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Congestion and delays at John F. Kennedy International Airport: A Concrete Approach

John Thomas Kenneally
Iowa State University

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International Airport: A Concrete Approach

by

John Thomas Kenneally

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Page

CHAPTER I. INTRODUCTION

At the outset I would like to make one point very clear: this study is not meant to serve as a general appraisal of all major airports and their delay characteristics. In the pages to follow I intend to show that a full marginal cost pricing policy may not be as straightforwardly appropriate at John F. Kennedy International Airport as many analysts have theorized for airports in general. Some of the evidence presented may be applicable in varying degrees to other major airports, but it is specifically geared to John F. Kennedy International Airport (JFK).

Most of the analysis of airport congestion and its economic consequences took place during the 1968-71 period. It was then, in the late 1960s, that the congestion problem reached crisis proportions. "Stacked" and "put in a holding pattern" were phrases commonly tossed about by air travellers using major metropolitan airports. Statistical analysis of traffic activity indicated intolerably high levels of delay and, when translated into dollar equivalents, tremendous economic costs. JFK International, being one of the nation's top five traffic hubs, was right up there among the most heavily congested airports. The traffic problem here was compounded by a factor which few other (if any) major hubs had to deal with: the close proximity of Newark and heavily used LaGuardia A special airspace structure (New York Metroplex) and facility (Common IFR Room) were created in 1969 to facilitate a more efficient flow of traffic and also increase the capacity of the area.

This situation stimulated a variety of studies in the economic literature which advocated a drastic change in the pricing policy used by airports in order to ration the use of these heavily congested facilities. Analysis was mainly quantitative with the emphasis on statistical analysis and subsequent economic interpretation of the results.

As a contrast in style, my approach is roughly 90% qualitative or causal in nature. It is my contention that this approach is more appropriate for JFK in light of various events and circumstances that have evolved over the past 10 years. I have chosen to examine the possible causes behind the delays as well as certain factors inherent in JFK operations which contribute in varying degrees to the level and structure of delays, as well as attempt to dispel some myths and erroneous assumptions about the industry perpetuated in the literature.

The first portion of the study is geared primarily toward giving the reader some general background on the concept of capacity, its measurement, as well as some technical data about JFK. Background material is also prsented on past programs aimed at alleviating airport congestion, criticisms of these programs, criticisms of the criticisms, and a look at the marginal cost concept for pricing airport runway services.

As the reader proceeds through chapters IV, V, and VI the impression may occur that the factors detailed and evidence presented represent a 100% coverage of the Kennedy delay-creating elements. This would be overly presumptuous on my part and as such would be self-defeating in the context of a causal approach.

Instead, I shall present certain evidence and draw specific conclusions about various phases of the activity at JFK which represent contributing elements to the problem of congestion and delay. The point emphasized here is that none of the factors dealt with can individually be regarded as "the cause." In combination they do explain many of the operational aspects of JFK International and are probably the major elements affecting its operation, but for the sake of generality and accuracy, I shall assume that there are other elements involved which simply have not been included here.

Finally, this study is not intended to serve as a complete negation of a full marginal cost pricing policy, but rather an investigation of specific aspects of JFK operations which tend to make marginal cost a very difficult concept to practically apply. At no point in this study have I denied the existence of delays and the associated social diseconomies, the existence of which theoretically dictates a congestion or delay toll be charged in the interest of economic use of scarce resources. The problem arises when we make the transition from theory to reality; accurate measurement of marginal costs is very difficult, especially when externalities such as noise, air and water pollution are taken into account; implementation of congestion toll pricing is not quite as simple and straightforward as much of the theoretical literature would convey (this is dealt with more specifically in a section on marginal cost pricing); and there are certain situations in which it is unclear as to exactly who should pay the congestion toll.

The depth and sophistication of this study was subject to a very strict financial constraint: my checkbook. Much more in-depth experimentation with simulation and statistical analysis would probably lead the analyst towards estimation of actual current marginal costs and an optimal strategy for its implementation into the airport system, but this involves a lot of money and data which simply was not available to me. I do believe the reader will find the material interesting and quite readable, an in-depth knowledge of economics is not a prerequisite since theory is minimal while operational reality is maximized, given the constraints mentioned above.

Throughout the narrative I have used the technical terminology of aviation as a means of smoother exposition and reduced volume of paper. In certain cases, I have provided brief definitions or explanations to aid the nonaviation-oriented reader.

CHAPTER II. RUNWAY CAPACITY

Determinants

The term capacity is conventionally defined as an upper limit which a system or process cannot exceed due to a strict set of physical, economic or time constraints. For instance, a manufacturing plant is constrained, i.e., its output, by the amount and availability of resources at any specific point in or period of time (other than the long run); every day we are aware of our capacity to accomplish a certain amount of work within a well-defined time framework. The point of these examples is that in the common usage of the term "capacity" we are talking about an inviolable level of activity which in all practicality cannot be surpassed.

However, when dealing with the concept of runway capacity, we must be aware of the many complex and variable factors which come into play in the day-to-day operations of a major metropolitan airport. These factors, which in certain combinations "change" the capacity of a runway, come under the following general headings: environmental conditions, airport geometry, aircraft mix and performance, and air traffic control procedures.

Aircraft mix refers to the variety of aircraft which regularly use a specific airport. The degree of mix can be considered as a function of the diversity of equipment used by the airlines serving a particular city, while this, in turn, depends upon the volume of traffic generated and the role which the city assumes in the national transport system. For many of the major hubs the mix of users runs the full gamut of airplane types, from the single engine general aviation type to the turbofan jumbo jets.

At the airports in the New York Metro area, this variability is present and differs across airports. For instance, at LaGuardia the primary distinction is between general aviation (G.A.) and commercial aircraft, the mix of jet traffic is relatively homogeneous with only minor exceptions.[1] The traffic for LaGuardia (hereafter identified as LGA) is mainly of a short to medium haul nature and thus, the type of aircraft used by the carriers reflects this fact.

The situation at Kennedy is vastly different, where over half the daily operations are involved in medium to long haul routes, including international flights. Due to the tremendous number of jumbo jets and four-engine turbofan aircraft, JFK is known as the "heavy jet" airport of the world.[2] In addition, we also have the usual twin and tri-jet types (B727, DC9, etc.) as well as G.A. and communter turboprops. On any given day, one can observe a Pilgrim Airlines 20-seat Twin Otter in from Poughkeepsie, New York, taxiing with a British Airways 747 just in from London Heathrow. As we shall observe later, this mix variability is directly related to runway acceptance rates.

