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出國人 職　　稱：副所長
姓　　名：林志明

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摘要：

本報告主要在摘要彙整加州大學柏克萊分校主辦之機場規劃研習課程內容，包括機場系統規劃、航空運量需求預測、機場容量分析、機場之規劃與設計、噪音分析與環境規劃課題等，另也提出研習結論與建議供有關單位參考。爲參考之目的，部份研習之講義亦併載於附錄中。

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備註：本研究之結論與建議不代表交通部之意見。

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ABSTRACT:

This report gives a brief introduction on the airport systems planning and design short course organized by University of California , Berkeley . The topics range from airport systems planning and travel demand forecasting to airport capacity analysis, airport layout planning and design , noise analysis , and environmental planning . For reference purpose , some conclusions and suggestions are made , and some handouts are also included in the appendixes.

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目　錄

摘 要

本次赴美國加州大學柏克萊分校參加機場規劃（Airport Systems Planning & Design）第二十七年之短期課程（27th annual short course），研習行程計九天，簡述如下：

五月九日（週六）：由台北啓程到舊金山；

五月十日（週日）：參觀奧克蘭國際機場（Oakland Int'l Airport）；

五月十一日（週一）至五月十四日（週四）：參加 U.C. Berkeley 舉辦之機場規劃短期課程研習；

五月十五日（週五）：參觀舊金山國際機場（San Francisco Int'l Airport）；

五月十六日（週六）：返程；

五月十七日（週日）：抵達中正國際機場。

研習課程內容包括：機場系統規劃、航空運量需求預測、機場主計畫、機場之規劃與設計、空域與機場容量、未來機場營運概念、機場營運與資訊科技、機場連外地面交通、客運航站規劃、機場系統模擬技術、航空公司營運課題、環境規劃與管理課題、機場噪音管理、機場財務課題、與現代化機場的管理課題等十五個部份,涵蓋面廣,內容也相當的精闢,謹摘列五點研習心得與建議,提供相關單位參考。

1.環保問題已漸爲世人所重視，爲期機場長期的發展能與機場周邊的地方發展共存共榮，建議各級政府主管當局應及早妥善協調，就機場周邊地區，釐訂一合宜的土地使用計畫。

2.機場連外及機場內部運輸系統的良窳，對於機場的營運有相當大的影響，建議政府相關主管部門應參考取法國外成功的案例，積極推動；同時對於失敗的案例，也

當引為殷鑒，以免重蹈覆轍。

3. 機場主計畫是勾勒一座機場終極發展之建設藍圖，為期能最經濟有效的運用有限的資源，使每一機場各階段的發展建設，均能與國家、社會與地區的發展相契合，爰建議民航主管當局應定期修訂各機場之主計畫。

4. 引進企業化經營的效率提升機場的競爭力，快速反應滿足多變的顧客需求已是國際趨勢，建議政府相關主管部門應未雨綢繆，及早規劃強化現有中正機場組織架構有所不足之處，俾能早日實現我國推動發展中正國際機場成為亞太空運中心的目標。

5. 此類的研習課程，對於從事航空運輸相關事業的人員而言，應是相當好的在職進修管道之一，建議交通部、民航局、相關單位及顧問公司能衡量其業務的需要，定期派員參加。

壹、研習記要

以下謹就本次研習程內容，分成十五個課題摘要彙整：

一、機場系統規劃

由英國 Loughborough University of Technology 的 Robert Cavers 教授講授，講授大綱包括機場系統、系統規劃及其工作要項、機場扮演的角色、網路效應與未來因應的作法等（請參閱第 19 頁之 AIRPORT SYSTEM PLANNING）。

二、航空運量需求預測

由 U.C. Berkeley 的 Mark Hansen 教授講授，主要內容包括：爲何需要運量預測？進行運量預測考量之變數有哪些？（如客運延人公里、貨運延噸公里、上下客人數、裝卸貨運量、起迄交通量、機型大小等）；預測的方式（例如以經驗法則判斷抑或藉由分析推估、由上而下或由下而上進行推估、進行點推估或區間推估、進行長期的預測或短期的推估等）；應用推估的模式（如線性模式、指數模式、對數模式

等)。歸納而言，預測本質上即具有相當的不確定性，因此，藉由系統性的分析方法來掌理不確性與風險或許是較好的解決之道。

三、機場主計畫

本節由 Parsons Infrastructure & Technology 之 Steve Stretchberry 先生主講，講授內容包括機場主計畫（或稱綱要計畫）概述、機場主計畫各階段進行的工作項目與案例評析等。

一般而言，於進行機場主計畫時，首先必須先確認興闢（或擴建)機場所需達成之目標、目的以及與其相關之課題，因此於主計畫第一階段作業時，即須決定機場各項需求，進行航空運量需求預測與系統容量分析，此時，也應將對環境的衝擊因素納入考量。設若為興建一座新機場，於機場主計畫第二階段接著即應進行可能機場場址評估。於第三階段，則進行機場佈設規劃，包括機場的佈局、土地使用規劃、航站區規劃、以及根據 FAR 77 進行水平面、圖錐面等飛航空域障礙之機場「假想面」規劃等。至於第四階段，則進行財務計畫，研析內容應含括預估之建造成本，經濟、財務可行

性評估，與財務計畫等。

案例分析是以舊金山灣區之奧克蘭國際機場爲例。

四、機場之規劃與設計

本節由英國 Loughborough University of Technology 之 Robert Caves 教授主講。探討的主題包括：機場之佈局（airport layout），例如跑道系統之佈設型式方位（orientation）與容量，航站與滑行道之佈設，與其它相關設施（如塔台、消防站）之佈設；跑道所需長度之估算原則；與空側幾何設計等。

由於涵蓋的範圍很廣，因此 Caves 教授僅能就各主題作很原則性的介紹，有關細節，建議可參閱 ICAO 以及 FAA 出版的相關報告（詳如第 29 頁）。

五、空域與機場容量

由 Leigh Fisher Associates 之 William Dunlay 先生講授介紹飛航交通管制之重要規定，例如按美國 FAA 之規定，在 IFR 作業地區，最小的前後飛航隔離，需有 3 海浬的水平距離，最小的上下隔離，則至少須保持 1,000 呎等；Dunlay 先生也

介紹了未來可能應用到的助航設施，例如 DGPS、WAAS(Wide Area Augmentation System)、ADS-B (Automatic Dependent Surveillance - Broadcast mode)，以及目前被廣泛應用於分析空域與機場容量之模擬程式軟體，如 ADSIM、RDSIM、SIMMOD 與 AIRNET 等（請參閱第 31-39 頁）。

六、未來機場營運概念

本節由 Airport Council International-North America 之 Richard Marchi 先生主講，介紹與目前航管概念絕然不同的自由飛航概念（free flight concept）。未來一旦藉由衛星裝載之助航設備與機載之全電腦化飛航管理系統（Flight Management Systems，FMS）建構完成付諸實施，預期航機未來航行的自由度，將可大幅度的提增，不僅有利於越洋（oceanic）與航路途中（en-route）空域的有效利用，同樣地，對於航機密度較高的終端空域（terminal airspace）的有效運用上，也將有所助益，當然，扮隨著自由飛航概念，未來機場的營運概念也須配合修正（請參閱第 41-53 頁）。

七、機場營運與資訊科技

由 Aviation Planning & Techonology Systems Consulting 之 George Blomme 先生講授，介紹廣爲許多機場使用之各類技術（types of technologies）以及其優劣點（請參閱第 55-85 頁）。

八、機場連外地面交通

本節由加州大學柏克萊分校運輸研究中心主任 Geoffrey D. Gosling 博士講授，主要內容包括機場地面交通規劃（諸如研究範圍、規劃目標、規劃相關課題等）、往來機場地面交通旅次特性、地面交通設施（例如停車設施、站前停車佈設、機場内道路與運人系統、轉運設施等）、規劃所需之資料、地面交通運具選擇（例如影響運具選擇之因子、運具選擇模式等）與計畫評估的方法，若需進一步瞭解可參閱相關資料（詳如第 87-90 頁）。

九、客運航站規劃

由 PB Aviation, Inc. 的 Hanan Kivett 先生講授。大體而言，

普見之客運航站規劃可區分爲集中式（centralized）與分散式（decentralized）兩類，如 Denver 新國際機場與香港赤臘角新國際機場採集中式之客運航站設計；而舊金山國際機場與洛杉磯國際機場等採分散式之客運航站設計，旅客往來各航站間或需利用機場穿梭巴士、運人系統（people movers）、電動步道，以縮短步行距離、節省時間。無論是採集中式或分散式，客運航站之規劃均應充份考量到機場營運的彈性與旅客的方便性（詳見第 91-100 頁）。

十、機場系統模擬技術

本節由 ATAC 的 Michael Abkin 先生主講，介紹由其公司開發完成之 Passenger and Baggage Flow Model（PBFM）。該程式軟體可用於模擬分析機場航站內旅客與行李的移動情形，以協助機場營運單位檢討有待改善之處並提出因應措施。

十一、航空公司營運課題

由美國航空（AA）之 Laura Moynihan 女士講授，主要內容包括航空服務業的特性（如資本密集、勞力密集等）、

營運的大環境（如須受機場登機門型式、跑滑道壅塞、宵禁限制、噪音管制之限制與遵行 FAA 的相關規定等）、飛航排班（原則上是從公司最大營收角度或從可調派使用之航機與服務人員限制條件來作規劃）、以及如何進行長期、短期或每日的營運規劃與進行營運績效管理等。

十二、環境規劃與管理課題

本節由 Environmental Science Associates, Inc. 之 Nona B. Dennis 女士講授，主要內容包括五個部份：(一)在進行機場規劃時對於環境面應有哪些考量（按美國已於 1969 年通過國家環境政策法案(The National Environmental Policy Act, NEPA)），該法案並已普爲世界各國所參用，作爲任一計畫在付諸實施之前必經之檢核模式）；(二)Environmental Action Choices ，係根據擬進行計畫對環境之影響大小，評議到底應進行何種程度之環境衝擊分析工作，例如應辦理 Environmental Impact Statement (EIS)？抑或是進行 Environmental Assessment (EA)即已足夠？(三)環境影響評估文件應涵蓋之內容及其架構；(四)環境影響評估文件需涵括的各項衝擊研究，例如：噪音、社會衝擊、空氣品質、水質、

衍生之社經衝擊、固體廢棄物等；(五)環境影響評估文件所需之附帶補充資料，如民眾的參與、公聽會、用地取得與對遷居戶之協助、以及有關如何確保空氣及水品質之具體行動規劃等（詳第 101-137 頁）。

十三、機場噪音管理

本節由 GTE Internetworking 之 Sanford Fidell 先生講授。如何有效降低機場噪音所帶來的負面衝擊，已是世界各主要國家在提供便捷的航空運輸之同時，必須共同面臨努力解決的課題，我國非常重視它，美國當然也不落人後。就美國而言，機場附近地區之土地使用型態大多有其共通性，也就是說，在緊臨機場地區，一般都供作航空相關產業使用，例如貨物承攬業、倉儲、租車服務業、汽車旅館、速食簡便餐廳、停車場、會議中心、與機場相關地面運輸場站等；而在近臨機場之區域，除原有沿著街廓興闢的老舊住宅區之外，一般均不准新建房舍；至於離機場再更外圍之第二圈，一般則以朝向低密度開發之住宅區發展。其土地使用分區管制之主要著眼，即在促使機場的營運發展能與附近土地使用互相配合，不致有太大的衝突，並期望因而能有效降低機場噪音所

帶來的負面衝擊。

十四、機場財務課題

本節由 Leigh Fisher Associates 的 Maureen Riley 與 Thomas Walsh 先生講授，主要內容包括機場財務課題與機場定價兩大部份。

美國機場建設資金的主要來源有：

(一)聯邦政府之補助款（Federal government grants-in-aid－Airport Improvement Program(AIP)）;

(二)機場營運當局之外借款（Airport debt）;

(三)旅客服務費（Passenger facility charges, PFCs）;

(四)州政府／地方政府之補助款與貸款；

(五)內生之資金流動（含投資收入）;

(六)公共投資（Public investment）;

(七)民間資金（即民營化）。

有關機場定價部份，則在介紹機場收費費率觀念，內容包括成本結構、機場支出定義、訂定費率的方法等，也說明了現有的收費法令架構與機制，並舉出許多機場在收費費率方面所採行的作法供參（詳如第 139-168 頁）。

十五、現代化機場的管理課題

本節由加州大學柏克萊分校運輸研究中心的 David Gillen 博士主講，其講題為“ Measuring, Monitoring and Managing Opportunities in Non-Aviation Revenues”（詳見第 169-193 頁），重點包括：

(一)為因應變遷的市場環境必須調整管理的方式

1.分散營收及支出責任；

2.力求透明化；

3.以顧客為導向。

(二)應視機場為一個企業體

1.為企業經營之需,需有一套新的系統與組織架構；

2.要有最大的經營彈性；

3.要創造足夠的誘因。

(三)非飛航與飛航營收之策略不能相背離

1.兩者均需有新的市場動力；

2.兩者均需重視品質（如品質管制，再造工程等）；

3.當市場變化時，兩者均需有調整的彈性。

貳、結論與建議

一、結論

1．加州大學柏克萊分校爲美國著名之高等學府之一，能於歷經二十餘載，仍持續費力精心規劃本項機場規劃短期課程，邀請學界（包括加州大學與英國的 Loughborough University of Technology）與產業界（包括顧問公司與航空公司）的實際工作者講授，於最短的時間內，廣爲介紹當前航空運輸重要的相關課題，無論是從機場系統規劃、航空運輸需求預測、機場主計畫規劃，到愈來愈受到重視的環保課題與財政課題，內容都相當的精闢。雖然有些已是耳熟能詳，然而整體課程設計涵蓋面廣，仍有許多不是平日工作有機會接觸到的部份，因此，雖然本次的研習時間很短，但覺得收益不少。

2．美國地大物博，伴隨經濟的繁榮，航空運輸也就扮演著服務的重要角色，其航空旅次量約佔全球總量之三分之一強。全國約有一萬七千餘座大小機場，其中只有三千三百座，被納入全國整體機場系統計畫中（the National

Plan of Integrated Airport Systems），而真正有正常航班提供空運服務的機場只有 570 座左右，其中又僅有四百餘座機場之交通量已達須由 FAA 設置管制塔台之標準。反觀我國台澎金馬地區，迄今開放提供民航使用之機場包括中正、小港兩國際機場，已達 17 個之多。兩國當前在機場營運上所面對的共通點是國民對於環保要求與航空噪音的管制意識愈來愈強烈，也因而直接影響到機場的擴建或新闢規劃。例如舊金山國際機場（SFO）當局，從保育野生動物著眼，為保護瀕臨絕種之 San Francisco Red Garter Snake，已將部份 SFO 之用地保留作為棲身之地而不作進一步的開發；奧克蘭國際機場，位於舊金山灣區的東側與 SFO 遙遙相望，雖也有亟需增闢跑道之需求，惟由於其擴建將破壞影響到當地溼地（Wetlands）的存廢，因此，尚難獲准興建。反觀我國亦然，民航局原擬配合發展中正國際機場成為亞太空運中心機場之政策，將 05L~23R 跑道北移 300 公尺，因民眾對航空噪音的厭惡以致激烈抗爭，至今無法執行。有鑒於此，深感政府有關當局實應及早妥善協調，就機場周邊地區，釐訂一合宜的土地使用計畫，以期機場的長遠發展能與周

邊的地方發展共存共榮；另外，對於機場附近現有之住家居民，建議民航主管單位也應研擬具體可行、合理的回饋彌補措施，以降低其在日常生活所受到的負面衝擊，並進而能爭取其協助與支持，俾利國家更長遠的航空建設計畫。

3. 機場連外運輸系統的良窳，對於機場的營運有相當大的影響。世界上許多主要機場，已出現不僅連外道路系統尖峰時段壅塞情形日益嚴重，連機場內的道路系統也常處於繁忙或壅塞的狀態，因此，有些機場當局除了尋求道路系統之積極改善之外，也已興建或正規劃連外的軌道系統（包括鐵路或捷運），例如日本的成田、羽田機場　，法國巴黎的戴高樂、奧利機場，英國倫敦的 Heathrow、 Gatwick、Stanstead 機場，荷蘭的 Amsterdam 機場，德國的 Frankfurt、Munich 機場　，美國的 Atlanta、Chicago　O'Hare、SFO 機場等。其中倫敦的 Heathrow 機場更於新近啓用一條快鐵系統，輔助原有的 Piccadilly 捷運線，以提供旅客至倫敦市區更便捷舒適的轉運服務。另外，近鄰之香港赤鱲角機場（CLK）於本年七月上旬啓用之同時，也已由機場快鐵線擔綱，提供旅客往

來香港、九龍市區與 CLK 之間高水準的轉運服務。至於機場內運輸系統服務之改善，多數機場藉助於 Shuttle Bus、People Mover、電動步道（Moving Walks）來縮短旅客步行距離，或以 AVI 結合電子收費（ETC）技術達成有效減少商用車輛進出機場次數的管理目標。類此國外改善機場內外運輸系統的種種作法或經驗，不管是成功的也好，收效不大的也好，均值得我國有關主管部門參考借鏡，以期我國的運輸系統建設均能發揮最大的效用。

4. 機場主計畫是勾勒一座機場終極發展（Ultimate Development）之建設藍圖，因此其計畫涵蓋面較廣，不僅包括機場內之各項設施，而且也包括了鄰近地區之土地使用計畫，其總體目標則一方面在以財務可行的方式研擬機場分期發展時程，以滿足航空運輸需求，一方面在配合社區的發展與其他運輸系統建設，同時又不致於對環境有過度的負面衝擊。

由於機場建設所需投入的成本相當的高，對於國家與地區的發展影響深遠，因此不論是增闢新機場或進行舊有機場之擴建，均須對其需要性進行詳細的分析。準此，

建議民航主管當局實應定期就各使用中之機場進行主計畫之修訂工作，以期能最經濟有效的運用有限的資源，使每一機場各階段的發展建設，均能與國家、社會、地區的發展相契合。

二、建議

1. 此類的研習課程（據悉除 U.C. Berkeley 按年舉辦之外，MIT 以及幾所大學也都有類似的課程），對於從事航空運輸相關事業的人員而言，由於規劃之研習時間不長（不致耽誤原有的工作），參加研習所需的經費不多（註冊費約一千至二千美金），而且規劃的課程相當合宜務實，因此可以說是很好的在職訓練管道之一，爰建議交通部、民航局、相關單位以及國內相關顧問公司能衡量其業務的需要，定期派員參加，並藉機與其他學員交換工作經驗。

2. 目前我國正在積極推動發展中正國際機場成為亞太空運中心的政策，未來此一政策能否成功落實，中正機場之營運主體能否隨著時代的腳步以企業化經營快速反應滿足多變的顧客需求，應是相當重要的關鍵因素之一，茲

建議交通部與民航局宜審愼參酌國外國際機場的營運趨勢（如英國由 BAA 經營倫敦 Heathrow 等機場之模式、荷蘭 Schiphol 模式、巴黎 ADP 模式、新加坡樟宜模式或香港 CLK 模式），儘早修訂出我國的經營模式，徹底強化中正機場在組織架構上有所不足之處，俾提升機場營運的競爭力。

3. 由國外許多機場連接市區軌道系統之成例，再對照我國中正機場連外軌道系統的發展規劃，茲建議已取得中正機場捷運線興建優先權之長生公司，於進行規設時，實應再廣泛蒐集國外相關的作法，俾審愼評選引進最合適之系統，提升其競爭力並發揮該運輸系統建設的效益。

4. 以美國主要之機場爲例，機場停車收入爲機場重要的營收項目之一，有些甚至高占三分之一左右，因此建議民航局宜檢討並善用主要機場之可用空間妥善進行停車場之規劃建設，除一方面可提供滿足旅客方便停車之需之外，另方面也可增加機場的營收，例如位在中正機場一期航站東西兩側之平面停車場，建議可儘早進行立體化工程。

參、附錄

Resource:Airport Systems Planning & Design (27th annual short course), May 11-14 , 1998 University of California , Berkeley

U.C. Extension Engineering

Airport Systems Planning and Design

MONDAY, MAY 11

8:30-9:00 a.m.	**Introduction** / Kanafani
9:00-10:00	**Airport systems planning** / Caves
10:00-10:30	break
10:30-noon	**Air traffic demand forecasting** / Hansen
noon-1:00 p.m.	lunch
1:00-2:30	**Airport master planning** / Stretchberry
2:30-3:00	break
3:00-4:30	**Planning issues** / Panel discussion

TUESDAY, MAY 12

8:30-10:00 a.m.	**Airport layout planning and design** / Caves
10:00-10:30	break
10:30-noon	**Airspace and airport capacity** / Dunlay
noon-1:00 p.m.	lunch
1:00-2:30	**Future airport operations concepts** / Marchi
2:30-3:00	break
3:00-5:00	**Airport operations and information technology** / Blomme ***(Change)***

WEDNESDAY, MAY 13

8:30-10:00	**Airport access** / Gosling ***(Change)***
10:00-10:30	break
10:30-noon	**Passenger terminal planning** / Kivett ***(Change)***
noon-1:00	lunch
1:00-2:30	**Airport simulation and modeling techniques** / Abkin ***(Change)***
2:30-3:00	break
3:00-4:30	**Airline operations and economics** / Moynihan
7:00	Dinner / Powell

THURSDAY, MAY 14

8:30-10:00 a.m.	**Environmental planning and management** / Wormhoudt ***(Change)***
10:00-10:30	break
10:30-noon	**Airport noise management** / Fidell ***(Change)***
noon-1:00 p.m.	lunch
1:00-2:30	**Airport finance** / Walsh
2:30-3:00	break
3:00-4:00	**Managing the modern airport** / Gillen
4:00-4:15	**Course summary** / Kanafani

Faculty members in charge

Adib Kanafani, Professor of Transportation Engineering, and Director, Institute of Transportation Studies, University of California, Berkeley

Geoffrey Gosling, Program Manager, National Center of Excellence for Aviation Operations Research, Institute of Transportation Studies, University of California, Berkeley

Instructional staff

Michael Abkin, Project Manager, ATAC, Sunnyvale, California

George Blomme, Aviation Planning & Technology Systems Consulting, Rancho Mirage, California

Robert Caves, Senior Lecturer, Department of Aeronautical & Automotive Engineering & Transport Studies, Loughborough University of Technology, Leicestershire, England

William Dunlay, Principal, Leigh Fisher Associates, San Mateo, California

Sanford Fidell, GTE Internetworking, Canoga Park, California

David Gillen, Adjunct Professor of Transportation Engineering, and Research Economist, Institute of Transportation Studies, University of California, Berkeley

Geoffrey Gosling, Program Manager, National Center of Excellence for Aviation Operations Research, Institute of Transportation Studies, University of California, Berkeley

Mark Hansen, Associate Professor of Transportation Engineering, University of California, Berkeley

Adib Kanafani, Professor of Transportation Engineering, and Director, Institute of Transportation Studies, University of California, Berkeley

Hanan Kivett, Vice President, PB Aviation, Inc., San Francisco, California

Richard Marchi, Senior Vice President, Technical and Environmental Affairs, Airports Council International - North America, Washington, D.C.

Laura Moynihan, Senior Project Manager, Information Technology Services Department, American Airlines, Dallas/Fort Worth Airport, Texas

Lynn Powell, Bechtel, San Francisco, California

Maureen Riley, Leigh Fisher Associates, San Francisco, California

Steve Stretchberry, Director, Aviation Services, Parson Infrastructure & Technology Group, Inc., San Francisco, California

Dan Wormhoudt, Vice President and Director of Airports and Port Facilities, Environmental Science Associates, Inc., San Francisco, California

Thomas Walsh, Leigh Fisher Associates, San Francisco, California

AIRPORT SYSTEM PLANNING

What is an airport system?

A system usually comprises a set of components which interact in a way which has at least the appearance of stability in the short term. If there are no interactions there is little point in performing a systems analysis; equally, if most of the influences on the 'system' components come from outside the boundaries of the defined 'system', then a systems analysis is unlikely to lead to a fruitful conclusion. An understanding of the behaviour of the system which is to be implanted or improved is therefore essential to its successful planning. Systems analysts usually probe deeply into the workings of a system in order to clarify its scope and function.

The number of ways in which the scope of a system involving airports can be defined is almost infinitely large. The situation can be formalised in the three non-orthogonal dimensions of:

- spatial scale
- transport system elements
- sectors of the economy.

Systems which are very large are usually incapable of a meaningful analysis because the nature of some of the interactions is inadequately understood, e.g. the effect of the provision of more flights on a regional economy. On the other hand, a too narrow system boundary can miss out areas which are ultimately more important than the areas being studied, e.g. the effect of political intervention on demand, or the effect of changing aircraft technology on airport size.

Airports should be seen as integral parts of the total air transport system. The system consists of physical components, their owners and operators, the controlling authorities and the rules under which it operates. It is strongly influenced by the needs of its ultimate consumers, the social and economic characteristics of the national setting within which it operates, the impact it makes on the local and global environment and its acceptance by the communities it serves. The ultimate consumers are the private passengers, the business passengers and the employers who pay their fares, and the freight shippers. The entities which speak for these interests are all stakeholders in the system, though their influence varies with the setting.

Ownership of the system's components are usually mixed. Airspace is a national asset, and ATC ownership and operation normally reflects this, though there are several instances of corporatisation and competitive operation of local airport traffic control. The large majority of flying in uncontrolled and controlled airspace is by privately owned aircraft, and ownership of the airlines is increasingly in private hands. Airport ownership is also moving out of the public sector as local and national governments decide that there are other priorities for spending and that they can have a competent airport system without needing to own it.

Operation of the airports is often in local or private hands, even when they are publicly owned. Russia, for example, intends its airports to pass to local authorities as joint stock companies, with eventual private participation through the sale of some of the government's remaining interest (*Flight, 19 June 1996, p 16*). Control of the airport operations is, in any case, achieved by a complex mix of national government, local government and airport owner policies and the regulations which support them. National government influences operations by controlling route rights, by airport and airline licencing, by the designation of international status and the staffing to support it, by granting of permissions to expand, and by the influence over local government policies and spending. Local government controls the land use, reviews the costs and benefits the operations provide for the local community, and often has a direct input to the management of an airport.

The airport owners will have policies aimed at the satisfaction of their own goals. Often the ownership mix of national government, state government, local government and private enterprise, results in the policies of the various owners being in conflict with each other and with the expectations of the professional airport management.

It might be presumed that governments' goals would include national, regional and local economic development, social integration, protection of national airline interests, protection of the environment and the minimisation of governmental spending. Private owners would be much more interested in obtaining a good rate of return on investment, with consequences for the preferred mix of traffic and use of assets. They would also wish to be proactive in defining the airport's roles, rather than government owners who would tend to regard it as a passive service provider. Government goals to promote competition may conflict with their equally strong goal of sustainability.

Governments' environmental policies are influenced by the global and local lobbies as well as by the internationally agreed policies on sustainability. Each airport community will strike its own balance between environmental and economic and social benefits and costs, and may well be in conflict with national policies. In many cases, the communities impose additional operating constraints to those recommended nationally and internationally.

Airlines are increasingly motivated by profit as well as the maximisation of market share, while being prime customers of airports which may or may not share these goals. The airlines wish to minimise infrastructure costs but, at the same time, they wish to minimise delays, to organise their airport presence so as to retain control of their operations, and to promote their own brand image. Airlines investing in an airport's terminal facilities, as is common in the US and is beginning to occur in Europe, require a secure environment, a say in the planning of new facilities and in the method of cost recovery. In particular, they will not be keen to contribute to a development fund which will allow new capacity to be provided for competitors. Change of ownership of the airport will also cause them concern, so that the possibility of privatisation may influence their investment strategies. British Airways is selling its stake in the hubbing terminal which was specially built for it at Birmingham, now that 40 per cent of the shares are likely to pass from the local authorities to the Irish Airport Authority (Aer Rianta).

The ultimate consumers' goals are to minimise their overall disutility of travel. This implies minimising time, cost and discomfort, and maximising safety, security, punctuality, choice and convenience. In general, this requires the availability of competitive airlines and airports close to the desired trip origin, with frequent direct services to their preferred destination. Since the optimum supply of transport will often not be available, the user is forced to make tradeoff decisions. This requires full information on the options available, each individual user then attempting to minimise his or her disutility.

In the long run, an airport's role would be determined by the preferences of the ultimate users if the system's internal efficiency were to be maximised and if the boundary of the system were to be drawn around air transport and its users. Not only does this require full knowledge of the future preferences of the users, but it ignores the rightful voice of the other stakeholders in the wider system. Unless their interests can in some way be represented by shadow utilities, methods other than quantitative systems analysis need to be used in order to develop an airport system which will be the best compromise for society as a whole.

Systems are usually dynamic: static equilibrium is usually difficult to achieve, because of unsynchronised changes in the variables influencing the system and also because of the tensions which exist between the various interested parties, or 'actors'. In the case of airports, examples of the changing variables are population distribution, technology, other modes of transport, passenger travel behaviour and political regimes. Some of the typical areas of tension are between consumer needs and supply capability; national and local interests; consumers and non-users. One could argue that a primary reason for airport system planning is to recognize formally and resolve as many of these conflicts as possible prior to implementation, even more than to harmonize standards (e.g. of safety and reliability) and to produce an economically efficient system.

Successful systems achieve dynamic stability by closing the input/response loop with negative feedback. Performance indicators are necessary to monitor the economic efficiency of an airport system, its quality of service and its positive and negative impacts on society. If the correct criteria are set as tolerable limits to these indicators, they should act as triggers for change.

What is system planning?

The discipline of Planning arose from a need to foresee and prevent future problems which might arise from an uncoordinated set of developments. This becomes more important as projects get bigger and take longer to come to fruition. Their justification requires the identification and quantification of benefits as well as costs, and also a clearer idea of the objectives. Thus the systemic approach becomes applicable, as embedded in the FAA's advice on State Airport System Planning. The aims and scope of system planning are stated suscinctly in the proceedings of a recent symposium (TRB, 1992):

"Aviation system planning is a continuous and iterative process that requires coordination and cooperation among federal, state, regional and local aviation planning agencies."

"The planning process involves both top-down guidance and bottom-up identification of needs, options, and proposed developments."

"Aviation system planning should cover the needs of all sectors of civil aviation and reflect a balance of their individual interests and the national need."

"System plans should look beyond aviation demand and infrastructure needs and take into consideration economic and social objectives to be advanced by commercial and private air transport."

"At each level from local to national, aviation system plans should describe current conditions, present a vision of the future, state the goals to be met, enumerate the criteria of success, and lay out a path of evolution from where we are to where we want to be."

It also says of strategic planning that it can be used as a thinking tool, evaluating options via 'what if' scenarios. It should be useful in establishing and defending priorities, and should be a corollary of business and marketing plans.

The strategic planning process is well described in the Federal Aviation Administration (FAA, 1989) advice on State Airport System Planning.

System planning should be concerned with the big questions, without ignoring the local operational consequences and constraints. A good example of the sort of questions which should be asked was given by the then Fleet Planning Manager for BEA (later the Chief Executive of BA) in 1965:

"One would question the need to operate a local network into London from nearby towns if this used up air space at the expense of the main domestic and international services"

"With present aircraft size the London-Paris frequency by all carriers will be 50 per day in 1970. Is this reasonable if it has the effect of precipitating more and more airports?"

"In the long term look at air transport it is also important that a realistic look at the integration of road and rail with air. Air feeder services are notoriously expensive"

"It seems reasonably clear that a large Vertical Takeoff and Landing aircraft, given the right cost level, is a requirement for the future if a multiplicity of airports, each one farther away from London than the last one, is to be avoided" (Watts, 1965).

Airport system planning starts with the setting of goals. Then an inventory is taken of the quantity and quality of existing infrastructure and the way it is being used. This will include the use of performance indicators tailored to determine those aspects where the system is falling short of its goals. The future traffic generation and its distribution through the system must be predicted, so that the shortfall of capacity can be determined and the additional required facilities can be estimated and costed. Both the distribution of traffic and, to some extent its generation, will depend on the supply of flights, which in turn will depend on airline strategy. Decisions on route starts, and on frequency and hence aircraft size will depend on the strength of demand and the probability of competition, so all of these factors also need to be predicted. Optional solutions have to be generated, designed and evaluated. The chosen solution has to be implemented and the system has to be monitored against the objectives, the objectives themselves being subject to change.

