The wake vortex advisory system has been sufficiently developed to demonstrate the feasibility and usefulness of the concept. However, further effort to complete the system development has not been vigorously pursued.

The development of a system to provide guidance so that aircraft may avoid encountering wake vortices has not met with great success. The wake vortex avoidance system development is premised on the concept that if the output of vortex sensors which could detect and track wake vortices and the output of meteorological sensors which measured wind direction and speed were combined in a data processor with data concerning the type and location of aircraft in the landing sequence, then the processor could predict anticipated vortex motion and decay and produce a safe separation criteria for the following aircraft. Experimentation with numerous vortex sensors, both acoustic and laser, has been undertaken and algorithms for the predictive model developed. However system development has not advanced much beyond the concept stage.

Neither a vortex advisory system nor a wake vortex avoidance system would permit reductions in minimum separation standards during meteorological conditions which support vortex generation and stability. The most direct approach toward resolving the wake turbulence problem would be the eventual alleviation of trailing vortices at the source. Aircraft aerodynamic modification has the potential for breaking up or minimizing the vortex more rapidly and thus providing improved safety and increased capacity. Aerodynamic alleviation is achieved by modification of the spanwise wing loading or by the generation of turbulence behind the generating aircraft, or by a combination of these two methods. Wake vortex research has been active for many years. It has included both analytical and experimental studies from many points of view. Recent flight-test results indicate that by oscillating the aircraft's lateral control surfaces, essentially total vortex alleviation can be achieved at a three nautical mile separation distance. It must be recognized that trade-offs or penalties may have to be paid to gain the reduction in vortex strengths desired, and engineering problems may be so complex that alleviation may not be cost-effective Aerodynamic alleviation may result in increased noise pollution and increased energy costs.

Of the three programs that have been discussed, the advisory system offers the best near term hope of recovering some of the airport capacity losses caused by wake turbulence. Experimentation and testing indicate that there are no procedural implications which should preclude its operational implementation. However, before operational implementation can be accomplished, the aviation industry - specifically the professional flying fraternity - must be convinced that the concept is valid and that under certain meteorological conditions, the advisory system can reduce current separation standards without adversely affecting safety. To increase pilot confidence in the system, consideration should be given to providing an electronic alerting device in the cockpit to advise the pilot as to the system status.

Thus, there is a need through intensive testing and numerous demonstrations to provide evidence that will convince the pilots that the system is safe and convince the airlines that it is cost effective. It must be recognized that a research and development program is not completed until the system is accepted by the users.

It is interesting to note that, even though the differences between IFR meteorological conditions and VFR meteorological conditions do not necessarily affect wake turbulence, pilots will voluntarily operate with closer separation standards during VFR than during IFR. Having visual contact with the leading aircraft or with an aircraft landing on a parallel runway permits reductions in spacing. It may be concluded that it will be necessary to await the development and implementation of an effective cockpit display of adjacent traffic before the capacity benefits of a wake vortex advisory system can be realized during IFR conditions. The additional benefits to be realized through the development of an avoidance system, over those obtained by the advisory system, are not great. Coupled with the lack of success in the development of an effective vortex sensor leads to the conclusion that further development of an avoidance system is subject to question.

Even though it can be successfully argued that research and development efforts to date have not produced an operationally practical means of alleviating wake turbulence through aerodynamic techniques, the potentials of those techniques for capacity increases are so great that accelerated activity in this program is warranted. Although responsibility for this activity is shared by FAA and NASA, industry - the aircraft manufacturers and the airlines - must play significant roles. FAA should take the leadership in sponsoring joint industry/government efforts to gain additional basic knowledge concerning the phenomenon and to promote the testing of candidate techniques. Only through the insistence of the airlines will the aircraft manufacturers implement successful techniques in future aircraft. In the past, the budgets of neither FAA nor NASA gave emphasis to this program. The pay-offs of many high priority, expensive, programs may not be realized unless additional emphasis is given to a wake turbulence alleviation program.

TERMINAL/AIRPORT CONFIGURATIONS AND FACILITIES

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Problems

The planning, design and construction of the airport terminal complex is a long term process, often requiring five to ten years to complete from concept development to move-in. Once completed, the terminal complex can be relatively inflexible to changes in the design parameters originally influencing conceptual design. For example, the aircraft fleet mix of an airport can rapidly change due to variations in marketing strategies of the airlines. These changes require subsequent modifications in the terminal configuration and the layout of aircraft parking facilities, ticketing, baggage claim facilities and the apron/taxiway/airfield interface. Additionally, the explosive creation of new airlines as a result of deregulation has generated new and different emphasis on the utilization of facilities, use and lease agreements, and operating strategies.

