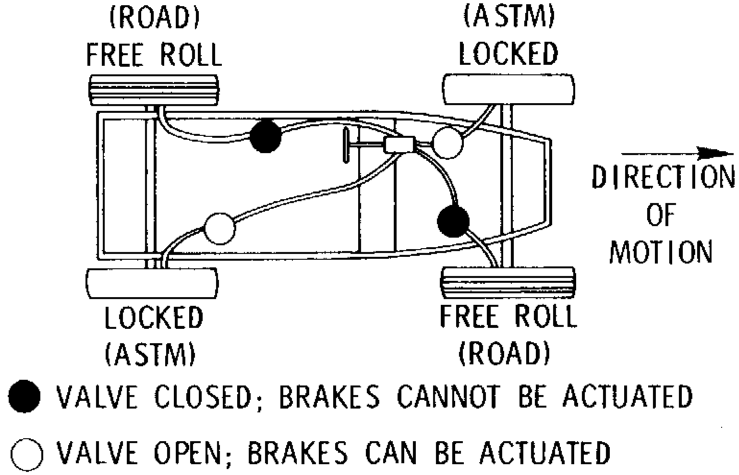


Figure 2

NASA DIAGONAL-BRAKED VEHICLE SYSTEM



(A) NASA DIAGONAL-BRAKED VEHICLE



(B) SCHEMATIC OF DIAGONAL-BRAKING SYSTEM

Figure 3

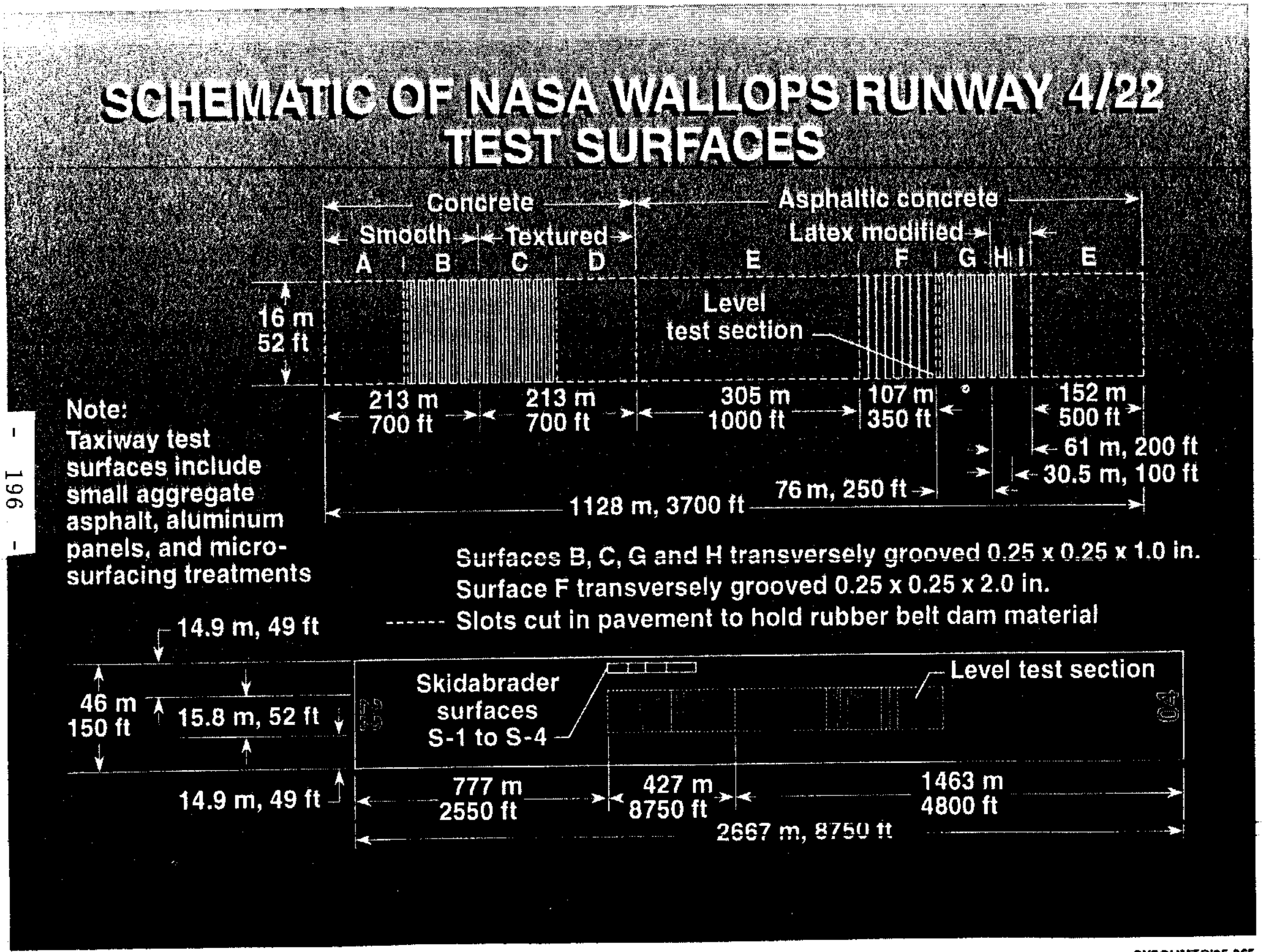


Figure 4

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SKIDABRADER EQUIPMENT

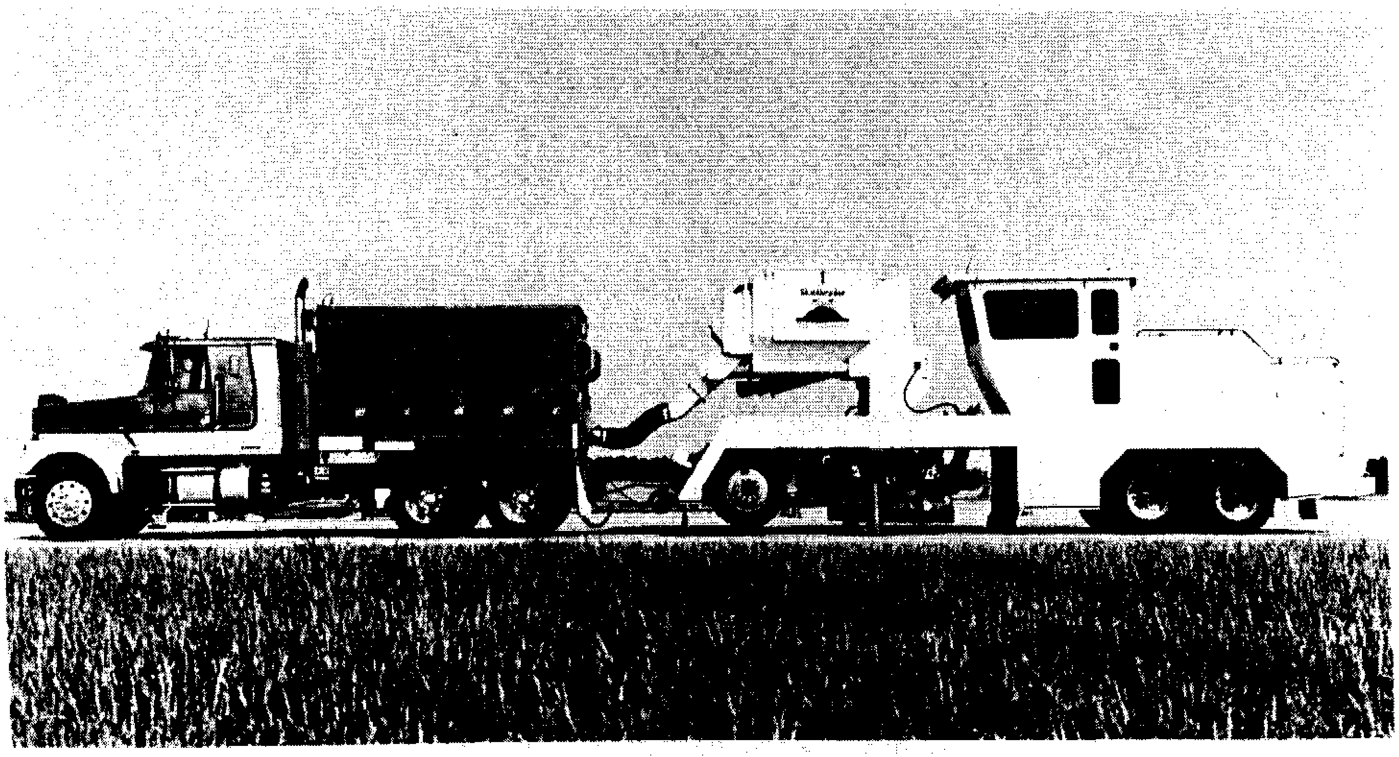


Figure 5

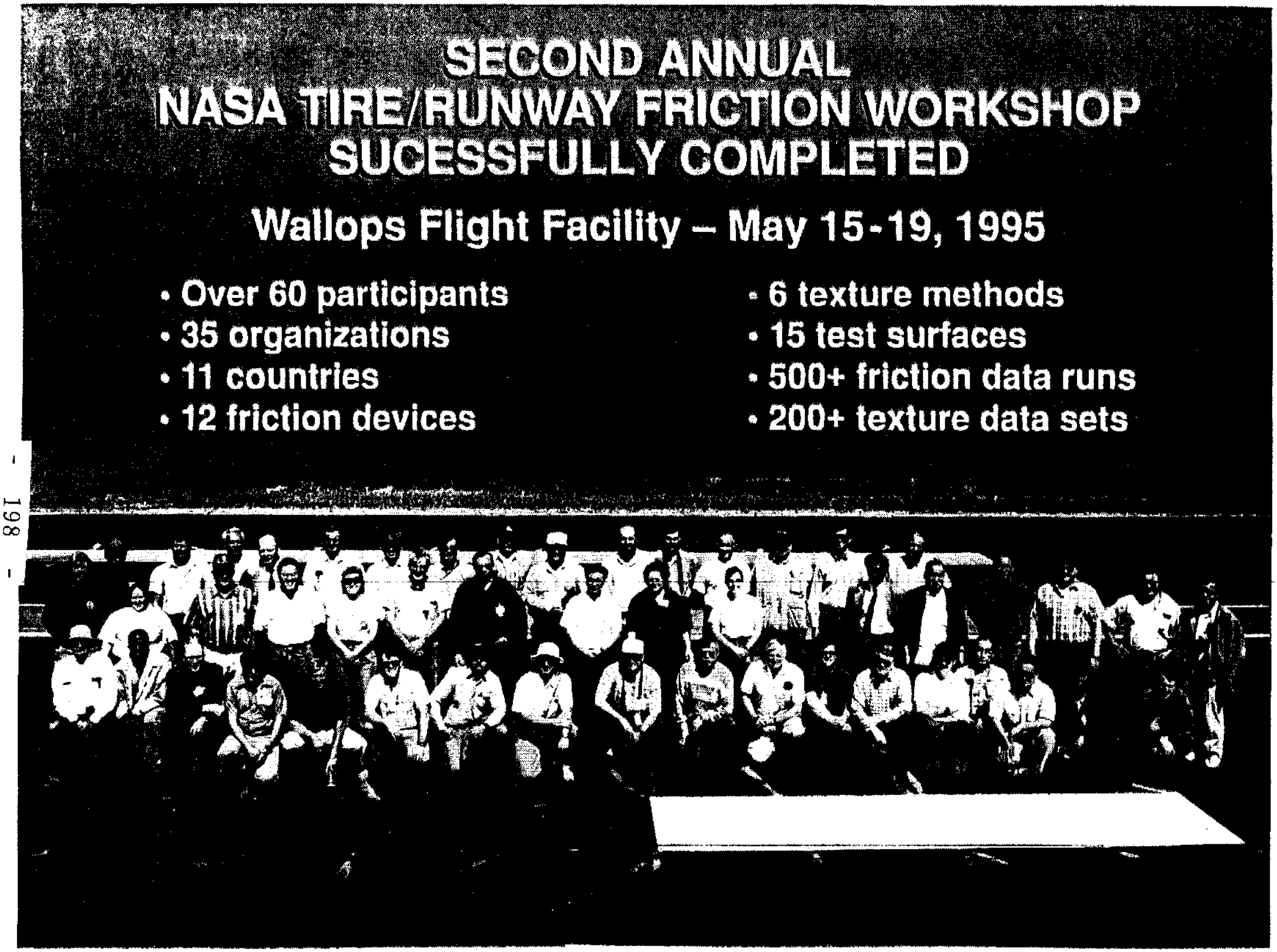

SECOND ANNUAL
NASA TIRE/RUNWAY FRICTION WORKSHOP
SUCESSFULLY COMPLETED
Wallops Flight Facility – May 15-19, 1995
• Over 60 participants
• 35 organizations
• 11 countries
• 12 friction devices
• 6 texture methods
• 15 test surfaces
• 500+ friction data runs
• 200+ texture data sets

Figure 6

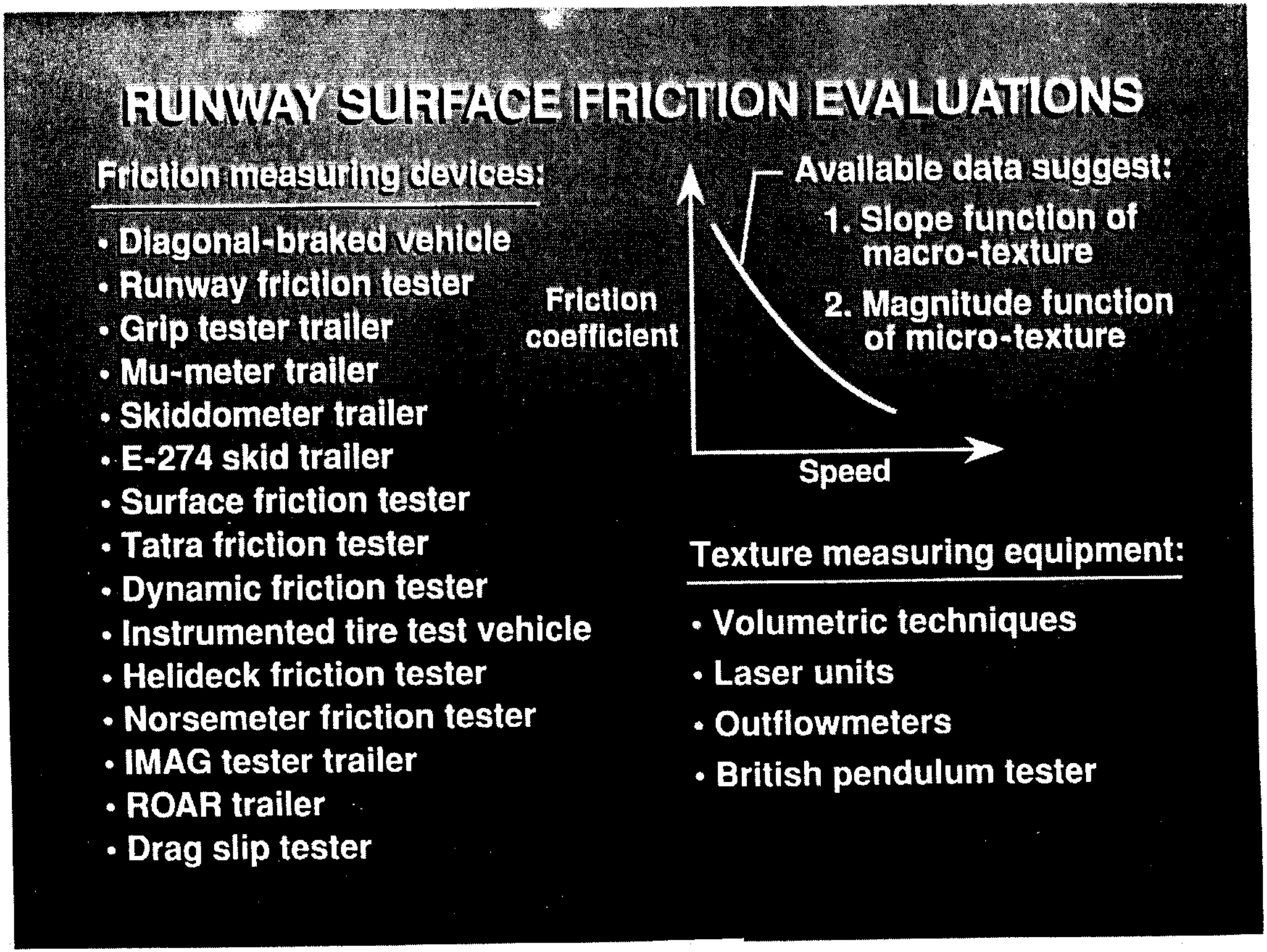

RUNWAY SURFACE FRICTION EVALUATIONS
Friction measuring devices:
• Diagonal-braked vehicle
• Runway friction tester
• Grip tester trailer
• Mu-meter trailer
• Skiddometer trailer
• E-274 skid trailer
• Surface friction tester
• Tatra friction tester
• Dynamic friction tester
• Instrumented tire test vehicle
• Helideck friction tester