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[1]Most LGA traffic is of the 727, DC9 type, with only about 2-5% being heavy jet DC10 and L-1011s. These two are the only types of heavy jet permitted to operate there due to the length of the runways. Part of one of LGA's runways is supported by pilings in Flushing Bay and is now being reinforced in preparation for the A300 Airbus.

[2]Heavy jets are defined as those aircraft which are capable of takeoff weights of 300,000 pounds or more whether or not they are operating at this weight during a particular phase of flight.

Airport geometry or layout is another very important factor affecting the performance of an airport. This item includes such things as runway orientation, number and spacing of runways, their alignment with respect to each other, location and types of exits, taxiway system, and terminal location.

At a major airport such as JFK, Chicago-O'Hare or Hartsfield-Atlanta, the primary objective of a runway-taxiway system should be the delivery of aircraft from their gate position to the runway (and vice versa) with a minimum of delay and conflicting movement with respect to other aircraft. Such improvements as high speed turnoffs and inbound-outbound taxiing systems at these and other major airports have done much to improve aircraft flows to and from the runway.

The third general factor involved in any airport operation is the air traffic control system. It is the responsibility of the ATC system to guide all aircraft to and from the airport environs safely and with expediency, i.e., minimum delays to system users. One of the most important elements of ATC service is to provide proper radar separation, both horizontally and vertically, between IFR (instrument flight rule) aircraft during various phases of flight. This separation becomes most pronounced during the last 20-40 miles of an arriving aircraft's route; it is at this time that arivals are lined up and sequenced for the approach to the airport area. The variability of the separation is a prime factor in establishing a delivery rate to the runway threshold,[3] which in turn is a barometer of the level of hourly usage.

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[3]Runway threshold is the beginning of that portion of the runway usable for landing.

Separation standards are determined with essentially one element in mind: the differences in aircraft size and performance. Special procedures or separations must be used when there is a significant amount of variance in the type of traffic being processed through ATC. The presence of large jets or small commuter and G.A. type aircraft in a mixed flow dictates extra long separation distances in order to offset the effects of wake turbulence from large aircraft. The occurrence of wake turbulence is an important element in the ATC operations at JFK and, as such, should receive a bit of explanation.

Every aircraft generates a pair of counter-rotating vortices trailing from the wing tips causing "wake turbulence." As aircraft become larger and heavier, the intensity of the vortices can pose significant problems for smaller aircraft. In fact, large aircraft generate vortices with roll velocities exceeding the roll-control capability of some smaller aircraft. Therefore, under conditions where aircraft separation in the arrival or departure phase is dictated by wake vortex strength considerations, this may be a limiting factor on runway capacity in segregated operations.

Finally, the most significant, yet uncontrollable factor involved in airport operations is the weather. Later on in this study attention will be given to the influence of weather changes on operations at JFK, but for now, suffice it to say that various weather patterns can cause an airport to experience some of its most extensive delay situations. Certain techniques and policies have been developed and are used to minimize the impact on traffic flows of adverse weather.

Definition and Measurement

Runway capacity, in most cases, will vary from airport to airport, depending upon the layout of the runway(s) and terminal area as well as the location of the airport with respect to the surrounding community. There exists a great variety of runway configurations in use at airports in the United States. These layouts are mainly a function of anticipated traffic volume (number of runways) and meteorological[4] and geographic characteristics of the area (orientation).

One version of runway capacity is known as "ultimate" or "saturation" capacity [18, p. 112]. This represents the maximum number of aircraft operations that a given airport can accommodate during a specific interval of time under conditions of continuous demand. A simple way of calculating this would be to take the reciprocal of the weighted average service times[5] of the aircraft using the facility. The weighting would be used to reflect the different requirements of various aircraft.[6] This version of capacity would seem to adequately indicate a facility's engineering capabilities, but from an economic angle it is incomplete. No measure or consideration of delay or congestion is incorporated in this definition, so we are talking about a physical number of planes and not necessarily an economically efficient number of planes.

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[4]As a general rule, the main traffic runways should be oriented as closely as practicable in the direction of the prevailing winds. Optimum runway directions can be determined from a device known as a wind rose which measures wind direction as a percentage of time.

[5]Service time is the time required to complete an operation before another aircraft may use the runway.

[6]Example: Assume homogenous mix with 30 second service times. The hourly capacity would be: 1/.0083 = 120 movements/hour.

As a result we have the alternative definition known as "practical capacity." This version states that capacity is that level of aircraft operations where the delays to the aircraft reach some maximum acceptable level. The definition is appealing in two respects: first, in contrast to ultimate capacity, this version does incorporate delay in conjunction with a level of activity; second, this definition implies that in the airside operation of an airport there are going to be some delays strictly due to the fact that there are so many coordinating elements involved and that it is unrealistic to expect these elements to perform flawlessly through time. In other words, there will be some average basic delay associated with each flight, having nothing to do with the congestion, but being simply a result of human factors operating in the dynamic setting of an airfield operation.[7] I consider this allowance for some average basic "noncongestion" type delay to be a very good feature of this definition.

There is a slight "weakness," however, in that the calculated capacity can change without any alteration in physical facilities.

The shape and position of the curve in Figure 2.1 is significantly influenced by the pattern of demand during a period of time. In other words, this pattern is quite variable given a change in some of our influencing factors mentioned earlier. With varying patterns we can see

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[7]In establishing its on-time criteria, the CAB considers a flight to be "on time" if it is within 15 minutes of its scheduled time.