These changes, brought about by new operating plans of the airlines, have had a significant impact on facilities layout and utilization of airports. There is a renewed focus on operating and marketing strategies which in turn significantly impact the terminal and apron operations of the airport.

Not only have specific facility requirements changed, but the peaking characteristics or "loads" have also changed. Renewed and more significant focus on fares and price competition has created significant changes in the peaking characteristics of the airlines. Likewise, the hubbing concept of airlines striving to keep passengers within their own system has created multiple peaks within the day, thus once again compounding the problems encountered by airport terminals striving to address peak hour demand.

While the total demand segment of the terminal area has been undergoing changes, the ability of airport operators to provide the necessary facilities has also become more difficult. Significant increases in capital costs, increased difficulty in financing, associated with the uncertainty of new airline entrants and new services, have all required a renewed interest in facility utilization and layout.

To account for the unknown in aircraft fleet composition, peaking and other design impacts, designers have historically over-compensated design parameters, such as gate dimensional criteria, concourse width, apron layout and taxiway/apron separation criteria. This has resulted in higher costs and a serious inability to respond to specific changes. For example, the design of cul-de-sac parking arrangements for aircraft, while providing convenient walking distances for the passengers, cannot conveniently or efficiently accommodate a change in aircraft fleet, as narrow body gates cannot easily be changed to widebody gates. Similarly, as the B-757, B-767 aircraft enter the fleet, the dimensional criteria for parking and holdroom specifications change, often resulting in a usable, but less efficient design.

The method used to prevent obsolete facility design has historically been an informal agreement by aircraft manufacturers, airlines and planners to define aircraft dimensional criteria which to an extent, are compatible with present airport design. Aircraft design engineers are then required to work within the prescribed dimensional envelope. For example, wing span clearance requirements are critical design elements at many large U.S. airports (such as La Guardia) where aircraft are parked in a linear, concourse arrangement. Changes in wing spans have a cumulative impact on facility design, requiring significant change in the width and orientation of aircraft parking positions. Likewise, existing runway lengths often cannot be extended due to cost, environmental, and political considerations. This presents a considerable challenge to the aircraft designer, and the historic process has often resulted in a compromise between facility/aircraft designs, with neither being optimized.

Principal factors affecting the terminal/airport configuration and layout include: The nature and pattern of aviation demand; The nature of the airport facility functions; and Operational or regulatory constraints.

Recent Changes In Demand Factors

The hub and spoke pattern of airline routing results in severe peaking problems due to the fact that the hub allows for a greater number of passengers to be distributed to alternative destinations within a compressed time period. Secondly, the hub and spoke pattern results in multiple peaks throughout the day where flights are scheduled to maximize load factors rather than reflecting travelers time preference for travel. Finally, the increase in regional and commuter traffic at airports has altered the aircraft mix, affected runway acceptance rates, created severe impacts on runway capacity due to vortex separation criteria, presented ground traffic problems on the apron-taxiway system due to jet blast considerations, and created additional problems related to apron parking positions.

Airport Facility Traditional Functional Factors

The airport's function as either a passenger originating or connecting facility significantly impacts the facility design. For example, the design at Atlanta reflects the mission of the airport as a major connecting hub, where over 70 percent of almost 35,000,000 annual passengers are connecting and do not require the services of ticketing, bag claim, curb front, or parking. If the connecting patterns were to change to one primarily of origin and destination, the landside facility design would be seriously inadequate. Similar problems have been addressed at Dallas/Fort Worth, which was originally designed as an origin and destination airport but is now used by the airlines as a major connecting facility.

Similarly, facilities with high interline commuter connections present design ramifications which may require interspersed commuter/air carrier facilities as opposed to separate facilities for each. Costs and facility implications significantly impact the final selection, but each situation dictates the solution, centralized versus decentralized.

Operational or Regulating Factors That Impact Capacity

Capacity problems at area controlled airports affect the interactions of airside and landside capacity balances. For example, slots filled with commuter aircraft decrease landside facility needs and landside capacity. Alternatively, a high percentage of wide bodied aircraft places increased emphasis on landside capacities. Free market entry and exit provisions cause fairly rapid changes in facility dimensional requirements which can not be resolved by inflexible facility design.

Solutions

1. Ground servicing and processing times significantly affect gate occupancy times. Minimizing passenger, baggage, and aircraft servicing times increases terminal capacity and efficiency, without attendant capital costs requirements.

2. Gate sharing (preferential/common), particularly among carriers with small market shares at an airport, results in more efficient design and higher utilization. Consideration of the sharing of other facilities and maintenance/service activities should also be explored.

3. Airfield capacity and terminal utilization can be maximized with fewer flights with higher load factors. The objective is to balance frequency with total demand.

