FINAL REPORT CR 137801

TERMINAL AREA EFFECTIVENESS FOR FUTURE AIRCRAFT

AGREEMENT #NCAR-655-501

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History of the Project

This project was undertaken as a result of discussions between Dr. William W. Happ, Dean of Engineering at California State University, Sacramento and Mr. Alfred C. Mascy of the Systems Studies Division at NASA-Ames Research Center regarding airport problems, NASA's interests in this area, and extant opportunities for collaborative research between CSUS and the NASA-Ames University Consortium.

The Task:

The original proposal for this project involves development of criteria for optimization of: (a) effectiveness of terminal area design for anticipated advanced aircraft design, (b) connectivity with feeder access modes, and (c) integration of the airport with regional business and industry needs.

Discussion of the task between the Systems Studies Division and the investigators reached the concensus that the original proposal had been too ambitious for its budget. Sponsor interest was expressed regarding identification of problem areas which would merit in-depth investigation, and thus the effort was diverted in this direction at a very early stage.

Utilization of Matrix Approach:

A Decision Matrix was developed to display various airport functions interfaced with facilities, to be used as a conceptual aid in the isolation of problem areas, priorities and impacted or impacting facilities and functions. This tool made it much easier to conceptualize the relationships of the functions to each other and to the facilities and thus to identify deficiencies or sources of problems.

Literature Search and Review:

Beginning concurrently with the Matrix development and continuing on throughout the project an extensive survey of recent (1970-'74) professional and technical literature regarding airport planning, design and operation was conducted. Over 500 abstracts were reviewed for possible interest to project objectives and for classification in the Bibliography; nearly half of these documents were obtained and studied in hard copy for information which contributed to the effort.

Literature and information sources which were utilized include the NASA-Recon Information Retrieval System, the CSUS Library, UC Davis Library, UC Berkeley Institute of Traffic and Transportation Engineering, California State Library of Sacramento and the National Technical Information Service (NTIS).

Problem Identification:

Information culled from the reviewed literature combined with the conceptual approach provided by the decision matrix led to the identification of many problem areas and solution strategies application of cost/benefit criteria - determining which problems could benefit most from the least effort - provided identification of 18 comparatively effort-responsive problems.

Topics Initially Investigated: a concise 200-500 word summary was supplied on each of the following problem areas:

A. Multimodal Access Planning: An investigation of alternatives in mode selection and facility design for airport access systems, to provide recommendations keyed to vario specific demand situations.

B. Multiple Concurrent Land Uses: An assessment of alternative uses of undeveloped airport land, providing evaluatic criteria and impact projections to be applied to proposed land uses by individual airport planners or administrators

C. Government Involvement - Jurisdictional Conflicts: An attempt to define statutory, de facto and perceived jurisdictions of various government agencies at federal, state and local levels responsible for airport planning and operation, documenting areas of conflict and assessing extent to which reconciliation has been or may be accomplished.

D. Noise Control/Containment for Airports: Documents and evaluates innovations in noise control technology to optomize effectiveness and environmental tradeoffs, focussing upon areas of correctible technological deficiency to facilitate direction of future R & D efforts.

E. Site Selection & Growth Potential: Development of a user-validated checklist and guidelines for evaluation of proposed airport sites or growth potential of existing airports.

F. Airport-Community Interface: Provides guidelines for planning and implementation of facilities and procedures keyed to preferences and needs of airport's host community

G. Alternatives in Intra-Airport Transportation: An evaluation of innovative options for intra-airport transportation, fostering recognition of intermodal compatibility and compatibility of modes with other airport operations.

H. Improving Passenger Flow: An analysis of passenger flow bottlenecks, providing procedures to decrease terminal area congestion & identifying new or needed technologies which may facilitate passenger flow.

I. Comfort, Convenience, Recreation, Safety & Security: Facility Requirements for Passenger Need Fulfillment: An effort to document passenger needs & cost of accomodation, emphasizing oft-neglected special classes of passengers such as elderly, children, handicapped and extended lay-overs.

J. Passenger Experience & Attitudinal Reactions: Develops guidelines and checklist for airport design or improvement characteristics to optimize passenger assessment of the transportation experience, directing implementation of facility design guidelines developed by the human engineering and environmental psychology disciplines.

K. Financial Self-Sufficiency for Airports: Documents current revenue management practices and evaluates shortcomings and available remedies, proposing alternative multi-concurrent resource utilization strategies to augment airport finances.

L. Reduction of Airfield Turnaround Time: Establishes guidelines for effective, efficient and safe utilization of apron space, ground support facilities and aircraft time.

M. Crisis: Emergency Countermeasures: Supplies airport planners and administrators with guidelines for improved emergency systems and procedures.

N. Air Traffic Control and Scheduling: Evaluates current procedures in air traffic control, documenting weaknesses and proposing expert-validated remedies and policies.

O. Facility Requirements for Future Aircraft Design: Determines compatibility of existing facilities and future aircraft demands, providing specifications for modifications or new construction.

P. Modelling and Simulation of Airport Operations: Reviews and evaluates effectiveness of modelling and simulation techniques developed by U.S. Army Corps of Engineers for design of facilities at Travis AFB for adaptation to planning of civilian airport of the year 2000, specifying areas of high impact of modelling and simulation to yield short-range returns in planning and operations improvement.

Q. Scaling and Dimensional Analysis in Airport Design: A feasibility study investigates the possibility of deriving laws for scaling physical as well as economic and social phenomena related to airport activity.

R. Forecast of Airport Congestion by Digital Simulation from Architect's Sketch: Develops technique to simulate entity flow of distinct constituents such as decisions, information or passengers; entity flow simulation may be utilized to forecast bottlenecks from architect's plan and recommend parameter modifications prior to erroneous and costly construction.

Consolidation & Deletion of Tasks

Subsequent to submission of the interim report including

the task definitions listed above, consultation with NASA monitors Fred Masey and Ed Schairer led to the consensus decision that certain tasks with overlapping or highly interrelated topics be combined for the final developmental stage, the preparation of detailed RFP/proposal documents. Certain other tasks were deleted on the basis of low priority in NASA's scope of interest in airport planning, or low predictable effort/benefit yield.

Reports Completed: The final product of this project is contained within seven documents: six task definitions and a bibliography. The contents of each are summarized below:

1. Site Selection & Growth Potential Factors: an expert validated checklist for airport site selection is developed through an assessment of the effectiveness of current criteria in application and projectible demand parameter modifications arising from new aircraft technology. Examination of factors affecting airport growth and viability including local economics, socio-cultural impact, multiple airport land uses and other airport-community interface components leads to establishment of guidelines for maximal airport-community integration.
2. Emissions and Noise Control/Containment for Airports: A comprehensive assessment of the airport noise and emissions problem defines the nature of aircraft noise and emissions and examines its impact upon the community. The effects and restrictions of abatement legislation and technologies are evaluated, and innovative alternatives for abatement programs are described. Specific

sources and types of emissions and noise of most immediate concern are identified, and alternate or interim approaches are offered to minimize their impact upon the community until such time as technological solutions are developed.

3. Financial and Legal Aspects of Airport Planning, Construction and Operation: Effort is expended in three primary topical categories. (1) Financing, documenting eligibility requirements and specifications of government funding programs. A review of airport case studies aids in determination of categories of airports financed and their sources, culminating in a listing of various agencies providing funds and alternative means available. (2) Government Jurisdictions, a systematic account specifying scope and function of government agencies and institutions concerned with planning and operation of airports, outlining jurisdictional parameters of each, overlapping areas of jurisdiction and past conflicts, and recommended procedures for resolution of jurisdictional disputes. (3) Financial Self-Sufficiency, an examination of case studies to define fiscal parameters which contribute to airport revenues, with identification of business resources in the community which may impell the self-supporting effort.

4. Intra-Airport Transportation & Other Passenger Flow Facilitators: A two-phase effort, beginning with an extensive evaluation of all available, prototype or short-term projected mode or modal combination options in intra-airport transportation, which results in provision of a

"catalogue" of performance profiles for all modes examined and recommendations for mode selection based upon several classes of system demands. In the second phase locational deficiencies and bottlenecks creating congestion and impeding traffic flows are isolated and analyzed, and proposed alternatives and recent innovations in flow facilitation are examined and evaluated. Recommendations are made for new approaches or required technologies, evaluated for feasibility, compatibility, cost/effectiveness and anticipated success in congestion relief.

5. Simulation and Modelling For Airport: An application of recently developed digital computer simulation techniques identifies bottlenecks and deficiencies in real-world or hypothetical airport baggage handling or access route systems, specifying crucial parameters which affect most critically the system's performance. The effect of parametric modifications upon system behavior may be projected, thus providing validation for planner decision-making involving system parameter assignment.

6. Guidelines For Airport Multimodal Access Planning: this study addresses itself to six basic objectives: (1) to project with reasonable certitude the role of the automobile in airport access and the demand for auto access and parking capacity in 1980-1990, and to identify sociological, demographic and technological factors upon which this demand is based. (2) to develop a demand-differentiated hierarchy of preferred public transit modes eligible for airport service in 1980-90 and to abstract

from the technical literature relevant performance measures for each mode. (3) to provide cost/effectiveness/desirability analyses of a number of airport-sponsored mass transit links serving the inner city or peripheral mid-point suburban areas to supplement inadequate or non-existent public transit systems. (4) to establish facility and other resource requirements to accomodate Personal Rapid Transit (PRT) or to allow low-cost conversion to PRT acceptance at a later date. (5) to develop cost/effectiveness measures for congestion-relieving access route design features such as segregated lanes or distinct roadways for buses, trucks and service vehicles. (6) to offer alternatives with adequate support studies for optimal combinations of modes to serve varied needs and a guide to facility requirement compatibilities lending themselves to a multimodal access terminal concept.

7. Airport Planning Bibliography: A listing of approximately 500 titles (with authors, source & publication date), indexed by author name, by topic, and by publication date in three separate sections. No such bibliographic document on airport planning was available at the beginning of this effort.

SITE SELECTION AND GROWTH POTENTIAL FACTORS

OUTLINE

I. Scope & Objectives

II. Technical Approach

- A. Current Site Selection Criteria
  - 1. Documentation and Comparison
  - 2. Case Studies of Representative Airports (N=50) Applications
  - 3. Statistical Analysis of Criteria Effectiveness
  - 4. Validation/Refutation of Standard Criteria
- B. Projected Demand Parameter Modifications
  - 1. Horizon Aircraft Technology
  - 2. Air Traffic Characteristice with STOL Facilitation
- C. Growth Potential: Airport-Community Interface
  - 1. Economic Trends of Candidate Site Environment
  - 2. Economic Impact & Exchange
  - 3. Socio-Cultural Impact & Exchange
  - 4. Multiple Concurrent Land Uses & Community Services
- D. Criteria & Guidelines for Airport Siting
  - 1. Checklist of Criteria with Guidelines
  - 2. Guidelines for Maximal Airport-Community Integration
  - 3. Validation by Experts and Assimilation of Feedback

III. Anticipated Benefits

IV. Selected Articles

V. Bibliography

SITE SELECTION AND GROWTH POTENTIAL FACTORS

SCOPE

No airport can be accurately conceived as an independent, static, isolate entity; it is an interacting component in numerous dynamic systems of regional, national and international scope. The viability, effectiveness and potential for growth of an airport are a function of its relationship with its environment. Thus, two extremely critical factors in airport planning are site selection, the choice of the airport's immediate environment; and the interface of airport and community, wherein it is determined what transactions will occur (and what tradeoffs will be accepted) between the airport and its surroundings.