The tasks of system planning

Whenever an authority has responsibility for the funding, the ownership or the management of more than one airport, it needs some structured way of determining investment priorities, and establishing standards and roles for the airports within the control of the authority. This has often resulted in categorisation of airports by size and function, the implication being that airports in the same category would be treated equally with respect to the criteria used for making decisions about their facilities and their operational capability. This would be true particularly in meeting the ICAO requirements for airports categorised as international gateways, and for deciding the extent to which domestic airports should also meet those standards. Some countries carry this top-down process through to the production of individual airport Master Plans which fit the system-derived roles and budgetary capability. Others incorporate locally determined Master Plans into national plans, to the extent necessary for the specific administrative responsibilities taken by the central authority. Either way, a system plan has to be compatible with viable master planning of each facility. The primary problems faced in national system planning have usually been the division between local and national funding coupled with differences in the perceived role of airports across the various regions of a country.

It has become more common for the number of airports to proliferate within individual regions of a country, with a mix of large and small airports serving a variety of functions. This occurs mostly in large and growing metropolitan areas, where land becomes increasingly scarce and environmental impact from aviation operations is particularly noticeable. It has therefore become necessary to ensure that the aviation activity uses the facilities in the way which is best for the whole community and that any necessary expansion of capacity be provided where it does the least harm and the most good. Objectives such as these can only be met within a community dedicated to cooperate in a system planning exercise which accepts inputs from a wide range of interests and then accepts the consensus decision. It helps if there is a defined framework for the process and studies which should be incorporated in it. The FAA's Metropolitan System Planning document, examined in the US case study, sets out to provide this guidance.

Master Planning is a technique recommended by ICAO (1985;1987) and by the US Federal Aviation Administration (FAA, 1985) as a process for the comprehensive planning of individual airports. The objectives of master planning are to allow orderly development compatible with the framework of local, regional and national economic and transport plans and with national and international aviation policies, while protecting and enhancing the environment. It should also inform public and private interests of aviation requirements, providing a planning framework which enables affected political entities to participate in the planning, and result in an optimisation of the land use. It will demonstrate an airport's commitment to its Business Plan and so to the airlines, to the users and to its contribution to the local and regional plans, helping to remove uncertainties in the community.

A prime objective of master planning is to determine the ultimate site capacity and then to protect it from the consequences of ill-considered disposition of facilities on the airport and from encroachment of incompatible land uses around the airport which might restrict either its physical expansion or lead to capping due to environmental impact. However, this may make it difficult to make large scale changes in response to fundamental shifts in market conditions. It also leads to the need to expose all the airport's long term strategy to public examination. This may make some airports loath to adopt the formal master planning path for fear of alarming the public unnecessarily about the follow-on consequences of allowing a relatively small initial development. Further, now that airports are more concerned with profits and competition, the long term plans may be regarded as commercially confidential, or, alternatively, they may be regarded as a bold play to attempt to overwhelm potential competition. Either way, the classic master planning approach is likely to be compromised by the new setting in which the airports find themselves, yet bottom-up system planning can only function from the base of competent individual master plans. The likely compromise will be to commit only, say, a 10 year horizon to a Master Planning exercise.

The primary airport planning task is to arrange the timely provision of capacity. The automatic provision of capacity in response to revealed demand is coming to be seen to be unsustainable; rather, it must be provided in an adequate and appropriate manner if the industry is to continue to grow in a way that is useful and acceptable to society. The test of adequate capacity is that the system should not be constrained to operate in such a way that the internal and external social costs without additional capacity are greater than the costs of additional capacity and the corresponding internal and external social costs. This is the judgement that strategic planning should be clarifying and which the planning process should allow to be expressed.

Appropriate capacity implies a distribution of capacity in which the level of its utilisation is justifiable by local social cost/benefit analysis. Strategic system planning should assist in the geographical distribution, and in the balancing of capacity across the system elements at each location, establishing best practice and assessing each location's potential to meet the demands imposed by the options for distributing it.

The levels of adequate and appropriate capacity cannot be decided without a system-wide analysis, whether the driver (a desire to invest) for new capacity is bottom-up or top-down. The interactions, both in supply and in demand, between the system elements are normally too strong to be ignored. It is becoming more difficult to add capacity to existing airports due to a shortage of land, environmental impacts from aircraft and ground traffic, the questioning of the need for further air travel, the inappropriate form of the planning process, the uneven power relationships which manipulate the process, funding problems, and investment risks in the face of an increasing uncertainty about future traffic. Yet airports have been shown to be elastic, and further opportunities are available to relieve bottlenecks at existing airports. In some other cases, it may be appropriate to increase capacity by developing alternative sites, even though there are usually access penalties which make it hard to convince airlines that they should provide service: also, it is more difficult to convince people not accustomed to aircraft noise to tolerate it than to continue to afflict those who already are accustomed.

The definition of airports' roles within a system

The air transport industry tended to produce orderly growth of traffic in the era of strict economic regulation. Airport roles and their levels of traffic were largely in the hands of the predictable route licensing regulators. The airport management function was seen as a demand-reactive provision of service and facilities, thus minimising the risks of overprovision. The public purse was expected to cover the remaining risk in the interests of continuity and the wider value of an adequate air transport system. The consumer had to accept the regulators' judgement of the necessary costs of providing a safe, regular and semi-social service, together with the limited choices which were deemed suitable. Communities around airports, and the wider community of environmentalists, tended to have to defer to near universal decisions in favour of providing transport capacity on demand so as to support the air transport industry and economic expansion.

The setting in which air transport has to function, at least in the western world and increasingly elsewhere as well, is now very different. The economic liberalisation of airlines, allowing the industry to set its own fares and frequencies, and to enter and leave routes at will, has been allowing a major restructuring of the air transport network, resulting in large perturbations in the traffic at many airports. The new opportunities for airlines to compete on price and quality of service imply considerable changes in the quantity and distribution of revealed demand, the demand being more driven by the desires of the consumers themselves than by the consumers' needs as perceived by regulators. These changes make it more difficult for airports to predict the demands to which they should react.

Global economic competition at the level of individual regions within a country, together with a realisation of the role which an airport can play in furthering regional ambitions, have caused the public authority owners of the airports to increase their marketing and expansion efforts. They have often been frustrated in this by lack of finance. More recent tendencies towards the privatisation of the airports, partly to alleviate the finance constraints, have created an even greater desire to compete and expand. Conversely, the increasing power of the environmentalists has increased the difficulty in achieving the necesssary planning approvals.

Network effects

Except when they are constrained by government intervention, airlines plan their network development very differently from the way a government agency, or private initiatives, would plan a system of airports. The main reasons for this are the mis-match of planning horizons and the different objectives. The most noticeable trend in a liberalised airline industry has been the formation of a hub and spoke network based on one or more 'fortress hubs' in the USA. The fortress allows the carrier a local monopoly and the opportunity to raise local fares in order to compensate for lower yield per mile for transfers across the hub. It is difficult to enforce anti-trust laws in these situations.

The freedom given to airlines by deregulation was not extended to airports. They had to accept the consequences of the airlines' strategies. Some were chosen as hubs and invested in order to cope with the very large increase in boardings. In many cases the hubs continued to prosper even through the recession, due to the success of their based airline(s) in the competition for transfer traffic, to the airport's ability to provide the infrastructure necessary for efficient operations and to a strong local market. The impact on the city's economy of the excellent air links which the hub brings tends to reinforce the local demand further, as happened at Pittsburgh (Dennis, 1995). This cushions the exposure to the 'soft' over-the-hub traffic which is more volatile and open to attack by other hubs.

There have also been many examples of hubs being established and then being dismantled, either because the main airline failed or decided to retrench. In the case of Charlotte, traffic rose quickly to four times the original levels, only to suffer severe cutback after a few years. In the UK, both Gatwick and Luton have seen many false horizons due to successive airline failures. Even the major hubs are not immune to the failure of their based carriers, as shown by Continental Airlines at Denver and Eastern at Atlanta (de Neufville and Barber, 1991). Now hubs are under attack from the low cost new entrants, for example US Air's Philadelphia hub by Nation Air and Air Inter's operation at Paris Orly by TAT and Air Liberté.

In contrast, there are airports which have been bypassed by the airlines' new strategies. Airports within ground access distance of a strong hub have lost service as passengers seek the utilities of greater frequency and choice of destination (Kanafani and Abbas, 1987), reinforced, particularly in Europe, by the wider variety of discount fares on offer. Other airports have lost jet service in favour of turboprop feeders. It is not a unique phenomenon of deregulation for airports' roles in a system to be changed quite dramatically. Shannon was perhaps Europe's main Atlantic gateway during and after the flying boat era, only to be overflown by most carriers as soon as aircraft had sufficient range capability to reach the continental capitals nonstop. The South Pacific islands have similarly been the butt of political and technological change (Taylor and Kissling, 1983). Now a new threat is posed by the globalisation of the airline industry, in that rationalisation of routes and hubs may result in some airports being neglected. One of the reasons that the Dutch government was not in favour of a KLM/BA merger may have been the fear that London might gain service at the expense of Schiphol.

It can only be concluded that liberalisation has brought uncertainty to the management and planning of airports. As with the airlines, there have been winners and losers. The difference is that airports have had little control over the outcome, but the uncertainty brings with it a series of opportunities and threats. It is probably easier for the opportunities to be grasped if an airport has the same blend of entrepreneurial management and freedom of expression enjoyed by the privately owned airlines who are leading the reshaping of the industry. Roles as hubs or spokes are up for bidding. Publicly owned and managed airports are equally welcome to bid, provided that the competition is not distorted. Geography, scale of operation, capacity constraints and the regulatory freedom enjoyed by the available carriers all dictate that some airports' roles in the system are more natural than others (Dennis, 1996). It will be neccessary for airports to understand the limitations of their ability to meet their ambitions as this less structured system evolves.

The Dutch government has certainly understood this, as well as understanding the huge role that Schiphol plays in the country's economy. They are well aware of the benefits and the risks of their 'Mainport' strategy for the airport. Their economy is small compared with those of the countries whose airports are competing for this role in Europe, so the only way that they can enjoy the same quality of service is to encourage KLM to develop a very strong hub and thus help to keep their economy competitive as well as directly feeding more jobs into it. However, the penalty is that the environment around the airport deteriorates, while the majority of the passengers whose travel is causing the damage are not directly interested in Holland at all. The threat is that other hubs will compete even more successfully, on the basis of their stronger local demand, resulting in a greater risk that Schiphol's investment will not pay off (Veldhuis, 1992). Intensive studies of the economic and environmental impacts have been undertaken, as have studies of the implications of competition, all of which can be regarded as state of the art in their field. The planning process is itself innovative in that a form of joint planning authority of the government, the regions, the airport and the airline was able to agree a plan which allowed sufficient expansion to guarantee that the airport could compete without undue constraint, while containing the environmental impacts to a tolerable level (Veldhuis, 1996). With the aid of a new runway, mainly for mitigating environmental impact, the airport should be able to grow to 40 mppa.

It is obvious that hubbing can become counter-productive, not least because it encourages more boardings than would be necessary for point-to-point flights. This trend is exaggerated further by 'air miles' schemes designed to defend the hubs.

Passenger desires and cost minimization are not the only determining factors in an airline's network planning. Legislation, competition, fleet capability and management strategies for survival and growth will all play their part. For the system planner, however, knowledge of consumer desires and total system resource costs as well as airline behaviour are all essential tools for the efficient planning of infrastructure and the shaping of the system for the best use of scarce resources. One outcome of a thorough investigation of resource costs would almost certainly be that the present competitive system's emphasis on frequency (to the detriment of aircraft size) and the costs of congestion are both wasteful.

At the small airport end of the spectrum, the big threat is that airlines will use regulatory freedom to downsize their operations in terms of routes and aircraft size, and ultimately pull out completely in the search for economies of scale. This can result in a downward economic spiral for the airport and, possibly, for its community. The airports can improve their chances by undertaking market analyses and entering joint marketing agreements, then offering incentives for new route starts or even create new airlines themselves when the analyses are sufficiently positive. However, they need to take care not to fall into the trap of being unable to get back to average cost pricing.

The future and how to tackle it

Air traffic continues to increase sufficiently quickly that there is a serious risk of congestion worsening and of the consumers' anticipated benefits of competition being thwarted unless more capacity can be provided. Experience of attempts to generate new airport capacity, at least in the developed world, suggests that airport entrepreneurs will face increased risk from three main uncertainties:

- user demand and its satisfaction by the airlines in a competitive setting
- capacity and cost implications of environmental protection
- refusal of planning permission after lengthy preparation, or duplicated permission leading to over capacity.

Can these uncertainties be managed so that there is an efficient future scale and distribution of capacity, or will the risks drive the system towards maximising the utilisation of the existing infrastructure at the expense of the utility of the system's users?

The future is bound to contain surprises. If it is to cope with change, infrastructure planning must be a continuous, adaptive process rather than a one-off attempt to generate a blueprint to formulate the future. Are the managers of the system and of individual airports ready to respond to this message, or are the requirements of the planning process, the politicians and the bankers going to continue to sustain the myth of a predictable future?

The uncertainty in predicting the future stems from likely but unforeseeable structural changes in politics, social behaviour, economic development and technology. Not only are these difficult to predict, but, if they were predictable, much of their benefit in promoting and complementing change would be diluted. Yet the 'myth of predictability' (Gifford, J L, 1993), where forecasters take the option of presuming that the most likely future is the 'business as usual' one, almost always results in technological obsolescence and underutilised facilities. Most importantly, it distorts the development of the market, freezing in the present situation by investing in it, so that beneficial change is thwarted by having to overcome the drag of sunk investment. This raises questions about the possibility of developing planning methods which recognize the probability of structural change, which promote solutions which retain maximum flexibility without causing undue planning blight, and which allow decision-makers to adopt them without being accused of not doing their job.

Scenario writing allows potential futures to be described, to which the forecasting techniques can be applied so as to explore the traffic implications of each of those scenarios. The most productive use of scenarios is to explore the range of feasible potential futures and their consequences in terms of the needs to which a system might be asked to respond and the steps it would need to take in order to respond effectively. It should be emphasised that the objective is not to preguess the future, even by assessing probabilities of the various potential futures and hence take a view on the most likely future. Scenarios explore potential futures so that some light can be thrown on the scope and flexibility which needs to be designed into the system, on the extent to which this might be accomplished autonomously by changes in the system's capabilities which would be embedded in any specific scenario, and on the consequences for the system's performance of not being able to meet the needs of some scenarios: alternatively, the identification of those futures which the system should not be designed to accommodate.

It can be taken for granted that the most likely future is the one which is presently being projected by in-house planners and system designers. It can also be taken for granted that, except in so far as the system's future use is predetermined by the closing off of future options by sunk investment, the most expected future will not coincide with any actual future state. In fact, it is extraordinarily difficult even to predict live births, which is the most fundamental of all the factors which might influence future demand for travel (Makridakis et al 1982), despite the apparent underlying logic behind the very long term trends.

Scenarios for future air traffic can be painted in terms of socio-political, economic and technological characteristics. Alternatively, they can be considered in terms of future demand and supply possibilities. Either way requires the incorporation of interactions between the descriptive groups, as well as the need to speculate on the implications of currently unknown initiatives in the management of processes and innovations in system capability. The important characteristics are that the scenarios should be cohesive and should show a feasible route from the present state to the potential future state.

The impact of technology and smart management on future capacity (or simply the assumption of future capacity) is often the most neglected area of supply prediction. Heathrow's growth is a case in point, early predictions being hampered by inhibitions on the maximum feasible size of aircraft and more recent analyses by under prediction of annual runway capacity. Despite the highlighting of these broader system implications in the literature (e.g. TRB, 1990), most studies only allow for changes in a single variable which is closest to the interests of the immediate focus.

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FAA ADVISORY CIRCULARS RELATED TO AIRFIELD PLANNING

00-2.2	Advisory Circular Checklist (10/15/88)
150/5020-1	Noise Control and Compatibility Planning for Airports (8/5/83)
150/5060-5	Airport Capacity and Delay (5/16/84) Change 1
150/5070-6A	Airport Master Plans (6/85)
150/5300-4B	Utility Airports, Air Access to National Transportation (6/24/75
150/5300-13	Airport Design (9/29/89) Change 1
150/5325-4	Runway Length Requirements for Airport Design (9/27/78) Change 1
150/5340-1F	Marking of Paved Areas on Airports (10/22/87)
150/5340-18B	Standards for Airport Sign Systems (8/21/84)
150/5390-2	Heliport Design (1/4/88)

AIRPORT SYSTEMS PLANNING AND DESIGN
27th annual short course
University of California, Berkeley

AIRSPACE AND AIRPORT CAPACITY

May 12, 1998

by

William J. Dunlay
Leigh Fisher Associates

1

Objectives of Presentation

- Increase understanding of airfield-airspace operations
- Introduce reasons/methods for analyzing airfield/airspace capacity

2

Factors that Affect Capacity and Delay

- Air traffic control rules
- Aircraft fleet mix
- Weather conditions
- Runway use configurations
- Approach and departure procedures
- Airspace interactions

3

Air Traffic Control (ATC) Basics

- IFR and VFR flight plans
- Towers, TRACONs, ARTCCs
- ✓ Central Flow Control Facility (CF^2)
- IFR Routes, STARS, and SIDS
- Radar vectoring

4

Aircraft Fleet Mix and Aircraft Separations

- Aircraft classified by weight and approach speed
- Affects minimum wake turbulence separations
- Recent changes – FAA Safety Notice N 7110.157, 7/16/96, and FAA Order 7110.65L

5

Aircraft Weight Classifications

- Small
  - Before N7110.157: <= 12,500 pounds
  - After N 7110.157: <= 41,000 pounds
  - Exemptions – SF-340 and ATR-42
- Large
  - Before N7110.157: > 12,500 pounds but <= 300,000 pounds
  - After N 7110.157: > 41,000 pounds but <= 255,000 pounds

6

Aircraft Weight Classifications (concluded)

- Boeing 757
  - MGTOW capability of 255,000 pounds
  - Technically a "large"
  - Practically a "heavy" requiring 1 n.m. less radar separation
- Heavy
  - Before N7110.157: > 300,000 pounds
  - After N 7110.157: > 255,000 pounds

7

Minimum Radar Separations

- Basic – 3 n.m. Horizontally or 1,000 feet Vertically
- Exceptions and wake turbulence rules:
  - ✓ On final approach: 2.5 n.m. except behind B-757 or heavy
  - Behind heavy: 4, 5, & 6 n.m. for heavy, large, and small, respectively

8

Minimum Radar Separations (continued)

- Exceptions and wake turbulence rules (continued):
  - Behind B-757: 4, 4, & 5 n.m. for heavy, large, and small, respectively
  - Behind large: 4 n.m. for small aircraft
- Between departures:
  - 2 minutes behind heavy/B757 on same runway or parallel within 2,500 feet

9

Minimum Radar Separations (concluded)

- Crossing flight paths – 2 minutes behind a heavy/B757
- Intersection departures from>500 feet down same runway – 3 minutes for small behind large & any aircraft behind heavy/B757
- Intersection departures from>500 feet down parallel runway within 2,500 feet – 3 minutes behind heavy/B757

10

Effects of Weather

- Wind speed and direction
- Cloud ceiling and visibility
- VFR weather conditions or visual meteorological conditions (VMC)
- IFR weather conditions or Instrument meteorological conditions (IMC)

11

Operational Weather Categories (airport specific)

- Full VFR – visual approaches
- Marginal VFR
  - Basic VFR (1,000' and 3 miles)
  - Visual separation (Tower)
- Full IFR
  - ILS Categories I, II, & III (a, b, and c)
  - Minimums affected by obstacles (TERPS)

12

2

Runway-Use Configurations and Operations

- Single runway – mixed operations
- Two parallel runways – segregated operations
- Two intersecting or converging runways – segregated operations
- Two parallel runways – simultaneous mixed operations

13

Runway-Use Configurations (concluded)

- Three (or more) parallel runways – simultaneous segregated operations
- Multiple parallel and converging runways
- Cross-wind runways
- Noise abatement runway uses

14

Types of Approach Procedures by IFR Flights

- Visual
- Non-precision instrument (VOR)
- Precision-instrument (ILS/DGPS)
- ✓ Land-and-hold-short operations (LAHSOs) – New FAA Order 7110.114
  - Intersecting Rwys, Twys, and flight paths
  - Dry vs. wet and day vs. night

15

Multiple Precision Instrument Approaches

- Simultaneous independent ILS approaches
- Parallel (staggered) ILS approaches
- Simultaneous converging instrument approaches (SCIAs)
- Dependent converging instrument approaches (DCIAs)

16

Controller Aids for Monitoring Approaches

- Precision Runway Monitor (PRM) system
  - High-update (E-scan) radar
  - Final Monitor Aid (FMA)
- Converging Runway Display Aid (CRDA) for conducting DCIAs
- Final Approach Spacing Tool (FAST)

17

Future Aids for Monitoring Approaches

- Differential Global Positioning System (DGPS)
- Wide Area Augmentation System (WAAS) and Local Area Augmentation System (LAAS)
- Automatic Dependent Surveillance - Broadcast mode (ADS-B)
- Mr. Marchi will cover

18

Parallel Runway Spacings for Simultaneous Instrument Use

- Close (<2,500') – single stream
- Intermediate (2,500' up to 3,400'/4,300')
  - Dependent (staggered–1.5nm) arrivals
  - Independent departures
  - Independent arrival and departures
- Far (>3,400'/4,300') – simultaneous independent approaches (<4,300' requires PRM)

19

Precision Runway Monitor System

Parallel Runway Spacings (continued)

- Just approved – independent approaches at 3,000' with PRM and 2.5°-offset localizer (JFK)
- Triples (airport elevation < 1,000')
  - Current radar – 5,000'
  - With FMA – 4,300'

20

Parallel Runway Spacings (continued)

- Triples (airport elevation > 1,000'
  - Requires approved FAA aeronautical study
- Authorized "triple" approaches:
  - DFW – 8,800' & 5,000'
  - DIA – 7,600' & 5,280'

21

Parallel Runway Spacings (concluded)

- FAA simulations for "triples" at ATL and PIT – 5,300' & 4,000' approved with PRM
- Planned "quadruple" approaches:
  - DFW – 5,800', 8,800' & 5,000'
  - DIA – ____?, 7,600' & 5,280'

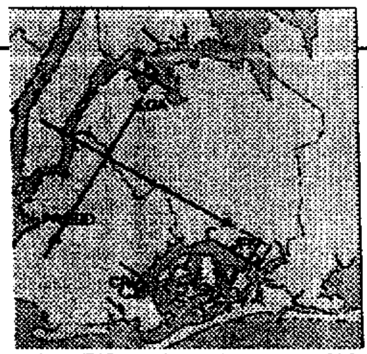
Pittsburg

22

Examples

- Runway layout configurations
- Airspace Interactions
- Approach procedures

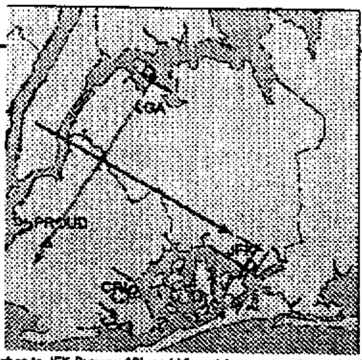
23



ILS Approaches to JFK Runway 13L and ILS Approaches to LGA Runway 4

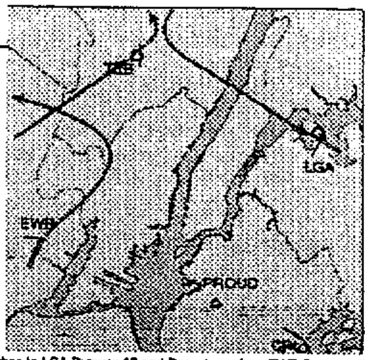
24

4



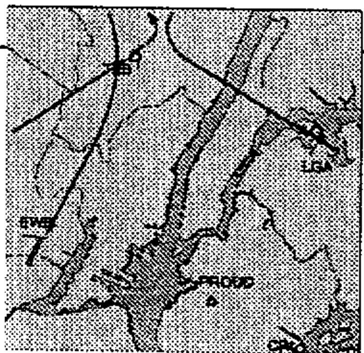
ILS Approaches to JFK Runway 13L and Missed Approaches from LGA Runway 22

25

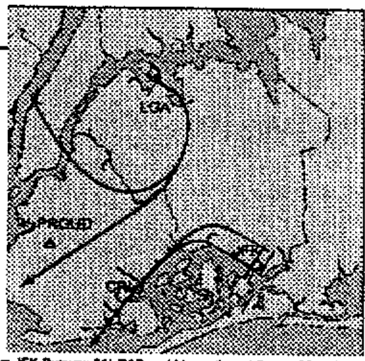


ILS Approaches to LGA Runway 13 and Departures from EWR Runway 4L/4R and TEB

26

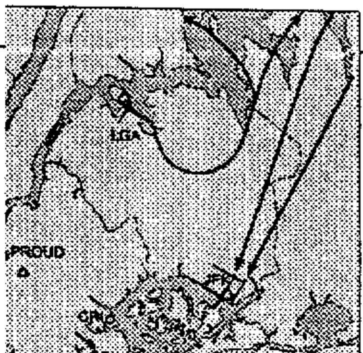


ILS Approaches to LGA Runway 13, EWR Runway 22L/22R, and TEB Runway 6 and Departures from TEB



Departures from JFK Runway 31L/31R and Maspeth and Coney Climb Departures from LGA

28



ILS Approaches to JFK Runway 22L/22R and Whitestone Climb Departures from LGA

29

Examples of Airspace Airfield Operations (demonstration)

- Airspace/ARTS radar flight tracks – Dallas/Fort Worth Region
- Airfield Graphical Simulation Display
  - ✓ Pittsburgh International Airport
  - LaGuardia Airport

30

Definitions -- Capacity

- Maximum sustainable throughput rate
- Depends on
  - ATC rules and airspace
  - Weather conditions
  - Runway layout and use configuration
  - Aircraft fleet mix and percent arrivals
  - Noise abatement procedures
  - Airspace interactions

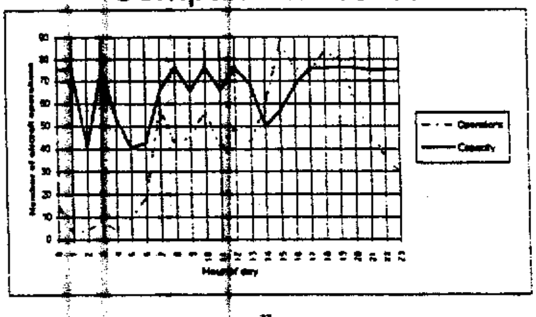
31

Definitions -- Capacity (concluded)

- Not a single number (visuals, basic VFR, IFR)
- Estimated using computer models
- Only part of the story – must compare with demand
- Avoid arbitrary "practical" and long-term (e.g., annual) measures

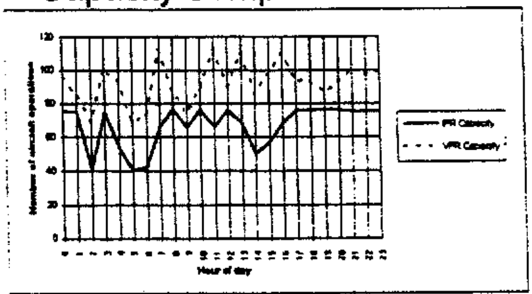
32

Example Demand-Capacity Comparison at JFK



33

Example VFR vs. IFR Capacity Comparison at JFK



34

Definitions -- Aircraft Delay

- Excess travel time, congestion delay (queuing, airborne hold, vectoring, speed control, or gate hold)
- Normally determined as "actual" operating time minus a "nominal" operating time

35

Definitions -- Aircraft Delay (concluded)

- A "capacity indicator" as opposed to "on-time-performance" indicator
- Underlying causes vs. where incurred Lack of meaningful "actual" data:
  - CODAS
  - ATOMS/OPSNET
  - ASQP – on-time performance

36

6

Applications of Airfield-Airspace Capacity Analysis

- Estimate benefits and timing of capacity improvements
- Compare alternative improvements
- Tradeoff delay costs with costs of construction, noise mitigation, and taxiing

37

Benefit-Cost Analysis (BCA)

- June 1997 FAA Guidance and Policy
- Transfers responsibility for preparing BCAs for to airport sponsors.
- Reduces threshold of projects requiring BCA from $10 Million to $5 Million.

38

Benefit-Cost Analysis (BCA) -- concluded

- Must accompany a grant or LOI application for projects commencing in Fiscal Year 1998.
- BCA considered by FAA on a "pass-fail" basis

39

Types of Analyses and Models

- Capacity, delay, workload
- "Back of the envelope"
- Handbooks and spreadsheets (e.g., Advisory Circular)
- Analytical models (e.g., FAA Runway Capacity Model and Delay Models)

40

Types of Analyses and Models (concluded)

- Fast-time simulations (e.g., ADSIM, RDSIM, SIMMOD, Airport Machine, FLAPS, AIRNET, NASPAC, TAAM, RAMS, other proprietary)
- Real-time simulations (e.g., the FAA Technical Center and NASA)

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F. FAA Order 8260.36A, *Civil Utilization of Microwave Landing System (MLS),* which contains the criteria now being used by FAA for all new Category I ILS installations.

IV. Instrument Approach Procedures and Navigation Aids

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B. FAA Order 7110.110, Dependent Converging Instrument Approaches (DCIA) With Converging Runway Display Aid CRDA), 11/30/92.

C. FAA Order 7110.98A, Simultaneous Converging Instrument Approaches (SCIA), 1993.

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C. National Oceanic and Atmospheric Administration (NOAA), *Aeronautical Chart Users Guide*, 4th Edition January 1995.

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F. FAA, *Pilot/Controller Glossary*—in back of both II.A. and V.B.

"Future Airport Operations Concepts"

Summary of Paper Presented at "Airport Systems Planning and Design" Short Course
University of California, Berkeley

Richard Marchi, Senior Vice President, Technical and Environmental Affairs
Airports Council International - North America
May 12, 1998

Air traffic service providers worldwide are considering modernizing Air Traffic Control (ATC) systems that often date from the pre- World War II era. As they consider the opportunities presented by new technology, they are also re-evaluating the fundamental concepts governing control of flight. To date, most of the effort to assess the impacts of these new technologies and concepts has occurred in the en-route and oceanic airspace. This paper attempts to stimulate development of an operations concept for ATC in terminal airspace and at airports. Since little development of new ATC concepts based upon the emerging technologies has occurred, the procedures described here should be considered as illustrative of the potential for innovative approaches, rather than as a presentation of mature or developed ideas. Nevertheless, these proposals attempt to demonstrate how the inherently different characteristics of the new technologies can be applied to an improved airport operations concept.

The current air traffic control concept is based on an array of ground based navigation and surveillance systems. Until recently, air carrier airplanes operating in the controlled en-route airspace were generally constrained to navigate along paths that were rigidly defined by equipment located in specific places on the ground. In the terminal environment, similar restrictions limit the number of initial approach fixes and final approach courses. Since the number of paths available is restricted by the available ground-based navigation equipment, an air traffic control concept evolved which limits the potential for conflict by restricting airplanes ability to maneuver without ATC clearances for pre-approved routes, altitudes and airspeeds. In the en-route airspace this often results in over utilization of the available routes, saturation of certain high density sectors and underutilization of airspace which lies outside of the established routes. In terminal areas, approaches are confined to runways having specific navigation installations.

New "free flight" technologies offer to provide significant relaxation of the restrictions of the current air traffic control concept. Satellite based navigation, coupled with on-board computerized Flight Management Systems (FMS) will increasingly free aircraft from these rigid ground-based routes. Using satellite navigation, an airplane can fly any path which is programmed into its FMS with a degree of positional accuracy not available from existing navigation systems. Although it is highly unlikely that aircraft will ever be allowed to maneuver at will in high density terminal airspace, the same technologies and air traffic management concepts which will support free flight in the oceanic and enroute environment can foster revolutionary improvements in the terminal environment. This paper attempts to describe a high level operations concept for that revolution.