• Norsemeter friction tester
• IMAG tester trailer
• ROAR trailer
• Drag slip tester
Friction coefficient
Speed
Available data suggest:
1. Slope function of macro-texture
2. Magnitude function of micro-texture
Texture measuring equipment:
• Volumetric techniques
• Laser units
• Outflowmeters
• British pendulum tester

Figure 7

RUNWAY FRICTION LEVEL CLASSIFICATION BY TEST VEHICLE

(1) Test equipment	(2) Test tire		(3) Test speed, km/h	(4) Test water depth, mm	(5) Design objective for new surface	(6) Maintenance planning level	(7) Minimum friction level
	Type	Pressure, kPa					
Mu-meter Trailer	A A	70 70	65 95	1.00 1.00	0.72 0.66	0.52 0.38	0.42 0.26
Skiddometer Trailer	B B	210 210	65 95	1.00 1.00	0.82 0.74	0.60 0.47	0.50 0.34
Surface friction Tester vehicle	B B	210 210	65 95	1.00 1.00	0.82 0.74	0.60 0.47	0.50 0.34
Runway friction Tester vehicle	B B	210 210	65 95	1.00 1.00	0.82 0.72	0.60 0.54	0.50 0.41
Tatra friction Tester vehicle	B B	210 210	65 95	1.00 1.00	0.76 0.67	0.57 0.52	0.48 0.42
Grip tester Trailer	C C	140 140	65 95	1.00 1.00	0.74 0.64	0.53 0.36	0.43 0.24