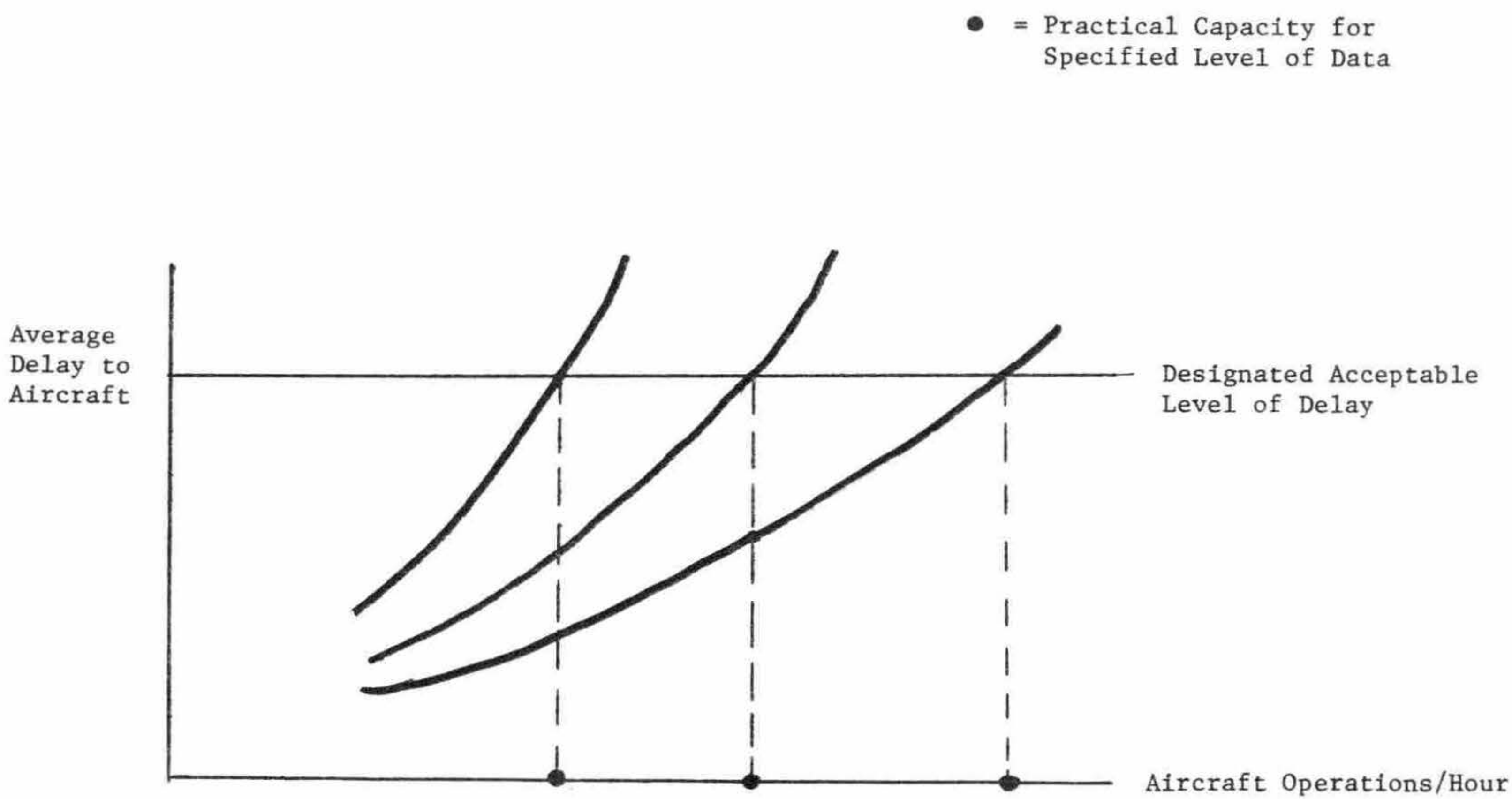

Figure 2.1. Specified Level of Delay

that the practical capacity has changed while no alterations have been made to the airport's physical facilities.[8]

What should be the acceptable level of delay? The Federal Aviation Administration has designated this to be four minutes average delay. The reason for choosing this figure was that its distribution is such that maximum delays will not exceed twenty minutes and some aircraft will actually have only a few seconds delay [2, p. 17-1]. At higher levels of average delay, the distribution spreads rapidly to the point where some aircraft are encountering delays of forty minutes and higher.

Calculations of these two versions of capacity involve different mathematical techniques. Experience has shown that the definition related to "ultimate" capacity yields values that are slightly larger than the definition which includes delay, but the difference is not large [18, p. 112].

John F. Kennedy International

By way of background, the initial Master Plan of 1946 for "New York International Airport" was conceived by the airlines and the city as a 12 runway tangential pattern capable of 360 peak hour movements. This capacity was premised on the expected developments of precise approach aids and ATC that would permit the use of 6 runways simultaneously--3 for landing and 3 for takeoff.

In 1949, after extensive investigation of meteorological history, characteristics of existing and future aircraft and the likelihood of ever

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[8]Actually this is not a drawback at all, but merely a reflection of the influence meteorological conditions have on runway acceptance rates, i.e., the distinction between IFR and VFR capacity.