While the airport planner has the capability to decide for or against a particular plot of land as his site, he is virtually powerless to subsequently change or control its environment. He is thus required not only to select his site and design features to meet demands at the time of initial operation, but also to anticipate and allow adaptability for, demands 20, 30 or 40+ years in the future. Similarly, he must anticipate the developmental trends of the environment, how this will modify the interface of airport and community, and inputs in the initial planning stage which may favorably affect these developments.

OBJECTIVES

- Evaluates effectiveness of current site selection criteria as promulgated by federal agencies, state agencies and planners in the private sector.
- To develop projections of airfield design criteria to accomodate 1980-2000 era aircraft.
- To provide guidelines for community and airport planners for maximization of airport-community integration, with recommendations for alternatives in airport services for the community.
- To inform the airport planner/designer as to the compatibility, economic feasibility and community desirability of various alternatives in concurrent land uses of airport land, such as energy farms, industrial parks, convention centers or sports arenas.
- To develop a site selection checklist and rating procedure incorporating, in addition to updated standard criteria such as existing ground and air transportation networks, topography, weather conditions, etc., considerations for:
  - Projected airfield design criteria for 1980 - 2000 era aircraft.
  - Community development impact of airport construction and operation.
  - Needs of communities near site and likely tone of airport-community relations.
  - Potentials for concurrent land uses.

CURRENT SITE SELECTION CRITERIA

Air transportation is now on the threshold of an era of rapid change; the decentralization of cities, aircraft advances such as the jumbo jet and STOL-craft, and steadily increasing passenger volumes are having and will continue to have marked effects upon the airport and demands placed upon its facilities. The possibility (and wisdom) of new airport construction is being questioned in many quarters now that public furor over emissions and noise has found a new focus upon the airport. The continued dominance and viability of the private automobile in ground transportation is in possible jeopardy due to steadily increasing operating costs, steadily decreasing reliability, its comparative fuel inefficiency and environmental hazards inherent in its inefficient nature. These and other evolutionary factors in transportation are likely to require major changes in the philosophy of airport planning, as the nature of the airport's relationship with aircraft, access systems, the sponsoring public and government undergo changes beyond its control.

Most airport planning decisions may subsequently be modified or rethought, although usually at great expense; runways may be redesigned, new buildings or parking lots constructed or new hardware may be purchased and installed. Airport siting, however, is essentially irreversible; "relocation" would in essence be construction of a new airport with minor savings in terms of relocatable equipment. The current location of the San Diego airport may once have been ideal but is currently evaluated between "undesirable" and "intolerable"; the siting criteria which led to that

choice of site did not reflect or anticipate change in the demographics of the city served, the types and numbers of aircraft eventually accepted, and resultant impact on highway congestion, noise and pollution levels.

An examination of site selection criteria currently in use and the results of their application provides a means of assessing the effectiveness of individual criteria for present situations and insight as to the impact of future changes in air transport and the airport's interfacing factors.

1. Documentation and Comparison of Criteria in Use
   a. Collect principal and secondary criteria and guidelines for airport siting promulgated by government agencies, transportation institution and private sector sources.
   b. Compare the criteria offered by the various sources; Identify lack of agreement on critical factors? Where and how do they differ?
   c. Prepare a composite checklist of siting criteria denoting alternative viewpoints and degree consensus among contributing sources, to form an appendix to the final report.
2. Representative Case Studies of How Criteria Are Applied
   a. Select an adequate sample (N=50) of airports by size and function (e.g., 15 Internationals, 15 Hubs, 15 Regional and 5 Municipal to serve as a testing sample).
   b. Visit 10 15 airports of those selected (several from each size/function category) and interview airport administrators, employees, passengers, and city planners and transportation officials to ascertain each airport's problems and deficiencies.

c. Extend this survey by telephone and letter for the remaining airports in the sample.

d. Is it possible to attribute difficulties identified in (b) and (c) to the choice of site? Would choice of another location have avoided these deficiencies? Which ones?

e. Test the correlation between the standard siting criteria documented previously and the characteristics of the sites actually selected for these airports. Where there is variation among contributing sources on a particular criterion, note which have been followed most often.

3. Statistical Analysis of Criteria Effectiveness.

a. Where alternative criteria are offered, determine whether one is more or less correlated with any particular related problem than the other(s).

b. Identify other relationships of problems and criteria; Does strict application of Criterion X commonly result in prevention of deficiency Y? Do airports exhibiting strict compliance with Criterion X exhibit greater or lesser tendency toward Problem Y than those which appear to deviate towards an unwritten Criterion X_1? (If X_1 displays less tendency toward Y, then perhaps it should replace X).

d. Identify problems which do not seem sensitive to any particular criterion offered; What factors could be responsible which do not appear among the criteria? How does the presence or absence of non-included Factor Z correlate with Problem Y?

4. Validation/Refutation of Standard Criteria

a. Prepare an effectiveness table for criteria which lists each criterion, its s urce, problems it may eliminate and problems it may en nder, with notation of critical statistics; include in appendix to final report.

b. Prepare an evaluation of all criteria, explaining impact in implementation, possible related problems, and parameter modifications, with justifications, which have in some cases, or may, improve upon current results of criterion applications.

c. Show where each criterion has been successful or has failed; note contingent factors which modify the criteria.

d. Prepare tentative revised checklist and guidelines for airport site selection in as detailed a fashion as possible, incorporating justifications and notation of exceptions and contingent modifiers.

PROJECTED DEMAND PARAMETER MODIFICATIONS

1. Horizon Aircraft Technology

a. Collect documentation regarding new aircraft types exhibiting unconventional performance parameters or facility requirements which are presently in conceptual or prototype development.

b. Visit or contact airframe manufacturers and aerospace researchers to obtain further information on projected performance and accomodation requirement parameters for unconventional aircraft foreseeably implemented before or during early 21st century.

c. Ascertain type and degree of impact these new aircraft will have upon;

- airport design, specifically runway & apron configuration
- air traffic control procedures
- obstruction clearance requirements
- noise & emission impact on adjacent areas.

d. Assess need to modify individual siting criteria to integrate these advances; substitute or add criteria as needed.

2. Air Traffic Characteristics with STOL Facilitation

Projections are needed for the type and volume of air traffic tomorrow's airports must accomodate. Specifically, the impact of developments such as STOL-type aircraft upon the major airport must be assessed.

Seven weeks after the Canadian Airtransit system was established, linking the cities of Montreal and Ottawa with frequent service via DeHavilland Twin Otter STOL-craft to STOL-ports nearer the centers of the cities, Airtransit had seized 40% of that airmarket and accordingly eased considerably air traffic loadings on the primary airports serving these cities. While numerous attempts to duplicate this phenomena with STOL service in the United States have failed, perhaps primarily due to inaccurate market analysis and public relations approach, the consensus among transportation planners is that short-haul STOL service will become a reality in the United States, most likely within the next ten years. DeHavilland Corporation has estimated that 73% of North America's small private airports are capable of accepting STOL-craft; since these are typically located more contrally with respect to the city served than the primary commercial airport(s).

These private airfields and specially constructed metropolitan STOL-ports will be the preferred landing sites, with STOL service to primary airports for access/Egress. With well over half the air travel in America being short-haul trips of 500 miles or less (and thus within STOL's practical range) it can be seen that a significant portion - perhaps half - of the air traffic load now sustained by our major airports could be distributed among these smaller airfields subsequent to STOL implementation.

a. Determine consensus or parameters of disagreement among transportation planners concerning likely growth pattern of short-haul STOL air transportation.

b. Define parameters of projected attrition in primary airport traffic loadings attributable to implementation of STOL service..

c. Assess probable impact of these modifications of passenger travel patterns to access route flows, noise concentrated areas and other factors impacting site selection.

d. Make changes as needed to criteria and guidelines under revision, documenting rationales for doing so.

GROWTH POTENTIAL: AIRPORT-COMMUNITY INTERFACE

The two primary factors bearing upon airport viability and growth potential are (1) sustenance of patronage by airlines and passengers, and (2) financial support from the host community for renewal or expansion modifications. The former hinges upon the development of the host community, i.e., its ability to draw visitors into the city via the airport by virtue of its business, industrial, educational or recreational activities. The latter,

financial support from the community itself, is a function of the airport's perceived value and importance from the community perspective.

This, the ideal site for airport construction is situated such that both the immediate vicinity and the general community served are engaged in or entering upon a sustained period of economic and cultural growth which will be augmented by airport installation; it is located so that the airport will not be deemed undesirable by local residents, and will display capacity for activities and services which will tend to maximize the local citizenry's appreciation of the airport's worth to the community.

Clearing defined criteria are needed to enable the airport planner to identify the site which displays the maximum tendency toward these desirable characteristics.

1. Economic Trends of Candidate Site Environment

   a. Compile, review and compare the leading techniques used to assess and project community economic growth.

   b. Distill from these the basic criteria which denote a community capable of sustained, steady growth.

   c. Provide identifying criteria for communities likely to experience a growth "boom" in response to airport installation, and communities which would economically be relatively indifferent to a new airport (if any such can in fact exist); define discriminatory criteria which determine the difference.

   d. Assimilate above findings into new criteria and guidelines or revision to those presently accepted. Criteria should

provide consideration for placement of airport where it will maximally augment local growth.

2. Economic Impact and Exchange

   a. Itemize direct and indirect economic interfaces of airport and community.

   b. What community characteristics tend to maximize airport usage (what generates traffic into/from this city)?

   c. Identify airport operational or site-related characteristics which benefit the local economy.

   d. Devise criteria which aid in identification of sites having optimal potential for mutually beneficial airport-host community economic exchange.

   e. Provide guidelines for maximization of airport financial benefit to community.

3. Socio-Cultural Impact & Exchange

   a. Review sociological and related literature concerning impact of major facility construction on neighborhood ties, community solidarity, reapportionment of school district boundaries and other potential social trauma.

   b. Establish positive and negative criteria drawn from sociological analyses which will aid in site selection in avoidance of socially traumatic impact.

   c. Document ways in which various airports have been socially or culturally advantageous to their communities; are there site characteristics which serve as faccilitative or limiting factors to these activities? Where appropriate and reasonable, devise criteria to facilitate this type of interchange.

d. Provide guidelines for airport-generated or airport-community cooperative efforts to maximize social and cultural benefits to the community of the airport's presence.

4. Concurrent Land Uses & Community Services

To ensure that the airport is perceived by the community as a valuable asset, it must (a) optomize its financial stability so as not to become a fiscal burden, and (2) seek means to serve community needs.