Figure 8

CT/RNWY FRCTNI95-267

40 X 14 TIRE TREAD WEAR PERFORMANCE

DRY, NONGROOVED CONCRETE; INFLATION PRESSURE, 1.17 MPa (170 PSI);
TIRE YAW ANGLE, 6 DEGREES

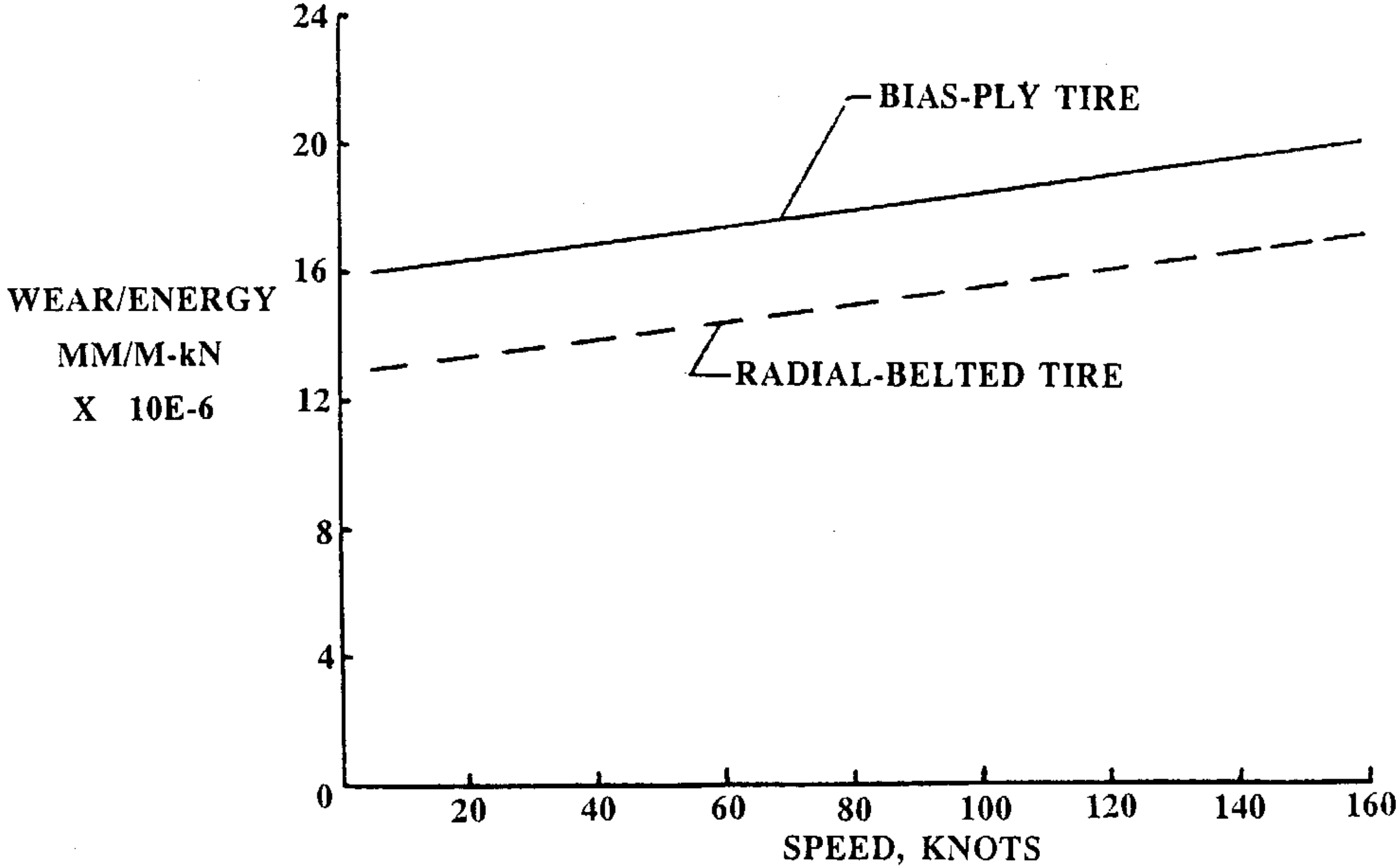


Figure 9

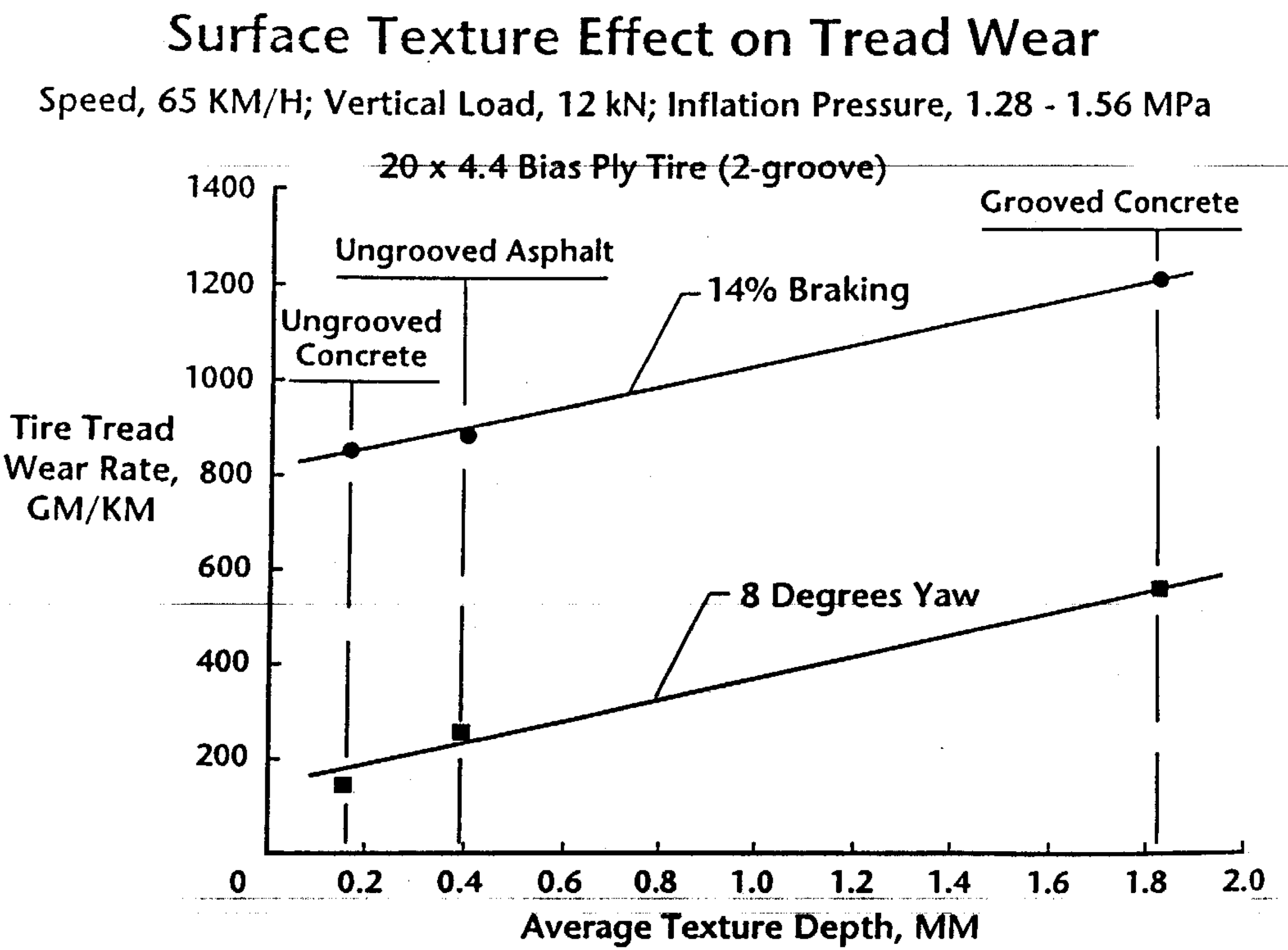

Surface Texture Effect on Tread Wear
Speed, 65 KM/H; Vertical Load, 12 kN; Inflation Pressure, 1.28 - 1.56 MPa
20 x 4.4 Bias Ply Tire (2-groove)
Tire Tread Wear Rate, GM/KM
1400
1200
1000
800
600
400
200
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Average Texture Depth, MM
Ungrooved Concrete
Ungrooved Asphalt
Grooved Concrete
14% Braking
8 Degrees Yaw

Figure 10

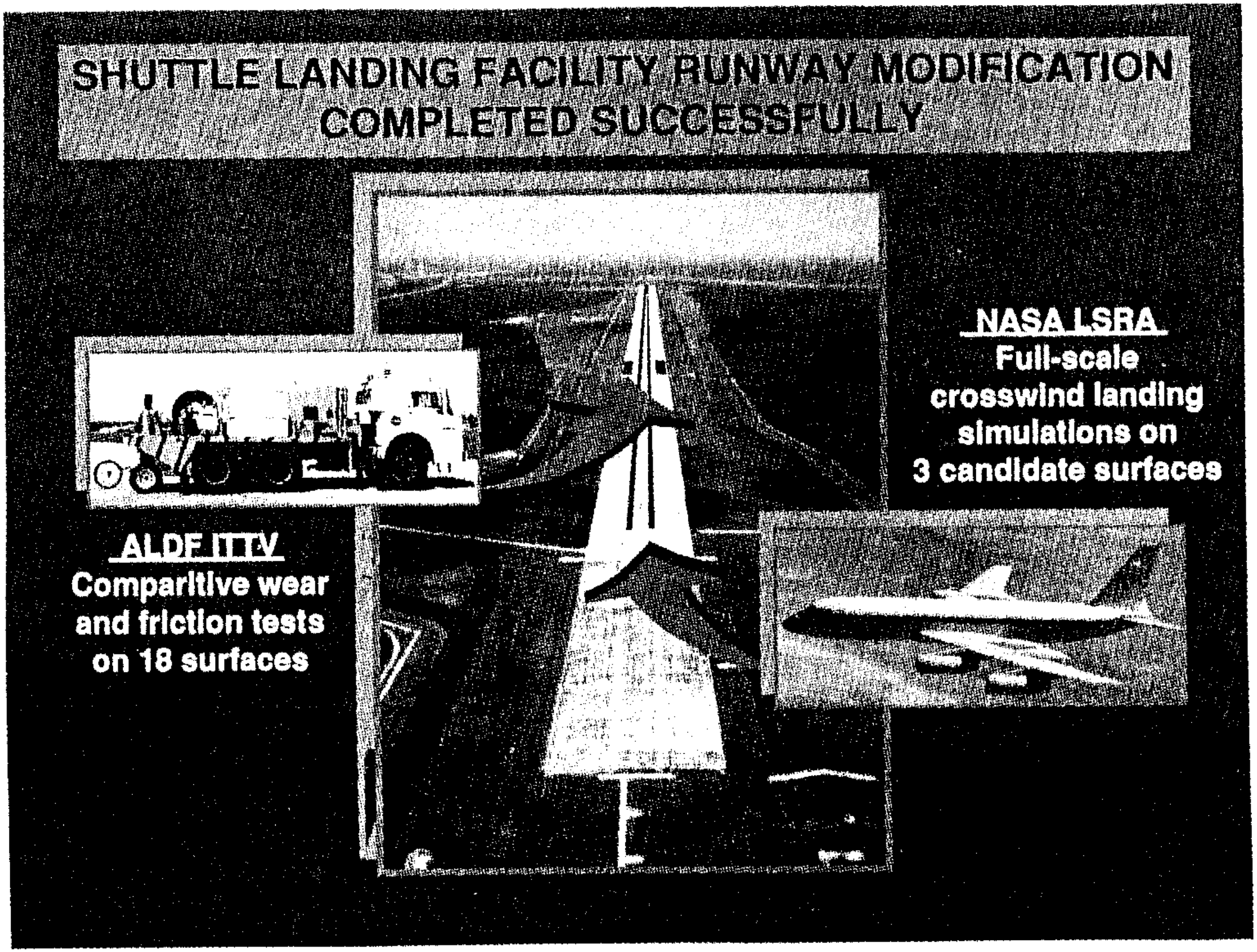

SHUTTLE LANDING FACILITY RUNWAY MODIFICATION
COMPLETED SUCCESSFULLY
ALDF ITTV
Comparitive wear
and friction tests
on 18 surfaces
NASA LSRA
Full-scale
crosswind landing
simulations on
3 candidate surfaces