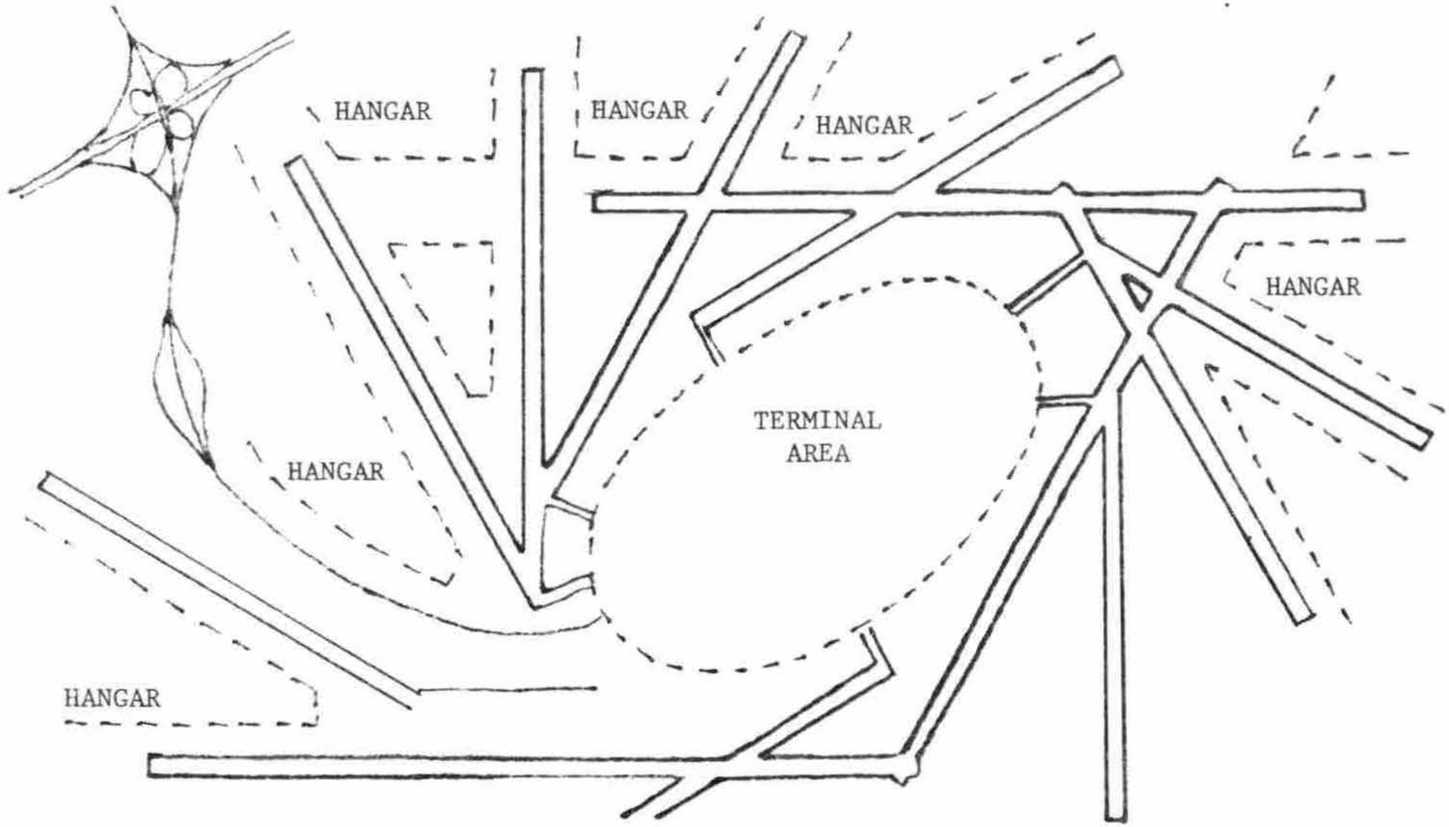

Figure 2.2. Tangential Runway System--City Plan, 1946 (almost uses 5,000 acres for runways alone)

achieving 100% efficient and precise traffic control, the Port Authority concluded that a basic runway pattern distribution should only include two runway directions at approximate right angles.[9]

JFK International is characterized today by this right angle-bidirectional runway pattern. Two sets of parallel runways[10] with a centrally-located terminal area comprise the layout of one of the world's busiest airports.

The capacity of an airport for aircraft movements is limited by its capability for handling inbound traffic under IFR conditions when all operations must be in the direction with least runway capacity. In the New York area, the prevailing wind is from the northwest, and the bulk of traffic (about 75%) operates from southeast (130°)-northwest (310°) runways, but northeast winds require operations in the northeast (40°)-southwest (220°) direction approximately 25% of the time during the months of January through June [23, p. 111]. All runways with the exception of 13R are ILS (Instrument Landing System) equipped for nearly all weather operation. The majority of runway exits are of the high speed design type, i.e., the angle that the exitway makes with the runway is very small, thus allowing aircraft to land and exit the runway at higher speeds permitting more rapid availability of the runway for use by the next aircraft.

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[9] Information provided by Donald T. Foley, Aeronautical Services Division, JFK International.

[10] There is also a runway for small aircraft.

The preceding features of JFK are very important in enhancing capacity utilization. The ILS facilities[11] help to minimize the reduction in capacity usually experienced during bad weather. For example, the lowest ILS minimums acceptable at the airport are for runway 4R which permits operations down to 200 foot ceiling and 1,800 feet visibility. When the weather does reach this level of severity, operations will naturally be slowed down for safety reasons, but the capacity loss will be kept to a minimum by virtue of the excellent facilities.

Before closing out this section, one other item should be mentioned which has a bearing on aircraft ground flows, it is known as a "crossing problem." This is a symptom of certain parallel configurations in that aircraft landing on an "outer" runway may have to taxi across the departure runway to reach the terminal. Fortunately, at JFK this problem is minimal. The 13L/31R - 13R/31L parallels have the terminal between them so that a crossing problem is nonexistent. Operations on the 4L/22R - 4R/22L parallels indicate a potential, but given the location of these points, arrival-departure interference is extremely minor.

Arrivals on 31R - Departures on 31L is considered by air traffic personnel to be the optimum runway configuration at Kennedy due to noise abatement considerations, prevailing wind, and ease of access [17, p. 2]. This configuration is also characterized by independent parallel operation. All configurations, however, are relatively free of arrival-departure dependencies.

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[11] JFK is one of the world's most highly instrumented airports, with seven of eight runways instrumented.