4. Taxiway-runway routes impact airline operating costs and strategies and should be used in determining terminal configurations and airline position assignments. Computer graphics and automated planning studies should be incorporated prior to construction to optimally locate the terminal complex with respect to the airfield.

5. New aircraft dimensional criteria should reflect maximum utilization of existing facilities. Similar aircraft should be grouped, where

possible, at facilities to have the most efficient service and space utilization.

6. Planning of all commercial facilities should reflect regional/commuter impacts and corporate/business general aviation needs. Minimizing the interaction between large and small aircraft using the same facilities increases facility design and operating efficiency.

7. Steps should be taken to incorporate more realistic design and separation criteria to effect a better utilization of existing and new facilities. In today's environment of high financing and capital costs, additional facilities are no longer the answer for flexibility. Better utilization of existing facilities must take on added importance.

8. Most importantly, all new facilities should address flexibility and changes of the current market. This includes incorporating flexibility and a response to change early in the design process, as the one consistent theme in the industry in the coming years, will be change.

INSUFFICIENT INFORMATION AND ANALYSIS: AN OBSERVATION

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Introduction

Valuable data has been collected and useful analyses have been conducted concerning air traffic systems operations and technologies. This information provides measures of various aspects of airport and airspace capacity and delay and provides a basis for planning and developing system improvements. However, the capacity and delay information currently assembled does have room for improvement since the data do not in all cases accurately and completely quantify capacity and delay conditions and do not precisely identify all causes of congestion problems. Some analysis efforts are not tightly coordinated with other efforts and not integrated in regard to a consistent system-wide orientation. Analysis results are not always widely disseminated in a timely fashion.

The following paragraphs briefly comment on the cause and nature of various data deficiencies for the purpose of defining potential problems and issues. Detailed analysis of the areas of concern and recommendations for resolution actions are not addressed and would be subjects for in-depth research.

Performance Measures and Analysis Methods

Deficiencies in the current state of performance measures and analysis methods are due, in part, to divergent views concerning the basic analysis procedures. Analysis procedures range from empirical studies and mathematical equations to large-scale computer simulations. Performance measures range from hourly delay to annual capacity. This situation is healthy from the point of view that numerous alternative measures and techniques have been demonstrated, are available, and may be refined and tailored for selected system evaluation and design purposes. On the other hand, the use of different performance measures and analysis techniques may contribute to inconsistencies among capacity and delay estimates, lost opportunities to complete a comprehensive data base, and lack of agreement on needed evaluation efforts.

The Airport Situation

Considerable effort has been concentrated on compacity and delay analysis because airport traffic handling capabilities are a dominant constraint on aviation operations. Alternative tools and techniques have been developed to quantify airport capacity and delay factors, and special site-specific study efforts have identified improvement programs for selected airports. However, apart from the site-specific individual airport study approach, uncertainties exist concerning the ability to identify, with a high degree of confidence, specific problem areas and system-wide solutions. Delay monitoring programs, for example, do not report similar and directly comparable data, cannot be considered precise, and are deficient in terms of reliably identifying sources of delay. Furthermore, capacity estimates are subject to question as demonstrated by practical annual capacity (PANCAP) calculations which are not consistent with actual traffic operations counts at various airports.

The Airspace Situation

Limited information has been assembled describing system-wide airspace capacity and delay factors and major efforts have not been devoted to establishing meaningful measures of airspace operating efficiency. In the case of en route airspace operations, where aircraft are subject to diversions from their preferred flight plan due to potential conflicts, control procedures, adverse weather and the like, delay is not necessarily the most significant measure of operating efficiency. For example, aircraft diverted to flight levels below their minimum fuel burn cruise level may experience significant fuel cost increases without experiencing delays. But, the degree to which aircraft currently are subject to excessive fuel burn and airspace delay conditions, the causes of those conditions, and future expectations are not well documented.

Information Integration

Evaluations of airport and airspace capacity and delay, of practical necessity, have focused mainly on specific topic areas rather than attempting comprehensively to integrate system-wide factors. For example, separate analyses have addressed airport capacity and delay, computer system capacity, air traffic control automation applications, controller human factors constraints, en route and terminal control procedures, controller productivity, and related topics. These studies have developed quantitative and qualitative information describing the various topics, but integration of the information has not been accomplished.

The deficiency in disseminating and integrating data is due in part to the specialized nature of each topic. Technical analysts tend to focus their attention on their area of expertise and develop very detailed knowledge concerning the topic. This information tends to reside with the specialists in each topic area, although specific information may be distributed through technical documentation and briefings. The situation arises in which persons active in airport and airspace systems operation and development may not have readily available and extensive data concerning technical areas outside their area of specialty and may not have a good