Since zoning protections for airports are often vague and inadequate, a typical recourse to ensure that the areas adjacent to the airport are not subsequently developed undesirably or unsafely has been to purchase much more land at the site than is actually needed, thus creating a "buffer" zone around the periphery of the airport. Alternative uses for this land can be found which contribute to airport revenues and community needs without impeding primary functions of the airport facility.

a. Document case studies or suggestions of innovative uses of airport land.

b. Document restrictions upon land uses dictated by safety and efficiency requirements of airport operation.

c. Consult with experts in many varied industries to ascertain what types of operations their industry could perform under these restrictions and whether location at the airport would be advantageous and feasible for these operations.

d. Similarally, consult recreation specialists to obtain inputs regarding recreational potential of such sites which may provide (1) revenue and/or (2) community service.

e. Where untried airport land uses have been suggested in professional literature, consult experts in the fields concerned for validation of feasibility.

f. Establish guidelines for airport land uses, indicating:

- various uses considered feasible,
- restrictions or contingency criteria to be considered in each specific case,
- potential revenue accruing from each activity,
- community benefits incurred,
- site characteristics required or having an impact upon land use feasibility.

g. Develop "optional" siting criteria relevant to airport land concurrent uses, such that the planner using the criteria may determine (1) whether a site under consideration is adequate for concurrent land uses he has in mind, or (2) what land uses his preferred (or chosen) site seems best suited for.

CRITERIA & GUIDELINES FOR AIRPORT SITING AND GROWTH OPTOMIZATION

1. Checklist of Criteria (with Guidelines)

Assemble both revised and retained criteria in a documentary form suitable for distribution. Individual criteria are to be clearly indicated as falling into one of three categories:

(1) mandatory; required for all sites,

(2) provisional; dependent upon other circumstances/criteria,

(3) optional; related to planners personal choices, such as criteria related to individual concurrent land uses.

Develop a comparative rating procedure by assigning weights to individual criteria or criterion groups and structuring a 5- or 10- point scale for assessment of site characteristics against criteria. Include explanatory rationale for weightings and scoring table (example given in enclosure 1). Package as an appendix to checklist.

2. Guidelines for Maximal Airport-Community Symbiotic Integration

This document will provide a comprehensive view of the interactive relationship of airport and community and the factors contributing to be inhibiting airport viability and growth.

Segregate guidelines into economic and social factors, with recommendations for optomization of each type of transaction between the airport and its host community. Include as a third section the findings on multiple concurrent land uses. As a summary provide recommendations for services this airport can provide to the community which will elevate the community's appreciation of the airport.

3. Validation by Experts and Assimilation of Feedback

Send copies of both documents to several experts in airport and urban planning for validation and response. When possible, visit these experts once they have examined the work. Solicit feedback by visit or letter included with documents; compare and assess feedback received. Any input of high disagreement should be investigated further; query the other experts concerning the dissentive opinion, attempt to approximate consensus.

Prepare final drafts of both documents, having validated and, where needed, modified the content. If unresolved areas of controversy remain, indicate them as such in main body when they appear, and include explanatory section in rear of document.

ANTICIPATED BENEFITS

The site selection checklist provides airport planners with more valid and comprehensive criteria than are presently available. The planner is enabled to project more accurately the effectiveness and viability of his airport in a particular site under consideration than is possible using current siting techniques.

The Guidelines for Optimal Airport-Community Symbiotic Integration provide the planner/administrator with a more accurate conception of the interaction between his facility and the host community upon which it depends. Recommendations are made which will aid in ensuring strong public support of the airport, including means by which the airport may take an even more productive - and visible - part in the local economy, such as concurrent uses of airport land which help the airport create more revenue for its own needs while bringing new cash flow and employment to the community. A clearer understanding of the social effects of the airport's presence and guidelines to optomize these effects ensures that the construction and operation of this airport will not be socially detrimental, but rather a valuable asset to the community.

Emissions and Noise Control/Containment for Airports

Outline

I. Scope of Project

II. Project Objectives

III. Aircraft Emissions Containment
   A. Environmental Effects
      1) Vegetation
      2) Animals
      3) Man-made materials
      4) Weather
   B. Technical Approach

IV. Aircraft Noise Abatement
   A. Areas of Consideration
      1) Public Health
      2) Legal and Regulatory Aspects
      3) Technological Advancements
   B. Technical Approach

V. Anticipated Benefits
   A. Aircraft Emissions
   B. Aircraft Noise

VI. Annotated Bibliography

Emissions and Noise Control/Containment for Airports

Scope of Project:

The problem of aircraft noise and emissions is receiving much attention. This is not necessarily a result of noisier and more polluting aircraft but because jet transportation is markedly greater and also because of the encroachment and increased density of residential communities adjacent to many airports. In addition, the recent concern for environmental protection has brought about objections from the public causing the government to legislate controls pertaining to aircraft noise and emissions. In order for the airport planner to effectively design an airport that is responsive to the community needs, he must have a complete understanding of the scope of this problem. This report will review and interpret recent case studies and reports on aircraft emissions and noise containment to develop comprehensive guidelines which can serve as practical tools for the airport/urban planner.

Objectives of Project:

- Defines the nature of aircraft noise and emmissions and study its impact on the community.
- Describes innovative alternatives for abatement programs.
- Evaluates effects and restrictions of abatement legislation and technologies.
- Identifies specific sources or types of emissions/noise of most immediate concern.
- Offers alternate or interim approaches to minimize impact of emissions/noise on community until such time as technological solutions are developed.

Aircraft Emissions and Containment

It was visible exhaust plumes from jet aircraft engines and exhaust odors which first generated protest against aircraft emissions. These complaints and the growing concern about air pollution lead to many studies into the nature and extent of aircraft emissions. The investigators found that while jet aircraft emit CO (usually the largest percentage of the total aircraft emissions), HC, NO_x, either SO_2 or particulates, and Pb[1], all of which have been found to have some adverse effect on the environment, air carrier emissions only contribute approximately 1-2% of the total air pollution in a metropolitan area.[2] But these reports only measured the specific emissions from aircraft and ground vehicles in the immediate vicinity of the airport and did not take into account the massive diverse ground traffic generated by the airport and the ground vehicles using adjacent airport related industrial and commercial activities. All of these contribute to air pollution in the vicinity of the airport and constitute a vastly greater portion of this than air carrier operations. So far, only a few studies have been proposed[3] to investigate the respective contributions of aircraft, airport induced ground transportation, and other urban sources to air pollution and its indirect effects on the communities surrounding airports. With the predicted increase in aircraft usage and its concentration of activity in certain areas the study of aircraft and airport related air pollution becomes necessary for the airport planner, aircraft designer and government legislating bodies.

[1] Platt, Melvin and E. Karl Bastress, p. 1905

[2] Westfield, William, p. 1437

[3] Sallee, G.P., p. 1333

Aircraft Emissions and Containment

Environmental Effects:

A. Vegetation Of the presently identified jet exhaust pollutants only NO_x has been found to be toxic to vegetation in varying levels of concentration but more must be particularly since many airports are located near farming communities and fields of crops.

- What plants are sensitive to what pollutants in what levels of concentration?

B. Animals Aircraft exhaust emissions are toxic to animals, but there is little information dealing with its effects on animals' activities in their environment. Also, does it have any adverse effect on human activities and does it have more effect on children? What are the long-range effects on animal and human life?

C. Man-made Materials Particulate matter can soil exposed surfaces of buildings and other structures causing an increase in the costs of cleaning and maintenance. It also can increase the corrosability of certain metals. In addition, nitrogen oxides can cause severe dye fading in textile and may weaken cellulosic fibers.[4]

- Can this be prevented or made less severe?
- What effect does this have on property value near airports?

D. Weather There is concern, especially with the advent of the SST, that exhaust products from aircraft may modify the atmosphere enough to cause local or even worldwide changes in the weather.

- What pollutants effect the atmosphere? To what extent, in what concentrations?
- What are the danger limits- how close are we now?
- What are the projections? Can these projections be accepted as valid?

[4] Barth, Delbert S., p. 1404

Aircraft Emissions and Containment

Technical Approach:

A. In order for the airport and urban planner, aircraft designer and legislative bodies to be able to effectively study and understand the aircraft emission problem they will need a concise profile of the exhaust products from the various airport traffic.

- Classify aircraft and estimate their pollutant emissions.
- Determine the composition of the various exhaust products.
- Establish the atmospheric transformations of these emission products.
- Determine relative amounts of emissions from aircraft, airport related ground vehicles, and other airport induced activities to the ambient levels of pollutants in the vicinity of the airport complex.
- Sugest methods and alternatives which will provide safe and economically feasible reductions of airport air pollution.

B. This report provides the airport and urban planner with a necessary comprehensive reference concerning the environmental effects and community impact of airport pollution.

- Identify and st dy medical case histories of specially exposed population groups- such as airport employees, aircrews, frequent travelers, residents and workers in surrounding areas- to determine whether any health problems are related to air pollution from airport complex.

- Study the effects of air pollutants on animal life in its environment- mating and reproduction, feeding, nesting and migration.
- Study the effects of aircraft exhaust odors on the surrounding community.
  - Determine how it is formed, when, where, and how to control it.
- Determine if a significant amount of money is spent on maintaining and cleaning textiles, building and other exposed structures.
  - Research corrosive resistent materials that could be economically used near airports.
  - Recommend methods which would retard the frequent need for maintence.
- Estimate the current and future effects of aircraft emissions on the atmosphere and weather.
  - Determine the chemical composition, quantity and its manner of mixing with the atmosphere.
  - Define pollutant levels which could produce perceivable meteorological effects.
  - Provide parameters of (1) current pollutant levels and (2) projected rates of pollutant accumulation and attainment of weather-impacting levels: State areas of technical controversy and describe investigations completed or underway to assess validity and immediacy of this concern.

Aircraft Noise and Abatement

Public reaction to jet aircraft noise is among the greatest constraints to aviation's growth.[5] It has often been instrumental in delaying or discontinuing airport construction and expansion projects. It has also been responsible for operational restrictions which result in a loss of runway capacity and in airlines' profits. In addition, the public concern with environmental problems has caused federal, state and local governments to enact legislation and regulations controlling aircraft noise. There has been much research into the source, abatement, and impact to the community of aircraft noise. Many advances have been made but the problem is complex and much remains to be accomplished. Because aircraft noise has become an economic, technological, social and political problem the airport planner and manager should be informed of the various aspects involved. This report will emphasise those aspects of the airport planner and manager.

[5] Becker, William B, p. 1936

Aircraft Noise and Abatement

Areas of Consideration:

A. Public Health Considerations Some recent studies suggest that sonic booms and aircraft noise encountered by surrounding airport communities con have adverse effects to its physical and mental health. It can be desruptive to behavior and subjective feelings. It may also be a potential risk to hearing and aggravate other physical ailments.

- What are the long range effects?
- Are there subtle or secondary effects to health?