The greatest value of the free flight concept in the terminal area will come from the recognition that past ATC procedures and methods can be replaced with a completely new paradigm, rather than from any attempt to emulate the literal relaxation of flight path restrictions being pursued in oceanic and en-route airspace. Since the principal capacity constraint at most airports results from the discrepancy between IFR and VFR runway capacity, this is an obvious focus for the new technologies.

Because of the higher precision available from augmented satellite navigation and surveillance, as well as from the markedly greater capability of modern aircraft Flight Management Systems (FMS), the procedures described are founded upon the assumption that TERPS will be extensively revised to recognize the advantages enjoyed by suitably equipped aircraft. Once this is accomplished, ATC procedures can be thoroughly reviewed to capitalize upon the advantages of free flight technologies.

The combination of greatly improved precision and freedom from siting constraints for airport and terminal area navigational systems which are characteristic of the emerging satellite- based ATC systems will permit a dramatic revision in airport operating concepts in the future. The specific proposals described in this article cover a wide spectrum of both benefits to users and difficulties in implementation. However, the intent of proposing innovative, even speculative, procedures is to stimulate discussion which will, hopefully, lead to a broad assessment of the way a new concept can be shaped to relax the constraints that the existing ATC paradigm imposes on airport operations.

"Future Airport Operations Concepts"

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University of California, Berkeley

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Introduction:

Air traffic service providers worldwide are considering modernizing Air Traffic Control (ATC) systems that often date from the pre- World War II era. As they consider the opportunities presented by new technology, they are also re-evaluating the fundamental concepts governing control of flight. To date, most of the effort to assess the impacts of these new technologies and concepts has occurred in the en-route and oceanic airspace. This paper attempts to stimulate development of an operations concept for ATC in terminal airspace and at airports. Since little development of new ATC concepts based upon the emerging technologies has occurred, the procedures described here should be considered as illustrative of the potential for innovative approaches, rather than as a presentation of mature or developed ideas. Nevertheless, these proposals attempt to demonstrate how the inherently different characteristics of the new technologies can be applied to an improved airport operations concept.

Background:

The current air traffic control concept is based on an array of ground based navigation and surveillance systems. Until recently, air carrier airplanes operating in the controlled en-route airspace were generally constrained to navigate along paths that were rigidly defined by equipment located in specific places on the ground. In the terminal environment, similar restrictions limit the number of initial approach fixes and final approach courses. Since the number of paths available is restricted by the available ground-based navigation equipment, an air traffic control concept evolved which limits the potential for conflict by restricting airplanes ability to maneuver without ATC clearances for pre-approved routes, altitudes and airspeeds. In the en-route airspace this often results in over utilization of the available routes, saturation of certain high density sectors and underutilization of airspace which lies outside of the established routes. In terminal areas, approaches are confined to runways having specific navigation installations.

Each of the different navigation and surveillance systems in use has performance limitations: many older systems have substantial error factors, especially at long ranges from the ground-based antennas. These errors require that separations be larger than would be possible if higher precision navigation and surveillance were available. The larger separations, in turn, result in lower capacity than would otherwise be possible.

New "free flight" technologies offer to provide significant relaxation of the restrictions of the current air traffic control concept. Satellite based navigation, coupled with on-board computerized Flight Management Systems (FMS) will increasingly free aircraft from these rigid ground-based routes. Using satellite navigation, an airplane can fly any path which is programmed into its FMS with a degree of positional accuracy not available from existing navigation systems.

The accuracy available from the United States Global Positioning System (GPS) of satellite navigation will depend on the particular methods used to correct system errors. Basic un-augmented GPS navigation is available anywhere in the world. However, the basic GPS accuracy available to civilian users (about 100 meters) is not sufficient for many commercial aviation needs. Several different schemes are under development by the United States Federal Aviation Administration (FAA) to increase both the precision and availability of the basic GPS signals. These augmentations conceptually consist of providing aircraft with additional signals transmitted within a defined volume of airspace from ground based locations via data link to correct for atmospheric propagation and other errors of the GPS satellite signals. In some cases modest improvements in accuracy are supplied over very large areas, while other augmentation systems provide higher accuracy corrections over a smaller geographic area.

The FAA is well on the way toward a planned first phase implementation of its Wide Area Augmentation System (WAAS) which will provide the accuracy necessary to support Category I approaches at virtually any runway in the continental United States. This system will allow decision heights of 250 feet above a runway threshold and a visibility minimum of 3/4 mile to runways not equipped with approach light systems. It will also permit decision heights of 200 feet and visibility of ½ mile to runways equipped with the Category I standard approach lighting system, ALSF-1. The full implementation of WAAS will support Category I approaches without requiring any navigation equipment on the ground, such as ILS or MLS. Exceptions will be at the boundaries of the augmented area where correction signal coverage is limited and in mountainous terrain where fewer satellites are visible to aircraft because of line-of-sight obstruction of the horizon.

Higher precision augmentation will be achieved by FAA's Local Area Augmentation System (LAAS). LAAS and other forms of local differential GPS (LDGPS) depend on monitoring GPS signals for error and providing correction signals from one or more ground stations located on, or near, the airport or airports being served. Unlike ILS, site requirements and costs for the ground equipment are modest, which will allow LAAS to be installed at almost any airport. Airlines are expected to widely equip their airplanes with LAAS, once standards are issued by FAA.

Current indications are that LAAS will easily support Category I precision approaches within a service volume of about 20 - 30 miles from the ground station. This will be particularly useful in certain coastal areas or mountainous terrain where WAAS may not be authorized for Category I minimums. In addition LAAS will likely allow low visibility Category II/III approaches at the airport at which the ground reference equipment is installed. A single LAAS installed at an airport will allow high precision approaches to all runways at that airport (and probably at nearby airports) with minimums depending on the availability of approach lights, other required visual aids and obstruction considerations.

Another new technology, Automatic Dependent Surveillance - Broadcast mode (ADS-B), extends the precision and wide area coverage of GPS into the ATC surveillance arena presently dominated by radar. This technique involves having each suitably equipped aircraft broadcast its GPS derived position via data link to ground stations for use by air traffic control for surveillance, and to all other aircraft within range for use in collision avoidance. Using ADS-B, surveillance coverage will be available in areas which are currently out of range of traditional radar, or where mountainous terrain obstructs radar signals. If the GPS signal is augmented by WAAS or LAAS, the surveillance precision will improve proportionally.

Coupled with these GPS based navigation and surveillance technologies are improvements in aircraft capabilities which either support the new technologies or extend their usefulness. Cockpit Display of Traffic Information (CDTI), when coupled with ADS-B, will provide greatly enhanced situational awareness to air crews. It can use the position information derived from GPS, coupled with terrain and airport surface mapping databases for enhanced proximity ground warnings or for high precision airport surface navigation. It can also use the ADS-B supplied position of other aircraft along with an airport map database to assist with runway incursion awareness.

Capitalizing upon these navigation and surveillance technologies will require continued development of high performance FMS and GPS navigation systems for all levels of users. This means providing inexpensive equipment for general aviation aircraft as well as equipment that can be economically retrofitted on older air carrier aircraft. It will also require a corresponding increase in ATC automation ... one which goes well beyond the levels currently contemplated in FAA's ATC modernization planning.

Taken together, GPS and the related supporting technologies will radically change the face of aviation and will allow unprecedented improvements in efficiency, safety and capacity.

The concept of "free flight", developed by RTCA at the request of FAA, is at the forefront of this change. It provides a vision of an Air Traffic Control system freed from the constraints of aircraft routings chained to rigid, ground based navigation systems. The crews of equipped aircraft will regularly be able to change altitudes or routings to take advantage of favorable winds, to avoid adverse weather or to reduce fuel consumption. The new concept is described as *"...a safe and efficient flight operating capability under instrument flight rules (IFR) in which the operators have the freedom to select their path and speed in real time. Air traffic restrictions are only imposed to ensure separation, to preclude exceeding airport capacity, to prevent unauthorized flight through Special Use Airspace (SUA), and to ensure safety of flight. Restrictions are limited in extent and duration to correct the identified problem. Any activity which removes restrictions represents a move toward free flight."* [1]

The effort to implement this new concept has initially and appropriately focused on the oceanic and enroute ATC domains where the most basic element of free flight, the ability to maneuver at will, can be implemented earliest. However, the same technologies used to support free flight can have extensive application in the terminal area, both in the reduction of delays due to inadequate airport capacity and to improve safety. Because of the inherent limits in high density terminal airspace, achievement of the benefits of free flight at airports will necessarily be a slower and somewhat different process. It is highly unlikely that aircraft will ever be allowed to maneuver at will in such high density airspace. Nevertheless, the same technologies and air traffic management concepts which will support free flight in the oceanic and enroute environment can foster revolutionary improvements in the terminal environment. What follows is an attempt to describe a high level operations concept for that revolution.

Landing Aids:

The greatest value of the free flight concept in the terminal area will come from the recognition that past ATC procedures and methods can be replaced with a completely new paradigm, rather than from any attempt to emulate the literal relaxation of flight path restrictions being pursued in oceanic and en-route airspace. Since the principal capacity constraint at most airports results from the discrepancy between IFR and VFR runway capacity, this is an obvious focus for the new technologies.

The development of terminal procedures such as Instrument Landing System (ILS) approaches in the United States is governed by "The United States Standard for Terminal Procedures" (TERPS). The current TERPS standards were designed to

[1] "Final Report of RTCA Task Force 3 - Free Flight Implementation", October 26, 1995, RTCA, Inc.

provide airspace protected against the risks associated with aircraft and aircrew performance limitations, navigation and surveillance errors. Together these individual error components comprise an "error budget" which TERPS considers in the establishment of obstruction clearances, landing minimums, missed approach procedures and other operational limitations. The navigation, surveillance and, to some extent, the aircraft performance components of the error budget will be greatly improved by the new technologies: therefore we should expect a corresponding reduction in the TERPS separation and obstacle clearance criteria to evolve.

Because of the higher precision available from augmented satellite navigation and surveillance, as well as from the markedly greater capability of modern aircraft Flight Management Systems (FMS), the procedures described here are founded upon the assumption that TERPS will be extensively revised to recognize the advantages enjoyed by suitably equipped aircraft. Once this is accomplished, ATC procedures can be thoroughly reviewed to capitalize upon the advantages of free flight technologies.

In thinking about the impact of the new technologies it is useful to make distinctions between those affecting the separation standards, minima, obstacle clearance requirements of TERPS ("separations"); and those affecting the development of ATC procedures, approaches, etc. ("procedures"). In each area, I have either assumed change (E.G.: reduction in separation standards or development of new ATC procedures) or assumed that improvements can be achieved using existing separations and procedures. This results in four categories within which to think of the new operations concept, as follows:

Existing Separations/ Existing Procedures

Existing Separations/ New Procedures

Reduced Separations/ Existing Procedures

Reduced Separations/ New Procedures

What follows are descriptions of hypothetical operational scenarios in each of the four categories.

Existing Separations/ Existing Procedures

Many U.S. airports which enjoy multiple approach runways during visual meteorological conditions (VMC) must revert to a single runway operation during instrument meteorological conditions (IMC). One of the most persistent difficulties in establishing secondary instrument approaches at United States airports is the unavailability of runways with sufficient spacing to meet the requirements for independent simultaneous instrument approaches. Current criteria require either 4300 foot separations between the runway centerlines, or 3400 feet of separation with the installation of a high precision/high update rate Precision Runway Monitor (PRM) radar. However, many airports cannot satisfy either criteria.

One innovative solution which was developed for Lambert St. Louis International airport (STL) illustrates the potential of GPS in addressing this problem. In the St. Louis case, a localizer was used to establish an approach course 4300 feet from the existing ILS runway. Aircraft flying this approach (usually turboprop commuter airplanes), after breaking out of the cloud cover at a ceiling consistent with the current TERPS criteria, then circles to land visually on a closely spaced parallel runway located 1500 feet from the primary ILS runway.

Unfortunately, because of the extensive land requirements needed to site a localizer, this innovative approach has had limited application. At many airports like Boston's Logan International airport (BOS) or Chicago Midway (MDW), existing closely spaced parallel runways cannot use this procedure because there is no suitable site for a localizer. Since the satellite navigation capability of either WAAS or LAAS doesn't require a site aligned with the approach course, it is possible to establish approach courses that meet the 4300 foot separation requirements, even though the actual runway separations may be substantially less than required for independent simultaneous operations. Current TERPS criteria will limit these "side step" approaches to minimum descent altitudes on the order of 500 to 1000 feet, with visibility of approximately 1 to 1½ miles. However, the mere establishment of a second independent instrument approach at many airports will provide a significant increase in capacity during additional hours of IMC operations, even though the coverage is limited by higher minimums than would be possible for a straight-in approach to a widely separated runway.

Also, within this category of approaches using existing separations and existing procedures, is the potential to use DGPS enhanced ADS-B to provide high precision, rapid update surveillance which can support the establishment of parallel approaches at the currently authorized 3400 foot separation without the need for a Precision Runway Monitor.

Existing Separations/ New Procedures:

At many U.S. airports with a high percentage of turboprop operations, attempts have been made to provide a separate runway for turboprop operations to segregate those aircraft from the wake-inducing large and heavy turbojet airplanes. For example, Atlanta (ATL) is currently proceeding with the construction of a 6000 foot long runway for regional turboprops, at a cost of approximately $440 Million. The central focus of a $15 Billion master plan upgrade at Los Angeles International airport (LAX) is the provision of new runways to separate regional turboprops from jets. Other airports are also planning commuter runways to help relieve congestion.

A potential solution to the capacity problems caused by very high numbers of regional turboprops in a given airport's fleet mix would be the development of new procedures allowing use of a single runway for multiple simultaneous turboprop aircraft operations. In this procedure an existing runway could be used for simultaneous landings and departures by turboprops, using local differential GPS to support the operations. Basically, a DGPS approach with precision curved missed approach would be established to the downwind portion of an existing runway. The available runway length would be approximately 4500 to 5000 feet. A 1000 foot safety area would separate the downwind "landing" runway segment from the upwind "takeoff" runway segment. An approximately 4500 to 5000 foot takeoff portion would be provided beyond the safety area, thus allowing a single 10,000 to 12,000 foot runway to serve double duty for turboprop arrivals and departures. At airports where turboprop operations now must be interleaved sequentially on a single runway, this new procedure would allow independent simultaneous operations on a single runway. Obviously, the concept of establishing two operational "runways" on a single piece of physical pavement will require innovative procedures development. The mere marking and lighting challenges of defining a single piece of pavement as two runways will be formidable. Nevertheless, significant increases in capacity can result.

Another area where the improved accuracy of DGPS can be applied is to obstruction clearance. At many airports, instrument approaches are commenced at fairly high ceilings because of obstructions in the approach area. Often the discontinuance of visual approaches to multiple runways occurs at ceilings of 2500 feet or more, with an attendant reduction in airfield capacity. In an environment where both aircrews and air traffic controllers know the aircraft's position within a few meters as a result of DGPS navigation and surveillance, obstacle clearance criteria should be able to be substantially reduced. One might envision equipping the controlling obstruction with an ADS-B transmitter so that it's position and elevation could be observed on CDTI, further enhancing safety. Using such tools, the conditions during which VMC operations can be continued can be extended, allowing use of higher runway capacities for longer periods of time.

Reduced Separations/Existing Procedures

LAAS with sub meter precision and less than one second update rates should allow operations on parallel runways separated by 3400 feet at substantially lower costs than today's PRM. However, this technique should also be able to support simultaneous independent approaches to runways having smaller separations than 3400 feet, given the availability of sub-meter precision for both navigation and surveillance.

Recent attempts to reduce the separations for these operations have suffered from difficulties caused by overshooting of the final approach course and violation of the required Non Transgression Zone (NTZ) during initial localizer capture. Given the FMS capability of new aircraft, these reduced separation parallel approaches might only be authorized if flown in an auto-coupled mode, thereby eliminating the variability caused by manually flown initial localizer capture.

To help resolve the problems caused by less than complete equipage among the fleet using runways approved for reduced separation instrument approaches, modified terminal automation should be developed to sequence packets of ADS-B equipped aircraft to approaches on closely spaced parallel runways either independently or with greatly reduced staggered separations when sufficient numbers of suitably equipped aircraft are available. At other times non-equipped aircraft will be sequenced to these runways with more traditional staggered separations. The entire process will be dynamic and will take advantage of the capabilities of suitably equipped users, while not excluding un-equipped airplanes.

At airports having closely spaced parallels and high percentages of potentially cooperating users (for example: San Francsco and Saint Louis where United Airlines and TWA, respectively, have a significant percentage of operations), the capacity increases could be substantial. There is little conceptual reason why aircraft equipped with sub- meter position determination and CDTI cannot operate in essentially VFR conditions when comparably precise surveillance is also available.

Reduced Separations/New Procedures

This final category of landing procedures, while the most speculative, is also the most promising. These procedures will take advantage of precise LDGPS navigation, ADS-B surveillance and advanced automation on aircraft and in ATCT facilities to revolutionize terminal operations. In these procedures four dimensional automated control will permit sets of cooperating aircraft to follow approach and landing paths which allow greatly reduced separations by applying the free flight concept of "alert zones" and "protected zones" to final approach courses. Under this scenario, each aircraft flies an auto-coupled final approach, either straight-in, intersecting or curved. These procedures will only be authorized for suitably equipped aircraft while flying coupled 4-D approaches. Under this concept, sequencing between airplanes on adjacent approaches will be set by ATC automation so that cooperating aircraft cannot inadvertently or intentionally enter another aircraft's protected zone without first triggering an alarm to both crews and to ACT when the automation system predicts an impending violation of either airplane's alert zone.

With this capability it should be possible to conduct approaches to closely spaced parallel runways at capacities approximating today's procedures for independent simultaneous runways. Simultaneous approaches to intersecting runways with FMS curved missed approaches should be able to be authorized at far less than today's TERPS plus 3 miles separation. Curved approaches to short finals in IMC will be possible, as will full autoland on side step procedures.

Another persistent problem at capacity constrained airports is the increase in separation required to avoid hazards to small and light airplanes from the wake vortices from preceding large and heavy aircraft. The current solution to this problem is to provide additional separation, depending on the types of aircraft involved. This has a serious negative impact on capacity. Existing guidance to smaller aircaft following large or heavy aircraft in Visual Meteorological Conditions (VMC) is to avoid dangerous wakes by flying a glide path that remains above the path of the wake-producing heavy aircraft, and landing further down the runway than the heavy aircraft.

In theory, it is possible to establish two instrument approach procedures procedures for a single runway, one with the traditional 3 degree glide path and 1100 foot touchdown point for large and heavy airplanes, a second with a steeper glide path and a touchdown point located further down the runway for small and light aircraft. With these two approaches available, during appropriate wind conditions, turboprop regional aircraft could be sequenced by ATC to the higher glide slope approach during IFR conditions, avoiding the increased separation penalty. Unfortunately, because of the expense and difficulty of siting a second ILS on an existing runway, this technique is not feasible with today's equipment. Since local GPS navigation does not require a specific site in order to establish a glide slope for the second approach, the establishment of a second "high angle" approach with a separate touchdown point is a relatively easy matter which could reduce delays at many U.S. airports having high percentages of turboprop regional aircraft operations. ATC automation to provide optimal sequencing to the dual glide paths should also be developed to support such procedures.

Other Benefits of New Technologies:

Beyond the benefit to be had by developing innovative approach procedures, the free flight technologies will allow important improvements in other airport operations. For example:

Runway Occupancy: Runway occupancy is sometimes determined by factors other than stopping performance. Airline terminal location can and does contribute to increased occupancy times. More than the absolute value of the occupancy, the high degree of variability between succeeding aircraft prevents controller optimization of runway throughput. Controllers routinely inquire as to the ability to exit at particular taxiways so as to better manage intervening departures during mixed operations. These transmissions often occur during periods of high cockpit workload and often do not convey the required information in time for the controller. A future scenario has the intended runway exit projected by the airplane FMS on the basis of expected landing conditions. The intended exit taxiway will be data linked to ATC automation for use in planning runway sequences. The use of pre-negotiated exit locations with data linked transmission of intended runway exit locations to controllers will allow better optimization of runway use. Minimum runway occupancy times, consistent with safety and operational needs, will be a mandatory feature of the future high capacity airports.

Airplane-derived runway friction measurement: On-board calculation of runway friction index as a function of runway position using information on applied brake pressure, deceleration and anti-skid characteristics should be data linked to ATC for automated dissemination, also via data link, to succeeding aircrews. Airport management should also receive these friction indices to assist with snow removal operations.

Airport surface operations: ADS-B equipage of airport operations, maintenance, snow removal, police and rescue & firefighting vehicles operating on the airport movement area will allow their position to be tracked in the same system being used for ATC surveillance. This will facilitate ATC/airport coordination during emergencies, snow removal operations or periods of low visibility, and wil permit including these vehicles in automated runway incursion prevention detection programs, such as AMASS.

Summary:

The combination of greatly improved precision and freedom from siting constraints for airport and terminal area navigational systems which are characteristic of the emerging satellite- based ATC systems will permit a dramatic revision in airport operating concepts in the future. The specific proposals described in this article cover a wide spectrum of both benefits to users and difficulties in implementation. However, the intent of proposing innovative, even speculative, procedures is to stimulate discussion which will, hopefully, lead to a broad assessment of the way a new concept can be shaped to relax the constraints that the existing ATC paradigm imposes on airport operations.

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What this Lecture will cover..

- Types of technologies at airports; their advantages and disadvantges: ***Pages 1-27***:
  - Overview of this Lecture
  - The pluses and minuses of technology at airports
  - Discussion of airport functions and the technologies that both serve and impact them
- Appendix A: Airport Internet Sites section: ***Pages 28-86***
  - Evolution of Airports/Aviation Industry Sites on the Internet
  - Airport Travel via Internet Information Scheduling, Reservations
  - Airport Photo Gallery
    - tracking the evolving look of Aviation sites on the Internet
- Appendix B: Internet Sites for Aviation Professionals - A Listing: ***Pages B1-B9***
- Appendix C: Aviation Technology Bibliography & Resources - updated as of May 3, 1998: ***Pages C1-C16***
- Looking to the Future: ***Final Page***

Our Focus..

- A Quick Tour of Airport Operations and the Impacts of Technology
- Airports Continue to Grow
  - Market-driven expansion/development: Europe, Asia, USA
- Airport Growth Fuels applications of new technologies
  - To survive in a competitive global marketplace, airports have to look to productivity and efficiency in the way they conduct business, especially with limited federal grants available in the U.S.. Technology helps on all counts.
  - Technologies can be a long-range asset - but there can be problems too...
    - One positive example: Airports need Real-Time data and information for airport operations; ground and air systems tracking; concession revenues.
    - One negative reality: The Y2K problem
- Keywords: Integrated Systems, Central Database/"Data Warehouse",
    - Cellular/Wireless, SmartCards, E-mail, Internet, Intranets, Microwave Systems, PCs, Network Computers, Wireless Cell/PIMs/PDAs

What Are the "Airport Operations" That We Are Talking About?

- Major airport service functions supported
  - Safety & Security
  - Airport Certification & Regulatory Requirements
  - Airside Monitoring & Control
  - Landside Monitoring & Control
    - Intelligent Transportation Systems
  - Customer Information
  - Business/Marketing/Revenue Development
  - Marketing:
    - How do we better service the customer?
    - But also, "How are we doing?"
      - "What's happening at airports elsewhere?"

The Technology Advantage - Example: Safety in Operations

- To compete effectively, airports must track all operations and maintenance, business revenues, expenses, lease agreements, and traffic trends as they actually happen. This is Real-Time tracking, and technology provides this.
  - Incident Resolution: Operations shops can be better prepared for incidents with computerized online guides to assist in handling potential or real trouble spots including expedited emergency vehicle access to remote locations, location of exit doors and windows on all types of aircraft, etc.
  - Incident Reporting to Management: In turn Operations can constantly feed management updated online information as to resolution of incidents via Videocam and CATV feeds and computer reports.
  - For ordinary day-to-day airport inspections, computer programs now provide advice on NOTAMs for specific day-to-day issues such as a series of taxiway lighting outages, pavement separation, and information on reporting these to control tower and resulting impact of aircraft operations.
  - Technology systems can also provide direct information to tower re potential flight obstructions resulting from construction on or near airports.

The Technology Advantage - Example: Airport Maintenance

- Normal work schedules: Computer programs issue daily instructions to maintenance crews as to routine work to be conducted on a regular basis at pre-determined calendar intervals.
- Maintenance crews, using easy computer data formats, input (1) which work is completed per schedule each day, (2) which work has been delayed and why (so computer can re-program and track this work), and importantly (3) which special jobs came up (emergency pipe or electric repairs for example), how long it took to complete the work and how much supply cost was involved. If the emergency work appears frequently enough, the computer program will insert routine pipe or electrical system inspections at greater frequency.
- Management can track maintenance and costs thereof on a day-to-day basis and order changes as appropriate.

Interface Areas between Airport Operations and Technology

- FAA Tower systems upgrades
- Airline (proprietary systems) always at cutting edge.
- For the Airports:
  - Real Time Information
  - Integrated Systems
  - Improved Communications
- For the Customers:
  - Airline Passengers:
    - Facilitated Information via the Internet - on and off the airports
    - Improved trip times due to Intelligent Transportation Systems
  - Airlines and other Airport Tenants
    - Ticketless Travel
  - Airport Workers

Impact on Customers -- Airline Passengers Enroute to Airport

- Before You Leave for the Airport:
  - Airline and Airport "800" telephone information services
  - Airport Information Systems in Many Cities:
    - AIR-RIDE Phone Systems: Some 20,000 calls per month for ground transportation information for Kennedy, LaGuardia and Newark Airports
  - Internet: Airport Access Routes, Schedules and Fares are on the Internet
  - Television:
    - Live Traffic Condition Pickups - Helicopters or Permanent Cams
    - Airline Flight Display Information
- Highway Advisory Radio enroute to the airport
- Intelligent Transportation Systems including Variable Message Signs enroute to the airport

Impact on Customers -- Airline Passengers At the Airport

- Intelligent Transportation Systems of all kinds in development
- Variable Message Signs on Airport Roadways
- Flight Information Display Systems at Terminal Curb Frontages
- Multi-Lingual Information for Overseas Passengers
- Interactive Video Kiosks: Smart Terminals
- CNN, CNBC, Disney, Fox, others
- SmartCards for Phones, other activities
- INSPASS to speed Inbound International Passengers
- Pre-Paid Parking & "E-Z Pass toll pay cards"
- Results -- Improved Customer Service

Newer Technology Applications Serving Airport Operations

- Intelligent Transportation Systems
- Airport Communications and Command Centers
- Management Information Systems
- Lease Document Management
- Videoconferencing
- Bar Coding
- Wireless Communcations

Pros and Cons of Automation

- Pros
  - Easier to Access Information on Airport Operations Systems
  - Better Management Monitoring of Airport Operations
  - Facilitates Tracking of Performance Measures/Control
  - Overall, More productive
- Cons
  - Higher Life-Cycle Costs
  - Annual Recurring Costs
    - Ongoing Maintenance & System Administration
    - Some Duplication of Data-Input and Data Management
    - Network Administration
  - Employee Stress
    - Staff fear of change and consequences
  - The Year 2000 "Millenium" Problem

Intelligent Transportation Systems Serving Airport Access Highways

- Smart Highways in the Future: Single Regional Systems
- Airport Systems
  - Automated Vehicle Identification Master Plan
  - Airport Central Taxi Hold Management
  - Electronic Traffic Management for On-Airport Buses
  - E-Z Passes
  - Freeway Management System
  - Geographic Information Systems for Facility/Traffic Management
  - Ground Transportation Information System
  - Highway Advisory Radio System
  - High Occupancy Vehicle programs for carpools and vanpools
  - Ride-Share Programs for Employees
  - Variable Message Signs
  - Video Imaging Detection System

Communications & Command Centers

- These Centers monitor or control all components of airport operations
- Development Milestones
  - SFO concept creator
  - ORD's $40 million center- on line 5 years ago
  - LAX' 24,000 sq. ft. center
  - Denver International Airport
  - Hong Kong Chek Lap Kok Airport - opens July 1998
- Determination of Need for Centers
  - What communications will be used?
  - Industry information - electronically derived
  - Consider public/private partnerships
  - Total Planning & Construction Costs
  - Total Annual Operating Cost
  - What are Cost-Benefits?