Figure 11

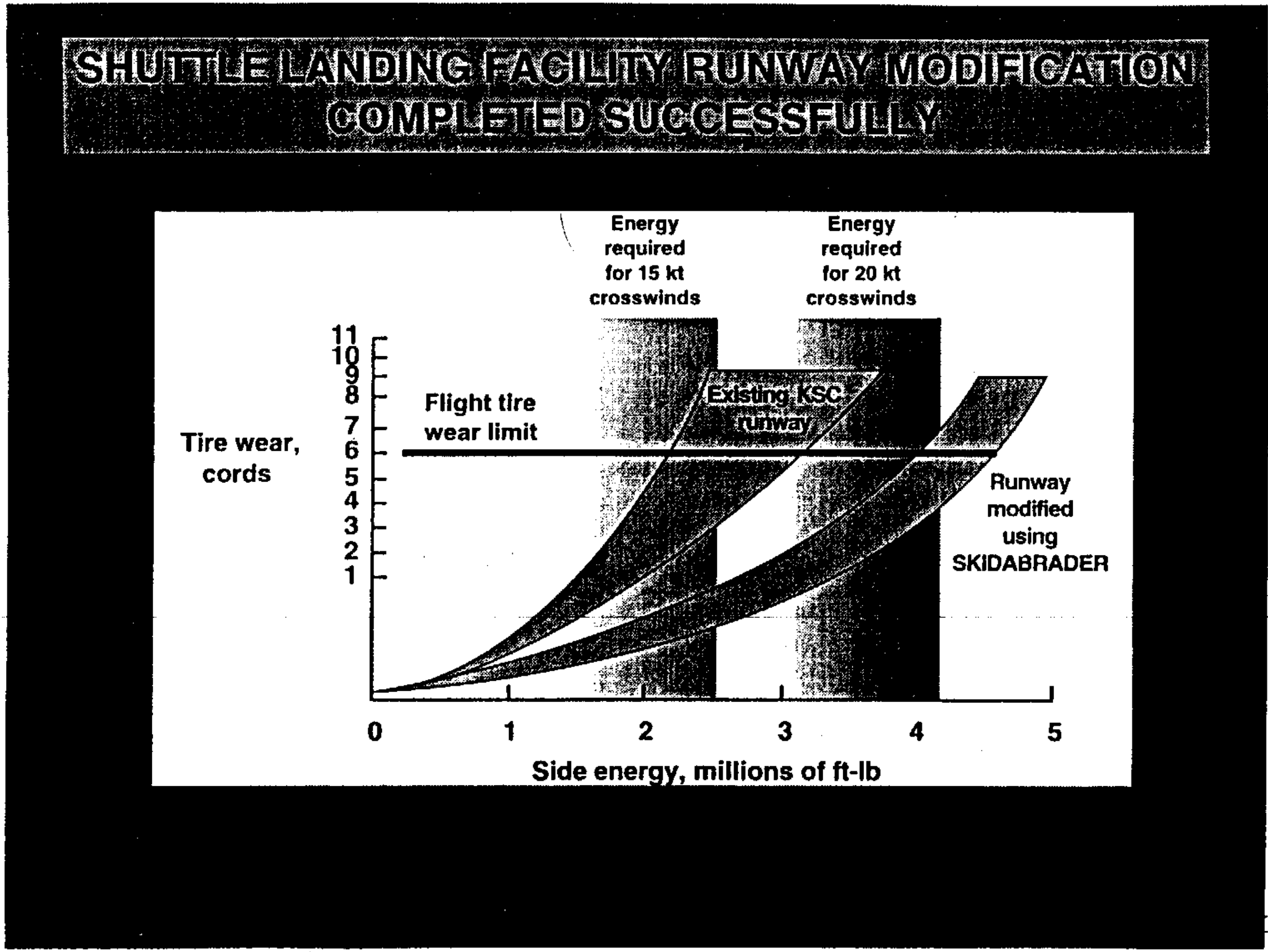

SHUTTLE LANDING FACILITY RUNWAY MODIFICATION
COMPLETED SUCCESSFULLY
Energy required for 15 kt crosswinds
Energy required for 20 kt crosswinds
Tire wear, cords
11
10
9
8
7
6
5
4
3
2
1
Flight tire wear limit
Existing KSC runway
Runway modified using SKIDABRADER
0
1
2
3
4
5
Side energy, millions of ft-lb