B. Legal and Regulatory Considerations Public law 90-411 was enacted in July 1968, establishing FAA with the authority and responsibility to regulate the control and abatement of aircraft noise and sonic boom. Many state and local entities are also adopting aircraft noise standards to control noise pollution. So far these laws are limited to the problems of aircraft noise at its source and path. They neglect the need for responsible land use planning and zoning for aircraft noise abatement purposes.

C. Technological Advancements The problem of airplane-generated noise is a complex issue and every feasible measure known to suppress noise is being implemented.[6] Millions of dollars have been spent and many more have been appropriated to achieve as much noise reduction as possible within the safety and design limitations of turbine-propulsion aircraft. Because so much money has been allotted to research in the field of airplane noise suppression this report recommends that only the technological

developments (i.e. SST, VTOL) which will have an impact on the surrounding communities be studied.

[6] Pulling, Ronald W., p. 1416

Aircraft Noise and Abatement

Technical Approach:

A. Public Health Considerations

Evaluate the medical histories of communities subjected to different amounts of aircraft noise exposure to determine if significant affects to physical and mental health occur.

- Determine if any apparent hearing loss occurs, esp. to persons living in airport neighborhoods for many years.
- Do any physiological changes occur, immediately following airplane generated noise and over a long period of time.
- Does adaptation to aircraft noise occur after prolonged exposure.
- Does aircraft noise aggravate or hinder the normal healing of persons already suffering from some type of mental or physical ailment.
- Does it significantly impair the rest and/or sleep of the community.
- Determine if certain age groups are affected more than others and to what extent does this occur.

B. Legal and Regulatory Considerations

This report will provides a comprehensive reference dealing with the legal implications and consequences concerning aircraft noise regulations for the airport manager.

- Describes what power the airport manager has to enforce aircraft noise abatement measures.

- Discusses the legal basis for claims or damages based upon sonic booms and what parties are held responsible.
- Discusses the problem and general outcome of injuctions or damages dealing with aircraft noise.
- Examines the zoning power, if any, that is available and what states are legislating airport zoning laws.
- Suggest innovative incentives and methods from which compatible land use can be locally implemented.

C. Technological Advancements

In order for the airport planner and manager to be fully aware of the state-of-art in the field of aircraft noise abatement he needs to be informed of the technological innovations and their noise impact.

- Establish standardization criteria for new develpments.
  - oo Amount of noise pollution they will contribute.
  - oo Parameters of tolerable or acceptable noise.
- Determine specific types of development which can be accepted within a certain range the airport.
- Summarize what is being developed in the field.

Emissions and Noise Control/Containment for Airports

Anticipated Benefits:

Aircraft Emissions and Containment

- Provides the airport designer and urban developer with a comprehensive profile of the specific emission contributions of aircraft, airport induced traffic ard other airport related activities.
- Documents the total impact of the airport complex and its emissions to the atmosphere and airport environs.
- Recommends various alternatives and procedures for safe and economically feasible reduction of airport induced emissions.

Aircraft Noise and Abatement

- Provides a better understanding into the limitations of the effects of noise upon public health.
- Furnishes the airport manager with a condensed reference of the legal and regulatory considerations dealing with aircraft noise and abatement.
- Documents innovations and technologies noise impact to keep airport manager/designer up to date.

Emissions and Noise Control/Containment for Airports

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Discussion of FAA's scope and role in regulating aircraft noise.

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This paper studies the evolution of jet engine noise reduction developments and the continuing progress that has been accomplished.

U.S. Dept. of Housing and Urban Development, Aircraft Noise Impact-Planning Guidelines for Local Agencies, Washington D.C., November 1972, TE/NA-472, 274 p.

Compilation of aircraft noise studies and reports to serve as an aid in implementation of noise abatement programs and policies. Extensive bibliography included.

Financial and Legal Aspects of Airport Planning, Construction and Operation

OUTLINE

I. Scope of Project

II. Financing

- A. Federal Sources
  - 1) Federal Assistance
  - 2) State Assistance
  - 3) Raised from Taxes
  - 4) General Obligation Bonds
  - 5) Revenue Bonds
  - 6) Bond Banks
  - 7) Private Financing
- B. Technical Approach

III. Coordination of Government Agencies

- A. Areas of Consideration
  - 1) Environmental
  - 2) Land Aspects
- B. Technical Approach

VI. Financial Self-Sufficiency

- A. Airport Management
- B. Technical Approach

V. Anticipated Benefits

- A. Financing
- B. Jurisdictional Considerations
- C. Financial Self-Sufficiency

Financial and Legal Aspects of Airport Planning, Construction and Operation

Scope of Project:

It has been predicted that in the next 10 years a total of $15 billion will be needed in new airport facilities. A unified approach to planning, engineering and financing airport projects is needed to effectively meet these requirements for new or expanded airports. The primary problem is the all-important financing of airport construction. Not only must the usual avenues of financing be examined but alternate and innovative means of providing capital requirements must also be considered. Environmental considerations and community disbenefits can impede the addition of new airports or their modifications. These constrictions must be successfully dealt with. Government agencies involved with financing, environmental policies, and the issuance of regulations relevant to airport planning need to be identified in order to coordinate their policies. Finally, the realization of financial self-sufficiency should be a major concern in airport management and design. The airport management will need to derive airport policies and pricing standards that could eventually generate financial viability. This report will develop usable information for the airport planners and managers in these areas of airport planning, construction and operations.

Project Objectives:

Financing:

- Documentation of eligibility requirements and specifications for government funding programs.
- Review of airport case studies to determine categories of airports financed and sources of funding.
- Compilation of various agencies providing funds for airport development and alternative means available.

Government Jurisdictions:

- Systematic account specifing scope and function of approximately 50 representative government agencies and institutions concerned with planning and operation of airports.
- Outline parameters of jurisdictional scope of each agency.
- Analysis of agencies overlap and conflicts including procedures for resolutions.

Financial Self-Sufficiency:

- Examination of airport case studies to define fiscal parameters which contribute to airport revenues.
- Identification of business resources in a community that can impell the self-supporting effort.

airports development.

- What amount can the state assist in the funding?
- Will state assist in paying for the access roads to the airports?

C. Funds Generated from Taxes - It has become difficult to secure taxpayer approval for financing airport construction. There is a need for research of case studies that have successfully attained taxpayer support.

- Can better PR sell acceptance to the public?

D. General Obligation Bonds - Again it has become increasingly hard to recieve support for bonds as a means to finance airports.

E. Revenue Bonds - This has become the most common approach to funding because it allows an opportunity to provide improvement and construction without direct burden to the taxpayer.

- What are it disadvantages?
- How successful has it been?

F. Bond Bank - A variation of revenue bond financing in which local municipalities issue long-term bonds at a lower interest rate than usual.

G. Private Financing - The private financing of certain facilities such as hangars, fuel distribution systems, hotels etc. is becoming very practical.

- What are advantages-disadvantages?
- What are consequences of using this approach?

Technical Approach:

Federal Level:

- Study and review the requirements and specifications of the government funding prograns.
- Research what type of facilities development it will finance and what amount of money is allotted for the different categories of airports.
- Survey the airports which have received funds from federal agencies over the last 10 years.
- Condense the material reviewed into guidelines that can be used as a reference and a tool by airport planners without having to go to various sources for information.

State Level:

- Determine amount of money available in each state, through what department it can be obtained, what areas of airport development it will finance.
- Itemize each policies and attitudes towards airport development.

Local Level:

- Compile case studies pertaining to airport financing through various sources of funding.
- Recommend the advantages and disadvantages to these different approaches.
- Suggest innovative or alternative proposals for funding airports.

Descriptors: airport economics, cost analysis, feasibility analysis, cost feasibility, trade-offs, economic factors, airport financing.

Coordinating Government Agencies:

A great many federal, state, and local agencies are directly involved with the legislation and enforcement of requirements and regulations that affect airport development and operation. For instance, many airport projects have been suspended since December 31, 1969 - the day the National Environmental Policy Act was made law, requiring that the environmental impact be a major consideration in planning construction of airports or other types of public facilities.[1] Additional delays are created by the Federal requirements that any business displaced by transportation projects, including airports, be relocated before the project can begin. Unfortunately, many states have not yet set up machinery or funds to do this.[2] It has become necessary that a systemic account of the scope and influence of these government agencies, their overlap, conflicts and procedures for resolution, be documented clearly.

A. Environmental - Current concern for the impact on the environment has given rise to legislation that protects communities and ecosystems adjacent to airports. Many laws and studies pertaining to the restrictions of aircraft noise, emissions and the location of airports are being compiled. It is essential that the airport planner be aware what the long-range effect of these demands on airport construction, the cost of meeting these requirements, the availability of sources for funding environmental measures, and conflicts among various environmental agencies.

B. Land Considerations - Conflict and controversies develop from

zoning around airports. Many times different political interests converge at airports and controversy arises as a result of diverse interest involvement. Land-use planning also receives regulations from various levels and frictions occur as to its regulations and uses. Determination of the scope at different levels of government agencies needs to be assessed. Procedures for resolutions of conflict must be documented or proposed where not established.

[1]Schwartz, Adele C., Policy-How to Loosen the Federal Purse Strings, p. 24.

[2]Ibid, p. 25.

Technical Approach:

- Determine agencies and their functions or facilities and their recognized scope of jurisdiction.
- Review agencies requirements and jurisdictions that could affect airport development and operation.
- Identify various agencies' jurisdictional and areas of conflict.
- Ascertain how conflicts are, have been, or might be resolved.

Compile case studies on jurisdictional confrontations and document

- How each was resolved
- If a policy agreement was established

Descriptors: zoning, property assesment, building codes, government agencies, jurisdictional conflicts.

Financial Self-Sufficiency:

Airport management requires financial programs which optimize airport earnings and increase its ability to expand in order to meet the air traffic demand placed upon it. This should be accomplished through facilities which are maintained, operated and priced on a sound business basis. Many airports have been unsuccessful in initiating sufficient revenue to adequately offset operationg costs. A recent study on airport financing by the Aerospace Corp. has found that only the nation's largest air carrier airports-those enplaning and deplaning more than 4 million passengers per year-earn sufficient revenues to meet operating and non-operating expenses and have the ability to finance large capital improvements.[3] It becomes necessary for airport management to develop a proacticable framework of policies and pricing standards that could ultimately produce a financially self-sufficient functioning airport. The purpose of this report is to derive revenue development guidelines for the airport managers and planner by:

- Examination of airport case studies to define fiscal parameters which contribute to airport revenues.
- Identification of the business resources in a community that can impell the self-supporting effort.

[3] Neiss, Joseph A., Economics of Small Air Carrier Airports, p. 10.

Technical Approach:

- Define parameters which contribute to airport cash flow:
  - Typical airport services: maintenance, gas, etc.
  - Shops, car rentals
  - Optional (less conventional): convention center, sports arena
  - Innovative contributors - banks, specialty shops, schools
  - Manufacturers - aircraft manufacturers, boat manufacturers
  - Export centers
- Study fifty test cases, typically 10 different categories of about 5 activities each and investigate profitability of each.
- Divide airport into functional areas and by revenue sources within each functional area.
- Determine the predictable expenses for each of the areas defined.
- Determine approximate amount of usage of given areas and decide how usage relates to the expense of operation and as a revenue source.
- Develop a quantitative rating system to project economic feasibility toward self-sufficeiency.
- Test the rating scheme for usefulness and effectiveness.
- Test the scaling and applicability to different sites (municipal, internal, local) and type of airport.