Communications & Command Centers Functions

- Aeronautical Monitoring
- Aircraft Arrival & Departure Information
- CCTV Monitoring
- Construction Scheduling
- Energy & Utilities Management Systems
- Environmental Tracking Systems
- Facility Maintenance
- Fire, Police and Security
- Radio Systems
- Signage Tracking Systems
- Stormwater Management Systems
- Terminal Management
- Transportation Services

Management Information Systems

- Key airport performance measures
- Traffic, Revenue & Expense, and Financial Trends
  - Airport
  - Airlines
  - Concessions
  - Airport Tenants
- Airport Daily Report
- Online Industry News including Aviation Daily Online

Airport Programs -- Safety & Security

- Aircraft Foam Arrestor Bed
- Aircraft Firefighter Fuel Trainer
- Airfield Drivers' Permit Program
- Breach of Rules
- Closed Circuit (CCTV) coverage
- Computerized Telephone Notification
- FAA-Mandated Airside Access Controls
- FAA Tower Emergency Alert
- Differential Global Positioning
- Hustler Enforcement Tracking
- Passenger & Baggage Screening
- Surface Movement Guidance
- Vehicle Registration Monitoring

Airport Programs -- Aeronautical Operations

- Aircraft Noise Abatement Monitoring
- Airport Duty Log
- Collection/Analysis of Terminal Records
- Communications - Airport/Airline
- De-Icing Systems
- Flight Information & Departure System
- Itinerant Aircraft Billing System
- Passenger Immigration Statistics
- Snow Equipment Tracking
- Three Dimensional Airspace Analysis
- Weather Systems

Airport Programs -- Landside Control

- Airport Lighting Control System
- Airport Tenant Alteration Management
- Automated Cargo Sort Facilities
- Building/Facility Management
- Common-Use Airline Terminals
- Intelligent Transportation Systems
- Interactive Information Kiosks
- Parking Revenue Control Systems
- People Mover Systems
- Supervisory Control and Data Management
- Teleconferencing
- Terminal Concourse Systems

Airport Programs -- Airside & Landside Operations

- Automated Baggage Handling Systems
- Closed Circuit Television Tracking
- Computer-Aided Dispatch Systems
- Environmental Databases
- Fire Protection Monitoring
- Gate Management System
- Maintenance Management
- Materials Management
- Project Control, Management, Scheduling
- Purchasing
- Structural Integrity Tracking System
- Telecommunications Integration
- Utility Bill Tracking System

Airport Programs -- Financial, Leasing & Billing Systems

- Airport Budget and Financial Systems
- Airport Performance Scorecard
- Aviation Business Enterprise Performance System (MBE/WBE)
- Contract Administration
- Document Tracking System
- Electronic Data Interchange
- Itinerant Aircraft Billing System
- Parking Revenue Systems
- Property Lease Management Programs
- Purchasing
- Timekeeping
- Traffic Audits
- Weights & Movements - Aircraft

Airport Programs -- Planning

- Collection and Analysis of Terminal Records
- Computer-Aided Design & Drafting for Airport Layout Plan
- Community Participation Agreements and Records
- Concessions Management: Point-of-Sale
- Project Management for tracking scheduling and costs
- Project Planning Systems
- Regional Planning Management Systems
- Simulation Analyses
- Telecommunications - Impact on Business Travel
- Three Dimensional Airspace Analysis Program

Airport Programs -- Marketing

- Airlines Traffic Data
- Airport Performance Scorecard
- Audit: FAA CATER Log vs. Monthly Airlines Traffic
- Comment Card Outreach Tracking
- Load Factor Report
- Standard Annual & Monthly Traffic Reports
- Yearly Control Sheets

Appendix B - Special Supplement

Internet Sites

for Aviation Professionals

George W. Blomme
Airport Operations & Information Technology
UC-Berkeley Airport Systems Planning & Design Course

May 4, 1998 update

Special Supplement

Internet Sites for Aviation Professionals
May 4, 1998 update

- What types of Air System Resources are on the Internet?
  - Identification of top airport, airline, aviation industry and resource sites
  - Real Time Flight Tracking
  - Airport News sites
  - Conference listings
  - Commission Reports/Hearings
  - Consultants

- What types of Planning Resources are on the Internet?
  - Airport Traffic Forecasts
  - Airport Layouts
  - Terminal Layouts
  - Ground Transportation Services
  - Master Plans
  - Aircraft Types / Configurations
  - Links to Other Sites

- What types of Travel Resources are on the Internet?
  - Airline and Hotel information and reservation systems
  - Road maps / ground transport routes and schedule information
  - Airport guide / terminal layouts
  - Restaurants and shops
  - Schedules arrivals / departures
  - Real time flight tracking
  - Construction impacts

- Internet Bonuses
  - Efficient search engines
  - Notification of changed information on your own list of Internet sites
  - Utilities
  - Downloads of updated programs
  - Program fixes
  - Free trial/demo programs

Special Supplement

Internet Sites for Aviation Professionals

May 4, 1998 update

- Airline Sites – Sample Sites
  - American Airlines
    - http://www.americanair.com/
  - Delta Airlines
    - http://www.delta-air.com/

- Airline Sites - Where to Search for them
  - IATA:
    (search for airline (2- and 3-letter) codes
    - http://www.iata.org/members.htm
  - Most common airline codes:
    - http://www.flifo.com/aircodeindex.html

- Airport Sites – Sample Sites
  - Chattanooga, TN
    - http://www.chattairport.com/
  - Denver International Airport
    - http://infodenver.denver.co.us/
  - Frankfurt Germany
    - http://www.norfolkairport.com/links.html (via Norfolk Airport link)
- Minneapolis-St, Paul
    - http://www.dot.state.mn.us/aeronautics/mdot.html
  - Osaka Kansai International
    - http://ks.kiis.or.jp/~kixinfo/
  - Port Authority NY&NJ Airports
    - http://www.panynj.gov/aviation/
  - San Francisco International
    - http://www.ci.sf.ca.us/sfo/
  - Tokyo Narita (in English)
    - http://www.narita-airport.or.jp/airport_e/i
  - Washington D.C.
    - http://www.metwashairports.com/

Special Supplement

Internet Sites for Aviation Professionals
May 4, 1998 update

- Airport Sites - Industry Sites with Best Links to Other Airport Sites
  - Norfolk International Airport:
    (besides providing linkages to other airports and other aviation services, this site has a updated-daily news aviation bulletin page, upcoming conferences, and more)
    - http://www.norfolkairport.com/
  - FAA:
    - http://www.faa.gov/
      (this site includes linkages to airports, airlines, education centers, general aviation, industry organizations, weather, libraries, entertainment, NTSB, Bureau of Transportation Statistics, & more)
  - AAAE:
    (official airport sites of AAAE members)
    - http://www.airportnet.org/
  - ACI-NA:
    - http://www.aci-na.org/
  - ATA:
    - http://www.air-transport.org/
  - 100 Best Aviation Sites:
    - http://biz.yahoo.com/news/airlines.html
  - Princeton site
    - http://dragon.princeton.edu/~dhb/airports.html
  - The Aviation Home Page:
    - http://www.avhome.com
  - Transportation Research Board:
    - http://www.nas.edu/trb/

- Airport Sites – Where to Search for them
  - Airport Search Engine:
    (search for airports by IATA abbreviation, city, or country)
    - http://www.uni-karlsruhe.de/~un9v/atm/ase.html
  - IATA:
    (search engine for locating airports by 3-letter codes or by city name)
    - http://www.iata.org/codes/

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Internet Sites for Aviation Professionals

May 4, 1998 update

- Aviation News Links
  - Jane's:
    - http://www.janes.com/
  - Yahoo Links:
    - http://biz.yahoo.com/news/airlines.html
  - Air Industry News Group:
    misc.transport.air-industry,misc.answers,news.answers

- Conference Planner
  - National Academy of Sciences Links:
    - http://www.nas.edu/trb/link/conflinx.html
  - University of CA-Berkeley ITS:
    - http://its.berkeley.edu

- Consultants
  - Nettleship:
    - http://www.nettleship.com/
  - Siemens Nixdorf Transportation Home Page:
    - http://www.snitt.com/
  - Systems Atlanta:
    - http://www.sysatl.com/
  - TransCore (an SAIC Company):
    - http://www.tcore.com/
  - Management Consultant Network International
    - http://www.mcninet.com

- FAA National Airport Information Resource
  - FAA Office of the Associate Administrator for Airports:
    - http://www.faa.gov/arp/arphone.htm

- General Information Sites
  - GeoCities:
    - http://www.geocities.com/
  - Los Angeles Times:
    - http://www.latimes.com/
  - New York Times:
    - http://www.nytimes.com/

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Internet Sites for Aviation Professionals

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- Hearings/Commissions
  - Commission on Aviation Safety & Security:
    - http://www.aviationcommission.dot.gov
  - House of Representatives:
    - http://www.house.gov/transportation/aviation/
  - USDOT transportation rulemaking including Federal Register:
    - http://dms.dot.gov

- Internet & Computer News & Utilities
  - CNET computer program upgrades:
    - http://www.cnet.com and http://www.download.com/
  - ZDNET:
    - http://www.zdnet.com/

- Internet Search Tools
  - Yahoo:
    - http://www.yahoo.com/
  - AltaVista:
    - http://www.altavista.digital.com/
  - Say Jeeves:
    - http://www.sayjeeves.com
  - Excite:
    - http://www.excite.com/
  - Metacrawler:
    - http://www.metacrawler.com/

- Notification that Internet Bookmarked Page has been changed
  - Informant:
    - http://informant.dartmouth.edu/
  - Internet Explorer 4.0 browser (Microsoft):
    (notification-of-change available for any site selected as a "Favorite", i.e. "bookmarked")

- Real Time Flight Tracking Site
  - Real Time Flight Tracking – The Trip.com:
    - http://flight.thetrip.com/

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Internet Sites for Aviation Professionals
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- Sites with Links to Conferences & more
  - American Society of Civil Engineers:
    - http://www.asce.org/
  - Embry Riddle University:
    - http://infodenver.denver.co.us/
  - Institute of Transportation Engineers:
    - http:www.ite.org/
  - National Academy of Sciences:
    - http://www.nas.edu/
  - Princeton University ITS Program:
    - http://dragon.princeton.edu/~dhb/
  - Texas Transportation Institute
    - http:/tti.tamu.edu/trans.html

- Transportation Resources Sites - General
  - U.S. Bureau of Transportation Statistics:
    - http://www.bts/gov/
  - Texas Transportation Institute:
    (connections to experts in the field, catalog of research publications, calendar of events, links to other transportation resources)
    - http://www.ttitamu.edu/
  - A side-by-side comparison of NEXTEA, BESTEA, and ISTEA II is available at http://www.fhwa.dot.gov/reauthorization/line as part of the Department of Transportation's web page.
  - Amazon – world's largest bookstore online (with book reviews)
    - http://www.amazon.com

- Travel – Reservations and Information and Schedules
  - Biztravel:
    - http://biztravel.com/
  - Expedia:
    - http:/expedia.com/

Special Supplement

Internet Sites for Aviation Professionals
May 4, 1998 update

- Travel - Local Information & Maps
  - City Maps (Microsoft series):
    - http://sidewalk.(name of city).com
  - City Maps (Yahoo series):
    - http://(city designation).yahoo.com/
  - Washington, D.C. Info/Maps:
    - http://dc.yahoo.com/

- Travel - Subway System Maps
  - Atlanta:
    - http://metro.jussieu.fr:10001/bin/select/english/usa/atlanta
  - Baltimore:
    - http://metro.jussieu.fr:10001/bin/select/english/usa/baltimore
  - London:
    - http://metro.jussieu.fr:10001/bin/select/english/united-kingdom/london
  - New York:
    - http://metro.jussieu.fr:10001/bin/select/english/usa/new-york
  - Paris Metro/RER systems:
    - http://metro.jussieu.fr:10001/bin/statmap/english/france/paris
  - Washington, D.C.:
    - http://metro.jussieu.fr:10001/bin/select/english/usa/washington

- Web-Page Authoring Sites on Internet
  - Listing of host sites for Web pages:
    - http://www.webhostlist.com
  - Free Web Page:
    - http://www.tripod.com
  - Free Icons:
    - http://idt.net/~jusric19/desktop.html

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Obtaining documents

1. U.S. Government reports (DOT, FAA, UMTA) can be obtained from the National Technical Information Service, Springfield, VA 22161. FAA Advisory Circulars can be obtained directly from the FAA.
2. UCB/ITS reports can be obtained from the Institute of Transportation Studies, Publications Department, 109 McLaughlin Hall, University of California, Berkeley, CA 94720.

Hanan A. Kivett, AIA
Vice President
Parsons Brinckerhoff Aviation

Senior transportation architect with over 30 years experience in planning and design of major airport terminals, rail transit and intermodal rail stations. Prior affiliations included Harry Wesse Associates, independent consultancy and Chief Architect for 16 railroad stations as part of the Federal Railroad Administration's Northeast Corridor High Speed Rail Project.

Major projects include:

- BART Extension to San Francisco International Airport
- Millbrae BART/CalTrain Intermodal Station;
- Kansas City International Airport
- Denver International Airport
- Munich II Airport, Germany
- Saltholm Off-Shore Airport
- Los Angeles Red Line Transit Stations
- Washington Union Station

Zürich

Authored and presented numerous papers to professional society-sponsored workshops, conferences and seminars on the subject of Airport Landside Terminal Developments, Rail Access to Airports, Art in Transit, and Rail Transit Design. Lecturer on these topics to a number of universities throughout the US.

Terminal Concepts-
State of the Art

- Centralized
  - Pier Fingers
  - Landside/Airside: Remote Piers or Satellites
    - Access modes: People Movers; Moving Sidewalks; Apron Buses/Mobile Lounges
- Decentralized
  - Individual Terminals by Airline or Destination
  - Distribution Systems between Terminals
    - People movers; surface buses; monorails; moving sidewalks

Examples

- Denver
- Orlando
- Washington National
- Washington Dulles
- Pittsburgh
- Cincinnati
- O'Hare
- SFIA
- Munich
- Oslo
- Paris de Gualle
- Hamburg
- Kuala Lumpur
- Chap Lok Kok
- Kansai
- Seoul

Major Issues

- Gate Flexibility for Fleet Mix
- Hold Room Sizing and Processing
  - SW Airlines Methods
  - United Shuttle
- Ticketing & Baggage Check-in Procedures
  - Security Screening Requirements
  - Positive Identification
  - X-ray requirements
  - Class differentiation (First; Business; etc...)
- Exclusive vs. Non-exclusive Use Facilities

Major Issues

- Curbside Capacity
  - Departures
  - Arrivals
  - Commercial vs. private vehicles
  - Number of levels
    - KCI; Atlanta; Oakland; San Jose
    - Orlando; Sea-Tac with 3 curb fronts
- Concessions/Passenger Amenities
  - Convenience; Major Shopping
  - Business Centers
  - Locations: Landside vs. Screened/Airside

Major Issues

- International Processing
  - Arrivals Circulation
    - Immigration and Customs Queuing
    - Number of Level Changes
    - Baggage Handling for Connecting Flights
  - Access to Connecting Flights
    - Number of Level Changes
    - People Movers; Moving Sidewalks; Walking
    - Signing/Information Systems
  - Bi-Lingual Services
    - Number of Languages
    - Interactive Kiosks

Lessons Learned

- Flexibility
  - Universal Ticketing and Gates
  - Adequate Queuing-Security; Bag Check-in; Boarding Passes
  - Hold Room Configurations-single vs. multiple gates
- Passenger Convenience
  - Walking Distances
  - Physical Environment
  - Shops/Concessions/Business Centers
  - Hotels/Conference Meeting Facilities

Lessons Learned

- Architectural Image
  - Civic Pride
  - Identity
  - Capital Costs
  - Operations and Maintenance Costs
  - Longevity and Durability
  - Expansion Potential
  - Flexibility to Accommodate Change
    - O & D vs. Hubbing; Major Carrier vs. Commuter

21st Century Issues

- Double Deck Aircraft
  - Hold Room Configurations
  - Loading Bridge Requirements
- Heightened Security Screening
  - Mandatory Baggage Matching
- Ground Access Constraints
  - Rail Access Modes
  - Seamless Connections
  - Downtown/Remote Processing and Check-in

Synopsis of Domestic Systems

Rail Access to Airports	Station Location			Internal Distribution				Remarks
	At Terminal(s)	Remote from Terminal(s)	Off Airport	Walk	People Mover	Moving Walks	Shuttle Bus	
I. In Operation								
Washington National		•		•		•		New connections in service July 1997
Atlanta	•			•	•			
Philadelphia	•			•				Multiple stops are provided on rail line.
Cleveland	•			•				
Boston		•					•	
Chicago O'Hare	•			•	•			
Chicago Midway			•			*	•	Increased activity will provide moving walks.
Baltimore International	•		•	•			•	Opened in late 1997 to International Pier
Oakland			•		*		•	LRT under study.
St. Louis	•			•				New station at SW terminal under const.
Newark			•		*		•	NEC Station under const.with monorail ext.
II. Rail Access Under Design or Study								
San Francisco	*			*	*	*		Consrtruction underway.
Dallas/Ft. Worth		*			*			Rail access under study.
Denver	*				*			Rail access under study.
New York Kennedy		*			*	*		Design/build in solicitation.
New York LaGuardia		*			*			Rail access under study.
Orlando		*						Rail access under study.
Miami			*		*	*		Rail access under study.
Portland	*			*				Rail access under study.
Washington Dulles	*			*				Rail access under study.
Las Vegas		*			*			Rail access under study.
Los Angeles		*			*			Rail access under study.
Seattle	*			*				Rail access in design
Norfolk	*			*				Rail access under study.
Raleigh	*			*				Rail access under study.
Salt Lake City	*			*				Rail access under study.
Austin	*			*				Rail access under study.

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Synopsis of International Systems

Rail Access to Airports	Station Location			Internal Distribution				* Remarks
	At Terminal(s)	Remote from Terminal(s)	Off Airport	Walk	People Mover	Moving Walks	Shuttle Bus	
In Operation or Under Construction								
London Heathrow	*			•			•	New system under construction.
London Gatwick	•			•	•			
London Stanstead	•				•			
Birmingham	•				•			
Paris Orly	•				•			
Paris Charles de Gaulle		•			*		•	People mover to open in mid-1998
Zurich	•			•				
Amsterdam	•			•				
Geneva	•			•				
Brussels	•			•				
Rome	•			•	*			People mover in design.
Barcelona	•			•	•			
Frankfurt	•			•	•			
Munich	•			•	*	•		People mover under study.
Hannover	•			•				Under construction
Dusseldorf	•			•				
Vienna	•			•				
Copenhagen	*			•		•		Under construction
Stockholm	•			•		•		
Oslo	*			•		•		New airport under construction.
Moscow	•			•				
Tokyo Narita	•			•	•			
Tokyo Haneda	•			•				
Osaka Kansai	•				•			
Hong Kong Chek Lap Kok	*				•			To open in July 1998
Bangkok	*			•		•		Under construction
Sydney	*			•				Under construction
Kuala Lumpur	*			•				Under construction

AIRPORT TERMINAL PLANNING AND DESIGN BIBLIOGRAPHY[1]

The following is a list of selected books and reports that include discussion and guidelines on airport terminal planning and design. It was prepared by the *Terminal Planning and Design Subcommittee* of the Landside Committee of the American Society of Civil Engineers to serve as reference materials for one building a library collection or doing research in this area.

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Environmental Planning and Management

Environmental considerations in airport planning can be organized in five separate areas:

(1) Environmental Considerations in Airport Planning

(2) Environmental Action Choices

(3) The Content and Structure of Environmental Documentation

(4) The impacts To Be Studied in Environmental Documents

(5) Supplemental Requirements of Environmental Documentation

Each of these is addressed below:

(1) ENVIRONMENTAL CONSIDERATIONS IN AIRPORT PLANNING

The National Environmental Policy Act (NEPA), passed in 1969, has served as a model throughout the world for examining the potential consequences of actions before they are taken. This model requires that the impact of proposed actions be studied and documented, and sets forth a basic premise that the benefits which derive from a proposed action must be sufficient to balance the environmental and socioeconomic costs which are generated.

In the early years of NEPA, the scope of concern for environment was largely limited to the natural environment: air and water quality, flora, and fauna, and other natural resources. In recent years, the scope of concern under NEPA has been expanded to include the social, cultural, and economic context as well as the natural environment. This is supported by policy in NEPA such as: "achieve conditions under which man and nature can exist in productive harmony to fulfill social and economic requirements of present and future generations."

In many airport projects it is the socioeconomic impacts to the neighboring communities that are the perceived to be significant issues, with impacts to the natural environment carrying relatively less weight in decision-making. Thus, environmental studies at airports must address in detail such impacts as community noise exposure; compatibility with surrounding existing and planned land uses; compatibility with off-airport zoning and other land use controls; impacts to public parks, recreation areas, schools, and other sensitive public facilities; potential impact to known or undiscovered historic, archaeological, or cultural resources; and associated secondary socioeconomic impacts, such as induced secondary growth, among others.

The requirements of NEPA constitute a kind of "umbrella" covering a number of other legislative mandates. Among those which are relevant to environmental issues that may result from airport construction and operation are:

- Department of Transportation Act of 1966 (4(f) lands)
- National Historic Preservation Act of 1966 (Section 106)
- The Airport and Airway Development Act of 1970
- Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970
- Clean Air Amendments of 1972
- Clean Water Act of 1972
- Coastal Zone Management Act of 1972
- Noise Control Act of 1972
- Endangered Species Act of 1973
- Flood Disaster Protection Act of 1973
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- Farmland Protection Policy Act
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- Floodplain Management Executive Order 11988
- Environmental Justice, Executive Order 12898

Additionally, other agency regulations have been issued setting forth requirements for coordination and review with federal, state, and local environmental agencies. Among the more problematic of these is the coordination of federal with state environmental review process, such as that of the California Environmental Quality Act (CEQA).

Basic Principles

In the consideration of linkages and relationships between environmental considerations and airport planning, two basic principles deserve attention. The first is the role environment plays in the planning process for airports, and the second is the concept of ecosystems.

The requirements of environmental documentation that are part of the airport planning process generate strongly held opinions. In some quarters they are looked upon favorably because they help preserve and maintain high environmental quality. Others see environmental mandates in a negative light. Still others, often through the courts, view them as an opportunity to elicit commitments from the airport authority.

The negative point of view about environmental requirements characterizes them as a roadblock to progress, because they must be satisfied before a proposed construction project may be implemented. While environmental mandates do help protect environmental amenities, the negative view is generally overstated. Environmental requirements do not necessarily prevent development of airports or other facilities, although they will influence plans and operations.

At a minimum, they prescribe a set of actions that a project sponsor must complete as a prerequisite to approval of proposed development and commit to implementing.

However, environmental analysis can also contribute valuable information on potentially sensitive areas on and in the vicinity of an airport site. A comprehensive environmental inventory prepared prior to initiating master planning or facility design can provide vital information on sensitive environmental and cultural resources, and identify environmental and socioeconomic constraints that would affect future planning and development. In this manner, potential impacts can be avoided or mitigated during the planning process, thus avoiding controversy and costly delay later on.

Airport environmental requirements specifically mandate that:

1. A proposed airport development action be studied to determine the environmental impact that its implementation will produce.

2. A proposed construction action be supported by facts which justify its implementation and the consequent environmental impact in terms of a real and readily identifiable need.

3. Plans must consider alternative actions.

4. Planners must involve the public in the planning process. The views of interested parties must be sought out and considered in the preparation of the plan.

5. The applicant for federal funds or actions must prepare environmental documentation.

Essentially, then, what environmental requirements do is alter and reshape the planning process—and often the plans—for airports as well as for other facilities.

In the traditional concept of planning, recommendations for future development were based on three criteria:

1. the technical feasibility of the proposed action,
2. the dollar cost, and
3. the political realities of the proposal.

Passage of NEPA in 1969 added a fourth factor. This is a concern for and sensitivity to environmental resources. This change has had a profound influence on the planning process: Environmental considerations are not something which planners add to a planning exercise once the plan is finished. Instead, consideration of environmental factors is integrated from the beginning into plan preparation and the decision-making process.

The second principle deals with the concept of ecosystems. Fundamental to any consideration of the environmental impacts caused by airport development is an understanding of the concept of ecosystems. What is an ecosystem? The simplest image is that of a spider's web, in which, when one strand is plucked, all the others distort and vibrate. But there is a danger in this kind of simile: the web has finite dimensions and suggests that ecosystems also are narrow and finite. In reality nature does not recognize sharp boundaries; the effects of a disturbance in one location may spread far beyond the immediate environs.

In airport planning, the concept of ecosystems assumes great importance. In order to evaluate environmental impacts, the planner must be able to predict how an ecosystem will operate as a result of making a change, such as building a new airport or new runway. If ecological relationships could be described in detail, this exercise would be straightforward. but the unfortunate fact is that, except in a few cases, we know very little about how ecosystems operate. Describing them is relatively simple, but it turns out that these descriptions, and the analytical models based on them, have limited predictive value. This lack of knowledge is no excuse, of course, for not making evaluations based on such information and knowledge as exists.

For planning purposes, the functioning of ecosystems may be illustrated by what have been called the three basic laws of ecology.

The first basic law: <u>Everything is connected to everything else</u>. At the level of a pond ecosystem, there is a broad acceptance of this law, but when this is translated into social or cultural terms, the level of understanding of cause and effect relationships begins to decline.

The second basic law: Everything has to go somewhere. In other words, there is no "away" to throw to. What this thermodynamic law tells us is that procedures must be developed to accommodate the waste products which result from positive actions. In general, this process can be characterized as recycling; increasingly waste is being regarded as a "resource."

The third basic law: There is no such thing as a free lunch. This law tells us that consequences or costs are associated with every action. For some period of time it may be possible to avoid or ignore costs, but it is inevitable that they will appear.

(2) ENVIRONMENTAL ACTION CHOICES

In determining whether environmental documentation is required for a proposed airport development action, an airport sponsor must examine the applicability of federal, state, and local environmental laws or permit requirements, and whether any of these may subject the project to formal environmental review. A preliminary evaluation of the proposed action will identify whether it has the potential to affect the environment with respect to noise, land, air, and water quality; and whether it is located in wetlands, coastal zones, or may affect historical or archaeological sites; or in areas inhabited by endangered species; or may affect public areas protected on environmental grounds. Where a specific project is part of a broader development action, such as a new airport layout plan, it is necessary also to consider the overall, cumulative impacts of the proposed action along with the impacts of past or subsequent related actions.

When a single proposed action is subject to the environmental review requirements of several federal agencies, guidelines of the Council on Environmental Quality (CEQ), the office in the White House with overall responsibility for implementation of NEPA by federal agencies, require that one agency be designated the "Lead Agency," and take the lead responsibility for directing the environmental review. The lead agency is also responsible for coordinating review and comment procedures by all agencies of interest. This is of particular importance where state-level environmental review is required.

For most airport planning and development projects, the federal responsibility of making environmental action decisions is largely in the hands of the FAA. The FAA has established guidelines for airport sponsors to follow in preparing the documentation. FAA Order 1050.IC, "Policies and Procedures for Considering Environmental Impacts," sets forth the manner in which the FAA shall comply with CEQ guidelines in all aspects of its activities. Issued in 1985, the FAA Order 5050.4A, "Airport Environmental Handbook," is directed specifically at airport planning and development projects under the Airports Program. (FAA Order 5050.4A is expected to be replaced by FAA Order 5050.4B, currently under review.)

As the lead agency, the FAA is obligated to review any proposed airport actions identified by the sponsor. The objectives and determinations of this initial review are two-fold: has the problem that the proposed actions intend to correct been accurately identified and appropriate alternative solutions proposed; and, is the proposed action covered by a "categorical exclusion" or does it require environmental documentation.

Actions defined as categorical exclusions in FAA Order 5050.4A, except under extraordinary circumstances, would be excluded from requirements for environmental assessment or other documentation. Categorical exclusions generally include actions that are limited in on-site disturbances, have no off-site impacts, and are not highly controversial on environmental grounds. Appendix B lists the types of actions defined as categorical exclusions.

Actions that are <u>not</u> categorical exclusions can proceed to either the environmental assessment process or directly to the environmental impact statement process. Actions that normally require an environmental impact statement are listed in Appendix C.

Actions that are neither categorical exclusions nor among those normally requiring preparation of an environmental impact statement (EIS), typically require an environmental assessment (EA) to be prepared in order to determine if the potential impacts are significant enough to require a full EIS. Actions normally requiring an EA are listed in Appendix D.

Under special conditions certain actions that are normally categorically excluded may require environmental assessment. The FAA may make a determination that the proposed action will have a significant *enough* impact that an EA is necessary. Appendix E illustrates the most commonly cited criteria for this decision.

When the FAA determines that some form of environmental review is necessary, the sponsor is required to provide data concerning the potential environmental impacts of the proposed action. The FAA expects the airport sponsor to prepare the environmental assessment. In this document, each potential impact must be systematically examined to determine whether it exceeds a pre-defined level of significance. Theoretically, the assessment should satisfy state requirements at the same time, although interpretations of "significant impact" may differ between state and federal lead agencies.

Beyond the preparation of the environmental assessment, there are additional steps to be followed in the environmental process. Although NEPA in itself does not require public hearings (albeit encourages public participation), the Airport Act of 1982 does require a hearing where a new airport location, new runway, or major runway extension is involved. A hearing is also generally held where there is substantial controversy on environmental grounds or where another agency with jurisdiction requests a hearing.

Therefore, if a public hearing is required, the opportunity will be offered after the FAA's review of the sponsor's draft environmental assessment to determine if it is adequate for the hearing. Review by state and local officials occurs through procedures set forth in DOT Order 4600.1 B, "Intergovernmental Review of DOT Programs and Activities." (This procedure replaces those set forth in OMB Circular A-95.) Reviews are usually conducted through a "single point of contact" for the region or with the local joint lead agency with direct jurisdiction over the airport. Sometimes a Council of Governments (COG) serves this function. Comments are incorporated into the environmental assessment by the sponsor; the document is then forwarded to the FAA and becomes an FAA document when approved by the agency.

If, on the basis of the environmental assessment, the FAA determines that the action has no significant impacts, it prepares a Finding of No Significant Impact (FONSI). If, however, the environmental assessment identifies significant impacts, the FAA proceeds with scoping and the preparation of an EIS.

After the decision to prepare an EIS is made, the FAA determines the significant issues related to the proposed action and the scope of the issues to be addressed in the EIS. This scoping process, which is an open, public process, is followed by the assignment of responsibilities for EIS preparation to be accomplished directly by FAA, or by a contractor selected by FAA in accordance with current procedures.

The processing of a draft EIS through to the proposed final EIS involves review through which FAA personnel, other federal agencies, state and local agencies, and any interested organizations and individuals have the opportunity to comment on the draft document. EPA plays a special role in the review process, under Section 309 of the Clean Air Act. Even after public and agency circulation of the draft EIS, there still may be some cases in which the FAA finds that the proposed action will not specifically alter the airport's impact on the surrounding environment and is not highly controversial on environmental grounds. If so, the FAA may prepare a FONSI. Otherwise, the FAA prepares the final EIS and an accompanying summary and forwards it to FAA headquarters for approval.

An approval of the EIS is only that. No decisions with regard to the proposed action itself can be made prior to 90 days after the notice of availability of the Draft EIS, nor until 30 days after publication of a notice of final EIS filing in the Federal Register.

(3) CONTENT AND STRUCTURE OF ENVIRONMENTAL DOCUMENTATION

The content and structure of environmental documents (i.e., an environmental assessment and an environmental impact statement) should encourage good analysis and clear presentation of the alternatives to the proposed action and the potential impacts. The detail to which each alternative and impact is addressed depends upon the purpose of the document as defined by CEQ regulations and FAA guidelines.

The FAA Airport Environmental Handbook (5050.4A) sets forth guidelines for the preparation of both environmental assessments and impact statements and is the current "bible" for all airports undergoing the environmental review process. The format and procedure are similar in structure but differ substantially in the level of necessary detail. According to the FAA, the environmental assessment is expected to systematically examine each potential impact to determine whether it exceeds a pre-defined threshold of significance and to contain sufficient information about each of the alternatives to determine whether to prepare an EIS or a FONSI. Even though this initial examination of the proposed action should consider a wide range of meaningful alternatives and a broad scope of environmental impacts, detail is not required. The analysis should be kept relatively simple.

On the other hand, the amount of detail in an EIS is commensurate with the extent and expected impact of the action as determined by the environmental assessment and the FAA scoping process, but should not be encyclopedic! All impacts defined as "significant" according to CEQ regulations for implementing NEPA (Section 1508.27) are to be analyzed in depth.

To be complete, both environmental documents must contain the following:

- A description of the project and an explanation of need for the project and the purpose that it will serve.
- Discussion of alternatives to the proposed action.
- Discussion of the baseline conditions of the environment to be affected.

- Analysis of the environmental consequences of the proposed action by impact category (detail categories of impact).

- Identification of the adverse impacts which cannot be avoided.

- A list of the names and qualifications of persons preparing the statement; a list of agencies contacted; possible permits necessary for proposed actions.

An EIS must also include:

- Consideration of the relationship between short-term uses of the environment and enhancement and maintenance of long-term productivity.

- A determination of any irreversible or irretrievable commitments of resources involved.

Description and Purpose

A description of the proposed project should contain:

- A detailed listing of the items of work to be accomplished, covering both construction and operation.

- Information on the location of the proposed development in relation to surrounding communities.

- Identification of all nearby recreation areas, parks, refuges, and historic sites (see also 4(f) Lands).

- Data on any federal lands to be transferred as part of the project.

The explanation of the purpose and underlying need that the proposed action is to serve is one of the most crucial elements of environmental documentation and generally accounts for a large proportion of public and agency comments. It must justify that the proposed action is necessary in order to support forecasted growth and achieve or sustain a safe and efficient airport or airport system.

Alternatives

The purpose and need are also the foundation for determining the range of the alternatives to be addressed. Meaningful and reasonable alternatives must be developed and evaluated, in relation to purpose and need. The evaluation should begin early enough in the planning and design of a project so that the beneficial and adverse effects of each alternative can be weighed; some alternatives may even be eliminated or modified at this stage.

Selection of an appropriate range of alternatives is particularly critical when preparing an EIS. If a project is challenged in the courts and the EIS becomes involved in litigation, one of the most difficult issues to defend is the sufficiency and comprehensiveness of the alternatives selected for evaluation. The FAA is required to base project approval on a finding that "no feasible and prudent alternative exists." The terms "feasible" and "prudent" are separate criteria and refer to sound engineering principles and sound judgment, respectively. The environmental documentation must show that no feasible or prudent alternative exits when all factors are considered.

The kinds and types of alternatives which should be considered include:

1. Basic Alternative – Fundamental choices on the type of facilities needed or level of service to be accommodated.

2. Site Location Alternatives

3. Development Alternatives – The layout, configuration, and size of the proposed facility.

4. Non-Physical Development Alternatives – These include institutional, scheduling, and pricing alternatives.

The alternative of no action, or a "do-nothing" alternative, must also always be considered.

Affected Environment

Baseline conditions must be described for the airport environs in a succinct but adequate manner, no longer than necessary to understand the effects of the alternatives. This section of an environmental assessment must describe the location of the proposal; all natural and built features of the area; land use, zoning, and regulatory framework; proximity to public places; and the socioeconomic characteristics of the region (e.g., population and employment). Baseline conditions as described in the environmental assessment will usually be adequate for inclusion in an EIS, unless a particularly significant impact requiring additional analysis is identified in the environmental assessment.

In describing the affected environment, it is helpful to estimate the area of likely impact, or the general geographic extent to which environmental impacts will be considered. A definition of affected environment can vary from airport to airport and must be tailored to the proposed action. Generally two levels of study area are considered, the site and vicinity, and the region. The first level constitutes the site and areas adjacent to the airport. Regional impacts affect a broader area. Table 1 suggests that some impact categories should be considered to a greater or lesser degree at both levels.