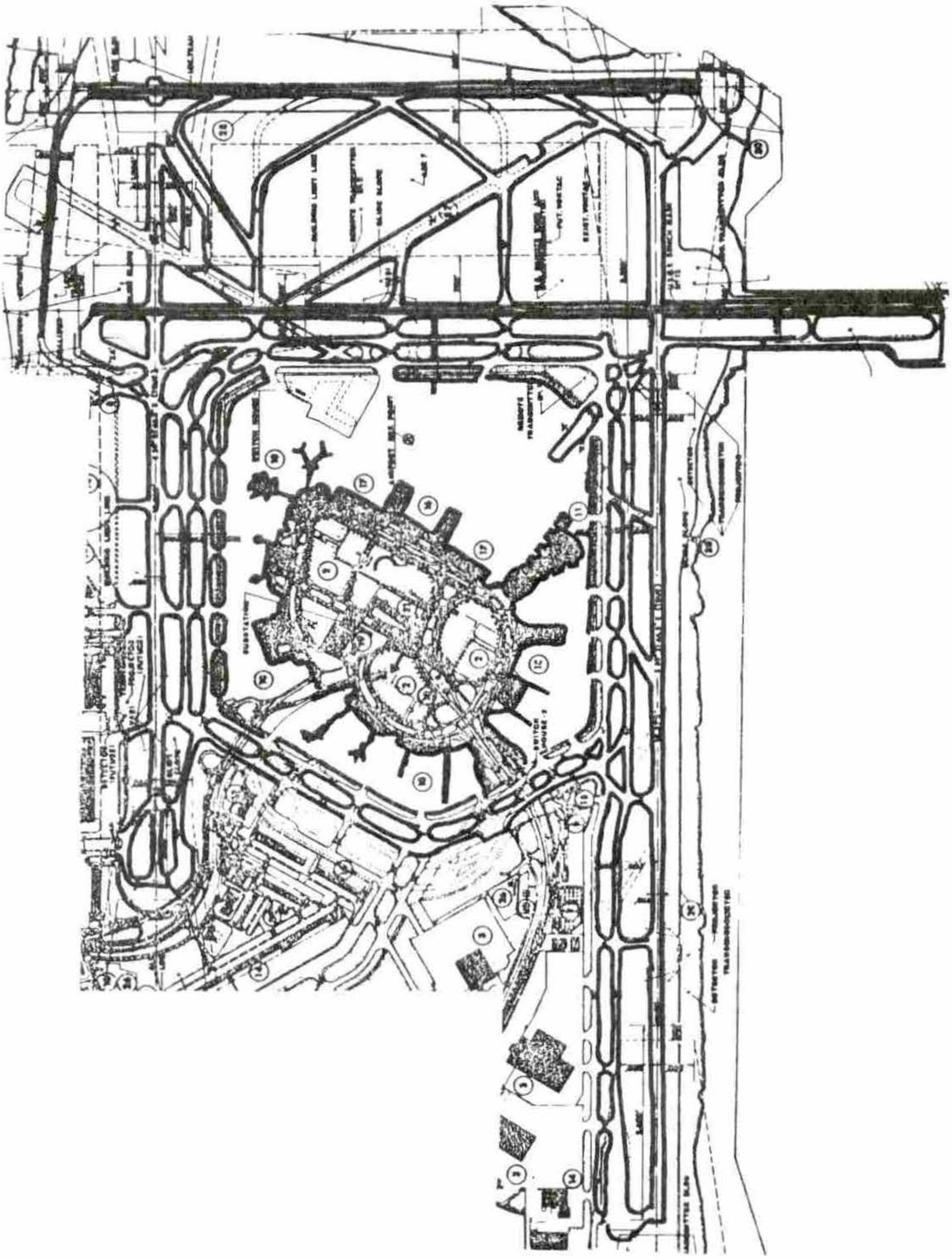

Figure 2.3. John F. Kennedy International Runway Configuration

CHAPTER III. CONGESTION REDUCTION

History

The prevailing system of landing fees at virtually every air carrier airport in the United States and much of the rest of the world is one which is based on aircraft weight. Such a system is known technically as "value of service pricing" because the price is related to the value of the service rendered by the airport to the individual user rather than to the marginal or additional cost incurred as a result of each use.

Until several years ago, value of service pricing was a fairly appropriate system for New York and other underutilized airports. For the most part, airport airside costs are fixed. Runway and taxiway systems are a "once only" cost, allowing for routine periodic maintenance. Due to the surplus capacity that most airports have had in the past, business and revenue could be maximized by the use of prices that charged most of the fixed costs against those most able to pay them--large, usually commercial, aircraft. This enabled airports to charge quite low prices to small planes that would be deterred from using an airport if they had to pay many of the fixed costs involved. Aircraft weight, which is a simple and fairly accurate proxy for the value of airport runway service, is widely used as a basis for runway charges.

Unfortunately, due to the tremendous growth in traffic in the 1960s and the introduction of jet aircraft into commercial service, this policy became less and less appropriate at major airports such as JFK, O'Hare and Washington National. At these high density airports about 70-90% of the users are commercial air carriers using jet aircraft ranging from twin engine DC9s to wide-body jumbo jets. For JFK the ratio of commercial traffic to general aviation is approximately 9:1, with roughly 50% of the commercial traffic being of the "heavy jet" category. The "encouraged presence" of the small G.A. aircraft in a traffic environment such as Kennedy created certain operationally and economically awkward situations.

In 1967, at Senate Aviation subcommittee hearings, Alan S. Boyd, Secretary of Transportation, suggested that airports might try offering incentives to both air carriers and general aviation to use airports less at peak hours by raising airport charges for services provided during these hours and lowering them during the off-hours [16, p. 26].

On August 1, 1968, the Port Authority imposed a $25 minimum fee on flights at the three major airports during certain hours believed to be particularly busy.[12] All pre-August charges were based on weight except for a $5 minimum charge. The increase was designed to eliminate some of the most inefficient users of the airport; i.e., those users and potential users who valued the use of the airport during the hours concerned at less than $25. As a result, there was a significant decline in general aviation traffic at JFK. In comparison to July, 1968, the declines registered in August and September (of the same year) during peak hours were 47% and 54%, respectively. For the same periods, the change in general aviation as a

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[12]The minimum fee applies to aircraft, with seating configurations of less than 25 passengers, which either land or take-off at JFK, or EWR during the periods 0800-1000, Monday-Friday, and from 1500-2000 every day.

percentage of total movements went from 5.7% in July to 3.6% in August and 3.1% in September during peak hours [25]. Data for that year as well as 1969 and 1970 verified the success of PONYA's action. The level, and more importantly, the structure of G.A. usage of JFK had been significantly altered, aircraft delays were reported much lower.[13]

At this time there was another congestion-reduction program instituted by the Federal Aviation Administration being used at certain heavily congested airports in the eastern United States. The program, known as "High Density Traffic Airports" (HDTA), was implemented in reaction to the exceptionally high degree of congestion at certain key airports during July and August, 1968.

In order to provide immediate relief, the F.A.A. designated five airports as HDTA and then imposed a reservations system together with other limitations that airport users were required to follow as a condition to use these airports. The basic rule was made effective on April 27, 1969. The system was promoted as being equitable, since all classes of aircraft operators were free to use any of these airports on a first come, first served basis so long as the operations did not exceed the quota specified. During the succeeding two years the F.A.A. gathered and catalogued much statistical information in order to evaluate the HDTA system. The conclusions were that the percentage of aircraft delays at the five airports decreased substantially and that there was a reduction in average daily operations.

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[13] [24]. Also at this time there was a relatively small decline for air taxi activity at JFK. This resulted from permits issued to air taxi operators exempting them from the $25 fee if they used a nonduty runway.

Objections to the HDTA quota system generally were based on the following: discrimination against certain classes of users; termination of the long-established policy of first come-first served; and not a proper exercise of the F.A.A. administrator's authority under the Federal Aviation Act of 1958.