Figure 12

C-17 TRANSPORT AIRCRAFT OPERATING ON SOIL RUNWAY

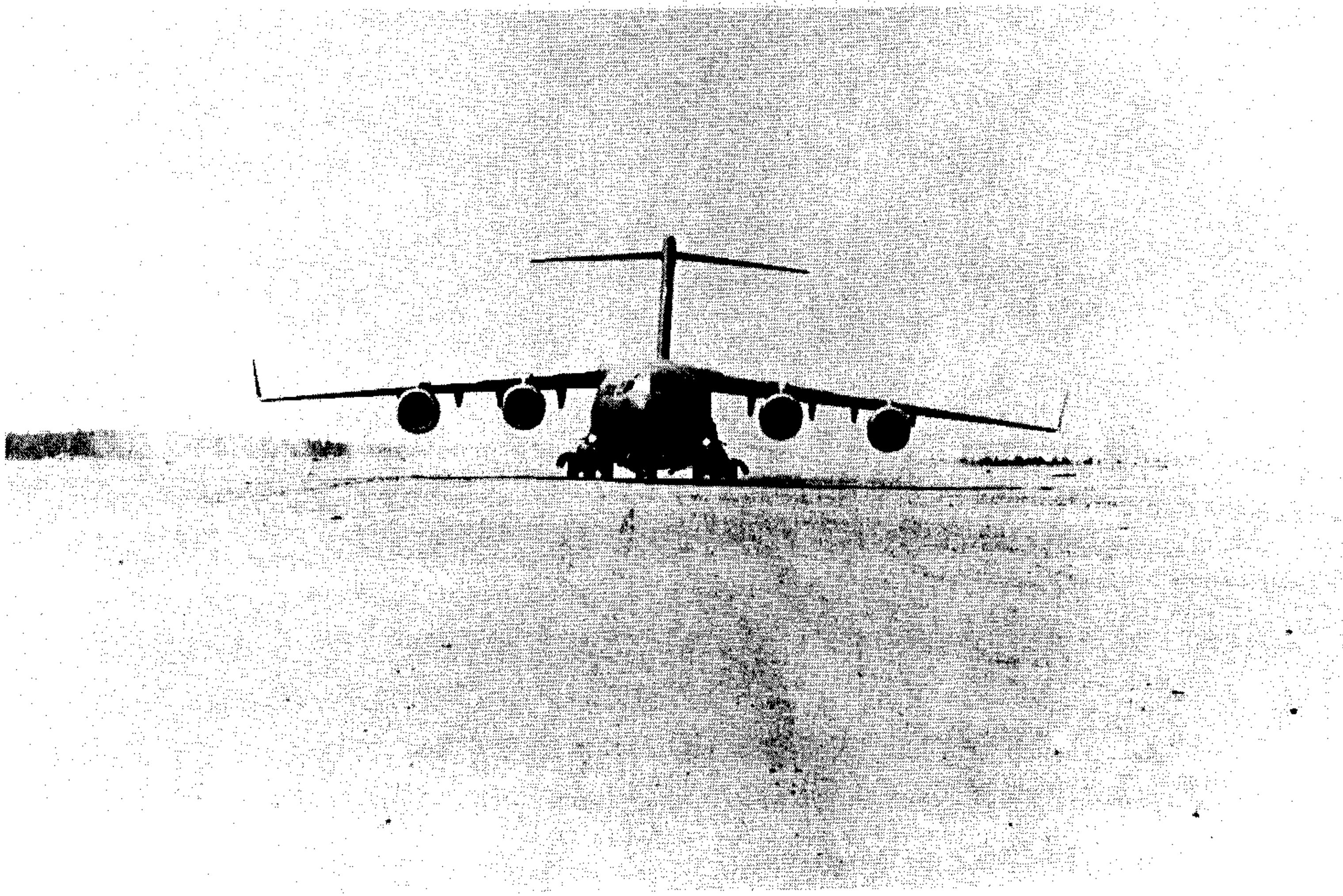


Figure 13

C-17 TRANSPORT AIRCRAFT UNDERCARRIAGE

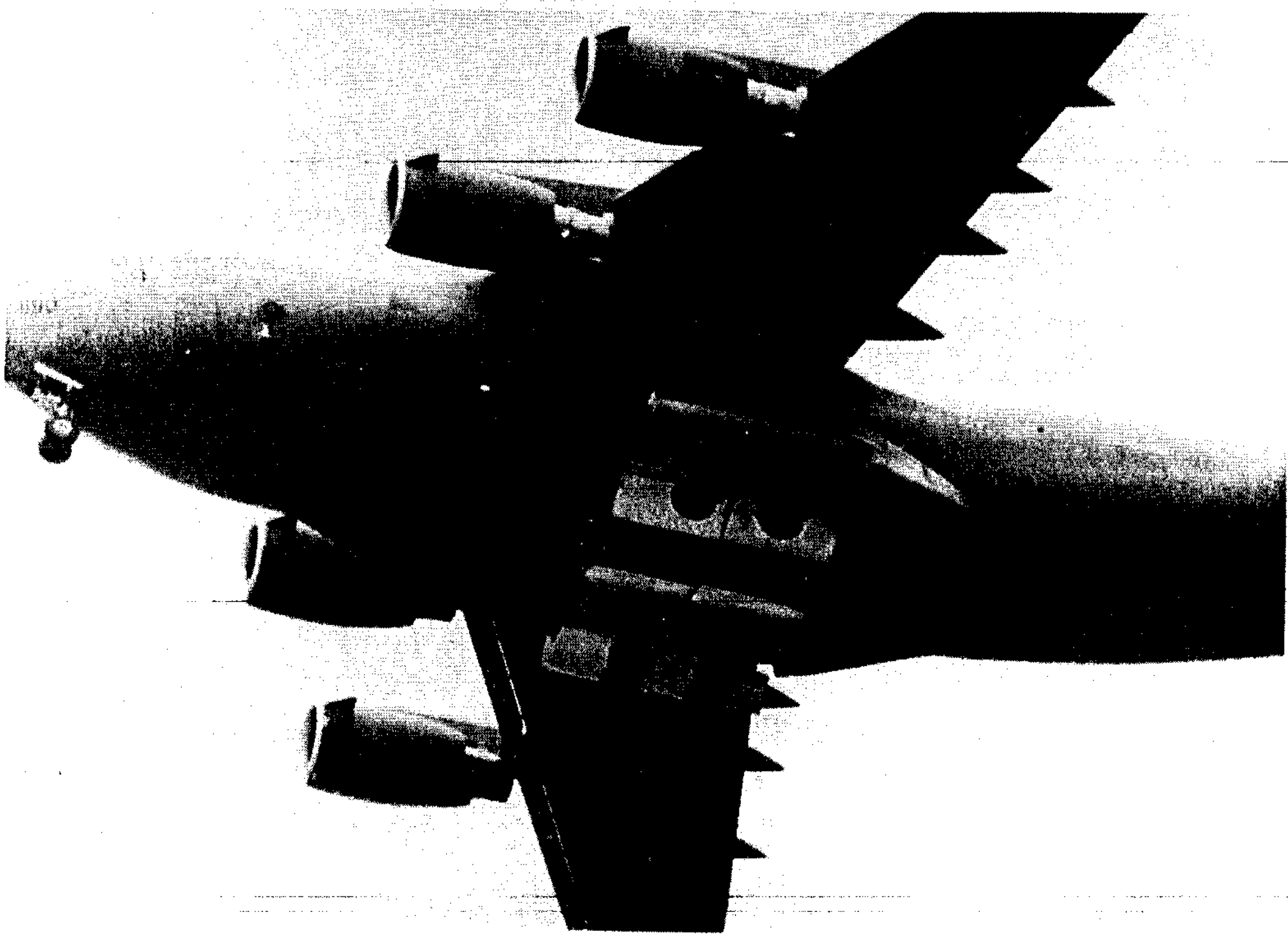


Figure 14

NASA DIAGONAL-BRAKED VEHICLE DURING RUN

Figure 15

PORTABLE DECELEROMETER UNITS

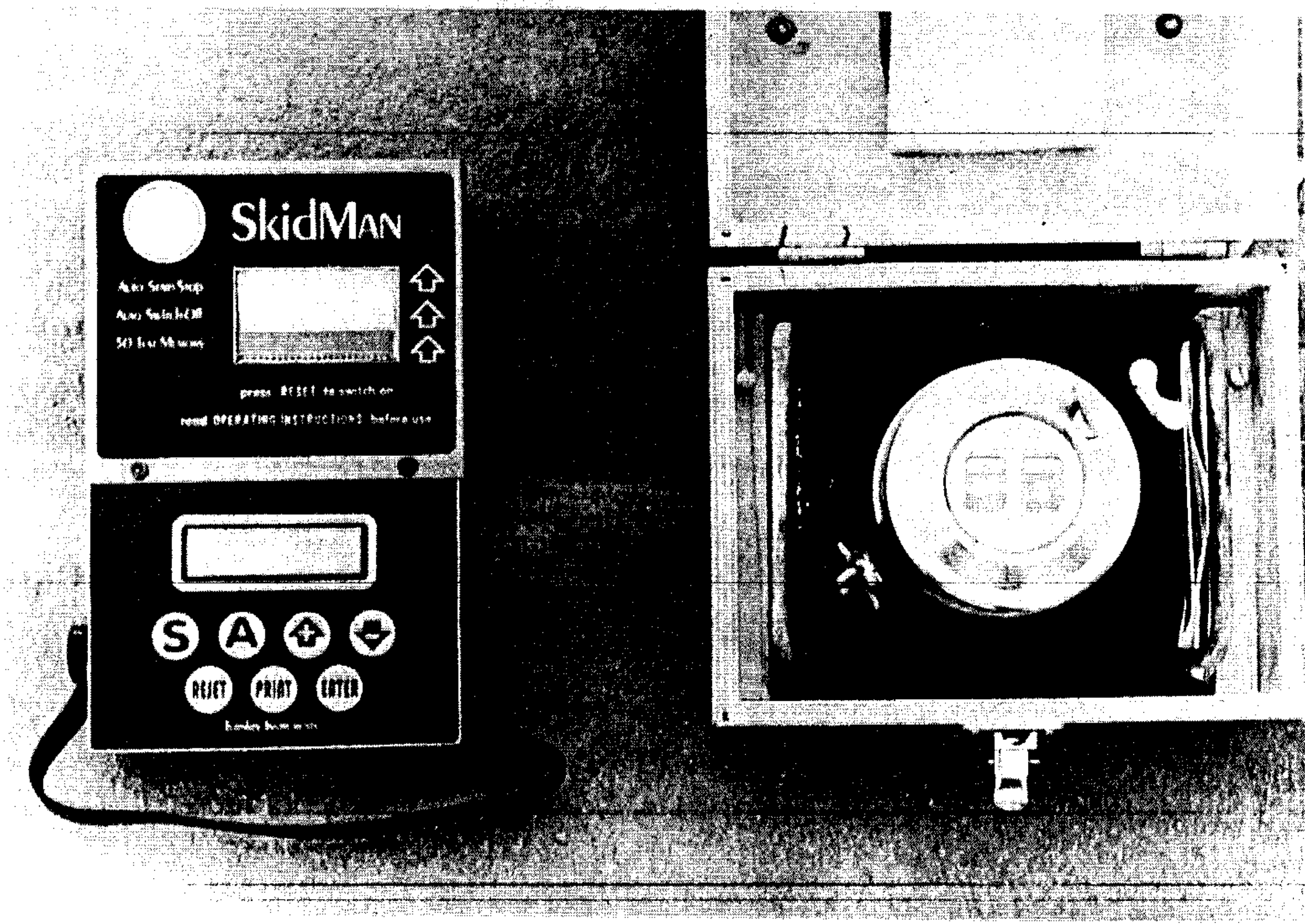


Figure 16

附件十

The Implementation of Joint Aviation Requirements

Presentation at the

48th annual International Air Safety Seminar
of the Flight Safety Foundation

and the

25th International Conference of
International Federation of Airworthiness

MANAGING SAFETY

Seattle November 7 1995

Klaus Koplin

Secretary General JAA

THE EUROPEAN JOINT AVIATION AUTHORITIES (JAA)

The Implementation of JAR's

PREFACE

Since several years JAA airworthiness codes for large transport aeroplanes, engines and propellers are used by industry and the European aviation authorities running the certification processes jointly. This has been extended to small aeroplanes and helicopters recently. JAR-145 (Maintenance Organisations) has been implemented and approximately 1400 organisations are approved in Europe.

The requirements for operation (JAR-OPS) has been adopted in March 1995 and the rules for personnel licensing will be finished mid next year. For both implementation procedures will be written and after an interim period of three or four years they will be binding in Europe.

This is a good occasion to review were JAA is today, how the joint work is performed and were it will go in future.

1. WHAT IS JAA?

Introduction

The Joint Aviation Authorities (JAA) are an associated body of the European Civil Aviation Conference (ECAC) representing the civil aviation regulatory authorities of a number of European States who have agreed to co-operate in developing and implementing common safety regulatory standards and procedures. This co-operation is intended to provide high and consistent standards of safety and a "level playing-field" for competition in Europe. Much emphasis is also placed on harmonising JAA regulations with those of the USA.

JAA Membership is based on signing the "JAA Arrangements" document of 1990. Based on these Arrangements and related commitments, the JAA's objectives and functions may be summarised as follows:

Objectives:

- To ensure, through cooperation on regulation, common high levels of aviation safety within the Member States.
- Through the application of uniform safety standards, to contribute to fair and equal competition within the Member States.
- To aim for cost-effective safety and minimum regulatory burden so as to contribute to the European industries' international competitiveness.

Functions:

- To develop and adopt Joint Aviation Requirements (JARs) in the fields of aircraft design and manufacture, aircraft operations and maintenance, and the licensing of aviation personnel.

- To develop administrative and technical procedures for the implementation of JARs.
- To implement JARs and the related administrative and technical procedures in a coordinated and uniform manner.
- To adopt measures to ensure, whenever possible, that pursuance of the JAA safety objective does not unreasonably distort competition between the aviation industries of Member States or place companies of Member States at a competitive disadvantage with companies of non-Member States.
- To provide the principal centre of professional expertise in Europe on the harmonisation of aviation safety regulation.
- To establish procedures for joint certification of products and services and where it is considered appropriate to perform joint certification.
- To cooperate on the harmonisation of requirements and procedures with other safety regulatory authorities, especially the Federal Aviation Administration (FAA).
- Where feasible, to cooperate with foreign safety regulatory authorities especially FAA, on the certification of products and services.

JAA's work was started in 1970 with the objective to produce common certification codes for large aeroplanes and for engines. This was to meet the needs of European industry, particularly for products manufactured by international consortia (eg Airbus). Since 1987 its work has been extended to operations, maintenance, licensing and certification/design standards for all classes of aircraft. Common procedures and the approval of design, production and maintenance organisations are covered. A single Joint Certification team, working on behalf of all JAA countries, is used for certification of new aircraft and engines. After the successful completion of the evaluations Type Certificates are issued simultaneously, and on a common basis, by all States.

JAA originated as the Authorities' response to the technical and economic needs of the European Aviation Industry. However, since 1 January 1992 JAA codes, as they are completed, are referenced in the European Community Regulation on Harmonised Technical Standards[1] and become law in the EC States.

Industry is fully represented in committees and working groups developing requirements and procedures and in a Joint Assembly and Joint Boards where policy issues are debated.

The JAA carry out their tasks of approval, certifications and safety monitoring using the staff of the national authorities, who also retain the responsibility for the legal findings, granting of licences and certificates, etc. The JAA Headquarters are responsible for the process of rulemaking, harmonisation and standardisation, (using specialist staff from the national authorities), the decision-making system, the "infrastructure" and various related tasks.

[1] Council Regulation (EEC) No 3922/91 of 16 December 1991 on the harmonisation of technical requirements and administrative procedures in the field of civil aviation.