TABLE 1

Impact Categories	Site and Vicinity	Region
Noise	X	
Land Use	X	
Air Quality	X	X
Light Emissions	X	
Social Impacts	X	x
Induced Socioeconomic Impacts	x	X
Water Quality	x	X
Historic, Archaeölogical Sites	X	X
Biotic Communities	X	x
Endangered Species	X	x
Wetlands	X	x
Floodplains	X	
Coastal Zone	x	X
Farmlands	x	X
Energy and Natural Resources	x	X
Solid Wastes	x	X
4(f) Lands	X	X
Construction	X	

By considering the full range of impacts on both the environs and in a regional context, a complete picture of the proposal can be drawn in an environmental context.

Environmental Consequences

In the past, a separate section in the EIS reemphasizing unavoidable adverse impacts was required. Under current FAA guidelines these impacts can adequately be addressed in the section on "Environmental Consequences." However, the impacts should be clearly identified in the context of trade-offs between short-term benefits at the expense of long-term costs, or vice versa.

Short-term effects are primarily those caused by construction. Discussion should indicate the duration and phasing of the construction, the nature of equipment to be used and describe safeguards which will be used to minimize harm to both physical and human environment.

Long-term effects must also be considered. These refer to the long-term operation and maintenance of the project and the social, economic, and environmental consequences. Generally, however, FAA considers predictions of impacts beyond five years to be speculative.

Any irreversible and irretrievable commitment of resources in the construction improvements should be identified. Consideration of such issues as materials and expected energy consumption should be included. Depletion of materials in short supply or significant irreversible changes in natural or cultural resources should be discussed. In the current environment, this analysis could include discussion of indirect emissions of greenhouse gases as a consequence of fossil fuel energy consumption.

Public Controversy

Virtually no airport development project today can be undertaken without some amount of controversy. Airport sponsors have long been required to conduct public participation activities, including informational meetings and public hearings. All such requirements still apply. Additionally, under the FAA Order 5050.4A an action that normally would not be subject to detailed environmental documentation, or would normally require only an EA, can become subject to public hearings and EIS requirements if the action is "highly controversial on environmental grounds."

This provision has had far-reaching consequences. An action can be considered "highly controversial" if opposed by any federal, state, or local agency, or by "a substantial number of persons affected by such actions." If an action involves relocation of homes or businesses and a dispute develops regarding the availability of adequate relocation housing, the project can also be defined as "highly controversial," and trigger comprehensive EIS requirements.

One of the obvious consequences of a strict interpretation of these provisions is that almost every airport planning or development action could be subject to EIS requirements if a small group of residents or others in the surrounding community become vocal opponents on the basis of noise impacts for example. The very fact that they are opposed and protesting may be enough to consider the project highly controversial.

An effective measure to minimize controversy or remedy the controversy before it becomes "highly controversial" is to establish an on-going comprehensive citizen participation program and incorporate it into the early phases of airport planning, prior to the point when EA or EIS requirements could be invoked. Citizen participation should be continued through the early phases of environmental review, including broad public exposure to and review of baseline environmental inventories. Most controversy and opposition is based on fear and uncertainty, resulting from a lack of knowledge about the facts of the proposed action or the actual environmental resources that may be affected. Once opponents become knowledgeable, their opposition may become a simple difference of opinion. Opposition may not entirely disappear, but the heightened and often emotional public controversy surrounding the project may subside.

(4) IMPACTS TO BE STUDIED IN ENVIRONMENTAL DOCUMENTS

Noise

Undoubtedly, the most pervasive and evident environmental impact caused by an airport is the noise generated by the operation of aircraft, particularly large jets.

In the preparation of an EIS, the need for an analysis of community exposure to aircraft sound should be accepted as a foregone conclusion. However, it is in the following situations that an analysis is mandatory:

- An evaluation of the location of a new airport.
- A new runway construction evaluation.
- A planned extension to or strengthening of an existing runway.
- The introduction of jet aircraft into a facility for the first time.
- The addition of a larger class of jet aircraft at a facility already accommodating one class of jet aircraft.
- Accommodation for frequent usage by special aircraft, such as helicopters, in proximity to noise-sensitive areas.
- In cases where the action is highly controversial because of perceived potential for noise impacts.

The first step in an analysis is to identify and develop detailed information on the major source of noise. In general, these will consist of some combination of:

- Air carrier aircraft; the most significant are jet aircraft equipped with low bypass ratio engines
- Military aircraft
- General aviation aircraft, including both non-jets and jets

Once the sources have been identified, the next step is to select and apply an analytic technique. Many noise analytic methodologies exist. The FAA requires that the Day-Night Level (DNL) method be used in most cases and that contours of equal noise exposure be plotted. FAA Advisory Circular 150/5020-1 describes the DNL metric. It is the 24-hour sound level in decibels, for the period from midnight to midnight, obtained after the addition of ten decibels to sound levels for the periods between midnight and 7 a.m. and between 10 p.m. and midnight, local time, for the annual average day. It accounts for aircraft types, number of operations, flight track utilization, aircraft performance, and time of day.

The analyses must be sufficient to determine if any existing planned noise-sensitive areas of the airport property would be exposed to cumulative noise levels exceeding Ldn 65, by each alternative.

The extent of noise impact detected is a direct function of two factors:

- The level of type of aircraft activity, and
- The density of the population in areas exposed to high levels of sound.

In terms of impact, the two parameters which must be considered are:

1. Annoyance – the extent to which sound interferes with the conduct of everyday life, and
2. Physiological Impact – the extent to which any person is exposed to noise levels sufficiently elevated to cause bodily harm.

Airport noise compatibility planning, through the approved FAR Part 150 program, is acceptable for purposes of the noise analysis in the preparation of environmental documents. Noise compatibility planning may therefore be incorporated in environmental documents if it addresses the same conditions and time frames for development. Noise exposure maps and documentation may be submitted as an assessment of noise impacts under this category, and noise compatibility programs tailored to reduce existing incompatible situations and mitigate impact can be introduced under the next category, Compatible Land Use.

Compatible Land Use

A fundamental reason that off-airport land use must be considered in airport planning and airport environmental evaluations derives from two sources. First, the passage of NEPA caused the area of concern to grow in size from the airport property line to the area surrounding the airport and beyond. Second, high levels of aircraft noise are not restricted to on-airport property. Consideration of the use of land in the vicinity of the airport, is therefore necessary, for it is the land use patterns that, in large measure, determine the magnitude and significance of the airport's environmental impact.

The ultimate objective of off-airport land use planning is to achieve and maintain mutually beneficial compatibility between the airport and its environs. Inherent in this objective should be the assurance that the airport can maintain or expand its size and level of operations to satisfy existing and future aviation demands, and that persons who live, work, or own property near the airport may enjoy a maximum amount of freedom from noise or other adverse impacts of the airport. Equally important is the protection of the public investment in a facility for which there may be no feasible future replacement. Such planning is needed because there are existing compatibility problems around nearly all airports. This represents a serious confrontation between two important characteristics of urban economics – the need for airports which meet regional and natural international transportation needs, and the continuing demand for local urban expansion, including residential and other sensitive uses.

Airport owners are finding essential expansion to be difficult and expensive, or even impossible at any cost. New residential and noise-sensitive development seems to surround the airport on all sides and is the source of continual threat of lawsuits for noise damage. On the other hand, ordinary citizens with lifetime investments in homes view the airport and its noisy aircraft as a threat to both hearing and peace of mind. To them the airport seems to be ever expanding, with more and bigger jets added every year. These conflicts may be reduced and new ones substantially avoided through the development and implementation of off-airport land use plans, often involving the removal of homes in noise-sensitive areas and the dedication of open space.

The 1977 FAA Advisory Circular 150/5050-6, "Airport-Land Use Compatibility Planning" introduced new ideas in planning for the long-term compatibility between airports and surrounding environs. It also set guidelines for the development of noise control plans for airports nation-wide. At many airports, noise compatibility plans serve as a basis for information to be included in environmental documents. The use of the findings and conclusions of such a study, where in effect at an airport, are acceptable as environmental documentation in environmental assessments, and may be used as baseline conditions in the preparation of an environmental impact statement.

The 5050.4A Environmental Handbook requires documentation of the sponsor's efforts to work with local land use agencies to develop comprehensive strategies to address issues of compatibility between airports and surrounding areas. In order for the environmental document to be accepted by the FAA, it must include assurance from the local planning community that the appropriate actions, including the adoption of zoning laws, have been taken (or will be taken). For instances where regulatory solutions are not feasible or viable, it may be necessary for the sponsor to address the issue through a program of acquisition of properties, as suggested above, acquisition of avigation easements, soundproofing programs, operational curfews, and so on.

Social Impacts

The acquisition of property to construct new airport facilities, to serve as a buffer for noise protection, or for safety or other airport-related purposes, may displace individual residents, business activities, and community facilities. As a result of such displacement there can be social, psychological, and economic changes both in the project area and in the communities where people and businesses relocate.

Assessment of the effects of displacement and relation are based on an inventory of displacement and relocation resources which consist of:

- Potential displacement areas.
- Impact on the neighborhood and housing to which relocation is likely.
- Numbers of individuals affected (i.e., in terms of age, income, etc.) and businesses affected (i.e., type of business, number of employees, etc.).
- Indication of ability to provide adequate relocation housing for the types of families to be displaced.

If relocation of businesses is involved, the provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 requires that the owner be offered assistance in finding a location and re-establishing the business. When displacement of persons is involved, a public hearing is mandated, at which time information will be presented on a relocation strategy in conformance with FAA Advisory Circular 150/51 00-1, 1, "Land Acquisition and Relocation Assistance under the Airport Development Aid Program."

Based on this information, informed judgments can be made with regard to the ability of potential relocated groups to successfully adjust to change in their living accommodations and community, and the potential effects on the neighborhood to which families and businesses are moved.

The Environmental Justice Executive Order 12898, issued in 1994, now requires that human health, social, and economic effects be considered in light of possible disproportionate impact on minority, low income, and other disadvantaged sectors of the community.

Induced Socioeconomic Impacts

Proposed actions which will change air passenger or cargo service at the airport will affect the area's economic structure. These changes can be measured by employment, household income, business activity, and resource utilization, and are classified as *primary effects* (i.e., direct expenditures for capital facility improvements and day-to-day operations); *secondary* or *"multiplier" effects* (i.e., indirect expenditures made as a result of primary purchases); and *related* or *allied effects* (i.e., business location and production decisions predicated, in whole or in part, on the availability of air cargo or air passenger service).

Choice of appropriate technique(s) to assess the impact of a change in air cargo or air passenger service will depend upon the nature of the proposed action that would increase or decrease airport activity, availability and/or reliability of data base, available budget, personnel, and the theoretical and practical limitations, of method.

Assessment techniques range from qualified judgment to mathematically technical input-output analysis, but in any case should be logical and clear not only to the analyst but also to public officials, airport operators, businesses, and residents of the affected communities.

The assessment of economic impacts of airport activities on a region's economy should be treated at a level of detail appropriate to the method and data sources available and to its relative importance in the broader context of the airport planning process and the scope of the environmental document.

Air Quality

Many airport activities generate air pollution. Among these activities are:

- Aircraft operations
- Surface traffic: passengers, visitors, and employees
- Maintenance and support activities
- Fuel handling
- Construction

Environmental assessment of air pollution is complicated by the fact that the regulation of pollutants from stationary and ground mobile sources and aircraft is divided among various federal, state, and local agencies.

Accurately estimating the contribution which aircraft operations make to the degradation of air quality has received considerable attention in recent years. To understand these methods, it is important to know that the engines with which aircraft are equipped produce a variety of pollutants. The amount of each in total and relative to one another is a function of the type of power plant which is being analyzed. Low and high bypass ratio engines produce different pollutant signatures. Turbine engines of all types and piston engines are much different in emission characteristics.

The major pollutants produced by airports are:

- Particulates
- Carbon monoxide
- Hydrocarbons
- Nitrogen oxides
- Sulphur dioxide

The amount of each pollutant produced by an aircraft engine varies with the flight segment. For example, an aircraft waiting in a takeoff queue on the ground with its engine at idle produces a different type and amount of pollution per gallon of fuel burned than it will once the engines reach full speed during the takeoff. In actuality, the amount of pollution produced when the engines are at idle is greater than when they are at speed, as aircraft engines are designed to operate most efficiently at speed.

In an air pollution analysis, the following operational modes should be examined.

- Taxi and idle
- Takeoff
- Climbout

- Approach
- Landing

Emissions from fuel storage and handling activities, as well as ground vehicles, including automotive vehicles and ground support equipment, must also be examined.

Basically, two types of analytic techniques for describing the dispersion of pollutants in the atmosphere are available: (1) box models, and (2) atmospheric dispersion models.

Box models, which assume uniform dispersion of pollutants, are relatively simple to apply. To use a box model, it is necessary to know only the number of landing-takeoff cycles by each type of aircraft and the rate of emission. Box models are appropriate only in non-controversial and non-critical situations.

Dispersion modeling is both more accurate and more complex. Application of this type of model requires an accurate simulation of actual airport operations. The output is isopleths of pollutant concentration at varying distances from the airport. Use of dispersion modeling is appropriate in situations where the magnitude or significance of airport impact on air quality is substantial.

The steps in air quality analysis, regardless of which analytic technique is employed, are basically six in number:

1. Determine ambient air quality conditions for each pollutant category.

2. Assess local meteorological conditions.

3. Determine type, number, and path of aircraft using the airport.

4. Calculate emissions from these aircraft.

5. Calculate the dispersion of pollutants in the atmosphere and their concentration through application of either a box or dispersion model.

6. Compare calculated concentrations with ambient conditions and applicable air quality standards.

Two provisions under the 1990 Clean Air Act Amendments are relevant to environmental analysis of air quality on airports. First, hazardous air pollutants (HAPs), such as reactive organic gases emitted by on-road motor vehicles, must be considered in existing inventories and forecasted emission calculations, although in the absence of ambient standards, it is unlikely that an increase in HAP emissions would constitute a significant impact. Second, federal agencies must make a determination of conformity with the state implementation plan (SIP) under EPA and local/regional air quality agency review procedures ("General Conformity Rule"), before taking action on a proposed project. This can be done in conjunction with the NEPA process or as "stand alone."

An emissions inventory for the existing and forecasted airport conditions must be conducted when the activity forecast is (1) a commercial service airport with more than 1.3 million annual passengers and more than 180,000 annual operations forecasted, or (2) a general aviation airport with more than 180,000 operations forecast annually.

The FAA Environmental Handbook does not provide guidance for addressing the air pollution impacts most often alleged by the public—e.g. fuel dumping, soot, oil film, unburned fuel, and contamination of swimming pools, clothing, cans, homes, etc. A standard FAA response would be applicable for most projects.

In all cases, the 1982 Airport Act requires that Airport Improvement Program applications not be approved unless there is "reasonable assurance" that the project will be in compliance with applicable federal (and state) air quality standards. Measures to minimize adverse air quality effects, including the conversion to clean-burning support vehicles, improved ground power and pre-conditioned air at terminal gates, and monitoring of air pollution during construction, must be incorporated into any airport improvement actions.

Water Quality

Impacts to water quality are of particular significance because of potential impacts to human health as well as aquatic ecosystems. If a proposed action involves changes to the storm or sanitary sewer system, water supply, or waste treatment facilities, among others, it is subject to the regulations and permit requirements under the Federal Water Pollution Control Act as amended by the Clean Water Act of 1977 and later amendments. A National Pollutant Discharge Elimination System (NPDES) permit is required under the Clean Water Act for discharge into or disturbance of waters of the United States. A water quality certification is required under the Airport Act for approval of any Airport Improvement Program application involving airport location, a major runway extension, or a runway location. If there is potential for contamination of an aquifer, coordination with the EPA is required under the Safe Water Drinking Act, as amended. Correspondence with the applicable federal and/or state agency under the Fish and Wildlife Coordination Act is necessary when a proposal may affect water resources (i.e., wetlands, ground water, etc.).

The EPA on November 16, 1990, released new stormwater discharge regulations which gave the aviation industry approximately one year to comply with the rule's complicated permit requirements. Airports, along with municipalities and industrial facilities, were required to file for a NPDES Permit, either in an individual application or group application form. The complex regulation applied to all airports, not just those involved in winter operations and de-icing activities. No airport was exempted, including those that use municipal sewer and/or separate stormwater systems. As a result, airports now implement Storm Water Pollution Prevention Programs (SWPPP) that include a wide range of best management practices to minimize contamination of receiving waters by stormwater runoff.

Parks, Opens Space, Public Lands (4(f) Lands)

Public lands, such as parks, wildlife refuges, and historic sites, constitute significant amenities in a community's environment. Under provisions included in the Department of Transportation Act of 1966, 4(f) lands are given special consideration to help protect them from negative impacts which may occur from development. When airport actions will impact designated 4(f) lands, first consideration must be given to determining if there is any feasible and prudent alternative to the action which would result in no impact to 4(f) land. If none exists, and this is fully documented, all impacts to 4(f) lands will be considered significant and require full environmental disclosure. When use of or impact upon 4(f) lands is unavoidable the sponsor must provide mitigation measures which will minimize these impacts. Mitigation measures can be extreme, to the point of requiring replacement of in-kind lands.

Historic, Architectural, Archaeological, and Cultural Resources

Airport projects can have important effects on the built and natural physical spaces and forms of an area, their relationships, their human use, and their historic, aesthetic, cultural, and archaeological value. The relationship between the physical elements or resources and the individuals who use and enjoy them are the focus of this examination.

The preservation of historic, architectural, archaeological, and cultural resources is particularly important to the character of the social environment. Changes in land use from airport actions, such as an expansion, may consequently disrupt the location of artifacts of cultural resources which would have been an integral part of a community heritage.

Two laws apply to this kind of impact. The first law is the National Historic Preservation Act of 1966, specifically Section 106, which established the Advisory Council on Historic Preservation. The Advisory Council's most recent guidelines for the "Protection of Historic and Cultural Properties" was published in January 1979. Under this directive, properties that are designated under, or may be eligible for, inclusion in the National Register of Historic Places must be identified within the airport's area of potential effect (APE). If properties are identified, detailed procedures are set forth in the 5050.4A Environmental Handbook and in Section 106 to proceed with the assessment of possible impacts.

The second law is the Archaeological and Historic Preservation Act of 1974, which provides for the survey, recovery, and preservation of significant scientific, historical, or archaeological data which may be destroyed or lost due to federal actions. If no information is available regarding the circumstances for the site of the proposed action, and consultation with the State Historic Preservation Officer and other expects results in identification of no information, it may be assumed that there is no impact. If the above cited reviews result in a recommendation for a professional survey of the site, it may be necessary to address the possibility of impacts further. Here again, the Environmental Handbook details the process to be followed.

Biotic Communities/Endangered Species

Biotic communities comprise interrelated ecological elements and conditions which can be changed or impacted by an airport construction/modification project. Several aspects of the flora and fauna of a community must be analyzed for potential impact. Consideration of endangered and threatened species is required for all proposals, pursuant to the Endangered Species Act Amendments (ESA) of 1978, which involves consultation with the U.S. Fish and Wildlife Service. If any waters of the U.S., including navigable waters, would be affected, the Fish and Wildlife Coordination Act applies, also requiring consultation with the U.S. Fish and Wildlife Service, the U.S. Army Corps of Engineers and state fish and game agencies.

If a proposal would impact only human-dominated areas such as previously disturbed airport property, or populated areas, it may be assumed that there would be no significant impacts on the biotic community. In addition, if the proposal would cause only a "minor alteration" to an existing habitat, such as the removal of a small percentage of a habitat (a few acres), then there may be an assumption of no significant impact.

Wetlands, Floodplains, Coastal Zone, and Wild and Scenic Rivers

Wetland

By definition, wetlands are areas that support aquatic and vegetative life on saturated or seasonally saturated soils. This generally includes land such as swamps, marshes, and bogs, but can include tidal overflow areas, estuarian areas, and shallow lakes and ponds. Wetlands are protected by both the Clean Water Act, Section 404, and the Executive Order 11990. The Order emphasizes the importance of wetlands to the natural ecosystem, and provides that any action that will impact these lands by fully disclosed for both immediate and long-term impacts. Any airport-related actions that are identified to have impact on these areas must be first avoided, then, if avoidance is not possible, the impact minimized, and only after these options have been fully explored, compensated by replacement at an appropriate mitigation ratio (typically no less than 2:1). Mitigation could include construction design controls as well as compensatory mitigation.

Floodplains

The location of a 100-year floodplain can have significant effects upon the design and expansion plans of an airport. As directed under Executive Order 11988, federal agencies must take action to reduce the impacts of floodplains on human safety, health, and welfare. The limits of the base floodplain must be identified so that encroachment of airport facilities upon these areas can be avoided. Should the proposed action encroach within the limits of a base floodplain, mitigation measures designed to minimize long-term loss of available flood storage volume must be identified in the environmental document.

Coastal Zone

Like all sensitive aquatic environments, coastal zone areas can be affected by airport activity. The analysis of airport activity upon coastal zones is typically performed under state and local coastal management programs. Related procedures for determining federal consistency with locally approved coastal zone management programs are contained in the National Oceanic and Atmospheric Administration (NOAA) Regulations (15 CFR Part 930).

Wild and Scenic Rivers

The Department of the Interior (DOI) is responsible for the National Inventory of River Segments, which identifies rivers considered to be "wild" and/or "scenic." Certain actions at airports can adversely affect designated rivers. When a river appears within the study area, it is necessary to include

DOI documentation of the classification of the river. Even if a river does not appear within the study area, it is advisable to state the location of the nearest designated river to fully show the absence of impact.

Farmlands

Farmlands are increasingly seen as a resource to be protected and managed. The Farmland Protection Policy Act (FPPA) authorizes the Department of Agriculture (USDA) to develop criteria for identifying the effects of federal programs on the conversion of farmlands to nonagricultural uses. Federal agencies (in this case the FAA) are directed to follow the guidelines and review procedures developed by the USDA (1984) to identify and evaluate the adverse effects of proposed actions on designated lands. Farmlands protected by the FPPA are either "prime farmlands" that are not already committed to urban development or "unique farmlands" that are lands of state of local importance. Identification of lands in question is made through the Natural Resource Conservation Service, formerly the Soil Conservation Service.

If farmlands that could be affected are identified, it is then necessary to complete an SCS Form AD-1006 for their review and evaluation. The form primarily scores the relative value of the site for preservation as farmlands. If the total combined score is less than 160, no further action is necessary. If above 160, there is some potential for impact. Alternative actions as mitigation measures must be considered. If the score is greater than 200, the degree of impact necessitates additional study. The high score indicates a potential significant loss of farmlands, and every consideration must be given to an alternative action to avoid the loss.

Energy Supply and Natural Resources

Energy considerations fall into two categories: those that relate to changed demand for stationary facilities, and those that involve the power or energy resources for the movement of air and ground vehicles. Fuel consumption is the primary focus of the latter category.

Natural resources, other than fuel, need to be examined only if the action involves a need for unusual materials or those in short supply.

For most airport actions, changes in energy or other natural resource consumption will not result in significant impacts. If the environmental assessment identifies situations where the actions create demands which exceed supplies, additional study will be required in an environmental impact statement. Although not yet required in NEPA documents, emissions of CO_2 and other greenhouse gases can be calculated as an indirect impact of consumption of energy from fossil fuel sources.

Light Emissions

Airport lighting, necessary for safe operation, can be annoying for some people, for example residents on hillsides within the airport viewshed. When proposed actions include the establishment of a new lighting system or the addition to an existing system, the environmental document must show the type of light source, location and size of the additions, the nature of the system (steady, flashing, color range, etc.) and method of installation (ground mount, pole mount, etc.) and possible mitigation measures to lessen annoyance (shielding or angular adjustments).

Only on rare occasions, for instance, when lighting directly impacts a nearby residential community, will the impact of light emissions be considered sufficient to warrant special study.

Solid Waste

Airport actions which relate to airfield development (runways, taxiways, etc.) will not normally include any direct relationship to solid waste collection, control or disposal. Terminal area, aircraft themselves, and landside improvements, on the other hand, typically involve generation of large amounts of solid waste. The primary consideration is whether the proposed actions will generate a type or volume of solid waste which is appreciably different than would be the case without the action. Consultation with local officials will result in an evaluation of these issues and an appraisal of the situation. Early coordination between the responsible agency and the airport sponsor can usually build mitigation measures into the planning process, necessitating a brief but accurate review of the process in environmental reports.

Construction Impacts

Short-term environmental consequences to be associated with the construction process need to be fully disclosed, since construction may occur over a substantial period of months or even years. These include noise associated with equipment on site, noise and dust from delivery of materials, truck traffic and haul routes, disposal of spoils, air pollution from dust and burning debris, and water pollution from erosion.

Federal, state, and local regulations must be identified as they relate to construction impacts and procedures for conformance described.

Other Impacts

It is worth noting that several topics that may be of concern to the local public – and in fact may be required under state environmental review of airport projects -- are not found in the 5050.4A Environmental Handbook. This is due in part to the 1985 date of issuance: topics not considered to be relevant at that time have taken on importance in intervening years. It is due also to NEPA guidance and FAA's implementation policies. For example, hazardous materials and wastes are not mentioned in the Environmental Handbook, and yet airports handle a variety of materials and wastes classified as hazardous; they also are responsible for remediation of hazardous waste sites. Ground traffic and transportation are notably absent from consideration, yet perceived in many locations as having impacts of great significance. Geologic and seismic conditions are not considered, although they have considerable bearing on the siting and design of public facilities such as airports. Air Safety, an issue raised frequently by the public in environmental review of airport expansion plans, is absent from the Handbook virtue of FAA policy. Public services and utilities are considered only peripherally under the topic of induced socioeconomic impacts. A topic that can raise interagency conflicts is that of bird strike hazard, especially where wetlands may be impacted by airport projects: in this instance, compensatory mitigation expected by fish and wildlife agencies may conflict with FAA safety policies. Some of these categories may be addressed in the forthcoming Order 5050.4B Handbook.

(5) SUPPLEMENTAL REQUIREMENTS OF ENVIRONMENTAL DOCUMENTATION

Beyond the preparation of environmental documentation, there are other procedural requirements. These concern:

- Public participation and conduct of public hearings
- Relocation and land acquisition policy and procedures
- Air and water quality certification

Public Participation

The various pieces of legislation and sets of regulations previously listed, taken together, direct that airport sponsors and planners seek out and consider the views of interested parties in the planning process. Interested parties, in addition to individuals directly affected by a proposed project, include federal, state, and local agencies, and the public at large.

The idea that there should be community participation in airport, planning is understood and accepted as appropriate and important. Thus, the key questions are: What form should a program take? and, How should it be implemented?

Having been through an extensive learning experience in airport planning in the past decade or more, responsible planners and government officials are now coming to the conclusion that there is no one technically correct solution to airport problems. More than this, they are saying that the only acceptable answers are those derived politically – that is, only those that result from open bargaining among contesting interested parties.

There is a wide range of possibilities concerning exactly how far this line of thinking can or should be extended in airport planning. Involvement of citizen groups may be a means of legitimizing what techniques airports know best and have been doing all along. In other words, citizen participation may be a way of "laundering" plans that might otherwise appear to be soiled. On the other hand, by opening the planning process to open discussion, something useful may be contributed. An open planning process may even lead to the "right answer," that could become the implemented plan.

Recent experience with other transportation exercises suggests that the more open the study process, the more likely it is that the final plan will be implemented.

The range of potential participants can be classified into four broad groups according to their primary concerns. These are:

1. The responsible agencies
2. The aviation community
3. Individuals directly impacted by a project
4. The broader community

How is community participation in the airport planning process implemented? The answer is to be found in the formulation and implementation of a program by the sponsor and the sponsor's consultant that generates a dialogue with interested parties.

Four fundamental types of interactions are:

1. Notification – the public announcement of the intention to undertake an action.

2. Consultation – the process of formal exchanges between the sponsoring agency and the public for the purpose of gathering comments, collecting data, and enlisting support for a project.

3. Discussion – implies informal exchanges between the sponsoring agency and interested parties (not required, but desirable).

4. Public hearing – a formal occasion at which time interested parties have an opportunity to express their opinions on the project, and do so on the record that will accompany an environmental assessment through the review and approval process.

Public Hearing

An airport sponsor must afford the opportunity for a public hearing to consider the economic, social, and environmental effects of a planned action and its consistency with the goals and objectives of the urban planning that has been carried out by the community.

Although the environmental acts and regulations are best served through the use of public discussions as a means of community participation in planning the project, these methods, as discussed earlier, are not legally mandated. A public hearing is specifically required.

The way in which the public hearing is conducted will have a great deal to do with whether it is a success, a disaster, or somewhere in between. If the public hearing does turn out to be a disaster, it will be one which returns to haunt the sponsor again and again, as a transcript of the hearing must accompany the environmental assessment throughout the review and approval process. Two things need to be done to avoid disaster:

1. Hearing procedures should be well planned so as to encourage constructive commentary and criticism rather than emotional outbursts.

2. The surprise element should be removed from the plan through a community participation program which runs the life of the planning itself.

Relocation and Land Acquisition

The principal legal mandate that concerns this issue is the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (PL 91-646). Public Law 91-646 specifies that in federally assisted projects requiring land acquisition resulting in displacement, the public agency shall provide:

- Moving and related expenses
- Replacement housing for homeowners, if required
- Replacement housing for tenants
- Relocation assistance advisory services
- Provision of housing

In addition, public agencies receiving federal financial assistance for a project involving land acquisition must conform with the following policies:

- In situations that require land acquisition, every effort must be made to acquire property by negotiation.

- The public agency shall reimburse the owner for all associated expenses in the property transfer transaction.

Air and Water Quality Certification

Is certification of air and water quality required? The answer is yes, if the project involves:

1. Airport location
2. Construction of a new runway
3. An extension to an existing runway

If certification is required, documentation must be prepared showing how the project complies with applicable standards.

Appendix A

Common Problems with Environmental Impact Statements

Over the years since the passage of the National Environmental Policy Act, environmental impact documentation has been prepared for a wide variety of airport and other types of projects. Many of these efforts have been subject to criticism for shortcomings of various kinds. Among the most common are:

- Lack of Objectivity – Discussion fails to fully disclose both adverse and beneficial aspects of the proposed action.
- Incomplete Statements – Not all of the possible impacts have been addressed.
- Unsupported Statements – Factual documentation to support all generalities and conclusions is absent.
- Misleading Statements – Use of ambiguous and misleading language such as: "There will be no apparent significant impact."

However, the commentary on environmental documentation has not always been critical. Thorough documentation, clearly presented, will insure that planning and decision reflect environmental values; undesirable environmental impacts are minimized; and environmental quality is restored or enhanced to the fullest extent practicable.

Regardless of one's personal opinion regarding the usefulness of environmental assessment, the facts are that no major action can be taken without thorough documentation of social and environmental consequences of a project. Requirements can be cumbersome and time-consuming, but if comprehensive analysis is initiated early, project delays should be avoided. Perhaps most important, controversy founded on lack of information or misinformation can be avoided from the outset, resulting in more orderly and much less traumatic project development.

For those attempting to prepare joint documents in which the requirements of NEPA and the FAA are to be conjoined with the requirements of state environmental review, for example, California Environmental Quality Act (CEQA), three precautions are advised. It has been found that, although the joining of the two processes is encouraged by both statutes, FAA has developed a number of idiosyncratic procedures and content requirements that suggest that the FAA document terminology and format must take precedence over the state format, must be clearly recognizable to FAA reviewers, and must not include issues of state-only concern except through prior agreement with FAA at local, regional, and headquarter levels. What may be acceptable at one level may not be acceptable at another. The second precaution follows the first: coordination between the joint lead agencies must be pursued both cooperatively and persistently, to ensure that FAA reviewers are in agreement on scope and contents of the document. The third precaution follows the second: the schedule must follow the time-scale of the FAA, with limited attempt to shorten the path.

Appendix B

Categorical Exclusions: Airport Actions That Do Not Normally Require Environmental Documentation

- Runway, taxiway, apron, or loading ramp construction or repair work including extension, strengthening, reconstruction, resurfacing, marking, grooving, fillets and jet blast facilities, except where such action will create environmental impacts off airport property.