In response, the F.A.A. indicated that the Administrator's discretion under the Act is broad enough to permit him to implement any remedy which has a real and substantial relation to the goal of affecting the efficient utilization of airspace so long as the action taken is not unreasonable, arbitrary or capricious. The rule does grant a greater priority to certificated air carriers who provide common carriage service. This is consistent with the policy of recognizing the national interest in maintaining a public mass air transportation system. So long as capacity is adequate to meet the demands of all airspace users without unreasonable delay or inconveninece, "first come-first served" remains the fundamental policy, however, when capacity limitations compel a choice, the public service offered by the common carrier must be preferred [10].

Review of Past Programs

The PONYA pricing alteration and the F.A.A.'s HDTA system are the two major congestion-relief programs over the last 10 years. Reactions to the two plans were varied and, in most cases, justified from an economic viewpoint.

PONYA's pricing scheme was the more acceptable in economic circles simply because it was an attempt to relieve congestion through the price mechanism. Viewed as a "small hesitant faltering step. . . towards a more rational price system," [31, p. 145], it was the first real use of the price mechanism to eliminate users on the basis of valuation. Economists saw this as a move in the right direction--that direction towards a marginal cost pricing policy.

Yet, in the light of its effect on G.A. users, it was judged insufficient, i.e., not a large enough increase. Some have advocated a $100 minimum[14] fee; this would virtually eliminate all G.A. traffic from the airport during the designated hours. Given the effects of the $25 minimum, it seems that further increases would lead to decreasing marginal effects on G.A. traffic, and beyond a certain point any additional increase may be unwarranted or unnecessary. Also during a period of such increases, the problem may become more political than economical.

The second program, originated by the F.A.A. was for the most part dismissed by analysts due to its "arbitrary" nature and detachment from a pricing mechanism. Some of the main objections and F.A.A. response to those objections have already been given, but a few additional thoughts have occurred on this particular item.

First, on a technical note, I have found certain studies[15] which have misinterpreted the HDTA system. From the phrase "IFR reservations" or "IFR operations quota," analysts have taken this to mean that the system is <u>only</u> used in bad or IFR weather [5, p. 27]. There is a difference

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[14] [31, p. 154; 23, p. 24].

[15] [32, p. 149; 23, p. 23].

between an IFR operation and IFR weather. IFR weather implies that meteorological conditions are such that the operation of a flight with respect to visual reference outside the aircraft is inappropriate.

As the speed of aircraft and the density of traffic in the airspace increased, there was more concern over the possibility of midair collisions. Accordingly, in certain parts of the airspace, IFR rules have been prescribed regardless of weather conditions. This is referred to as "positive control airspace" [18, p. 89]. A flight conducted under IFR in controlled airspace must submit a flight plan and, thereafter, comply with ATC clearances or traffic control instructions [15, p. 30]. All commercial airline flights conducted at the HDTA's are under IFR, regardless of the weather.

Another point raised was that the quota was fixed far in excess of what could be handled under "IFR conditions." First of all, the quota was, and is, not "fixed" in the sense of a strict upper limit; operations are allowed without reservations if they can be accommodated without adverse effect on allocated operations.

Secondly, this statement, again, indicates a misinterpretation of "IFR reservations." As stated by the F.A.A. [10, p. 18], the number of allocations specified are in excess of the capacities of the airports to handle IFR traffic in IFR conditions with minimum delays and they were selected with the realization that under IFR weather conditions delays will occr. Permitting some delay appeared preferable to restricting the total operations to the actual IFR minimum delay capacity resulting in unused capacity when the weather is above IFR conditions.

In some cases, the HDTA system was referred to as an "arbitrary assignment of landing and takeoff slots" [20, p. 197]. This suggests a "shot in the dark" methodology as well as a passive role for the air carriers. The basic rule, issued on November 27, 1968, was made effective on April 27, 1969. During this five-month period the air carriers and scheduled air taxi operators, acting in concert through scheduling committees, were able to scale down their scheduled operations to satisfy the quota allocations. The F.A.A. experience, as indicated by statistical study covering the four-month period subsequent to the issuance of the rules showed that none of the users were deprived of the use of any of the five HDTA, except on infrequent occasions, and only during the early evening rush hours. During the sixteen-month period following issuance, the Airport Reservations Office of the F.A.A. was able to approve or provide an acceptable alternative reservation for virtually all requests [11, p. 29]. The ruling was supported by the airlines both in its initial issuance and through periodic extensions.

"Arbitrary" is exactly the word used in describing what a ruling by the Administrator should not be. His authority to establish measures for the efficient and safe utilization of airspace is based on the condition that such actions taken are not unreasonable, arbitrary or capricious [11, p. 29].

Finally, when a new proposal or amendment to an old one is made public through an announcement in the Federal Register, called a Notice of Proposed Rulemaking (NPRM), written comments are solicited from the general public, public officials and other interested parties. In reviewing the F.A.A.'s background material and amendments for the HDTA system I noticed something about the nature of the objections raised concerning HDTA. In one such amendment [10, p. 17], 11 categories of assertions were listed in reaction to the quota system. Among these I found absolutely nothing in the way of an objection to the system on economic grounds. No where in the series of amendments and NPRM's is found any protest to the fact that congestion reduction was attempted (and was successful) through a means completely removed from that which economic efficiency would dictate, i.e., the price mechanism.

Yet, during this period (1968-1972) a host of studies appears in the literature which shows in various ways how a pricing solution ("peak load" and "marginal cost") would lead to the most efficient outcome and maximize general welfare. If the quota system was so economically objectionable, why was no protest raised (where it would be heard) by analysts in the field?

Marginal Cost Pricing

The use of some economic incentive rather than various administrative controls could alleviate long-term allocation and development problems if those incentives could be tied to the true costs and benefits of airport access.

The basic cost of an operation without delays might be $X. This cost would remain approximately constant for each operation until the number of operations approaches the maximum capacity of the airport. From this point on there will be a critical divergence between cost as perceived by the individual (private) and the costs incurred by the system as a whole (social). With the facility now becoming increasingly congested, each additional or "marginal" user will incur a cost of usage as well as imposing delays and costs on other users. Thus, we have the two components of total delay at a congested facility: private (individual delay and cost) and social (delay and costs imposed on other system users by a marginal operator). It is the specific purpose of a marginal cost pricing policy to recover the gap between social and private cost and give operators a more economically accurate sense of their airport cost impact.