Descriptors: Revenue development, economic factors, cost effectiveness, assessments, cost analysis, cost reduction, airport management.

Anticipated Benefits:

Financial

- Provides an easily readable condensed review of requirements and specifications for the various levels of government funding that can be used as a guide by airport planners and developers.
- Documents various alternative means available to finance airport construction and modification, citing the advantage and disadvantage of each.

Jurisdictional Considerations

- Determines perceived jurisdiction of governing agencies.
- Establishes outline of jurisdictional territories indicating resolved and unresolvedoverlaps.

Financial Self-Sufficiency

- Provides useful data base and economic feasibility rating procedure to aid in airport business projections and decision making for:
  - Municipal planners and urban developers
  - Land development agencies
  - Chambers of Commerce
  - City and municipal planning commissions
  - Transportation consultants

Annotated Bibliography

The sources used in preparing this report are listed below with a short discussion of the source's scope and content.

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Documents systematic approach to planning airports in large metropolitan areas. Extensive bibliography.

INTRA-AIRPORT TRANSPORTATION & OTHER PASSENGER FLOW FACILITATORS

OUTLINE

I. Scope & Objectives

II. Intra-airport Transportation

- A. Technical Approach
  - 1. Airtrans Analysis
  - 2. Identification of Alternative Modes
  - 3. Performance Analyses
  - 4. Anticipated Passenger Reaction
  - 5. Adaptability & Growth Potential
  - 6. Efficiency - Safety Trade-offs
  - 7. Facility Requirements and Compatibility
  - 8. Economic Feasibility
- B. Recommendations

III. Bottleneck Location & Elimination

- A. Technical Approach
  - 1. Definition of "Bottleneck"
  - 2. Location of Bottlenecks
  - 3. Identification of Causal Procedural Deficiencies
  - 4. Recommendation of Alternative Techniques & Technology
  - 5. Assess Cost/Effectiveness/Desirability of Alternatives
  - 6 Structure Field Tests For Modifications
- B. Recommendations

IV Anticipated Benefits

- A. Intra-Airport Transportation
- B. Bottleneck Location & Elimination

V Selected Articles

VI Bibliography

SCOPE OF THIS EFFORT

As ground area and function distribution of airports and the corollary travel distances continue to increase, the problem of transporting people, baggage and/or cargo within the airport facility becomes one of primary concern to the airport planner. Efficient management and control of these entity flows can only be accomplished with the implementation of a thoughtfully planned and selected intra-airport transportation system. Dallas-Fort Worth, a prototype of sorts for the super-airports of the future, is foreseen as extending at its full development about four miles in length; to cope with this magnitude of function distribution an automated internal transport system called Airtrans was developed and installed. While Airtrans is not the ideal system, it is the first clear step in the direction of incorporating intra-airport transit in the initial terminal design, and as such should be analyzed carefully for the underlying causes of its advantages and inadequacies so that subsequent systems may represent improvement. In addition, the consideration of the actual operating performance of Airtrans provides some tangible basis for comparison with other prototype or conceptual systems under consideration.

As traffic volume increases, bottlenecks impeding passenger flow impose increasingly greater costs to the airport in man-hours and efficiency reduction due to increased congestion. If future traffic volumes increase at projected rates and improvements are not made in the efficiency of passenger processing and flow, the effectiveness of the airport could conceivably be severely handicapped. The locations of and processes entailing bottlenecks must be identified and analyzed so that recommendations of modified processes or technology may be addressed to the actual causal relationships rather than to surface symptoms alone.

OBJECTIVES

To recommend alternatives in intra-airport transportation, modes and modal combinations of high compatibility are examined, using the Dallas-Fort Worth Airtrans system as a known standard, with emphasis on specific performance requirements:

- Basic System Performance Data, such as passenger capacity, speed, acceleration/stopping rates, etc.
- Anticipated Passenger Reactions
- Adaptability & Growth Potential
- Efficiency-Safety Tradeoffs
- Facility Requirements & Compatibility
- Economic Feasibility

Recommendations are made for intra-airport transit mode selection based upon several classes of system demands. An appendix of system "performance profiles" provides detailed information on each system evaluated upon the above criteria categories.

In the second phase locational deficiencies and bottlenecks creating congestion and impeding traffic flows are identified:

- Factors and processes leading to congestion are isolated and analyzed
- Proposed alternatives and recent innovations in flow facilitation are examined and evaluated.
- Recommendations are made for new approaches or required technologies, evaluated for feasibility, compatibility, cost/effectiveness and anticipated success in congestion relief.

INTRA-AIRPORT TRANSPORTATION

A painstaking analysis of the Dallas-Fort Worth Airtrans system and the actual effectiveness of that system provides a measure of known values against which other proposed systems may be weighed to confidently project the utility and effectiveness of each. The steps in the evaluation process to which each mode will be subjected correspond to the primary concerns of the airport planner: Can it do the job effectively? Will the passenger react favorably to this type of system? Can it expand easily to meet increased future demands? Can it operate safely with optimal or claimed efficiency? What are the requirements for its facilities and how does this affect other airport functions? Can we afford this system, and is it worth the cost?

Technical Approach

1. Airtrans Analysis
   a. Review all available descriptive and evaluative literature on Airtrans.
   b. Observe Airtrans in operation: talk to passengers, operating personnel and airport management concerning system problems and strengths.
   c. Develop a "performance profile" on Airtrans denoting areas of adequacy and deficiency and corollary performance parameters.
   d. As evaluation of other modes (below) proceeds, evaluate Airtrans along the same criteria to establish a standard for comparisons.
2. Identification Of Alternative Modes

The numerous intra-facility transit systems now undergoing field, prototype or conceptual development must be identified and their performance parameters documented prior to actual evaluation or comparison. To this end:

   a. Review all published materials regarding the function and performance of these systems.
   b. Visit designers of these systems to obtain more specific information.

c. Observe, where possible, systems operating in real or experimental settings.

3. Basic Performance Data

Assemble profiles of each mode/system, to comprise an appendix to the final report, documenting all quantitative data on system performance such as:

a. Passenger capacity per vehicle (module)

b. Cruise speed

c. Standing time at each stop

d. Acceleration-deceleration "g" forces

e. Acquisition and installation costs

f. Operating and maintenance costs

g. Costs per seat/mile in varying passenger volumes

4. Anticipated Passenger Reaction

The primary concerns of the passenger are comfort, convenience and security: if a system is so designed that the passenger is uncomfortable due to overcrowding, must carry luggage through a maze of turnstiles or decipher complex route maps to determine his destination, or he/she is made to feel unsafe due to a history of minor electrical failures such as has plagued Airtrans, a significant number of passengers may attempt to avoid use of the system. This would usually be accomplished through one of two alternatives, both undesirable to the airport management; (1) use of taxis to reach other destinations within the airport, thereby augmenting access system overloads, or (2) avoidance of that airport when possible in favor of another. Thus projections are needed for passenger reactions to the systems under scrutiny, based upon such criteria as:

a. Seating; How dense is the seating arrangement? Must the passenger sit face - to = face with a stranger in close proximity?

b. Aisles; Are they sufficiently broad to simply walk down them, or must one pick one's way through feet, luggage, etc.? Can they be negotiated via wheelchair or crutches?

c. Luggage; Is it carried onto the system by the passenger, or loaded outboard by service personnel? If passenger must carry, must it be lifted overhead for storage? How is it ensured that the aisles will not become filled with baggage?

d. Motion; How much perceived motion does the passenger sense? Excessive bouncing, sway, acceleration or braking forces? How smooth is the riding sensation in general?

e. Vehicle entrance/exit; Must the passenger negotiate steps or stairs? What provisions for wheelchairs and crutches?

f. Route Selection; Must the passenger choose between vehicles or routes? What means is provided for discrimination between choices? What potential exists for passenger confusion and error?

g. Perceived Safety; Does the passenger feel safe? Is a human operator on board, or does the passenger conceivably feel himself at the mercy or a machine?

h. Passenger-Vehicle Relations; What is the likely emotional response - will the system seem harsh and impersonal or friendly and concerned to a weary traveler?

5. Adaptability & Growth Potential

The single most prominent problem of today's airports seems to be growth capacity. New and vastly increased demands upon passenger and aircraft acceptance capabilities of older designs which did not foreseee loadings of the magnitude now imposed create severe problems concerning efficiency and safety. Dallas-Fort Worth again sets an example with its "modular" approach entailing a basic design suited to present demands as a component core to a fully developed master plan for a super-port projected to attain full growth near the turn of the century - 25 years after commencement of airport operations. It is of primary concern to the planner to ensure that all systems within his design will be able to be easily expanded to meet future load demands as

dictated by maximum airfield capacity of the fully matured airport. The alternative intra-airport transportation systems must be assessed for this potential by application of the following criteria;

a. Is this a vehicle-module system? Can capacity upon existing routes be expanded simply by adding more vehicle units to the system? To what limit?

b. Is this a route-module system? Can new routes be 'plugged in', or is a total redesign of the system required?

c. Would modifications for expansion require a total system shutdown? A partial shutdown? For how long?

d. Will the components of the system be a production item, or "one-offs" to build this particular system? Will additional vehicles, guideways, etc. be available in 10 years if/when needed for expansion?

e. What are the costs of expansion?

f. What impact upon existing architecture to expand through a new wing of a terminal? Can system be adapted to serve conventional structures, or are extensive modifications of buildings required for tunnels, etc.?

6. Efficiency-Safety Tradeoffs

Frequently efficiency and safety are juxtaposed in a tradeoff manner such that the maximization of one can only be achieved at the expense of reducing the other. Hence it must be ensured that (1) adequate safety considerations are inherent in the design concept, and (2) that these safety factors are realistically represented in the performance data promulgated by the system designers. An assessment of the systems' safety and efficiency under proposed safeguards is attainable by determination of:

a. Do all critical sub-systems, such as propulsion, braking, suspension and exits, have 'fail-safe' backup or override systems which ensure safe recovery from intra-system breakdowns?

b. Do backups/overrides exist to cope with extra-system difficulties?

c. Is allowance made for human fallability? Do automated systems allow for delays due to slow-boarding passengers?

d. How vulnerable is it to vandalism or terrorism?

e. How can a passenger manage to get hurt? How is this prevented or made unlikely? Can improvements be made? At what cost in dollars and efficiency?

f. Do published performance data reflect all needed safety considerations? Or do they presume that passengers will board and seat themselves within a set time period before acceleration which may be dangerous to an unstable standing or walking passenger?