- Installation or upgrading of airfield lighting systems, including runway end identification lights, visual approach aids, beacons, and electrical distribution systems.

- Installation of miscellaneous items including segmented circles, wind or landing direction indicators or measuring devices, or fencing.

- Construction or expansion of passenger handling facilities.

- Construction or repair of entrance and service roadway within airport property.

- Grading removal of obstructions on airport property and erosion control actions with no off-airport impacts.

- Landscaping generally, and landscaping or construction of physical barriers to diminish impact of airport blast and noise.

- Projects to carry out noise compatibility programs.

- Land acquisition associated with any of the above items.

- Federal release of airport lands (see par. 31, 5050.4A).

- Removal of a displaced threshold.

- Acquisition of an existing privately owned airport, as long as acquisition only involves change of ownership.

- Acquisition of security equipment required by rule or regulation for the safety or security or personnel and property on the airport (14 CFR Part 107), safety equipment required by rule of regulation for certification of an airport (14 CFR Part 139), or snow removal equipment.

- Issuance of airport planning grants.

- Airport Improvement Program actions that are tentative and conditional and clearly taken as a preliminary action to establish a sponsor's eligibility under the Program.

- Retirement of the principal of bond or other indebtedness for terminal development.

- Issuance of airport policy and planning documents including the National Plan or Integrated Airports (NPIAS), Airport Improvement Program (AIP) priority system, and advisory circulars on planning, design, and development programs not intended for direct implementation or that are issued by the FAA as administrative and technical guidance to the public.

- Issuance of certificates and related actions under AIP (14 CFR Part 139).

- Issuance of grants for preparation of noise exposure maps and noise compatibility programs per Sections 103(a) and 104(a) of the Aviation Safety and Noise Abatement Act of 1979 and 14 CFR Part 150 determination on noise exposure maps and approval of noise compatibility programs.

- Airspace determinations (see par. 25, 5050.4A, Advisory Actions).

Source: FAA Order 5050.4A.

Appendix C

Actions Normally Requiring an Environmental Impact Statement

- First-time airport layout plan approval or airport location approval for a commercial service airport located in a standard metropolitan statistical area.

- Federal financial participation in, or airport layout plan approval of, a new runway capable of handling air carrier aircraft at a commercial service airport in a standard metropolitan statistical area.

Note: Even though these actions normally require an environmental impact statement, the preparation of the environmental impact statement will usually be preceded by an environmental assessment. If the environmental assessment demonstrates that there are no significant impacts, the action shall be processed as a finding of no significant impact instead of an environmental impact statement.

Source: FAA Order 5050.4A.

Appendix D

Actions Normally Requiring and Environmental Assessment

- Federal financial participation in, or airport layout plan approval of, the following categories of actions shall be subject to the analysis of an environmental assessment and subsequent decision as to whether to prepare an environmental impact statement or a finding of no significant impact.

  – Airport location.
  – New runway.
  – Major runway extension.
  – Runway strengthening which would result in a 1.5 Ldn or greater increase in noise over any noise-sensitive area located within the 65 Ldn contour.
  – Construction or relocation of entrance or service road connections to public roads which adversely affect the capacity of such public roads.
  – Major new construction or expansion of passenger handling or parking facilities with federal funding.
  – Land acquisition associated with all the above items plus any land acquisition which results in relocation of residential units when there is evidence of insufficient comparable replacement dwellings, major disruption or business activities, or acquisition that involves land covered under Section 4(f) of the DOT Act (recodified 49 USC Subtitle 1, Section 303, January 12, 1983).
  – Establishment or relocation of an instrument landing system, or an approach lighting system.
  – An airport development action that falls within the scope of paragraph 24, or that involves any of the following:

    a. Use of Section 4(f) land.
    b. Effect on property included in or eligible for inclusion in the National Register of Historic Places or other property of state or local historical architectural, archaeological, or cultural significance.
    c. Land acquisition for conversion of farmland, scoring over 160 on Form AD-1006, protected under the Farmland Protection Policy Act (FPPA) to nonagricultural use through federal financial assistance or through conveyance of government land.
    d. Wetlands, coastal zones, or floodplains.
    e. Endangered or threatened species.

- FAA requests for conveyance of government land for airport purposes under Section 516 of the 1982 Airport Act unless the proposed use of the land is a categorical exclusion (see Appendix B).

Source: FAA Order 5050.4A.

Appendix E

Extraordinary Circumstances: Conditions Under Which Actions That Are Normally Categorically Excluded May Require Environmental Review

- An action that is likely to have an effect on properties protected under Section 106 of the Historic Preservation Act of 1966.
- Use of Section 4(f) lands.
- Acquisition and conversion of farmland scoring over 160 on Form AD-1006 and protected under the FPPA to nonagricultural use through federal financial assistance or through conveyance of government land.
- An action that is likely to be highly controversial on environmental grounds. A proposed federal action is considered highly controversial when the action is opposed on environmental grounds by a federal, state, or local government agency or by a substantial number of the personnel affected by such action.
- An action that is likely to have a significant impact on natural, ecological, cultural, adequate relocation housing.
- An action that is likely to cause substantial division or disruption of an established community, or disrupt orderly, planned development, or is likely not to be reasonably consistent with plans or goals that have been adopted by the community.
- An action that will cause a significant increase in surface traffic congestion.
- An action that is likely to significantly impact noise on air quality or violate local, state, or federal standards for air quality.
- An action that is likely to have a significant impact on water quality or contaminate a public water supply system.
- Actions found to be inconsistent with any federal, state, or local law or administrative determination relating to the environment.

Appendix F

A New Way of Doing EIS's

Options available to an airport sponsor when preparing an EIS under CEQ Regulation 1506.5(c) are as follows. Either the EIS is prepared directly by the lead agency, with the sponsor providing environmental information or the EIS is prepared by a contractor selected by the lead agency.

In the Toledo EIS, the court found that the FAA violated CEQ regulations by failing to select a contractor. FAA's argument that the agency had prepared the EIS was rejected. FAA's actions had included: (1) guidance of work, (2) independent review, and (3) editing.

The court indicated that FAA's involvement was mostly commenting on and active editing, not preparation "to put into written form." Further, the court noted that concurring in an airport sponsor" selection of an EIS contractor is not the same as selecting one independently.

The court did decline to invalidate the EIS solely on the grounds of contractor selection. It was found that this error did not compromise the objectivity and integrity of the NEPA process. FAA was ordered, however, to have the contractor execute a disclosure statement, if it could not then promptly decide what measures to take in response.

The U.S. Justice Department now considers contractor selection to be a significant litigation concern. FAA has been urged by Justice to modify its current practices to conform to the letter of the CEQ regulations.

Draft policy now under consideration, therefore, holds in cases where airport actions require preparation of an EIS that the FAA will either prepare the EIS or the FAA will select a contractor to do so.

NOTES

AIRPORT FINANCE

27th Annual Short Course
AIRPORT SYSTEMS PLANNING AND DESIGN
University of California, Berkeley
May 14, 1998

by:

Maureen Riley, Senior Associate
Thomas Walsh, Senior Associate
Leigh Fisher Associates

TOPICS

Section 1—Airport Financing

A. Sources of airport capital

B. Airport privatization

Section 2—Airport Pricing

C. Overview of airport rates and charges concepts

D. Airport rates and charges legal framework

E. Overview of airport concessions

SECTION 1—AIRPORT FINANCING

A. SOURCES OF AIRPORT CAPITAL

1. Federal government grants-in-aid—Airport Improvement Program (AIP)

    a. FAA Reauthorization Act of 1996 (expires September 30, 1998)

    b. AIP funding levels have (until recently) declined (see graph)

    c. Current AIP fund distribution

Entitlements
- Primary airports (see formula below)
- State General Aviation Allocation (18.5%)
- Cargo (2.5%)
- Alaska

Discretionary
- Minimum $148 million plus annual LOI commitment
- Noise (31% of discretionary)
- Military Airport Program (4% of discretionary)

Returned entitlements
- Small Airport Fund
    - Nonhub airports
    - Noncommercial service
- Small hubs

- Passenger entitlement formula—to calculate FY 1998 entitlement, use calendar year 1996 enplanements as follows:

Enplaned passengers	Entitlement funds per passenger
0- 50,000	$7.80
51-100,000	5.20
101-500,000	2.60
501,000 +	0.50

- Minimum entitlement = $500,000

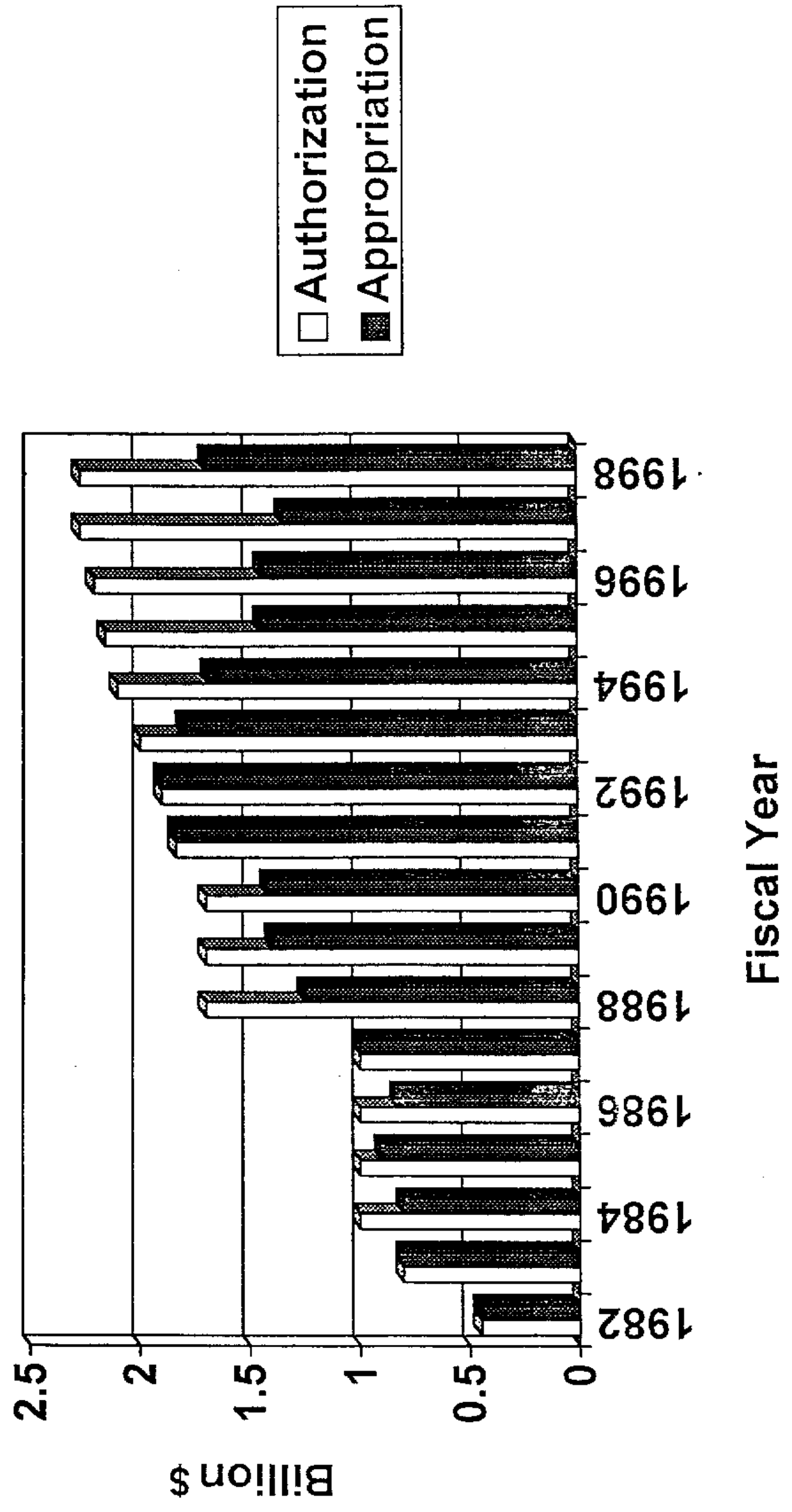
- Cargo entitlements

    — Airports with an aggregate landed weight in excess of 100,000,000 pounds or those primarily served by cargo aircraft

    — Allocated among airports on the basis of total annual landed weight

    — No single airport can get more than $4 million per year

AIP FUNDING LEVELS



d. AIP participation rates

Noise compatibility projects	
Large hubs	80%
All other	90
Other projects	
Large hubs	75
All other	90

e. Letters of Intent (LOIs)

- An LOI allows an airport to proceed with a high priority capacity enhancement project using non-federal funds, and be reimbursed with federal grants on dates specified in the LOI.
- The FAA placed a moratorium on LOIs in 1994 (but maintained full funding for existing LOIs)
- The moratorium was lifted in 1997—two new LOIs (Midway, Seattle)
- FAA LOI policy
  - Limited to "airside capacity projects and supporting development directly related to the airside projects"
  - Evaluated on the basis of
    - (1) National air transportation system benefits
    - (2) Project benefit (e.g., aircraft delay savings) and cost
    - (3) Non-federal financial commitment
  - Each airport seeking an LOI competes with airports of similar size
  - A benefit-cost analysis is required for any LOI funded capacity-related project
  - Best candidates are new airports and new runways or major runway extensions at cities where the primary airport exceeds or is expected to exceed 20,000 hours of annual air carrier delay

f. Discretionary AIP grant policy

- Prioritization of projects
  - Safety and security
  - Preserve existing airport infrastructure
  - Bring airports into compliance with standards (including noise mitigation)
  - Upgrades to service and increases in airport system capacity
- FAA requires the airport sponsor to perform a benefit-cost analysis for capacity projects with a requested discretionary grant of $5 million or more
- FAA Reauthorization Act new criteria
  - State's support for project
  - Anticipated passenger growth (20% in past year)
  - For reliever airports, diverted operations and cost savings

g. Airport Capital Improvement Plan (ACIP) National Priority System

- An ACIP is complied annually by the FAA
- FAA applies numerical ratings to list projects in order of priority
- This listing (plus other factors such as overall AIP funding authorization and passenger enplanement levels) determine grant awards for a given airport.

h. State Block Grant Program (8 in FY 1997 and 9 in FY 1998)

i. National Civil Aviation Review Commission (final report issued December 1997)

- Reviewed existing and innovative funding mechanisms
- Assessed FAA's and aviation/airport funding and safety needs through 2002
- Found that the FAA "lacks the organizational, management, and financial wherewithal to keep pace with the dynamic aviation community"
- Recommended FAA funding and management improvements, including a minimum AIP grant program of $2 billion per year for the next 5 years

2. Airport debt

a. General Obligation Bonds

Secured by a pledge of the full faith, credit, and taxing power of the political jurisdiction

- Tax-supported (debt service paid through tax levies)
- Self-sustaining (debt service paid from airport revenues)

b. Revenue Bonds (General Purpose Revenue Bonds)

Secured by a pledge of the "net revenues" (total revenues—M&O expenses) of the airport or the airport system

c. Double-Barrel Bonds

Secured by both a pledge of airport revenues <u>and</u> the full faith, credit, and taxing power of the jurisdiction

d. Commercial paper

e. Bank loans

f. Special Facility Bonds (Special Purpose Revenue Bonds)

Secured by a pledge of the revenues derived from net lease with tenant of facility

3. Passenger facility charges (PFCs)

   a. $18 billion approved through March 1998

   b. Pay-as-you-go

   c. Leveraged—support debt

      - Stand alone PFC financing
      - Double barrel PFC bonds
        - PFC-backed bonds primary pledge to back bonds is from PFC revenues
        - PFC-enhanced bonds
      - Tax exempt commercial paper (TXCP) and other short-term borrowing
      - Privately placed bank lines of credit ("revolvers")

   d. Project eligibility (under 1990 Act)

      - Preserve or enhance capacity, safety, or security
      - Reduce noise or mitigate noise impacts
      - Enhance competition

   e. Project eligibility (under regulations and AIP reauthorizations)

      - AIP eligible airport development (including land acquisition)
      - Airport planning
      - Terminal facilities
        - Includes gates, baggage area, ticketing areas, security devices, holding areas, waiting areas, associated corridors
        - Excludes concession areas, restaurants, public and employee parking, rental car facilities
      - Noise compatibility planning
      - Noise compatibility measures to reduce or mitigate noise
      - ADA compliance and federal mandates

   f. Maximum PFC level is $3; airports pushing for increase to $5

4. State/local governments (grants and loans)

5. Internally generated cash flow (retained earnings), including investment income

6. Public investment

7. Privatization

B. AIRPORT PRIVATIZATION

1. Airport privatization is an increasingly important trend outside the United States.

   a. The private sector has proven that airport enterprises have a value

      - United Kingdom
      - Australia/New Zealand
      - South Africa
      - Continental Europe
      - South America

2. Airports in the U.S. are already privatized in many ways

   - Parking management contracts
   - Terminal concessions
   - Third party cargo development
   - Contract services
   - Passenger handling and aircraft servicing

3. Impediments to sale or long-term lease of airport assets

   - Financial advantages enjoyed by public airport sponsors
     - AIP grant assurances ("defederalizing")
     - Revenue diversion prohibition
     - Loss of tax-exempt status
   - Airline agreements
   - Bond financing documents
   - Collective bargaining agreements
   - Limited universe of qualified bidders
   - Implementation risk
   - Limited experience in private sector management of a whole airport facility in the U.S. except at relatively small airports
   - Anti-trust implications under private ownership

4. FAA privatization pilot program

   a. Lease of 1 large hub, 3 medium and small hubs, and 1 general aviation airport

   b. General aviation airport can also be sold

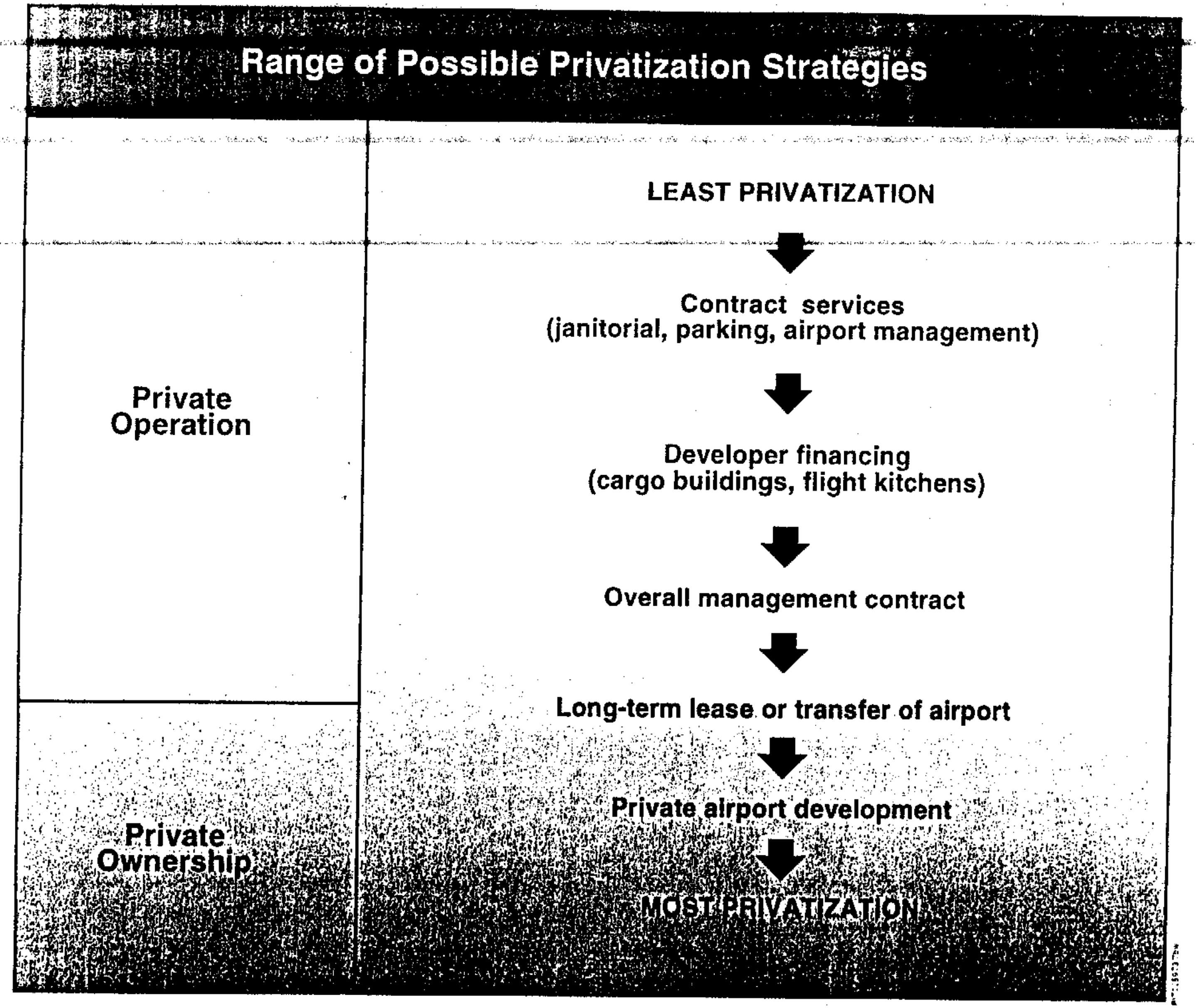
   c. 65% of airlines serving must agree

   d. Airports can receive AIP grants and collect PFCs

   e. The sponsors of Stewart International Airport (New York) and Brown Field (San Diego) are the first two applicants under the pilot program

5. Case Studies

   a. BAA experience in United Kingdom is not directly transferable to U.S.
      - Basis of BAA's success is retail revenue enhancement
      - More than 80% of BAA system passenger traffic is international
      - High import duties on luxury goods and high value-added tax structure in European Union



RANGE OF POSSIBLE PRIVATIZATION STRATEGIES

April 1996

LEIGH FISHER ASSOCIATES

b. Toronto Trillium Terminal (Build/Operate/Transfer Approach)
  - Transport Canada committed to divestiture of major airports to local authorities while facing major, urgent need for terminal capacity in Toronto
  - Transport Canada determined private sector could respond fastest, issued RFP for developers
  - After lengthy negotiations, Airport Development Corporation (ADC) selected. Lockheed was designated operator with 27% of shares
  - Project completed in 1991, including 1.2 million sq ft, 29 gates, hotel, garage, office building at cost of C$550 million
  - Transport Canada received $30 million at opening and 3% of gross, increasing to 6% in later years
  - New airport authority bought out private interests

c. Indianapolis International Airport (Management Contract Approach)
  - Indianapolis Airport Authority (IAA) issued RFP in 1994 for management contract; 5 proposers
  - Although IAA had strong financial performance and outstanding economic development record, IAA chose to negotiate with BAA and Lockheed
  - BAA selected on basis of guaranteed savings of $32 million over 10 years: total savings estimated by BAA of $105 million
  - IAA retains control of all capital development/investment
  - Airlines are beneficiary under residual lease agreement

d. Newark "Tactical Privatization"
  - Conclusions
    - Outright sale/long-term lease precluded by federal grant assurances and master lease with City of Newark
    - High and potentially unacceptable level of implementation risk
    - Labor union agreements and the airline master lease restrict the benefits of an overall airport management contract
    - Opportunities to implement cost savings through "tactical" privatization of selected airport functions and internal changes
  - Key elements of Newark program
    - Private developer concession revenue enhancement programs
    - Private developer cargo facility program
    - Outsourcing selected maintenance tasks
    - Rationalize staffing
    - More efficient use of police resources
    - Reductions in Authority-wide administrative overhead
    - Greater use of private contractors/consultants for design and management of capital projects
    - Annual savings of between $13-16 million

e. JFK International Arrivals Building (IAB)
  - Port Authority solicitation for design, construction, and operation
  - Joint venture of LCOR/Schiphol/Lehman Brothers selected
  - $934 million special facility bond financing in April 1997
  - 1.4 million square feet, 16 contact gates, and 12 hardstands
  - Unique retail concept

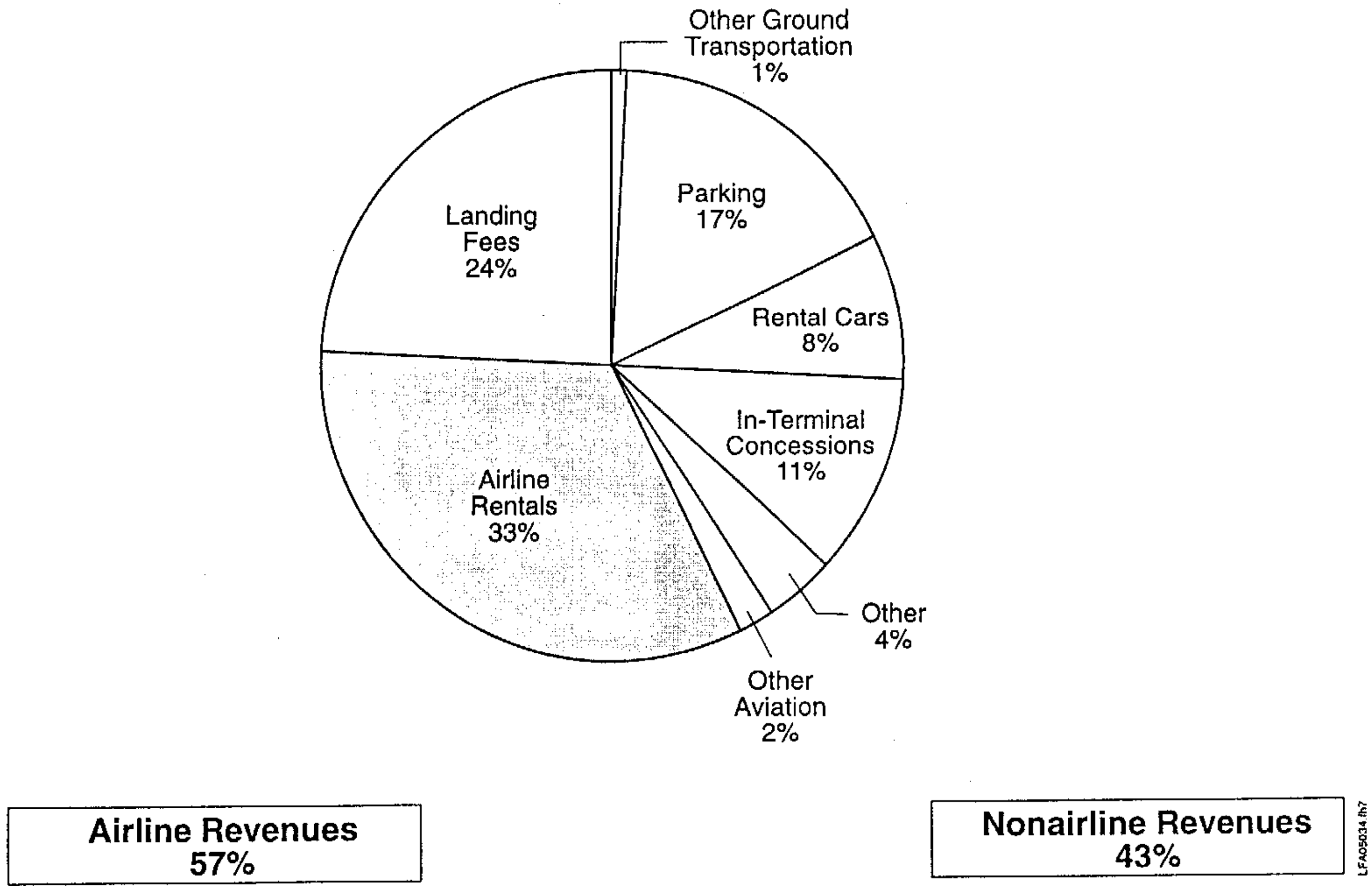
f. Stewart International Airport

- Located about 60 miles north of New York City
- Owned by the State of New York, and handles about 400,000 enplaned passengers per year
- The State wanted to attract private initiative and capital to the development of the Airport
- Issued an RFP for private developers in mid-1997, and submitted a preliminary application to the FAA under the airport privatization pilot program
- Several private development teams submitted proposals
- In April 1998, announced that National Express plc is the "preferred bidder". National Express bid $35 million plus a share of Airport revenues for a 99-year lease for the Airport.

g. Harrisburg International Airport

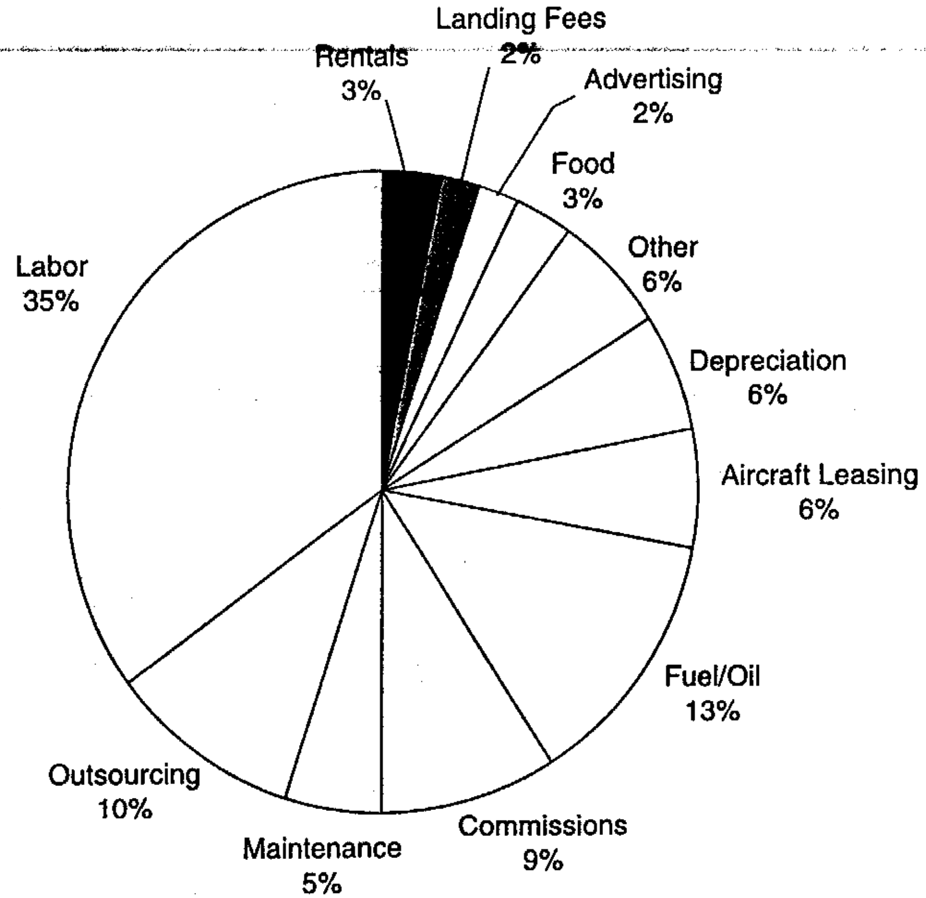
- Previously owned and operated by the Commonwealth of Pennsylvania
- Transferred to a local authority (Susquehanna Area Regional Airport Authority) in January 1998
- SARAA hired BAA to operate the Airport, for a 10-year term
- BAA will be paid a management fee ($500,000/year fixed-fee; an incentive fee for cost reduction; 20% of cost savings beginning in the 4th year)
- Performance penalty—after 4 years, failure to reach specified cost reductions can reduce fixed fee by the percentage BAA misses the target
- SARAA retains responsibility for police, management staff, airline agreements, airline rates and charges, marketing, capital expenditures, long-range planning, and environmental policy.

DISTRIBUTION OF OPERATING REVENUES
Typical Large Hub U.S. Airport



Source: The Airline Monitor, March/April 1993.