The economic theory of congestion indicates that if a user is not required to take into account the cost he imposes on others, a facility will be overused. Efficient usage of the facility would require a "congestion toll" equal to the cost of delay that the marginal user imposes--marginal external delay. Theoretically, social costs would be covered and congestion decreased. The difficulty lies in determining the social costs and properly adjusting fees to reflect them. Unfortunately, there are a number of factors that complicate the determination of such a price structure, ranging from analytical obstacles to policy questions specific to certain sensitive segments of aviation.

One immediate problem is the fact that there is no guarantee that setting landing fees equal to some fixed component plus the marginal delay cost at a particular time will lead to equilibrium conditions. An immediate institution of a marginal cost pricing scheme could have the effect of overly reducing traffic. Adjustments (possibly drastic) made by the scheduled carriers would change the structure and possibly the level of airport usage which would, in turn, create a new set of prices. With prices readjusted downward, some operations that had been driven away previously would be lured back. This sequence might continue interminably with no assurance of eventual convergence to an equilibrium level of prices. Over time such undamped oscillations in prices and traffic would be dynamically unstable and less than optimally efficient [5, p. 114].

An actual "equilibrium" marginal cost price would be such that if recomputed in the same way using data generated since the previous recomputation, the change in prices would reflect only normal traffic growth. Equilibrium prices differ from full MC prices in that they allow for the effects of the reduced use resulting from high prices [5, p. 115].

So we can conclude that use of full marginal costs as prices without some sort of practical adjustments would introduce potential economic volatility into the airport system. However, to determine by analytical means a set of equilibrium prices would be a formidable task. Knowledge of traffic pattern variation under different sets of prices would be a necessary precondition to determination of such an equilibrium.

Unfortunately, prior research in this area has not considered demand elasticity, i.e., there is no information on the sensitivity of airport demand to changes in runway usage charges. And, without this information, the effects of any specific price structure on the pattern of demand for airport operations cannot be predicted [30, p. 30].

The air transport system in this country is composed of a very complex network of airports ranging in size from the 5,000 acre Kennedy to the much smaller community fields served by local carriers. In such an interdependent environment the problem of congestion at any one airport cannot be considered in isolation. To determine a truly optimal airport price structure, it would have to be determined for networks of airports rather than for just one. Such a mathematical endeavor would require a degree of complexity far beyond current analytical models and techniques [30, p. 31].

Marginal cost pricing could result in a schedule of charges which may be hard for certain kinds of aviation or types of flights to pay. Regional (local), commuter carriers and short-haul trunks would be strongly affected. Pure marginal pricing would probably eliminate flights for which the airport fees are a significant percentage of the value of the flight to the operator.

This is, in fact, the purpose of such a price structure--to ration out low value users; but if we consider the value of such flights not only in terms of their revenue but also in the context of their role in the air transport system, additional consideration is necessary.

The commuter and local service (local carriers, better known as regional carriers, are slowly moving out of the small community category and are operating more like trunks) carriers provide air transport on routes of lesser density between small traffic centers and between those centers and principal centers. They serve those routes which have been abandoned by the major trunks due to uneconomic operations and company expansion. As such, they provide a very important feeder function, i.e., bringing passenger traffic to the major airports which otherwise may not have used the major trunks. Carriers such as Ozark, Southern, Allegheny, Ransome, Pilgrim, etc., generate passenger traffic for the larger trunk airlines and thus, provide a valuable service in the air transport system.

Airport administration could hardly be expected to make such a radical change in pricing policy in a single step, given the extremely different natures of the current and proposed systems. A great deal of their apprehension would be with respect to the reactions by various aviation interest groups. In addition, the inability of analysts and of economic theory to determine in advance equilibrium pricing schedules and to forecast the precise effects of marginal cost pricing on airport usage raises some financial risks [30, p. 36].

A true and satisfying evaluation of the economic and political costs and benefits of marginal cost pricing can only come about by actual experience and not theory.

This will conclude most of the background material on airport congestion in the New York area. The usual format for this type of study is to include a "review of literature" section dealing with previous publications in the field. Due to the limited amount of material (especially during the last few years) and the structuring of my work, I shall intersperse such critical reviews throughout the analysis where appropriate. I believe that this approach will better lend itself to organization and continuity.

CHAPTER IV. THE MAIN CHAPTER

Runway Capacity and Utilization

Runway capacity and utilization deals with the actual amount of hourly traffic in relation to the designated hourly capacity of the runway system in use. The Federal Aviation Administration through its Eastern Regional Office has specified capacities for JFK's major configurations. As shown in Table 4.1, these figures vary slightly across configurations, but rather substantially across weather conditions, the maximum capacity occurring when the weather is VFR, allowing visual approaches (VAPS) by certain aircraft, and use of a side runway. This side runway feature is one which, of the three New York airports, only JFK is able to make full usage of due to the size of the field and the runway layout. For example, if the duty runways are designated as 22R/L, overflow traffic can be cleared for 13R. Operations in this pattern will, for the most part, be noninterfering and will take some of the pressure away from the main flow. All of JFK's parallel configurations permit use of a side runway under VFR conditions to enhance traffic flows and capacity.

In spite of the high capacity layout and the relatively sophisticated instrumentation of the runways, analysis of F.A.A. statistics and airline schedules reveals some surprising results concerning the utilization of that capacity. It is my contention that through a combination of reduced airline activity and increased acceptance rates, excess capacity exists at JFK.

Table 4.1. John F. Kennedy International Engineering Performance Standards (EPS)[a]

Config. ARR - DEP		IFR	BASIC	VFR VAPS[b]	VAPS + SIDE
4R	4L	52	71	71	81
22L	22R	52	71	71	81
31R	31L	68	71	71	81
13L	13R	61	71	71	81
Single runway		45	45	--	--

[a]Source: [19].

[b]VAPS refers to visual approaches.

Proof of the latter portion of the preceding statement was arrived at by analysis of F.A.A. Performance Measurement Standards reports which contain daily summaries of hourly traffic activity at JFK during the hours from 1200-2100 local time, listing actual traffic using Kennedy runways and the EPS appropriate to the configuration in use. A comparison of the two numbers gives a performance index (PI) which represents the percentage of EPS capacity utilized in that hour. Table 4.2 presents a listing of the PIs for the month of March, 1977.