2. GENERAL ORGANISATION OF THE JAA

2.1 Membership

Membership is open to States who are members of the European Civil Aviation Conference (ECAC), which currently has 32 member countries, and JAA are an "associated body" of ECAC. Membership takes effect when the 1990 "Arrangements" are signed. Twenty-three countries are members of the JAA today - see Figure 1.

The two-stage membership system which new States have to go through entails an evaluation and assessment process, with a satisfactory outcome, before the transition from Candidate to Full Member status. At present there are 18 Full Members and 5 Candidate Members (Cyprus, Malta, Monaco, Poland and Slovenia). Several States have started the process towards Candidate membership (Czech Republic, Slovak Republic, Hungary, Turkey).

2.2 Structure of the JAA

The JAA (see Figure 2) are run by the JAA Committee (JAAC) which is comprised of one member from each member State - generally the person responsible for all the safety regulatory functions covered by JAA in each authority. Day-to-day matters are decided by the Executive Board, which has six members selected from members of the JAA Committee. Broad policy decisions and final approval of the budget are decided by the JAA Board which comprises the Directors General of Civil Aviation of the JAA member states.

The Foundation Board, responsible for the affairs of the Stichting Beheer (a Dutch "foundation") which formally handles the business management role for JAA Headquarters; this foundation has no involvement in JAA technical policy.

2.3 JAA HQ Staff

The Headquarters staff is headed by a Secretary-General and has six divisions - certification, regulation, maintenance, operations, licensing, and administration.

In 1995 30 staff members are appointed at HQ. This number is planned to increase to 36 in 1997. HQ budget is 2.7 million ECUs in 1995 (US $3.6 m) planned to rise to 3.1 million ECUs (US $4.1 m) in 1996 and to around ECU 3.6 million (US $4.8 m) in 1997.

If JAA HQ retain their present activities, the long-term staff and costs are not expected to change greatly from these levels.

2.4 Funding of JAA HQ

At present JAA are funded by national contributions (85-90%), plus income from the sale of publications and training (10-15%). National contributions are based on indices related to the size of each country's aviation industry. The "largest" countries (France, Germany, the United Kingdom) pay around 20% and the smallest around 0.6% of the budget. All countries pay a minimum of 0.5% of the budget to cover "basic" costs of membership.

3. STATUS AND IMPLEMENTATION OF JAA WORK

3.1 Certification

JAA are committed to the joint certification of new aircraft, engines and propellers. They are finalising a joint system for the approval, using a multinational Team or local Authority, according to the complexity, of these products, Auxiliary Power Units (APUs) and equipment coming under the Joint Technical Standards Order (JTSO) system.

At present JAA have adopted, amongst others, codes for the certification of large aeroplanes (JAR-25), small aeroplanes including commuters (JAR- 23), helicopters (JAR-27 and -29), engines (JAR-E), Auxiliary Power Units (JAR-APU), propellers (JAR-P) and equipment (JAR-TSO).

Joint Type Certifications have already been completed on the following aircraft:

Airbus A-340
McDonnell Douglas MD-11
Jetstream 4100
Canadair CL600-2B19 Regional Jet
Dornier 328
CASA CN-235-100
Saab 2000
Boeing 777-200 (engine P & W)
IPTN CN 235-110
Airbus A320-232
Airbus A320-214
Airbus A321
Airbus A330
Airbus A330-321/-322
Airbus A330-341/-342
Airbus A340-212/-312
Falcon 2000

In addition the following joint aeroplane certification programmes are in progress:

Boeing 777-200 (2 models)
Boeing 777-300
Learjet 45
MD 90-30
Tupolev 204-200
Citation X
Canadair Global Express
Airbus A319
Boeing 737-600, -700 and -800
MD-95-30
EMB-145
Dash 8-400
Gulfstream V

The JAA and FAA have agreed to work together on a "Cooperative and Concurrent Certification" process, where the JAA and FAA evaluation teams integrate their work. This process is being applied, to the extent possible, on the Boeing 777, Learjet 45, the Boeing 737-600, -700 and -800, the MD 95-30, and, probably, to other future aircraft.

Joint Type Certification/Validation for engines have been completed on:

Williams International FJ44	(for Citation Jet)
Pratt & Whitney Canada PWC 119B	(for Dornier 328)
Allison AE 2100A	(for Saab 2000)
General Electric CF6-80E1A1/A2	(for Airbus A330)
Rolls-Royce RB211 Trent 700	(for Airbus A330)
Pratt & Whitney PW 4164/4168	(for Airbus A330)
CFE Company CFE 738-1-1B	(for Falcon 2000)
Rolls-Royce RB211 Trent 800	(for Boeing B777)
Pratt & Whitney PW 4074/4077/4084	(for Boeing B777)

Additional 13 Joint Engine programmes are in progress.

For helicopter, small aeroplanes and propeller similar procedures are used but adapted to the less complexity of products.

For helicopters one JAA type certification to JAR-27 was initiated in the last quarter of 1994 (Eurocopter EC 120). Further three validations of the FAA primary certification are in progress:

- MD HS MD 900 Explorer (JAR-27)
- Bell 407/407T (JAR-27).
- Sikorsky S 92

JAR-21, "Certification Procedures for Aircraft and Related Products and Parts", was adopted in November 1993 and became effective on 1 January 1995. JAR-21 covers the policy and arrangements between JAA and European industry applicants for product certification and design and manufacturing approvals, and will be jointly implemented by JAA on the basis of an agreed schedule in a progressive manner.

Currently JAR-21 is applicable to new European products and shortly to new imported products as well. There is a need for products previously certificated nationally by one or more JAA member states or jointly certificated to be caught-up. This catch-up process is a special process to define a standard for existing aircraft accepted by the JAA member states which allows free movement of existing aircraft in the "JAA space" without constraints.

Work has started on JAR-39 (Airworthiness Directives) and an NPA is scheduled for early 1996.

In addition JAA publish Joint Implementation Procedures for certification. These define the arrangements between the JAA Members to achieve the mutual recognition of the joint certification; they are developed in discussions between JAA and industry. All these procedures outline the concept of a single joint multi-national team carrying out the evaluation on behalf of all JAA countries. The Certification Committee is finalising proposals for the full range of products.The first draft of these procedures (Joint Multi-national and Joint Local Procedures) are used as Interim Procedures from 1 January 1995. Draft two of the JAA Multi-national and JAA Local Procedures are distributed for formal consultation with comment period ending 30 July 1995. Adoption is expected in the 1st quarter of 1996.

Procedures for Design Organisation Approval (DOA) have been adopted. Product Organisation Approval (POA) procedures for Product manufacturers were distributed for consultation and comments are being reviewed. The final procedures will address POA for products, parts and appliances. JAA considers that the completion of procedures for Supplemental Type Certificates (STC's), is a matter of high priority. Furthermore additional procedures should become available to enable the progressive implementation of JAR-21.

JAR-36 (Noise) deserves a specific mention. It was developed on the basis of ICAO Annex 16. The first draft included numerous National Variants which reflects the high political and environmental need of some countries to have more stringent requirements. Many commentators (notably FAA, AECMA, AEA, the US industry) have strongly objected to their existence. A process to minimize these National Variants has been but might require further action at Directors General level.

3.2 Maintenance

(a) JAR-145 : "Approved Maintenance Organisations"

This code was issued in July 1991 and adopted on 1 January 1992. All organisations carrying out maintenance on aircraft used for Commercial Air Transportation are required to be in compliance with JAR-145 to carry out such maintenance; this amounts to some 1500 organisations in Europe. At this time around 1400 such approvals have been completed.

The JAA concept for the approval of maintenance organisations is that this is the responsibility of the national authorities; however, an important foundation for the mutual acceptance of maintenance approvals is the use of Maintenance Standardisation Teams (MAST). Three such teams are operating and so far two visits have been completed to all "full" JAA members and the third round of visits are now under way.

With the experience JAA have gained with these teams the sequence of visits will be reduced and the number of team members will be reduced from three to two.

There is a need to accept organisations outside Europe and procedures have been developed to achieve this without compromising JAR-145 standards. Around 1200 US repair stations and 90 Canadian maintenance organisations have already applied for acceptance. So far around 920 US and 57 Canadian repair stations have been accepted and also 35 from other countries.

Organisations located in the USA/Canada which have been accepted by JAA are subject to sample audits carried out by maintenance international standardisation teams (MIST) operating in a similar manner to MAST teams. Canada and all regions of the USA have been audited at least once.

(b) JAR-65 : "Certifying Staff"

JAR-65 was submitted to the NPA in April 1995. More than 1000 comments were received and are presently analyzed. The JAR covers the qualification requirements for JAR-145 maintenance personnel who will release aircraft to service in the future. The JAR proposes that a standard European document will be issued by either the JAA-NAA or specially qualified JAR-145 organisations. The document is known as the Certifying Staff Qualification Document (CSQD).

"Grandfather rights" for existing personnel is a key feature and it will only be necessary to qualify for the European CSQD if either changing the scope of existing NAA Authorities licence of moving to another JAA Country.

(c) Training Schools, JAR-147

The third Draft was issued April 1995 of this JAR which will specify the requirements for the approval of schools such that they may satisfy part of the JAR-65 requirements including in particular the conduct of basic and type examinations to be accepted by the JAA-NAA as a basis for issue of the proposed CSQD.

3.3 Operations

JAR-OPS Parts 1 and 3 (covering Commercial Air Transportation by aeroplanes and helicopters respectively) were adopted by the JAA Committee at the end of March 1995. After a transition period of 3 years implementation of JAR-OPS will be required with effect from 1 April 1998 and this will occur initially under national legislation. JAR-OPS will be subject to "phased implementation" with the operators of large aeroplanes (those over 10 tonnes MTOM or with 20 or more passenger seats) and mixed fleets of large and small aeroplanes being affected first followed 1 year later (1 April 1999) by the operators of small aeroplanes.

The Subparts of JAR-OPS Parts 1 & 3 on Flight and Duty Time Limitations and Rest Requirements (Subpart Q) have not yet been adopted as the JAA Committee wished to review a recently released NASA document on the subject and also to take account of the FAA's proposed rulemaking in this field. A final decision on the adoption of Subpart Q is expected before the end of 1995 or early 1996.

As the adopted versions of JAR-OPS 1 and 3 have now been published (publication date was 22 May 1995), work has now been completed on development of the Operations Joint Implementation Procedures which were agreed by the JAAC in October 1995 and will be published in January 1996.