MAJOR CARRIERS
SYSTEMWIDE EXPENSE PROFILE
1996



Airline fees and charges 4-6%

Source: *The Airline Monitor*, March/April 1998

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SECTION 2—AIRPORT PRICING

D. OVERVIEW OF AIRPORT RATES AND CHARGES CONCEPTS

1. Cost Center Structure/Cost Accounting Procedures

   a. Typical primary (revenue-producing) cost centers

      - Terminal Building
      - Airfield
      - Parking/Ground Transportation
      - Other Building and Ground Areas

   b. Typical secondary (indirect) cost centers

      - Administration
      - Aircraft rescue and fire fighting
      - Security
      - Roadways
      - General maintenance
      - Utility systems

2. Definition of Airport Costs

   a. Operation and maintenance expenses (direct and indirect)

   b. Equipment and capital outlays

   c. Debt service and debt service coverage ("as specified in financing agreement or covenants")

   d. Reserves for emergencies and unanticipated operation and maintenance expenses

   e. Amortization of investment in depreciable assets (net of grants and PFCs)

   f. Environmental remediation costs

   g. Bad debt expense

   h. Assessments, settlements, and judgments (net of insurance proceeds)

   i. Other negotiated funding amounts

3. Rate Methodology—the basic concepts

a. Compensatory

- Recover fully allocated operation and capital costs of facilities occupied or used (pay for what you use)
- Terminal rentals

  Terminal cost
  ÷ Usable (rentable) space
  = Average rental rate

- Landing fees

  Airfield costs
  ÷ Total landed weight of all aircraft
  = Landing fee rate

- Airport sponsor assumes financial risk that nonairline revenues will cover the costs of nonairline facilities and retains for its discretionary use the profits derived from such nonairline activities

b. Residual (single cash register)

- Recover residual amount required to keep airport or cost center whole, after identifying all costs and allowing credit for all nonairline revenues
- Terminal rents (cost center residual)

  Terminal costs
  – Nonairline terminal building revenues (rentals and concession fees)
  = Airline revenue required
  ÷ Airline rented space
  = Required average rental rate

- Landing fees (cost center residual)

  Airfield costs
  – Nonairline airfield revenues
  = Airline revenue required
  ÷ Airline landed weight
  = Landing fee rate

- Landing fees (airport residual or airport system residual)

  Total airport (system) costs
  – Revenue from all sources other than airline rates and charges
  – Airline terminal space rentals
  = Airline landing fee required
  ÷ Airline landed weight
  = Required airline landing fee rate

- The financial risk is transferred to the airlines in return for negotiated limits on the amount of profit to be retained by the airport sponsor

c. Hybrids

Table 1

SAMPLE CALCULATION OF TERMINAL BUILDING RENTAL RATES UNDER ALTERNATIVE RATE METHODOLOGIES

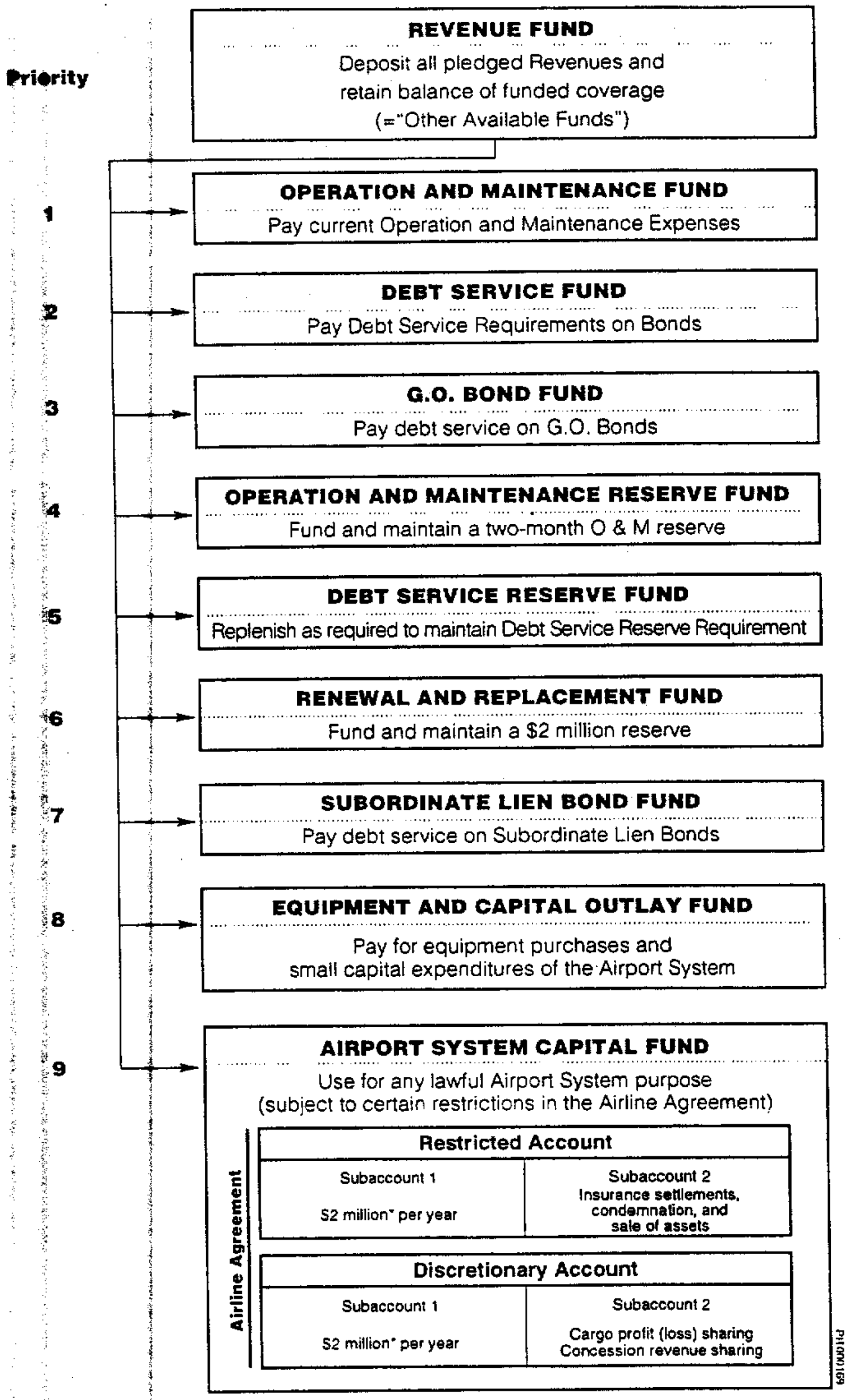
	Compensatory	Commercial compensatory	Cost center residual
Terminal Building Costs	$4,600,000	$4,600,000	$4,600,000
Total usable space	200,000		
Total rentable space		100,000	
Average rate per square foot	$23.00	$46.00	
Airline rented space	75,000	75,000	
Airline rental revenue	$1,725,000	$3,450,000	
Nonairline terminal revenue			(2,800,000)
Net airline rental required			$1,800,000
Airline rented space			75,000
Effective average rate per square foot			$24.00

Table 2

SAMPLE CALCULATION OF LANDING FEE RATES UNDER ALTERNATIVE RATE METHODOLOGIES

	Compensatory	Cost center residual	Airport residual
Landing area costs	$2,500,000	$2,500,000	
Total airport costs			$8,000,000
Nonairline landing area revenues		(200,000)	
Total airport nonairline revenues			(4,800,000)
Airline rental revenue (assuming compensatory method)		———	(1,725,000)
Net cost		$2,300,000	$1,475,000
Total landed weight	3,600,000		
Airline landed weight		2,700,000	2,700,000
Landing fee rate (per 1,000 pounds)	$0.69	$0.85	$0.55
Airline landed weight (1,000 pounds)	2,700,000	2,700,000	2,700,000
Airline landing fee revenue	$1,875,000	$2,300,000	$1,475,000

4. Generating discretionary funds
    a. Funding debt service coverage (DFW, ATL, ORL)
    b. Segregating cost centers (ORD, PHL, CHS)
    c. Funding negotiated discretionary accounts (ORL, PIT)
    d. Sharing nonairline revenues (SFO, IND)
    e. Sharing profits from terminal concessions (RNO, ABQ)
    f. Sharing airport profits (SAT, DSM, RIC)
    g. Enplanement formulas (DFW)
    h. Funding noncash costs (amortization) through rates
    i. Other formulas
5. Funding of Debt Service Coverage
    a. **Real or Funded** coverage = coverage funded in the rate base each year (DFW, LAX)
    b. **Demonstrated** coverage = coverage demonstrated as a result of funding debt service on subordinated bonds (PIT, CHS)
    c. **Rolled** coverage = coverage funded once and rolled over to meet rate covenant each year (PIT, CLT)
    d. Hybrids (ORL, CLE)
6. Flow of funds under revenue bond structures (see application of revenues chart)



*Subject to Implicit Price Deflator Index

SUMMARY OF THE APPLICATION OF REVENUES AS ESTABLISHED BY THE BOND ORDINANCE AND THE AIRLINE AGREEMENT

County of Allegheny, Department of Aviation

PAS/TAW5

E. AIRPORT RATES AND CHARGES LEGAL FRAMEWORK

1. Legal framework

   a. Statutory and constitutional provisions

      - Interstate commerce clause—prohibits undue burden and discrimination
      - Airport and Airway Improvement Act of 1982 (AIP grant assurances)
        - Airport revenues can be used only for airport purposes
        - Available for public use on fair and reasonable terms without unjust discrimination
        - Must be as self-sustaining as possible
      - Anti-Head Tax Act of 1973 (AHTA)
      - PFC Act of 1990 (amended AHTA)
      - FAA Authorization Acts of 1994 and 1996
      - Chicago Convention and bilateral agreements—same fees charged to foreign airlines

   b. DOT policies mandated by Federal Aviation Administration Act of 1994

      - Airport rates and charges
      - Rules for resolving disputes between air carriers and airports
      - Policies and procedures for enforcing federal restrictions on the use of airport revenue

   c. Key judicial decisions

2. Key judicial decisions on airport rate litigation

   a. Evansville

      - Original head tax case heard by Supreme Court
      - Rates must be "reasonable in relation to costs"
      - Reasonable was not defined in this case, but subsequent litigation defined three-part test
        - Not discriminatory, arbitrary, or capricious
        - Assessed in fair approximation of use of facility
        - Not excessive in relation to costs incurred

   b. Raleigh Durham

      - Airlines claimed rates were excessive in relation to costs
      - Court ruled the 2-cash register system (terminal and airfield) is OK—terminal does not have to subsidize landing fees
      - Prohibited prefunding (runway project)

c. Boston (Massport)

- General aviation runway extension—air carriers did not want to pay
- Ruling
  - Rates reasonable in relation to costs
  - Conferring benefits is not relevant to rate-making

d. Indianapolis

- Rates were excessive in relation to costs and unreasonable
- Concession profits must be taken into account in rate-making
- Airport generated "obscene" profits
- Airport negotiated residual cost agreement with airlines

e. Denver

- Compensatory rate-making systems are not inherently unreasonable
- Profits from compensatory system (i.e., concession revenues) can be used to help fund replacement facilities
- City cannot charge airlines directly for the cost of a facility until they have beneficial use (prefunding) <u>even if both parties agree</u>

f. Grand Rapids (Supreme Court)

- Airlines contended rates were unreasonable because the compensatory approach is illegal, and results in exorbitant profits that exceed costs
- Airlines also claimed that rates discriminated against airlines in favor of general aviation (ARFF)
- Ruling overturned Indianapolis—Court found that the compensatory method is reasonable
- Court said the review of reasonableness is not judicial business—it should be decided by the Secretary of Transportation and the Secretary should establish standards
- Focus shifted from courts to Congress/DOT

g. Los Angeles

- Airport residual use agreement expired in 1992
- City wanted general fund to realize a "return on investment" from airport
- City adopted compensatory landing fees July 1, 1993 through rate ordinance
- Landing fee increased from $0.51 to $1.56 per 1,000 pounds
- New rates result in $30+ million surplus
- Airlines claimed rates were "unreasonable" and refused to pay
- City threatened to deny access to airlines who did not pay increased fees
- District Court dismissed airlines' challenge to new rates and ruled that the airlines have no right to bring their Anti-Head Tax Act (AHTA) claims to court
- District Court never reviewed the reasonableness of LAX rates

- Airlines looked to Congress to override GRR decision and foreclose LAX
- U.S. Court of Appeals decision (January 1997) found that airports need not use historical cost basis for airfield land—contradicts DOT rates and charges policy

3. Key events leading to DOT policy

   a. U.S. Supreme Court suggested in Grand Rapids decision that DOT play a more significant role in rate disputes (March 1993)

      - To define "reasonableness" and
      - To establish dispute resolution procedures

   b. LAX adopts new compensatory rates by ordinance

   c. Airline lobbying on Capitol Hill

   d. FAA Authorization Act of 1994 (August 1994). Requires DOT to issue rules:

      - Rates and Charges
      - Dispute resolution
      - Revenue diversion

   e. Rates and charges policy

      - Interim policy issued February 1995
      - Revised proposed policy issued September 1995
      - Final policy issued June 21, 1996

4. Key principles applicable to rates and charges policy

   a. Preference for local resolution

   b. Compensatory and residual rate-making approaches are acceptable

   c. Allowable costs:

      - Reserves and debt service coverage as required by bond indentures
      - Funding of operating reserves and contingencies
      - Pro rata shares of "indirect" capital costs (including airport roads and fire-rescue facilities)
      - "Imputed interest" (amortization) on expenditures of funds except for funds obtained through airfield fees and debt financing (if debt service included in rate base).
      - Environmental remediation costs, including costs to comply with federal, state and local laws and regulations; off-airport mitigation associated with airport aeronautical development; noise mitigation in accordance with approved Part 150 program or other disclosed noise compatibility program; costs of environmental insurance or self-insurance
      - Cannot prefund—can only recover costs for facilities in use except for acquisition of land for near-term future airport development

- Recover only *historical cost* for airfield and public use roadways land; airports can use other valuation methods for other property. Averaging costs to achieve common rates is allowed
- Costs of designated reliever airports may be included in air carrier rates provided all facilities owned by single entity and costs are reasonably related to aviation benefits provided to aeronautical users who bear them

d. Unjust discrimination

- Can make reasonable distinctions between signatory and nonsignatory aeronautical users

e. Congestion pricing

- "Properly structured" peak period pricing system allowed if fees established to *enhance* the efficiency of the airport

f. Financially self-sustaining

- Federal law does not require each airport to be self-sustaining. Policy states that airports only be as financially self-sustaining "as possible"

g. Use of airport revenues

- Illegal revenue diversion to be addressed under separate policy
- FAA may review "progressive accumulation of surplus"

h. Does not apply to rates set by an existing agreement

5. Complaints filed and decided to date

a. Complaints dismissed

- Northern Mariana Islands
- Lehigh Valley (Allentown)
- Denver

b. Puerto Rico settled

c. Los Angeles—2 proceedings

- Landing fees found to be unreasonable in part
- Can only charge historical cost for land, not fair market value
- Inclusion of amortization costs in the rate base is reasonable
- Allocation of roadway costs is reasonable—based on acreage, then equalized between terminal and airfield (i.e., aeronautical cost centers)
- Indirect cost allocations

d. Miami

- American Airlines operates a hub and accounts for approximately 50% of passenger traffic
- $2.8 billion terminal redevelopment program
- Six airlines contended that charging all airlines under an equalized rate methodology was discriminatory and violated federal law
- DOT ruled that the rate methodology was reasonable because over time all airlines will have new facilities

6. Rules of practice for proceedings concerning airport fees, issued February 1995 (see timeline on next page)

7. The U.S. Court of Appeals for the District of Columbia vacated the U.S. DOT's final policy on airport rates and charges (August 1997).

- The court concluded that the provisions in the policy allowing charges for nonairfield aeronautical facilities (e.g., terminals, hangars) to be determined using "any reasonable method", while charges for airfield facilities could be determined only on the basis of historical cost was "arbitrary and capricious".
- The policy is currently being reconsidered by the U.S. DOT.

8. Revenue diversion policy

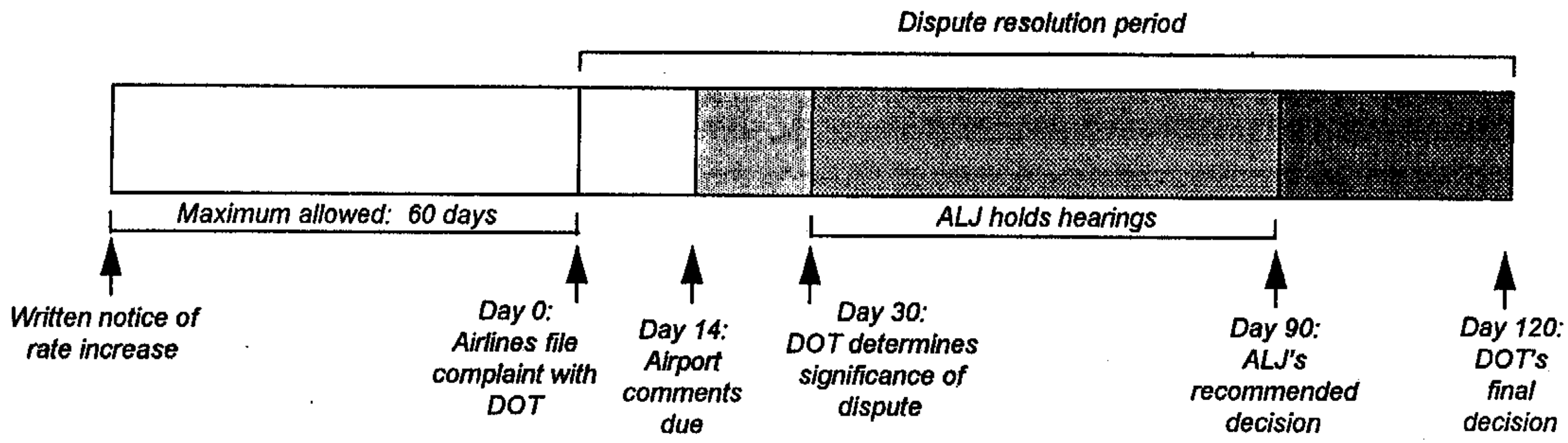
a. Prohibited uses of airport revenue

- Direct or indirect payments, other than payments that reflect the value of services and facilities provided to the airport, that are not based on a reasonable, transparent cost allocation formula calculated consistently for other units or cost centers of government
- Use of airport revenues for general economic development, marketing, and promotional activities unrelated to airports or airport systems
- Payments in lieu of taxes, or other assessments, that exceed the value of services provided or are not based on a reasonable, transparent cost allocation formula calculated consistently for other units or cost centers for government
- Payments to compensate nonsponsoring governmental bodies for lost tax revenues exceeding stated tax rates
- Loans of airport funds to a state or local agency at less than the prevailing rate of interest
- Land rental to, or use of land by, the sponsor for nonaeronautical purposes at less than the amount that would be charged a commercial tenant
- Impact fees assessed by a nonsponsoring governmental body that the airport sponsor is not obligated to pay or that exceed such fees assessed against commercial or other governmental entities

b. "Lawful" and unlawful revenue diversion—airports "grandfathered" before 1982

c. Consideration of lawful diversion in awarding AIP discretionary grants

TIMELINE FOR DISPUTE RESOLUTION
U.S. DOT Rates and Charges Dispute



d. Monitoring/detection

- Annual report
- Annual single audits (OMB Circular A-128)
- Investigation following third party complaint
- DOT Office of Inspector General audits

e. Allocation of indirect costs

- No specific method required, but only operating and capital costs, directly and substantially related, may be allocated
- Method may not result in over allocation to enterprise or proprietary funds

f. Sanctions for noncompliance

- Withhold future AIP grants
- Withhold approval to modify existing grants to increase funds
- Withhold payments under existing grants
- Withhold approval of PFC applications
- File suit in U.S. district court
- Assess civil penalties (maximum $50,000)

E. OVERVIEW OF AIRPORT CONCESSIONS

1. Measuring concession performance

   a. Basic statistical unit for measuring concession revenues is enplaned passenger

   b. Gross revenue per enplaned passengers reflects performance of concession

   c. Revenues to the airport per enplaned passenger reflect the financial arrangement (minimums, percentages, other payments)

2. Ranges of revenues per enplaned passenger (see chart)

3. Alternative methods for selecting concessionaires

   - Competitive bidding
   - Competitive proposals
   - Negotiation with single concessionaire of sole-source basis

4. Auto parking

   a. Three types of arrangements

      - Concession agreement (small airports)
      - Management contract
      - Self operation

   b. Maximum rates consistent with local comparables and off-airport competition

   c. Revenue control systems

5. Rental cars

   a. Concession agreements

   b. 8% to 10% of gross revenues against guaranteed minimum payment

   c. Rentals for terminal counters, ready/return parking, and service facilities

   d. Imposition of new customer facility charges (CFCs)

      - Washington National
      - Denver
      - Colorado Springs
      - Proposed

6. Off-airport parking and rental car charges

   a. Parking

      - Annual fee
      - Percentage of gross revenue
      - Per courtesy vehicle trip
      - Per space

   b. Rental cars

      - Percentage of gross revenue
      - Number of vehicles
      - Annual fee
      - Per courtesy vehicle trip

7. Food and beverage

   a. Concession agreements

   b. Percentage of gross revenues against guaranteed minimum payment

   c. Required investment

   d. Competitive proposals

8. News, gifts, and other merchandise

   a. Concession agreements

   b. Percentage of gross revenues against guaranteed minimum payment

   c. Competitive proposals

   d. Negotiated agreements in specific situations

9. Fundamental changes in airport commercial management

   - Branded concessions
   - Street retailers
   - Street pricing (or close to it)
   - DBE requirements increasing
   - Exclusive master agreements giving way to multiple agreements, competition
   - Airlines more receptive to commercial initiatives
   - Developer arrangements at large hubs

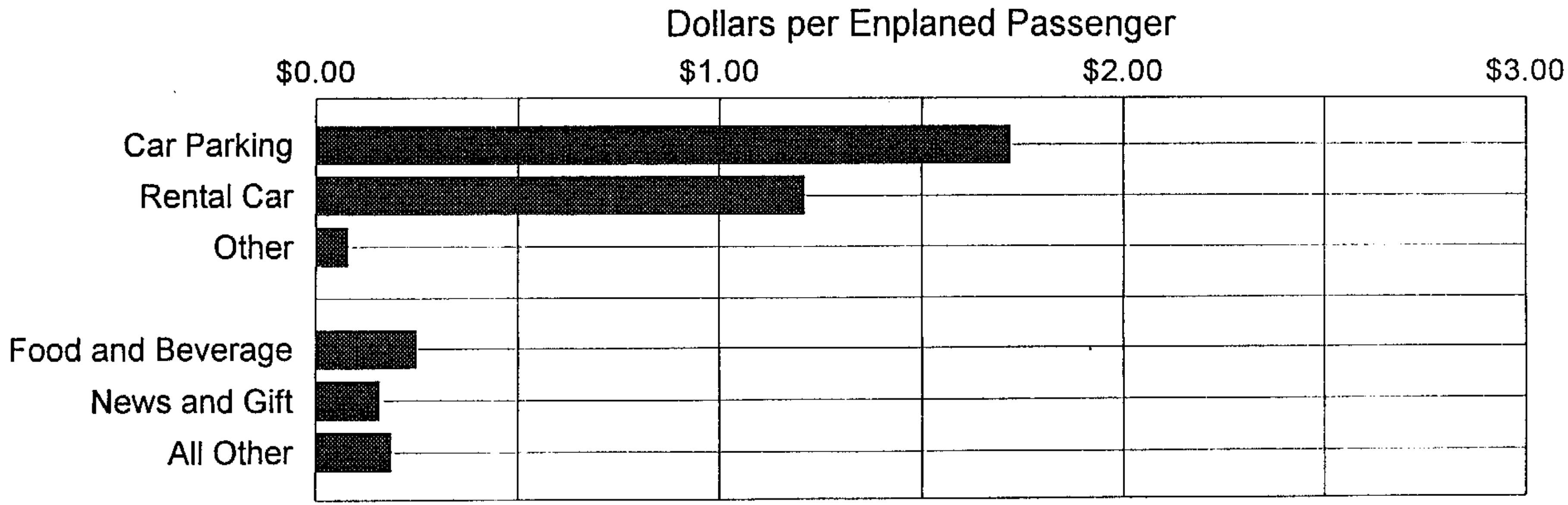
10. Various management approaches to food/beverage and merchandise concessions

- Traditional approach
  - Minimum number of agreements, usually with traditional concessionaires
  - Concession program managed by staff
- Developer approach
  - Developer responsible for all concessionaire selection, day-to-day management
  - Developer usually not an operator
  - Developer provides financing, planning, development skills in return for long-term fees
- Principal concessionaire approach
  - Single operator subcontracts for all other concessions (SEA)
- Partnership
  - Sharing of profits
- Management contract (MIA)

11. Developer agreements are increasing at large hubs

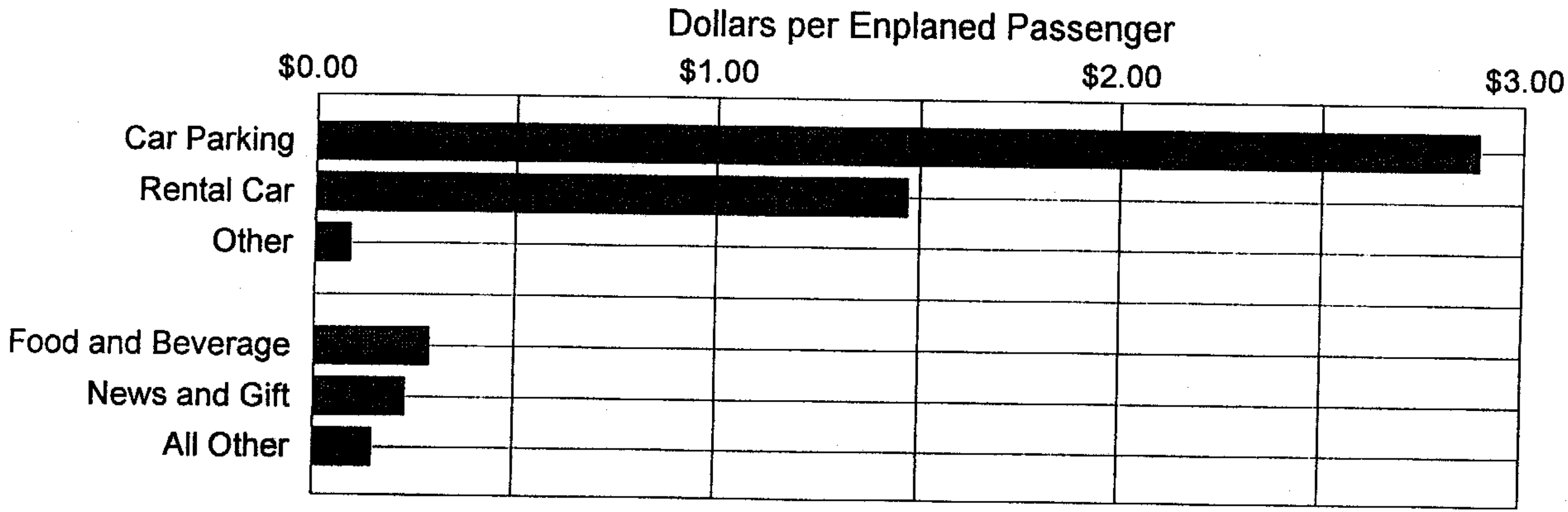
1988 Washington National: Food and beverage (Host, formerly Innovative Foodcourts)
1989 Houston: Food and beverage (Entertainment One)
1992 Pittsburgh: Food and beverage and merchandise (BAA Pittsburgh)
1993 LaGuardia: Food and beverage and merchandise (Marketplace 2000)
1994 Philadelphia: Food and beverage and merchandise (Marketplace 2000)
1996 Boston—Terminal C (Westfield)
1997 Washington National and Dulles (Westfield)

COMMERCIAL REVENUE PER ENPLANEMENT, 1995
Large Hub Airports



Source: AAAE Survey of Airport Rates and Charges, 1995/96.
Note: Excludes duty free.

COMMERCIAL REVENUE PER ENPLANEMENT, 1995
Medium Hub Airports



Source: AAAE Survey of Airport Rates and Charges, 1995/96.
Note: Excludes duty free.

Measuring, Monitoring and Managing Opportunities in Non-Aviation Revenues

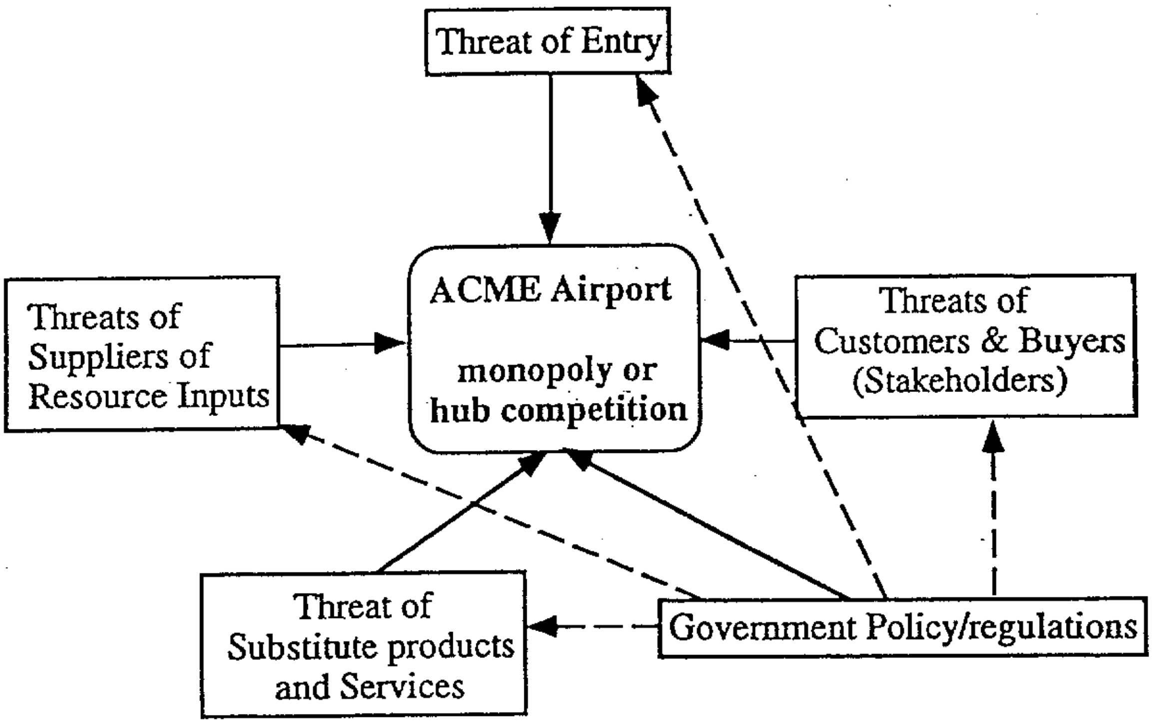
David Gillen

Institute for Transportation Studies
University of California - Berkeley

Airport Short Course, May 1998

OUTLINE

- Changing context
- Modern Airport-governance, traffic, organization & strategy
- Value-Chain and modern Airport Management
- Operationalize - Measurement/Management
- Monitoring
- Conclusions



Five Forces affect prices, costs and investment

ESSENTIAL ELEMENTS OF COMPETITIVE STRATEGY FORMULATION

The strategy must reflect the unified, comprehensive and integrated plans to ensure objectives are met.