7. Facility Requirements and Compatibility

The interface of the transportation system and the various parts of the airport which it serves is crucial to proper mode selection and design of the airport as a whole. A determination of the required support facilities and architectural design features, and the compatibility of these facilities and their functions with adjoining activities is required to avoid efficiency-reducing conflicts and bottlenecks. It thus becomes necessary to define:

a. Structure Requirements: Tunnels, guideways, piers, supporting structures, etc.

b. Space Requirements: Ground area at pickup points, pathway height & breadth, storage, machinery and maintenance spaces.

c. 'Retrofit' Installation: To be installed during expansion modification of existing airport, what types of construction/modification is required? Will this impinge upon existing facilities/functions?

d. System Activity: Points served would usually include boarding & arrival gates, ticket counters, baggage claim, customs, lounges & parking lots; do any conflicts possibly exist between these activities and operation of the system? Congestion potential? Are there noise- or odor-generating components which should be isolated?

8. Economic Feasibility

Once the airport planner knows that certain systems can meet his needs, he then must apply the ultimate criterion, money, in order to select one particular system from the many which may be adequate. An assessment of the economic feasibility of each must consider the costs of acquisition, installation, operation and maintenance over the life-cycle of the system, and passenger fares at projected volumes which would balance these costs.

a. Select three large airports representing different layout concepts - such as JFK, San Francisco and Dallas-Fort Worth - and for each transportation system under consideration design a circuit or route plan to interconnect boarding and arrival gates, ticket counters, baggage claim, customs, immigration, ancillary passenger services and parking lots. Use identical routes for as many systems as is practical at each airport to maximize ease of comparison, but employ most efficient routing of each.

For Each System: (b thru g)

b. Calculate acquisition costs for vehicles & equipment required to accomodate passenger volume presently handled and volume anticipated by 2000.

c. Calculate cost of installation at these existing airports.

d. Estimate cost of construction of system if integrated with initial construction of airports identical to these examples.

e. Project operation and maintenance costs over a 25-year period.

f. Project total costs for a tentative 25-year life cycle of system acquisition, construction, operation and maintenance.

g. Estimate costs per trip, or passenger fares which would pay off total costs in 25 years.

Recommendations

The final report on this phase of the effort will include, as an appendix, performance profiles on each system considered with notations relating to the evaluation criteria applied. The main body of the report will document the application of the criteria to each system, evaluative decisions made (and their supportive warrants) and comparative effectiveness and feasibility of the systems under the criteria. Recommendations will be made as to:

- System selection based upon variables of passenger volume, function distribution and funds available.
- Types of applications for which each system seems best suited.
- Possible combinations of modes to serve different functions: i.e., one system may be ideal for intra-terminal service while another is best for terminal-parking lot travel. Such recommendations of combinations must be justified by application of the same criteria.

PHASE II: BOTTLENECK LOCATION & ELIMINATION

While there exists theoretically no reason why an enplaning passenger could not enter the airport, check his bags, buy his ticket or check in, proceed to the gate and board his plane, all in the space of perhaps 5 minutes, in actuality this process typically takes 30 minutes or longer. A simulation model of a passenger passing through the airport would probably show that total process time to enplane breaks down roughly as 40% queueing time (lines) 40% proceed time (from transaction to transaction) and only about 20% actual activity (performing necessary transactions). Implementation of an effective intra-airport transportation system can significantly reduce proceed time (provided its own queueing time is reasonable); the next step in optomizing passenger flow through the terminal facility is the identification and elimination of bottlenecks which generate queues, congestion and short tempers.

Technical Approach

1. Definition of Bottleneck

For these purposes, "bottleneck" refers to the causal factors and origin point of queueing or proceed time (unproductive time expended) on the part of the enplaning or deplaning passenger, who is attempting to complete a prescribed set of transactions within the airport en route to an airside or landside departure from the airport.

2. Location of Bottlenecks

Initially the locations at which bottlenecks occur must be identified so that each may be studied in depth.

a. Study passenger flows through three airports; time-plot the flow of 100 enplaning and 100 deplaning passengers, noting time expended proceeding to, queueing for, and performing each transaction.

b. Rank-order transaction points for bottleneck value; i.e., which transactions result in the longest queueing times? Between which transactions do the greatest proceed times occur?

3. Identification of Causal Procedural Deficiencies
   a. For each bottleneck location devise a flowchart representing each phase of the transaction and time plot for procedure.
   b. Which procedural steps are unnecessarily time-consuming?
   c. What sub-processes contribute to the activity time duration of the transaction?
   d. What are the time-consuming steps in these sub-processes?
4. Tentative Recommendations for Alternative Techniques & Technologies
   a. Review all literature relevant to airport operation procedures for information on passenger processing techniques & technology.
   b. What innovations have been successfully implemented? By whom, where? What suggested innovations are as yet untried?
   c. Consult authors or implementors of recently implemented or conceptual innovations for detailed information.
   d. Devise original innovative techniques & technology for passenger processing facilitation.
5. Assessment of Cost, Effectiveness & Desirability of Alternatives
   a. Document (or estimate if untested) costs of implementation of each innovation, including impact on labor costs, cost of employee training, amd equipment costs.
   b. Evaluate effectiveness of each: if available, document results of tests performed, with close examination of 'realism' of experimental situations. To what extent does each innovation reduce queueing and resultant congestion? How reliable is this innovation? How does it function under extreme loads?

c. Determine whether each would pose greater, lesser or equivalent demands upon the passenger as compared with current procedures. Given a choice, would most passengers prefer to do things this way?

6. Structuring of Field Tests of Innovations

If certain innovations, which are at present only in a conceptual stage of development, appear from the cost/effectiveness/desirability analysis to show considerable promise:

a. Structure testing procedures by which they can be tested in application, preferably in an actual airport operation situation but alternatively under simulated circumstances.

b. Consult airport/airline administrators to assess feasibility of performing such tests at their facilities (presumably to their benefit).

c. Perform such tests as are possible; document and assess results.

Recommendations

In addition to a summary, analysis and evaluation of recent innovations in optimal-efficiency passenger processing, recommendations are provided for:

- Innovations of high projectible success which warrant immediate widespread implementation.
- Innovations of high projectible success under certain prescribed conditions, which may be successfully employed at specific types of airports or to certain demand situations.
- Field testing of certain innovative concepts which hold great promise but are presently unexplored or neglected.

ANTICIPATED BENEFITS

The Intra-Airport Transportation phase provides the airport planner with a thoroughly documented summary of the state-of-the-art in intra-facility transit systems. Carefully documented evaluation of the modes available results in precise recommendations for matching systems with airport needs.

The Bottleneck Location & Elimination phase provides the planner and administrator with an insight into the mechanics of passenger flow, how bottlenecks develop, and recent innovative techniques and technology which can produce maximal efficiency in passenger handling at minimal cost. In addition, groundwork is laid out for follow-up investigation of promising innovations, the testing of which lies beyond the scope and budget of this effort.

SIMULATION AND MODELLING FOR AIRPORT

OUTLINE

I Scope of Work

II Overview of Airport Simulation

1. Simulating Passenger Airway at Airports
2. Air/Ground Interface Simulation
3. Evaluation of Airport Baggage Handling Facilities
4. Use of Simulation in Cargo Facility Design
5. Simulation of Bank Customer Flow: An Analog for Passenger Processing at the Terminal

III Objectives

IV Technical Approach

V Deliverable Items

VI Anticipated Benefits

VII Related Articles

VIII Bibliography

Scope of Work

Designing and evaluation of airport operations such as baggage handling, access and service routes is not now responsive to the increasing complexity of airport planning. Technological - sociological - economical constraints are superimposed on the staggering task of processing more and more passengers, freight, and baggage. To illustrate: baggage flow parameters depend upon facility layout, construction, and equipment, typically loading docks, transfer stations, storage areas, and type of equipment used. If planning had been responsive to need, flow patterns due to increased use of jumbo jets should have been simulated to predict severe stresses on airport facilities. Deficiencies in facility construction should be detected before they occur rather than relying on remedial action subsequent to costly implementation. "Band-aid" solutions are more costly still - when an airport terminal design is proven inadequate, remedial measures such as replacing the baggage transportation carts or expanding the baggage handling system itself are employed. Needed now are improved concepts for strategic planning of an airport. Proposed in the following section is an investigation of

(i) bottlenecks in a baggage handling system,

(ii) of congestion in passenger flow through access systems to the area, and

(iii) the applicability of the modular network simulation technique for modeling airport problems.

Modelling for Digital Simulation

Digital simulation extends predictability where analytical methods are limited on account of data quantities, interacting paramenters or flow characteristics. Modular network simulation techniques developed during the past three years (Ref. 1-20) provide a fresh start to understand dynamic behaviour, such as airport congestion. This modelling approach is based on a network formulation commonly referred to as the HAD (Happ, Akiba, Dabaghian) modular network technique. The technique is unique since it meets the need for a clearly defined interface between the description of the system and the corresponding computer readable modules, provided by a library of modules. These modules are characterized by "primitives" common to every system or environment. In turn, interchangeable modelling units are structured from elementary logic processing components. The components are provided by many user-oriented programming languages, an example is GERTS GQ an acronym for Graphical Evaluation and Review Technique Simulation, using Gated Queue node as one of its primitives.

Overview: Simulation Applications for Airports

Simulation: Since the advent of digital computers a plethora of powerful analytical tools have had a permanent impact. Among these, simulation is vital

(i) for planning, designing and forecasting transportation needs;

(ii) for assessing effectiveness of facilities such as airports designed in response to needs prior to their actual construction;

(iii) for evaluating alternatives in design or approach under normal and exceptional loading.

As defined by Martin Shubic[1], "A simulation of a system or an organism is the operation of a model of simulator which is a representation of the system or organism. The model is amenable to manipulations which would be impossible, too expensive or impractical to perform on the entity or prototype. The operation of the model can be studied and, from it, projections concerning the behavior of the actual system or its subsystems can be inferred".

Thus, simulation is a technique to model the real-world situation and to conduct experiments representing parametric modifications to the real-world system. Simulation will not solve the problems but will detect the deficiencies and bottlenecks residing within the system: once the model of the system has been validated (shown to behave identically to the system it represents), changes in the model can be made to predict benefits or problems which would result from such changes being made in the real-world system.

What Problems Have Been Investigated?

1. Simulating passenger arrivals at airports.

The model which was simulated was designed for the evaluation of expansion plans for International Arrivals at John F. Kennedy International Airport[2]. The system considered had three major components;

- Federal Inspection,
- Baggage Claim Area Assignment and
- Matching of Passengers with their Baggage,

each of which was broken down into several sub-systems.

After the model had been written in GPSS II and validated for accuracy, changes in parameters highlighted the critical importance of the primary inspection process for international passengers. Alterations of the model in the baggage claims section resulted in improved operations which were implemented in the Spring of 1970.

In addition to improved understanding of the interfaces among the three major components in this system, the simulation model has provided the means for all concerned planning entities to evaluate alternatives and gain insight into the impact one particular decision may have upon the system as a whole.