These are the procedures to be followed by the authorities in implementing JAR-OPS in all JAA Member States. Included in this material will be the system of Operations Standardisation Teams (OPST) (similar in function to the MAST system for maintenance), which are planned to come into operation in the second half of 1997. In advance of this standardisation activity, JAR-OPS training for both authorities and industry personnel is scheduled to commence in the last quarter of 1995.

In addition to the above-mentioned operational regulations, draft requirements have also been developed for simulators (JAR-STD Part 1). The draft has been out for consultation and the final draft is being prepared. It will be presented to JAAC for adoption in December 1995. The document is designed to enable a single evaluation of a Flight Simulator to be carried out by a Joint Team, the findings of which should be acceptable to all JAA Member Authorities. Such a process should result in considerable savings in that repetitious evaluations by individual authorities will no longer be required.

3.4 Licensing

Licensing deals with the drafting of common Standards and Joint Implementation Procedures (JIP) for these standards in the field of Personnel Training, Testing and Licensing in Aviation.

JAR-FCL deals with Flight Crew Licensing and divided into 5 Parts: Part 1 is Aeroplane, Part 2 is Helicopter, Part 3 is Medical, Part 4 is Flight Engineers and Part 5 is dealing with Gliders and Balloons.
Part 1 and 2 deal with requirements, acceptable means of compliance and guidance material for training, testing and licensing of Airline Transport Pilots, Commercial Pilots and Private Pilots for aeroplane and helicopter. This includes the training and testing for Instrument, Type, Class and Instructor ratings and for Examiners.

Part 3 contains the material regarding the health condition of the pilots and further comprises the Aviation Medical Manual, a guidance for Authorised Medical Examiners.

JAR-FCL has been out for a NPA round of comments and presently these comments are carefully reviewed. The FCL Committee will in a series of monthly meetings discuss these more then 2000 comments to avoid to much delay. Adoption is now scheduled for mid next year and after a transition period of two years it will be implemented on 1 July 1998.

Comments has also been asked on requirements for Flight and Navigation Procedures trainers I and II until 15 July 1995 and they are reviewed presently. This document will be part of JAR-STD (Synthetic Training Devices) joining Part 3 (A).

When JAR-FCL Part 1, 2 and 3 are adopted work will start on Part 4 (Flight Engineers) and Part 5 (Gliders and Balloons).

For the standardisation of the implementation of JAR-FCL there will be a system of standardisation teams (LIST- and MEST-teams) working according to the same construction as is designed for Maintenance. A JIP document will contain procedures regarding these teams. JAR-FCL training for authorities personnel and interested parties will start after adoption of the document.

4. JAA CONVENTION

4.1 Introduction

JAA are developing a Convention with the intention to give a more formal and legal status to JAA, to reinforce the commitment of member states and to facilitate the development of JAA. It is believed that this will strengthen JAA and remove some of the present obstacles to progress.

The JAA Board set up a Treaty Working Group in June 1992. The Working Group has completed its draft Convention and it has been presented to the JAA Board.

In March 1995, the JAA Board concluded the discussion on the draft Convention, and although there are some remaining issues that still have to be settled, final agreement is getting close. The latest draft has been sent to all the JAAB members for their relevant National Authorities to consider the legal aspects and implications etc. In a workshop for the users of JAA in July 95, the Convention was presented and the users were invited to give their comments.

4.2 Scope and Form of the Convention

The Convention does not radically change the JAA as we know it today. It is declared in the draft that the purpose of the Convention is to enable the National Aviation Authorities (NAA's) to act through JAA as a de facto single Aviation Authority, leaving it to a future process to create a single European Aviation Authority.

This reflects that a decision is still to be made by all member states to commit themselves to the concept of a single Authority which would replace the NAAs, or more probably reconstitute them as JAA regional offices.

The tasks of JAA remain the same under the Convention. The organs of JAA remain the same and so does the funding. The principle that JAA shall move forward step by step, assuming new tasks when it is considered appropriate to do so, is unchanged. The obligations of the NAAs are in essence unchanged, but since the parties to an International Convention must be States, the obligations are on Member States to ensure that their NAAs do what is required of them. The obligations are set out in a rather more precise way than in the Arrangements Document which provides the current basis for JAA. In particular, it is expressly stated in the Convention that Member States must recognise and accept certification given by another Member State unless JAA has found that the NAA of that Member State is not applying the standard of the relevant JAR. Each Member State will also be required to ensure that its NAA co-operates with JAA with regard to standardisation activity by the JAA. In particular, an NAA will have to take any remedial action required by JAA following a standardisation team visit. The further development of JAA's monitoring role should become an important tool in enhancing safety standards.

What is new about the Convention is that it translates the present "members club" of participating NAA's, whose legal status, rights and obligations are not always clear, into an international organisation with legal personality and status. With a Convention JAA can also enter into a Host Agreement with the country, in which the Headquarters is established, relating to the privileges and immunities for JAA staff, experts performing work for JAA, and representatives of JAA Member States on the territory of the Host State, whilst exercising their functions for JAA. By this JAA can enter into contracts, employ staff, set up pension schemes etc.

So far JAA has managed to act by consensus without the need to use a voting procedure, it is however unrealistic to think that an international organisation, as the JAA will become under the Convention and with an expected increased number of Member States, will always be able to achieve consensus and therefore voting procedures for the JAAB and JAA Committee (JAAC) have been laid down.

On most decisions it is proposed that both JAAB and JAAC decisions shall be taken with a two-third majority of the number of votes, which would be cast if each member had cast a vote.

For financial matters related to budget and National Contributions a weighted voting system is proposed.

The functions of JAAB and JAAC are rather detailed and set out in Annexes to the Convention and may only be amended by the JAAB.

A possibility for the review and downgrading of JAA membership status is also proposed. When the Board has reason to believe that a Member State is in serious breach of its obligations, the Member State may, after a fixed procedure, be relegated to the status of a JAA Candidate Member State thereby losing voting rights, and automatic acceptance of certification.

As mentioned above the latest draft Convention has been circulated to the JAA Member States for national consultation in Foreign Offices in preparation, hopefully, for early final agreement. It is intended that the Convention will be taken up again by the JAAB in December this year for approval and the plan is to organise a Diplomatic Conference for the final adoption in 1996.

The comments from the users received so far are asking for further development of the JAA organisation into a real "single European Authority" and for a clear solution concerning the involvement of the European Union.

In the meantime, efforts will have to be made in order to solve the few remaining outstanding issues. This includes the European Union's position in relation to the Convention as the EU-Commission has stated on several occasions that the EU should become party to the Convention. The EU Commission, however, still needs to present this position in a request for a mandate to the EU Council, who will decide on the matter. Hopefully this will also be clear before the diplomatic conference planned for next year.

5. Outlook

Appendix 1 summarises the present position on JAR's, both those already adopted and those yet to be adopted.

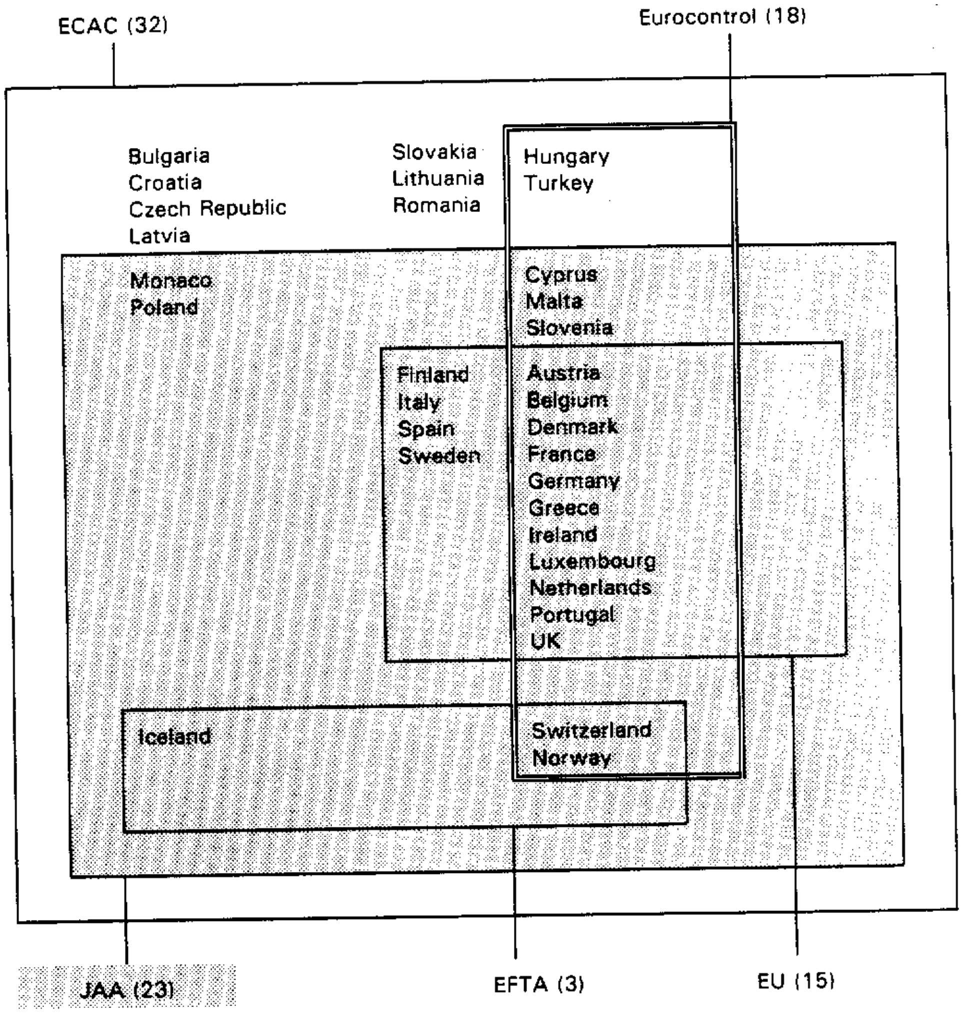
Work has started on JAR-11 (JAA Regulatory and related procedures) with adoption tentatively scheduled for late 1996. A working group is also discussing retroactive airworthiness requirements (JAR-26). These are safety requirements that shall be used in already operating aircraft.

The application of JAR's for airworthiness and maintenance has shown that a joint European aviation system can work. The present procedures can solve to a large extent the problems coming from still existing national legislation. But they are partly an administrative burden and creating additionally cost without a safety benefit. Further development is necessary.