Four Determinants of Strategic Action

- resources
- industry structure
- external environment
- managerial preferences

↓

Decisions

- statement of airport aims & objectives
- analysis of trends & components of demand
- examination of competitive position of airport (strengths and weaknesses)
- decisions of services offered & customers served
- development of marketing strategy to place services in marketplace
- development of management structure with stated objectives & incentive scheme
- financial forecast with stated resource requirements & use

CONTEXT

◊ airlines have achieved significant internal cost efficiency - ↓ in cents/RPM

◊ increased focus on external costs - airport charges (5% in N.A., >15% Europe/Asia)

◊ shift in ownership/governance structure

◊ shift to customer focus

◊ shift in risk

Proportion of Landing Fee Payments in Total Operating Costs (Systemwide)

Year	American	United	Delta	Northwest	USAir	Continental
1980	0.014	0.015	0.015	0.024	0.020	0.011
1981	0.013	0.013	0.015	0.021	0.020	0.010
1982	0.013	0.014	0.016	0.022	0.021	0.013
1983	0.013	0.014	0.015	0.020	0.020	0.012
1984	0.015	0.014	0.014	0.019	0.017	0.017
1985	0.015	0.014	0.014	0.018	0.016	0.015
1986	0.018	0.015	0.016	0.019	0.018	0.017
1987	0.019	0.016	0.017	0.015	0.018	0.022
1988	0.018	0.015	0.016	0.015	0.017	0.021
1989	0.018	0.015	0.016	0.015	0.015	0.020
1990	0.017	0.016	0.017	0.015	0.016	0.020
1991	0.019	0.017	0.018	0.018	0.017	0.021
1992	0.019	0.019	0.019	0.022	0.019	0.024
1993	0.018	0.019	0.019	0.021	0.019	0.023
1994	0.018	0.019	0.019	0.023	0.018	0.026

THE AGENDA FOR AIRPORT MANAGEMENT

1. New Marketing Strategies
   - connecting traffic (long haul), manage traffic mix

2. Identify Key processes in Value Chain
   - time, cost and quality; concentrate on CORE businesses, define strategies

3. Implementation of TQM Principles
   - customer focus, identify processes, quality in design and delivery

4. CORE Competencies
   - aviation and non-aviation revenues

MODERN AIRPORT

Governance structure	- private management/contracting - direct correlation between non-aviation revenue share and profitability (operating profit before depreciation)
Traffic	- actively manage traffic profile - focus on connecting passengers - high correlation between non-aviation revenue and Int'l connecting traffic
Organization	- in business units - shift from functional structure to customer service
Strategy	- commercial orientation - core business, differentiate along new value chain

CHANGING VALUE CHAIN

Traditional Value Chain		New Value Chain
Airport marketing- treat as unit with general focus	→	client oriented airport marketing- Aviation, Non-aviation
Airport Handling, Operations & Maintenance - functional, airport provided (pax, ramp, cargo) SUPPLY	→	disintegration and joint management with airlines, service providers, focus on quality management (Landside, Airside) DEMAND
Concessions - long term contracts, maximize rent, minimize quality and choice, afterthought	→	Commercial management - treat as CORE business

NEW MANAGEMENT PARADIGM

constitute an increasing proportion of total revenues

contracts are:

- short to medium
- managed as completely separate businesses
- encourage innovation and new activities in all areas (add value to customer)
- develop comprehensive retail plan

Quality Monitoring - set, monitor and enforce standards for:

- price - street pricing
- choice - variety - diversity
- availability
- quality
- name brands - product positioning

NON-AVIATION REVENUES

(concessions, parking, car rentals, commercial development)

MODEL - MANAGE - MONITOR - MARKET STRATEGY

Model: quantify traffic - who, route, transfers, potential for hubbing

Manage: establish framework for influencing traffic - routes, gates, slots, pricing

Monitor: set of measures to assess success, performance versus standard, link performance to incentives [S-W-O-T]

Strategy: link commercial plan to traffic opportunities, recognize traffic profile is endogenous, measures allow management

- retail competition - increases passenger utility
- service commitment - establish standard, monitor and maintain
- pricing strategy - airport specific but 'common principle' (street pricing)
- accessibility - direct traffic flow with revenue maximization in mind (e.g. YVR)

BEST PRACTICE AIRPORT SERVICE CONCEPT

1. identify customer needs and preferences (market segments)
2. define service package
3. define key quality dimensions (KQD's)
4. measure KQD's
5. benchmark and establish performance measurement
6. balance [marginal] gains and losses from improvements (revenue vs costs)
7. link performance measures and management strategy
8. monitor customer satisfaction, perception and expectations
9. establish continuous improvement to link performance & satisfaction
10. shift governance structure [hierarchy to team/partnerships]

CONTINUOUS IMPROVEMENT PROCESS

Dialogue	←	Value	←	Output	←	Process	←	Input
↓								↑
Customer		Perception		Product		Production		Procurement

Partnering Approach - An Example of Modern Management Approach

Contracting
- specific inputs
- price focus
- delivery to standard
- contract sets ceiling
- traditional vendor/customer
- minimize costs s.t. standard

Partnering
- contract for quality standards
- focus on cost effectiveness
- continuous improvement
- contract sets floor
- co-planning, co-management
- develop customer/supplier relationship

MEASURING CUSTOMER SERVICE

Objective Measures of Customer Service

Pro	Con
■ precise measurement	■ potentially expensive
■ link to standards	■ discrete (all or nothing)
■ simple interpretation	■ linkage to strategy unclear
■ link to real-time management	■ limited or spotty coverage of issues

Subjective Measures of Customer Satisfaction

■ user perspective (not instruments)	■ expensive
■ reflect different expectations	■ management interpretation/suspicion
■ everything is measurable	■ perceptions change slowly, service delivery changes quickly

QUALITY MONITORING TOOLS FOR DIFFERENT CUSTOMERS

Passengers	➤ continuous measure	- demographic - socio-economic -business/leisure
	➤ ad-hoc	- focus groups, opinion-meters
Stakeholders	➤ regular	- in-depth and panels
Concessions	➤ regularly	- face to face

INSTRUMENTS FOR MONITORING

Comment Cards

Pro	Con
■ immediate	■ self-selection
■ inexpensive	■ measure extremes
■ PR opportunity	■ limited control
	■ difficult to link to management strategy

Interviews

Pro	Con
■ systematic	■ slow
■ comprehensive	■ expensive
■ scientific and systematic	■ specialist knowledge
■ can target a group	
■ link to standards	
■ link experience/demographics/attitudes	

SUCCESS STORIES

Vancouver	- retail plan from existing concessions for innovation, economic viability - theme of 'street' scene - 100 % increase in satisfaction ratings - > 30% increase in revenue
Schiphol	- conceptually same as Vancouver - shift in governance to 'partners in customer service' (not landlord)
Auckland	- follows Schiphol model - concession space focus on openness and centralization

Melbourne, Cairns, Pittsburgh, Indianapolis, Tampa

CONCLUSIONS

1. adjust governance to changing market circumstances
   - decentralize revenue and cost responsibility
   - transparency
   - focus on the customer
   - manage cultural change from within

2. align comprehensive strategic approach with success drivers

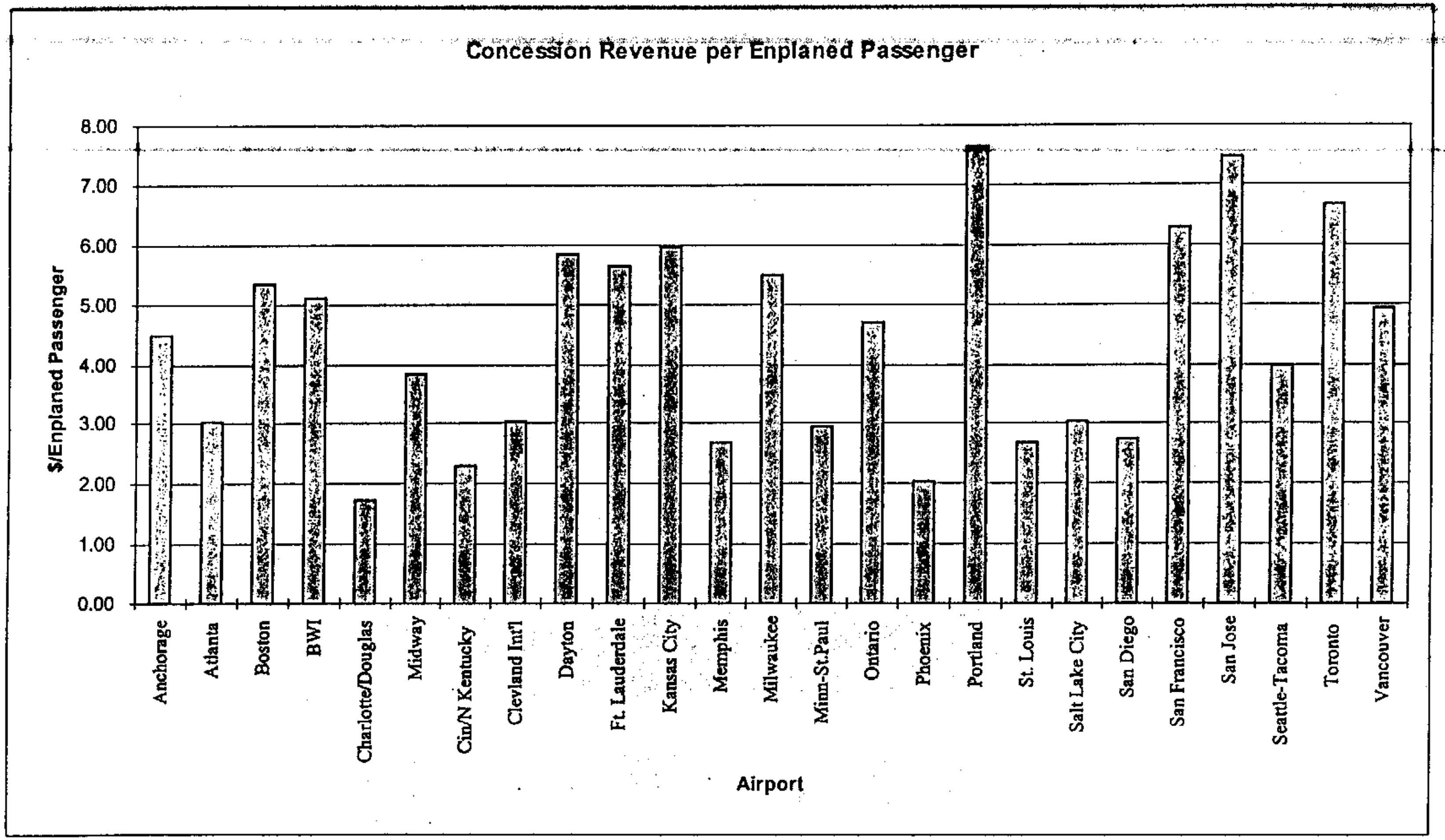
Success Drivers	Strategic Approach	Functional Strategies
(i) Airport location	develop traffic	pricing, marketing
(ii) Customer costs	value for money	create market to obtain price/quality nexus
(iii) Service quality	develop retail & other non-aviation revenue	new view of quality, use airport assets

3. recognize the airport is not a utility it is a "business"

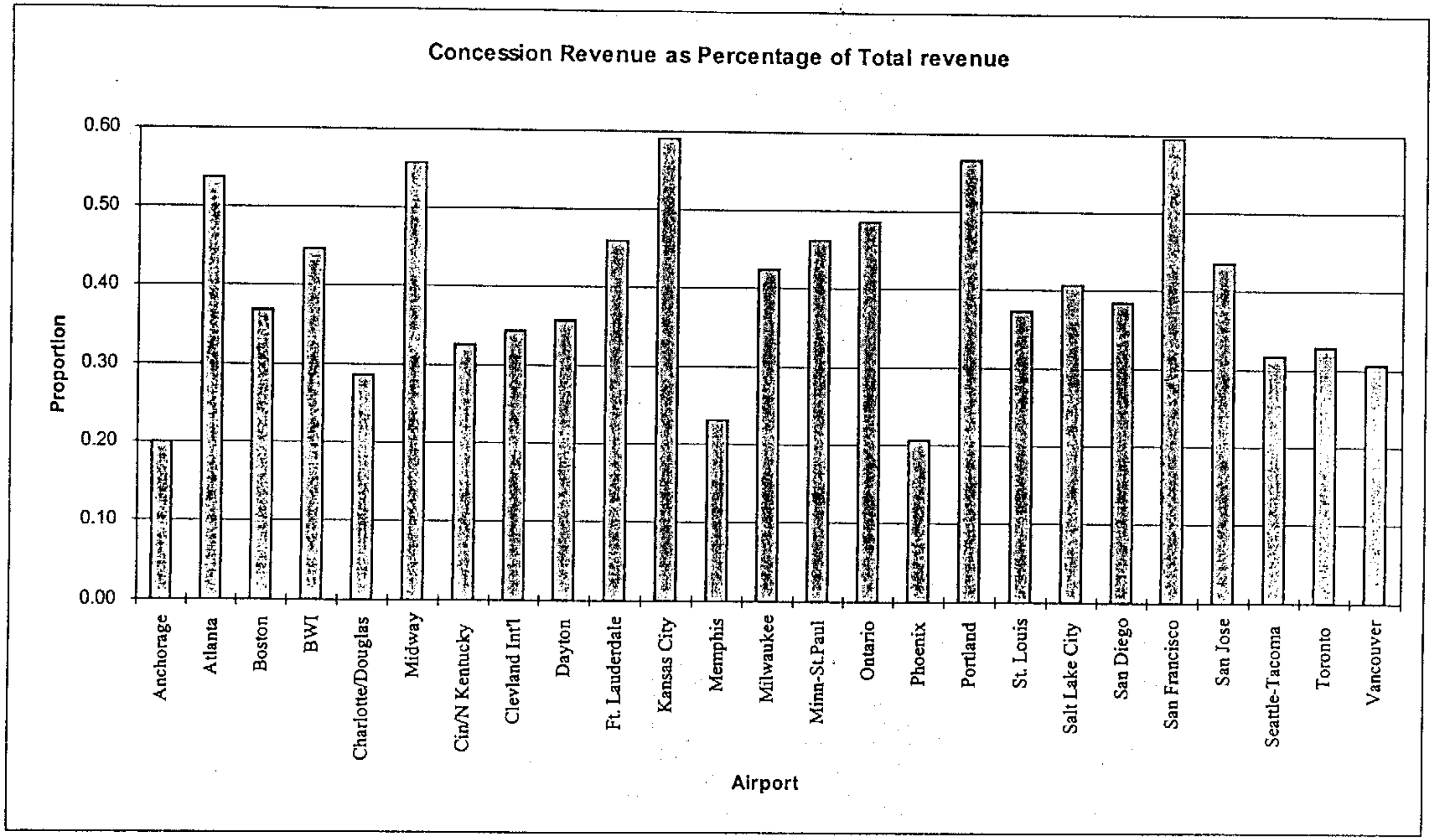
- businesses need new systems and organizational structures
- maximize flexibility
- ensure incentive compatibility

4. the non-aviation revenue strategy cannot be divorced from the aviation revenue strategy

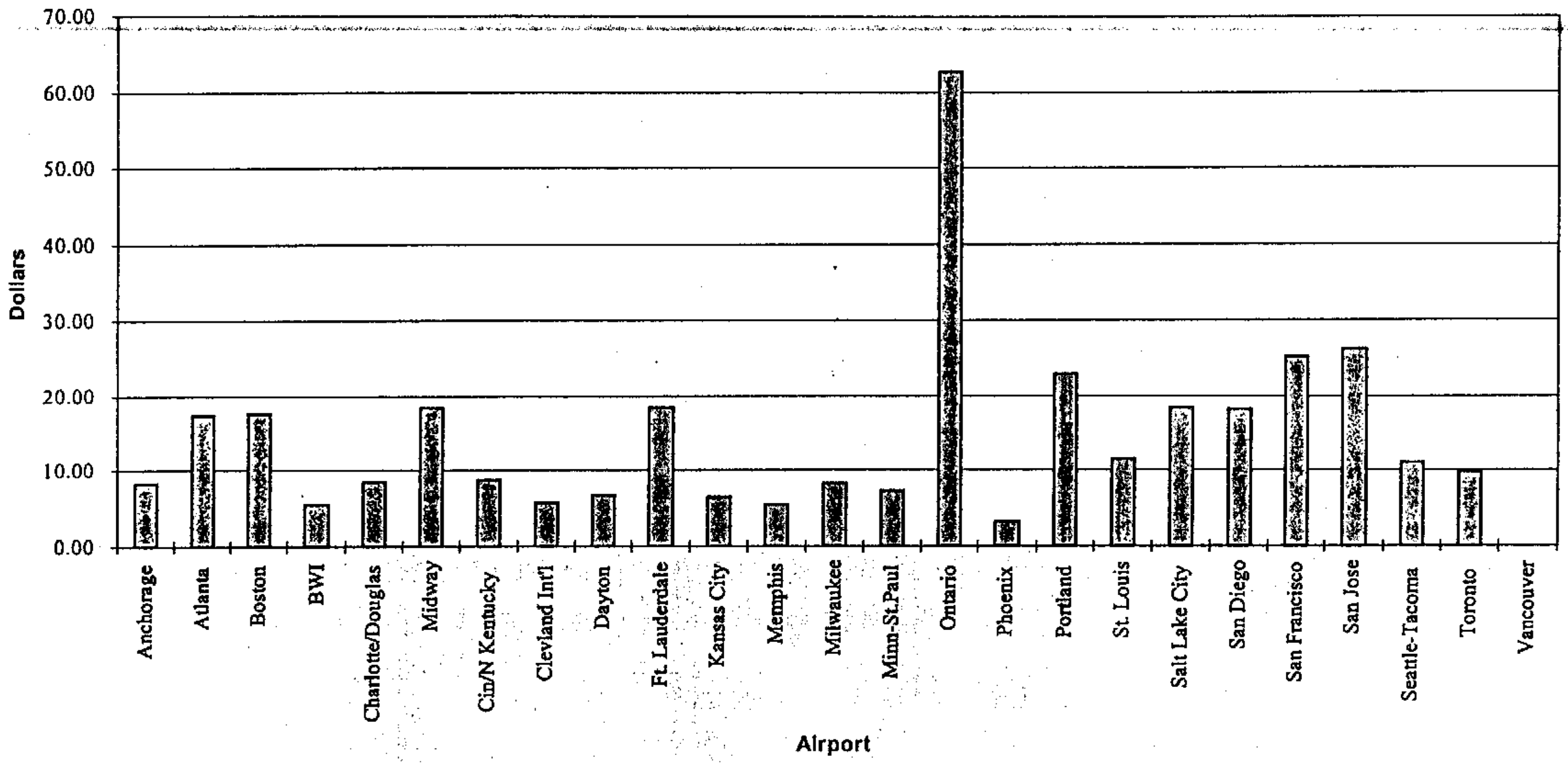
- both require new marketing initiatives
- both require attention to quality (TQM, reengineering etc.)
- both require flexibility to adjust when markets change

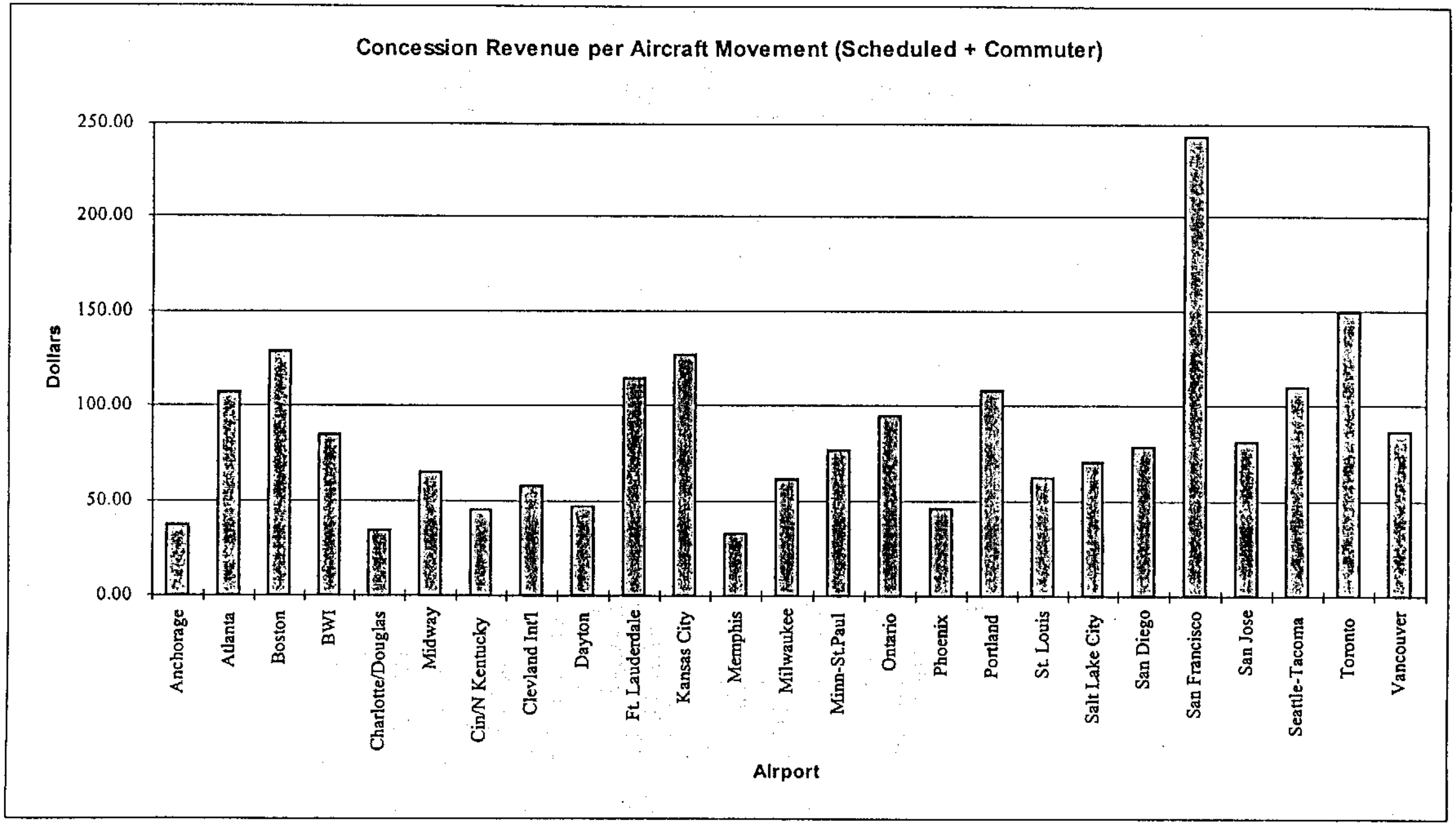


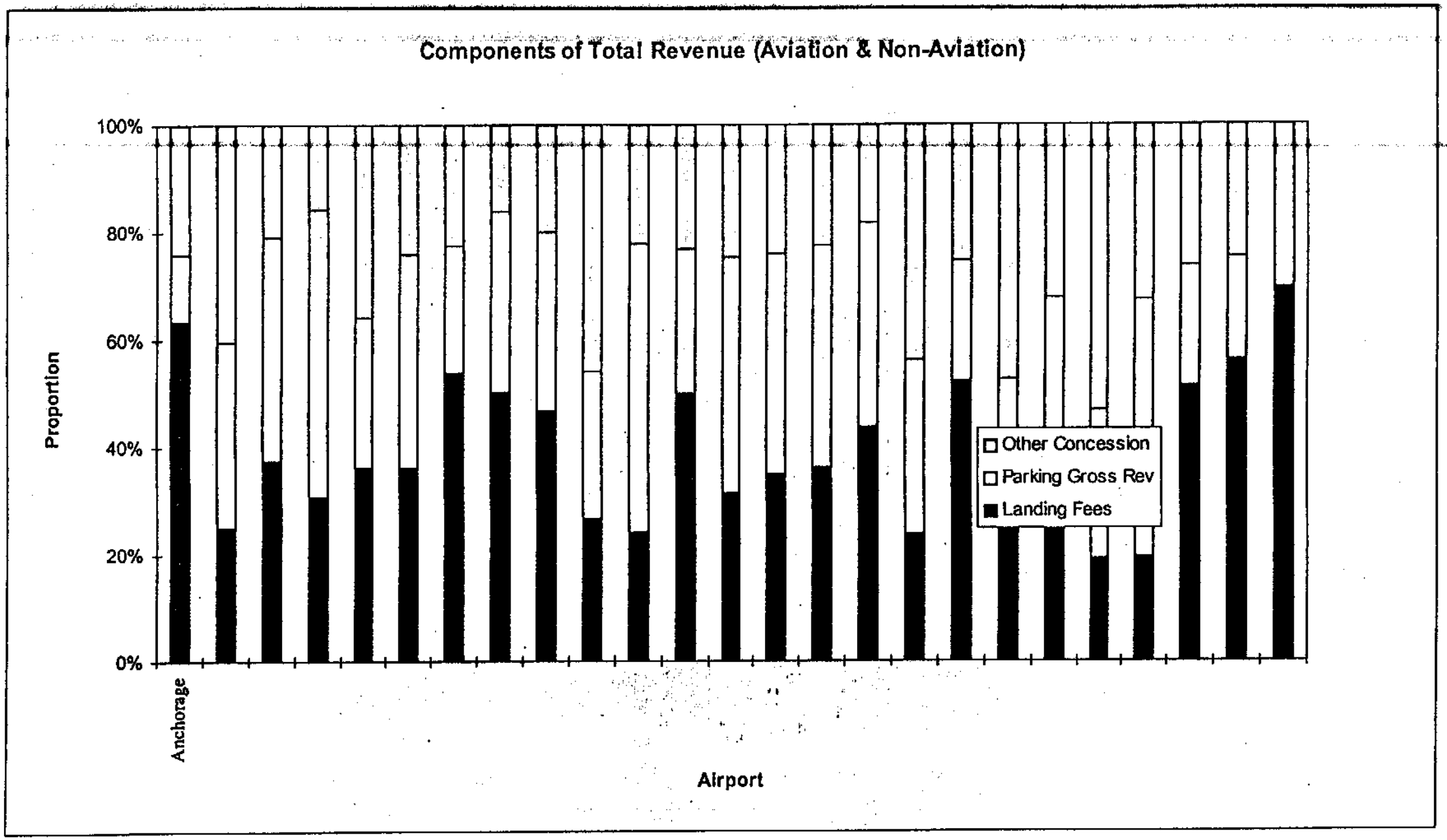
Concession Revenue per Enplaned Passenger
$/Enplaned Passenger
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Anchorage
Atlanta
Boston
BWI
Charlotte/Douglas
Midway
Cin/N Kentucky
Clevland Int'l
Dayton
Ft. Lauderdale
Kansas City
Memphis
Milwaukee
Minn-St.Paul
Ontario
Phoenix
Portland
St. Louis
Salt Lake City
San Diego
San Francisco
San Jose
Seattle-Tacoma
Toronto
Vancouver
Airport


Concession Revenue as Percentage of Total revenue
Proportion
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Anchorage
Atlanta
Boston
BWI
Charlotte/Douglas
Midway
Cin/N Kentucky
Clevland Int'l
Dayton
Ft. Lauderdale
Kansas City
Memphis
Milwaukee
Minn-St.Paul
Ontario
Phoenix
Portland
St. Louis
Salt Lake City
San Diego
San Francisco
San Jose
Seattle-Tacoma
Toronto
Vancouver
Airport

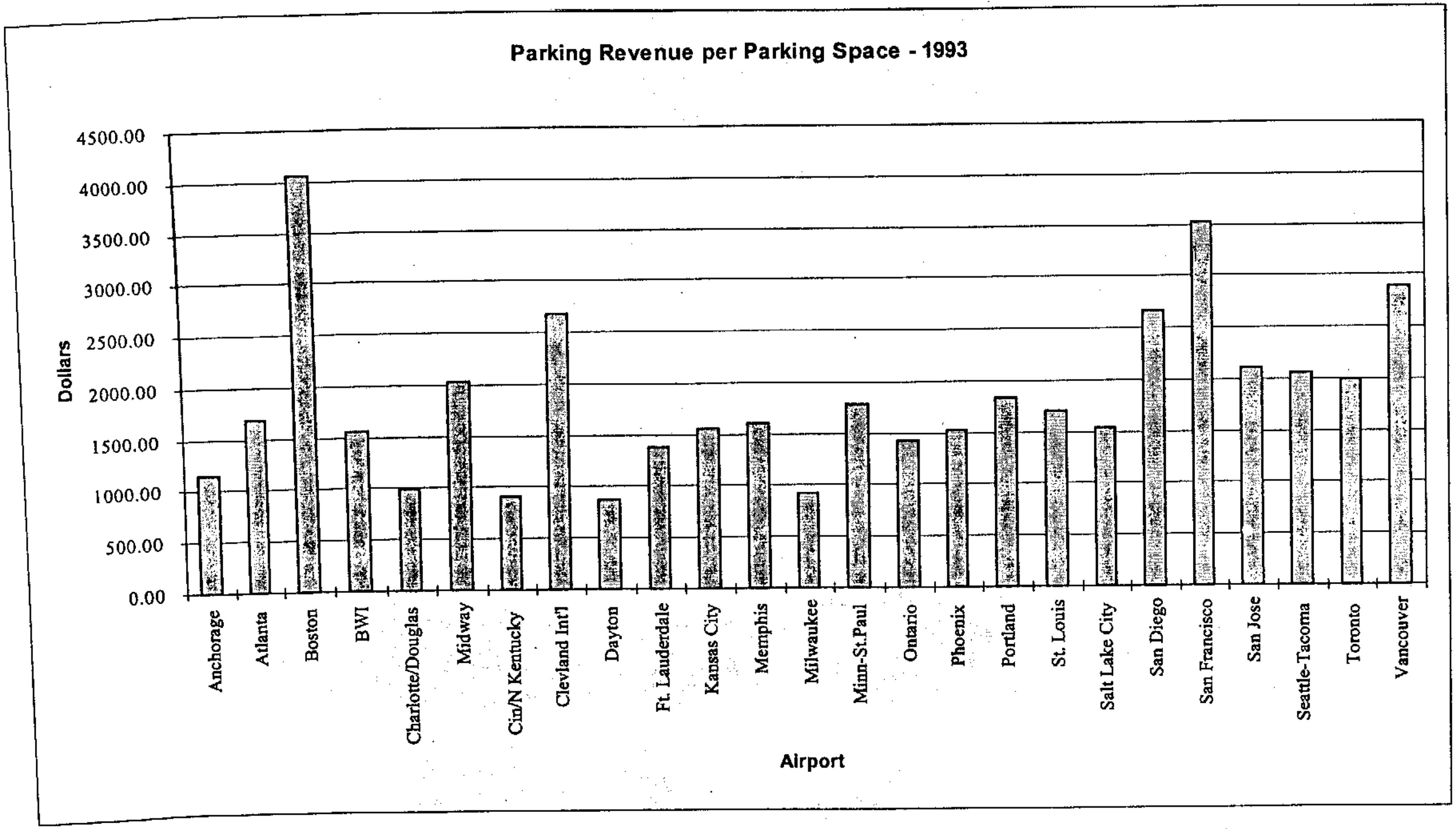
Concession Revenue per Square Foot of Terminal Space




Concession Revenue per Aircraft Movement (Scheduled + Commuter)
Dollars
250.00
200.00
150.00
100.00
50.00
0.00
Anchorage
Atlanta
Boston
BWI
Charlotte/Douglas
Midway
Cin/N Kentucky
Clevland Int'l
Dayton
Ft. Lauderdale
Kansas City
Memphis
Milwaukee
Minn-St.Paul
Ontario
Phoenix
Portland
St. Louis
Salt Lake City
San Diego
San Francisco
San Jose
Seattle-Tacoma
Toronto
Vancouver
Airport



Components of Total Revenue (Aviation & Non-Aviation)
100%
80%
60%
40%
20%
0%
Proportion
Anchorage
Airport
Other Concession
Parking Gross Rev
Landing Fees


Parking Revenue per Parking Space - 1993
Dollars
4500.00
4000.00
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
Anchorage
Atlanta
Boston
BWI
Charlotte/Douglas
Midway
Cin/N Kentucky
Clevland Int'l
Dayton
Ft. Lauderdale
Kansas City
Memphis
Milwaukee
Minn-St.Paul
Ontario
Phoenix
Portland
St. Louis
Salt Lake City
San Diego
San Francisco
San Jose
Seattle-Tacoma
Toronto
Vancouver
Airport

機場規劃研習報告

著　者：交通部運輸研究所
發行人：林大煜
發行所：交通部運輸研究所
地址：台北市敦化北路240號
電話：（02）23496789
經銷處：交通部運輸研究所運輸資訊組
地址：台北市敦化北路240號6樓
電話：（02）23496882
印刷者：全能辦公事務用品有限公司
地址：台北市復興北路33號5樓
電話：(02)27734633．27734634
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