2. Air/Ground Interface Simulation

This study was initiated in 1967 by the Transportation Research and Planning office of the Ford Motor Co. at the Salt Lake City, Utah airport[3]. Their objective was the simulation of a novel transportation interface system involving separation of aircraft parking positions from this terminal building and utilization of dynamic gate assignments. The feasibility and operational

behavior of such a system was investigated through an "Air/Ground Interface Simulation" written in the GPSS/360 simulation language.

Studies were conducted in the areas of:

- Arriving and Departing Passenger Flow,
- Gate Requirements,
- Vehicle Requirements, and
- Effect of Terminal Offset Distance,

each of which was examined through three versions of the model;

(1) The basic model, which simulated the transfer system between the terminal and the aircraft;

(2) The separate loop model, which includes the basic model and additionally simulates a separate transfer system between the airport and the motropolitan CBD transportation center; and

(3) The integrated system model, through which the passenger could ride from the transportation center to his aircraft without transfer.

This investigation exemplifies the applicability of computer simulation techniques for planning and evaluation of alternate designs for airports prior to erroneous and costly construction.

3. Evaluation of Airport Bagge Handling Facilities.

3.1 Simulation models of airport baggage handling systems.

Hypothetical baggage handling systems for large-capacity aircraft were modelled by Gerald L. Robinson of the Battelle Memorial Institute using GPSS III[4].

The study investigated:

(1) average delay for individual passengers,

(2) standard deviation of this individual delay,

(3) maximum delay for individuals, and

(4) total delay for all passengers, in "passenger hours".

This study shows how baggage handling system may be evaluated via computer simulation, but was unfortunately conducted with very limited capabilities.

3.2 Modular Approach for Modelling Baggage-Handling Systems.

Materials and decision flow for baggage transfer in an airport was investigated by Y. Akiba of California State University at Sacramento[5]. A logical plan to analyze process interactions and to explore alternative resource allocation effects was developed using the Modular Network Simulation Technique. The procedure entails modelling and simulating a representative material transfer cycle involving carts, shipping containers and related handling equipment.

4. Use of Simulation in Cargo Facility Design

4.1 Work by Corps of Engineers, Champaign

The cargo handling aspect of traffic flow in an air freight terminal complex and the cargo flow patterns are simulated. An investigation at the Construction Engineering Research Laboratory (CERL) by Happ and Porte[6], supported by the office of the Chief of Engineers, established a computer simulation model relating facility parameters to traffic flow at an air cargo terminal. The model was simulated by GERTS IIIQ technique and exercised to forecast deficiencies in air terminal design with respect to projected cargo flow.

4.2 Work at UCLA/Travis AFB

To cope with vast increases in cargo handling requirements brought about by the introduction of the jumbo jet, a new cargo

handling system proposed by Dortech was implemented. Dortech's approach utilizes towline carts for station-to-station transfer within the cargo terminal and stacker bins for aggregation of cargo for future shipments. The parameter study of the Dortech approach by means of a GERTS III Q simulation model was conducted at UCLA by Porte, Happ, Lee and McNamee[7]. With steady state conditions, the critical bottleneck areas were studied for average system performance.

4.3 Work at CSU, Sacramento

Network elements from the GERTS III Q language have been assembled into "modules" simulating entity-handling processes frequently recurring in activities. A library of modules facilitates modelling of complex multi-server queueing problems by combining modules into networks.

These modular techniques have been applied by Happ, Akiba and Dabaghian at CSUS to the analysis of an air cargo terminal facility[8]. Emphasis has been placed upon the development and validation of a comprehensive and powerful modular technique.

5. Simulation of Bank Customer Flow: An Analog for Passenger Processing at the Terminal

Customer flow and congestion in a bank, involving processes analogous to terminal passenger processing operations, were analyzed using the modular network approach by Akiba and Dabaghian at California State University, Sacramento.[9]

Repeated computer executions of the simulation program permit the collection of statistics at strategic points in the system allowing inference of system performance measures such as mean queueing lengths, typical processing and service times,

average busy time for each manager and each teller, and the average number of balkers from the system per unit time. Access to pertinent system information is both timely and in a format acceptable and useful to management. Bottlenecks and slack areas are readily identified; increasing customer arrival rates will eventually cause queueing and/or balking measure to become unacceptable at critical locations. Vulnerability studies forecasting performance under varying conditions of system impairment --one manager absent, both, one or more teller out, etc.--are readily carried out. Minor structural revisions of the model permit performance comparisons between competing systems.

Objectives

- Demonstrates the applicability of the modular network simulation technique to airport planning decision-making.
- Identifies bottlenecks and deficiencies in real-world or hypothetical airport baggage handling and access route systems.
- Specifies crucial parameters which affect most critically system performance.
- Projects effect of parametric modifications upon system behavior.
- Provides validation for planner decision-making involving system parameter assignment.

Technical Approach

Work Statement: Each phase's work hours represent student time.

Phase 1: Problem Identification (240 hrs.)

(1) Personal contact with an engineer working in industry who will serve as advisor.

(2) Undertaking a detailed review of technical publications related to this problem.

(3) Documenting the specific problem is a 2 - 5 page report.

Phase 2: Modeling and Validation of Simulator (240 hrs.)

(1) Construct the simulation models of proposed systems.

(2) Validate the models against the proposed systems.

Phase 3: Design of Computer Experiments (480 hrs.)

(1) Conduct parametric study for the proposed systems.

(2) Evaluate improvements need by identification of operational bottlenecks.

Phase 4: Follow-up and Documentation (280 hrs.)

(1) Document Phase 1 - Phase 3.

(2) Evaluation of user responses.

(3) Preparation of User's manual.

Deliverable Items

- Concise review of existing airport simulation.
- Simulation models of representative baggage handling system and access and service roads.
- Identification of operational bottlenecks in baggage and access systems.
- Construction strategies to eliminate or compensate for such bottlenecks.
- Identification of effects on system paramenters when a component is eliminated and how such component modification will change the performance of the system.

ANTICIPATED BENEFITS

The user-oriented method developed here can be used by airport planners, engineers, and managers who are familiar with their airport operations and permits:

- traffic flow to be exercised in alternate options;
- a more rational approach to evaluate an architect's plans against projected traffic, volume and demands;
- an evaluation of the effectiveness of these techniques towards planning and operation for the integrated airport of the year 2000;
- specification of areas of high impact of modelling and simulation to yield short-range return in planning and improving airport operations.

This investigation will provide further understanding of the existing airport operations, identify the bottlenecks and/or forecast possible bottlenecks from architects plan and recommended parameter modifications prior to erroneous and costly construction. In addition to this, anticipated benefits from the modular network simulation are:

- alternatives of a resource assignment can be explored on the basis of explicit assumptions;
- the resultant effect of component changes on system productivity can be studied;
- decisions on subsystems need not be distracted unnecessarily by the complexity of the entire system;
- system weaknesses residing in each component can be identified;

- vulnerability analysis pinpoints the most crucial parameters; for example, in the baggage handling process the cart travel and return time may be the critical factor for the baggage transfer time, and
- sensitivity analysis detects important incremental changes of parameters in the system.

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GUIDELINES FOR AIRPORT MULTIMODAL ACCESS PLANNING

Scope

Until recently, the problem of passenger transportation to and from the airport has not been held to be an essential consideration in airport design. However, current access route congestion difficulties have had such an adverse effect upon the efficiency of primary airport operations as to make airport access a matter of direct concern to the airport designer/planner and administrator. The purpose of this effort is to provide information and guidelines on various aspects of this problem, thus contributing to a more thoughtful approach to access planning.

Objectives

A. To project with reasonable certitude the role of the automobile in airport access and the demand for auto access and parking capacity in 1980 - 1990, and to identify sociological, demographic and technological factors upon which this demand is based.

B. To develop a demand-differentiated hierarchy of preferred public transit modes eligible for airport service in 1980 - 90 and to abstract from the technical literature relevant performance measures for each mode.

C. To provide cost/effectiveness/desirability analyses of a number of airport-sponsored mass transit links serving the inner city or peripheral mid-point suburban areas to supplement inadequate or non-existent public transit systems.

D. To establish facility and other resource requirements to accomodate Personal Rapid Transit (PRT) or to allow low-cost conversion to PRT acceptance at a later date.

E. To develop cost/effectiveness measures for congestion-relievirg access route design features such as segregated lanes or distinct roadways for buses, trucks and service vehicles.

F. To offer alternatives with adequate support studies for optimal combinations of modes to serve varied needs and a guide to facility requirement compatibilities lending themselves to a multimodal access terminal concept.

SPECIFIC AREAS OF WORK (4000 hours)

A. Role of the Automobile in Airport Access (500 hours)

B. Public Transit Mode Selection (1000 hours)

C. Airport-Operated Transit Links (500 hours)

D. Acceptance Capability for Personal Rapid Transit (750 hours)

E. Congestion-Relieving Access Design Features (500 hours)

F. Multimodal Airport Access Terminal (750 hours)

A. ROLE OF THE AUTOMOBILE IN AIRPORT ACCESS

When public transit between population centers and the airport is unavailable or inadequate, the private or rented car because of cost is preferred over privately-owned public carriers such as limousines and taxis. Assuming that by the turn of the century most areas capable of supporting an airport are expected to implement at least one public transport mode, will this result in a significant reduction in auto usage for airport access? Current planning guidelines call for 2.5 parking spaces per peak hour passenger. Will continued acceptance of this scale result in wasted, empty parking lots? Will the mystique of the private auto prevail?

Objectives

- To project the impact of full-scale mass transit implementation upon automobile usage for airport access.
- To establish design criteria and guidelines for access route and parking design based upon these projections.

Technical Approach (500 hours)

a. Assemble six case studies of airports recently receiving new public mass transit service.

b. Document impact of mass transit implementation on passenger:automobile acceptance ratios.

c. Extract from statistical data and forecasts on travel habits projections as to automobile usage trends assuming that mass transit systems continue to evolve and develop.

d. Examine case studies of urban transportation networks to extract trends in impact upon auto usage and congestion due to mass transit implementation.

e. Establish design criteria and guidelines based on summaries and evaluation of information developed in a, b, c & d: project parameters meters of auto usage reduction in airport access with implementation of adequate mass transit access systems. Recommend scaling ratios relating access road and parking capacity to passenger volume.

B. PUBLIC TRANSIT MODE SELECTION

The newfound public awareness of the need for energy conservation and skyrocketing gasoline costs have rendered use of the private auto less attractive and thus ensured the acceptance and growth of public mass transit, wherein lies the most obvious hope for relief of access congestion. Public transit mode selection is decided not by the airport but by regional and municipal planning and transportation agencies; however, such planning bodies will better serve their constituents by examining in greater detail the modal preferences related to airport service needs.

Objectives

- To determine in depth preference structures for airport public transit mode selection keyed to representative demand situations.
- To establish definitive guidelines in a form useful to planning agencies for the interpretation and utilization of these preference structures.

Technical Approach (1000 hours)

a. Assemble available relevant descriptive and performance data on all innovative as well as evolutionary conventional mass transit modes anticipated available for implementation in the 1980 - 2000 period.

b. Prepare comparison analyses from data on each mode to include criteria such as:

- Performance effectiveness: cruising speeds, stopping distances, turnaround time at enroute stops, etc.
- Safety: during operation, fire hazards, crash safety,...
- Terminal area facility requirements: space, structures, personnel, costs,...