The JAA Convention will give JAA a formal European legal basis and might be the first step to a Single European Aviation Safety Authority. As this can be a lengthy process and furthermore needs a careful balance with the European Union an assumption of the time needed cannot be made. But JAA will continue with its work and will be the genesis of a European Authority.

Figure 1

ECAC, EU, JAA, EFTA and Eurocontrol



JAA Organisation

Figure 2

te 1: The organisation is the whole of the JAA organisation, i.e. working groups, committees, headquarters and the governing bodies (JAAB, JAAC and EB/FB)

Note 2: The Administration is the Organisation excluding the governing bodies. The Administration is under the Terms of Reference for the Secretary General

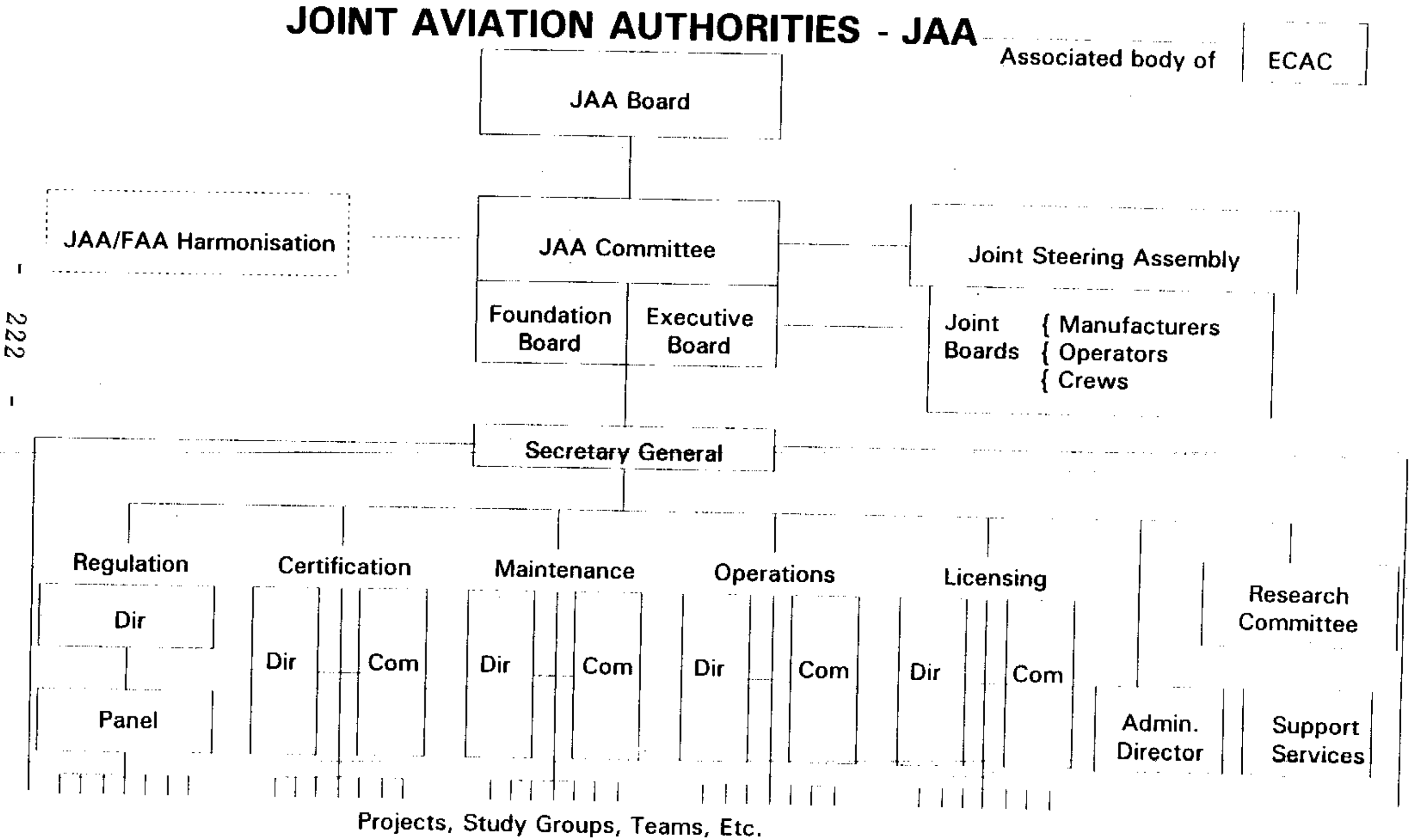
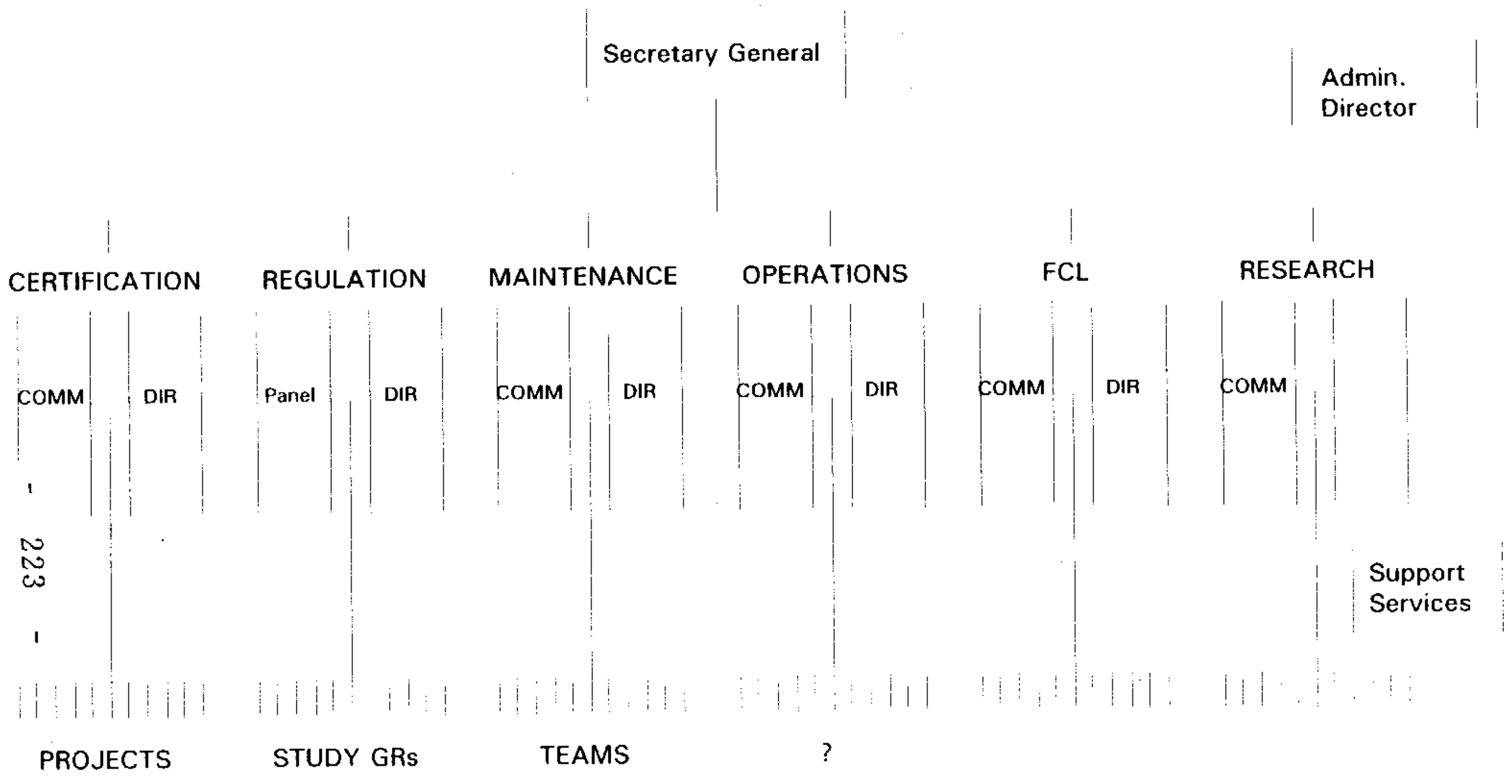


Figure 3

JAA Administration

Note 2: The Administration is the Organisation excluding the governing bodies.
The Administration is under the Terms of Reference for the Secretary General

JAA: UNDER THE UMBRELLA OF THE SECRETARY GENERAL



JAR'S ADOPTED AND PUBLISHED

CODE	TITLE	BASE CODE
Airworthiness Standards		
JAR-1	Abbreviations & Definitions	--
JAR-21	Certification of Aircraft & Related Products and Parts	FAR Part 21
JAR-22	Sailplanes & Powered Sailplanes	German code for Sailplanes
JAR-23	Small Aeroplanes	FAR Part 23
JAR-25	Large Aeroplanes	FAR Part 25
JAR-27	Small Helicopters	FAR Part 27
JAR-29	Large Helicopters	FAR Part 29
JAR-APU	Auxiliary Power Unit	FAA TSO C-77A
JAR-AWO	All Weather Operations	--
JAR-E	Engines	UK BCAR Section C
JAR-P	Propellers	UK BCAR Section P
JAR-TSO	Technical Standard Orders	FAR Part 21 Subpart O
JAR-VLA	Very Light Aeroplanes	--
Maintenance Approval Criteria		
JAR-145	Approved Maintenance Organisations	FAR Part 145
Aircraft Operations		
JAR-OPS	Operations	ICAO Annex VI

JAR's CURRENTLY IN DRAFT FORM OR UNPUBLISHED

CODE	TITLE	BASE CODE	ADOPTION
Certification Standards			
JAR-36	Noise Requirements	ICAO XVI	1996
JAR-11	Rulemaking Procedures	--	
Flight Crew Licensing			
JAR-FCL	Flight Crew Licensing	ICAO Annex I	1996
JAR-MED	Medical requirements	ICAO Annex I	1996
Maintenance			
JAR-65	Certifying Staff	FAR Part 65 Subpart E	1996
Aircraft Operations			
JAR-SIM	Simulator Standards		1996
JAR-26	Retroactive Airworthiness Requirements		1996

Future codes under consideration, but not yet under full development:

CODE	TITLE	BASE CODE
JAR-34	Emissions	--
JAR-39	Airworthiness Directives	--