- Pathway requirements: road/railbeds, guideways, tunnels, costs per mile,...
- Passenger desirability: comfort, convenience, privacy, security,...
- Total costs of acquisition, construction, operation and maintenance
- Fare:passenger volume ratios for self-sufficiency of system.

c. From results of case studies in Section A (Role of Automobile) assess the factors causing one transit system to have greater or lesser impact on auto usage than another and extrapolate where possible to corrolary characteristics of anticipated systems.

d. Rank-order systems, documenting justifications and rationales for rankings, in order of preference for five levels:
   - of annual passenger volume, ranging from the small regional facility enplaning less than 500,000 to the super-airport handling 20 million annual departures.
   - of population center - airport distance, ranging from 10 - 75 miles.
   - of proximity to adequate links with operating public transit modes, from 10 - 50 miles.
   - of en-route developments; residential, agricultural, business, industrial, & natural (unspoiled).
   - of travel time for same trip by private auto (0.5 to 2.5 hours).

e. Establish (tentative) sample weights for each ranking criterion; develop overall scoring system with negative point structure (1 pt. for 1st ranked, 2 for 2nd, etc.) such that each mode/system can be assigned an overall score for a particular set of criteria selected from the 5 categories (e.g., a score for each mode for a situation entailing four million annual passengers, 20 miles from population centers, 15 miles from transit links, passing through residential areas, with equivalent travel time by auto 30 minutes; and for each other possible combination

of variables).

f. Rank all modes for each combination of criteria.

g. Identify combinations of two modes which score best for each set of criteria.

h. Identify three-mode combinations best for each criteria combination.

i. Deliverable item is a handbook of guidelines for airport public transit mode selection. The handbook will consist of an assembly of items a - h above, indicating five rank-ordered best choices for each set of parameters and anticipated costs of each, with justifications of choices and with appendix of descriptive/performance data for each candidate mode.

C. AIRPORT - OPERATED TRANSIT LINKS

At many airports public transit systems offer only a few trips daily, typically for airports in remote locations. Alternatives for providing adequate departure frequency include:

(i) airport-operated transportation directly to and from population centers;

(ii) a link with some midway point in the peripheral suburbs which can be served at considerably less cost than the metropolis itself by an airport-sponsored system.

(iii) In addition to the modes considered for a public transit system, there is another candidate which may be well-suited for this short-haul application. The recently introduced "park 'n ride" systems featuring easily accessible parking lot/terminalscomplexes in sub-urban areas serving one or more metropolitan terminals with mini-buses on a high departure frequency have generally been highly successful both financially and as a means of alleviating highway congestion where public transit is inadequate.

Objectives

- To evaluate utility and feasibility of "park 'n ride" systems for airport access.
- To provide guidelines for airport-sponsored access systems keyed to representative demand situations.

Technical Approach (500 hours)

a. Assemble case studies on existing park'n ride systems to fulfill data requirements listed in Section B-b.

b. By adapting evaluation criteria outlined in Section B, rank all modes,

including park 'n ride, for application to an airport - public transit linkage, with three or more suburban pickup points, under each set of variables.

c. Evaluate park 'n ride as a full-service system serving the Central Business District (CBD) and six suburban pickup points along the same criteria.

d. Deliverable item is handbook of guidelines for airport-sponsored access systems providing documented justifications and recommendations for mode selection to serve a broad variety of representative demand situations.

D. ACCEPTANCE CAPABILITY FOR PERSONAL RAPID TRANSIT (PRT)

Travelers in the 1980-- 2000 period are likely to witness the implementation of PRT systems featuring four- or six-passenger units computer-dispatched on call and programmable to make stops as requested by the passenger. This concept has been advanced as potentially the most attractive public transit alternative to the automobile, due to its privacy and the absence of undesired enroute stops. Projections as to acquisition, construction, operation and maintenance costs show it to be economically competitive with existent bus & rail modes, with the capability of providing service to areas lacking the population density to make mass transit feasible. Considerable effort has been expended in examining the usefulness and feasibility of such a system for intra-urban transit; however, the specific application to airport needs has not received the attention it needs. As with the mass modes, there are two options; the extension of the public urban PRT system, or, if no urban network has been implemented, the use of PRT as a link between the airport and selected connection points with the existing urban/suburban public transit system.

Objectives

- To provide a cost/effectiveness feasibility study on PRT as applied to airport access.
- To develop design guidelines for guideway and terminal requirements for PRT implementation at airport.
- To establish design guidelines and criteria to facilitate low-cost post-construction modifications to accept PRT systems implemented subsequent to commencement of airport operations

Technical Approach (750 hours)

a. Assemble most recent descriptive/performance/cost data for each PRT design concept in or near prototype development.

b. Document guideway and terminal facility requirements for each design likely to achieve implementation.

c. Evaluate PRT as compared with other transit modes for application as airport - public transit link network. Identify demand situations for which PRT is best suited.

d. Establish design guidelines & criteria for initial airport construction to allow for low-cost post-construction modifications to accept PRT systems implemented at a later date.

e. Deliverable item is a handbook for planners providing:

- Performance and facility requirements data, with financial assessments, for first-generation PRT systems.
- Recommendations, with justifications, of effective applications of PRT as an airport-operated link with public transit systems.
- Design guidelines and criteria for airport construction prior to PRT implementation such as will allow adaptation to PRT acceptance capability at a later date at minimal cost and disruption of airport operations.

E. CONGESTION - RELIEVING ACCESS ROUTE DESIGN FEATURES

The actual layout of access routes has a direct impact on congestion. If divergent alternate roads are spaced too closely or inadequately marked to allow the automobile driver sufficient decision-making and response time, a bottleneck occurs as each driver decelerates to decide where to go. Though guidelines exist for access route planning, either they are inadequate or they have been in many cases ignored or misunderstood; thus they need review and possibly revision. In addition, there are specific design features which need cost/effectiveness evaluation. One of these, segregating bus and truck routes into and through the terminal complex, might be deemed mandatory; JFK International's severe access congestion problem is considerably aggravated by the maneouvering of public access and intra-airport buses in the midst of auto and taxi traffic. Some relief was provided in the newer international facilities such as the routing of airport buses by means of a segregated driveway to a pickup point beneath the Pan Am complex which is easily accessible to passengers yet isolated from other through traffic. The optimal accomodation for buses and trucks would probably be either dedicated lanes or distinct roadways in terms of effectiveness, but comparative costs of such alternatives must first be assessed and weighed against the benefits of this type of construction.

Objectives

- To review current access planning guidelines by examination of their actual applications in operating airports.
- To identify innovations in access planning showing high potential as congestion alleviators.
- To investigate in depth the potentials and costs of function-segregated access routes, such as dedicated lanes or distinct roadways for buses, trucks and service vehicles.

C1

Technical Approach (500 hours)

a. Assemble six case studies of recent new major airport constructions or major access route modifications.

b. Gather information concerning bottlenecks in these new access systems; what are the conditions which tend to generate congestion? Under what conditions does the same traffic volume flow smoothly?

c. Document recommendations of current access designs; in which aspects do the case studies conform? In which do they deviate? Do the bottlenecks occur in design conformities or deviations?

d. Examine other operational access routes for solutions to bottlenecks in case studies. What innovations have been successfully implemented? At what costs?

e. Document installations of dedicated or distinct bus/truck/service lanes; to what degree have these alleviated congestion? What are the additional construction costs? Any special maintenance or other incidental costs (extra street cleaning labor, divider light replacement, etc.)?

f. Provide updated guidelines for access route design, providing alternatives with cost/effectiveness comparisons where practical.

g. Deliverable item is an updated handbook of access route design guidelines recommending specific design features which contribute to congestion relief.

F. MULTIMODAL AIRPORT ACCESS TERMINAL

An assessment is made in sections B and C of modal combinations best suited to various representative access demand situations likely to confront an airport. Terminal area facility requirements for each mode are documented. A centralized access or "feeder" terminal linked to airline terminals and other airport activities by an intra-airport transportation network would optomize efficient management and control of entity flow within and about the airport terminal complex. Terminal facility construction costs for each mode have been assessed. However, combination of modes need not mean simple addition of costs; in many cases modes may be able to share certain facilities, reducing costs; in others, complications may arise due to incompatibilities and induce an increase on the additive costs.

Objectives

- To determine the compatibility of recommended modal combinations for the construction of a multimodal access terminal facility.
- To project costs of construction of such terminal facility for the various recommended modal combinations.
- To provide design criteria for multimodal access terminals to accomodate the ten modal combinations covering the broadest scope of demand situations.

Technical Approach (750 hours)

a. Examine facility requirements for each component mode in modal combinations responsive to each set of 5 demand criteria as identified in Section B. Are there space-sharing compatibilities? Conflicts? What are likely costs?

b. Assess compatibility in subsequent introduction of PRT service with facility requirement data for prime candidate designs identified in section D.

c. Provide guidelines and data base for multimodal access terminal construc-

tion, delineating modes of high and low compatibility, where costs can be reduced through sharing of facilities and where incompatibilities render combinations infeasible.

d. Develop design criteria for a multimodal access terminal for each of the ten modal combinations which are recommended as best suited for the greatest number of demand situations in Section B. Utilize all possible space-sharing potentials so as to minimize space consumption and costs.

e. Deliverable item is design handbook for multimodal access terminal and system, rating all combinations for compatibility and with notations as to cost and effectiveness impacts of compatibilities and conflicts. Handbook will also provide design criteria for multimodal terminals to accomodate ten most frequently recommended modal combinations.

ANTICIPATED BENEFITS

Airport planner/designers will be provided with:

- Guidelines and design criteria for access route and parking planning based upon projected parameters of auto usage reduction with implementation of adequate mass transit airport access systems.
- Handbook of guidelines for airport public transit mode selection for over 3000 basic demand situations such that planners or administrators can locate recommendations for indivual or combined modes=best suited to their specific situation, thus providing a basis for persuasion of transportation planners as to airport needs and preferences.
- Handbook of guidelines for airport-sponsored access systems providing cost/effectiveness/desirability analyses, recommendations and documented justifications for mode selection to serve a broad variety of representative demand situations.
- Handbook of PRT implementation/adaptability guidelines, including:
  - Performance and facility requirements data, with financial assessments, for first-generation PRT systems.
  - Recommendations, with justifications, of effective applications of PRT as an airport-operated link with public transit systems.
  - Design guidelines and criteria for airport construction prior to PRT implementation to facilitate low-cost adaptation to PRT at a later date.
- Handbook of updated access route design guidelines including cost/effectiveness analyses and recommendations for specific design features which contribute to congestion relief.
- Design handbook for multimodal access terminal and system, with ratings

of all modal combinations for compatibility and cost/effectiveness impact analyses of compatibilities and conflicts. Handbook provides design criteria for multimodal terminals to accomodate ten most frequently recommended modal combinations.