Initially, the reader will notice that capacity utilization is relatively low between 1200 and 1500, many of the PIs being less than 50%; however, this is not at all unusual for most of the nation's airports, being merely a reflection of the fact that airport usage is a very definite

Table 4.2. Runway Capacity Utilized as a Percentage of EPS[a]

Date \ Hour	12	13	14	15	16	17	18	19	20	21
March 1, 1977	38	41	45	59	75	67	78	91	63	72
2	39	39	41	59	77	65	84	68	62	64
3	37	42	43	53	70	77	90	98	63	70
4	37	41	39	49	80	90	96	90	75	73
5	33	41	43	58	74	78	69	84	63	63
6	33	36	48	53	85	65	90	89	69	63
7	35	39	51	45	74	83	78	84	49	67
8	38	61	61	51	80	74	81	85	63	67
9	39	52	38	62	68	74	78	78	58	65
10	37	46	55	54	78	77	78	91	72	65
11	58	62	56	58	73	79	79	86	67	64
12	59	78	64	77	99	50	65	96	106	100
13	44	31	42	63	48	44	54	85	86	71
14	38	39	58	58	73	70	72	88	49	67
15	39	41	48	68	78	73	75	84	58	67
16	41	42	39	66	73	79	72	90	69	79
17	51	49	55	34	77	64	84	106	83	62
18	44	50	54	58	96	106	100	110	127	100
19	32	46	38	56	75	69	65	93	65	69
20	35	67	60	81	104	106	119	133	112	100
21	49	35	54	59	77	78	70	85	49	67
22	38	49	49	21	48	64	75	85	59	67
23	39	46	56	46	70	77	83	84	56	72
24	46	54	61	59	80	75	86	106	74	
25	44	54	45	82	81	73	94	100	70	65
26	28	31	52	68	86	75	80	90	63	69
27	37	30	51	63	79	81	81	89	65	79

[a]Source: [9].

Table 4.2. (continued)

Date \ Hour	12	13	14	15	16	17	18	19	20	21
March 28, 1977	44	31	45	88	75	93	93	92	64	60
29	45	38	63	59	83	73	79	86	60	62
30	39	35	44	109	116	89	97	88	102	108
31	44	39	48	54	89	79	85	91	85	70

function of time and that this period is one of characteristically low traffic activity. The PIs for the late afternoon and evening hours show the increase in activity associated with the classic airport "rush hour,"[16] which, again, is common in varying degrees to the majority of the world's airports as well as most transport systems (air or surface).

The real significance of these Performance Indexes becomes evident when they are aggregated categorically. The results are as follows:

% of Capacity Utilized	% of Time Occurring
greater than 100%	5%
80-100%	21%
less than 80%	74%

For various reasons, to be dealt with in succeeding sections, the runway capacity of JFK is underutilized a substantial portion of the time.

[16]The term "rush hour" in this context does not refer to a single 60-minute hour, but rather a period of time usually from 1500-2000 hours (local time).

However, reiterating the introductory theme, this does not prove the nonexistence of delays and social costs, it is merely a comparison of calculated practical capacity versus actual usage.

An objection might be raised at this point concerning the limited sample used of one month out of possibly an entire year. The reader must keep in mind that the type of traffic involved here is composed of over 90% scheduled commercial flights whose daily operations do not vary (with the exception of unscheduled changes) to any recognizable degree. If we use the Official Airline Guide [26] as a barometer of schedule variability, the majority of schedule alterations occur at time changes, i.e., daylight savings-standard time. The fluctuation from month to month would probably have only very minor effects on the results of Table 4.2.

Another objection might be that the presence of adverse weather introduced some distortion into the PIs. The effect of weather on Kennedy operations will be discussed later in an important section on delays, but suffice it to say for now that weather problems are common to all months and that the EPS do vary to reflect changing airport environmental conditions.

The former portion of the statement made earlier made reference to a decline in airline activity as a contributing factor to subcapacity utilization of runways at Kennedy International. Proof of this statement was reached by a comparison of airline schedules listed in the Official Airline Guide for October, 1977, with an "average schedule" as compiled by Carlin and Park [5, p. 45] for the weeks of September 1, 1967, and February 1, 1968. The results are shown in Table 4.3.

The results are rather impressive. A very substantial decline in the level of scheduled flights has occurred since 1968. The morning hours registered some of the more dramatic changes while the afternoon and evening changes, although still quite substantial, were smaller by comparison. This seemingly unbalanced decrease between the two periods may be, in part, accounted for by the relative volume of traffic carried during those hours.

Overall, there were 142.3 fewer arrivals, 164.9 fewer departures and a total of 317.2 fewer operations scheduled for October, 1977. In terms of a time frame of reference, Carlin and Park's composite schedule listed 838 operations during a 15-hour period, while the CATER LOG [1] for October 7, 1977, showed 889 actual operations in 24 hours.

Table 4.4 presents a similar analysis for actual general aviation traffic; notice again the tremendous decline in the level of activity.

To get more of an idea why airports were so congested and delays so high, let me recreate a situation which could have occurred at JFK in the late 1960s.

With 1978 technology, basic VFR capacity is 71 operations/hour; in terms of 1967-68 capability, the capacity would be much lower, possibly in the 50-60 operations/hour range. Suppose the configuration in use on a given day had a capacity of 52 operations/hour, the airport would be operating near capacity all morning with the heavier evening rush still

Table 4.3. A Comparison of Air Carrier Scheduled Operations: 1977[a] versus 1967-68[b]

	8 am	9	10	11	12	13	14
ARRIVALS							
C & P	17.9	15.1	20.3	17.2	24.8	21.4	29.3
10-77	11	2	9	8	5	12	19
% REDUCTION	39	87	56	53	80	44	35
DEPARTURES							
C & P	33.9	33.7	28.5	18.4	26.1	20.1	24.2
10-77	10	23	16	9	11	11	6
% REDUCTION	71	32	44	51	58	45	75
TOTAL							
C & P	51.9	48.8	48.8	35.6	50.9	41.5	53.5
10-77	21	25	25	17	16	23	25
% REDUCTION	60	49	49	52	69	45	52

[a]Source: [26].

[b]Source: [5, p. 45].

15	16	17	18	19	20	21	22
32.4	48.9	39.9	37.3	28.3	34.4	24.7	17.4
30	39	30	15	23	25	18	11
7	20	25	60	19	27	27	37
24.6	21.5	30.9	43.3	35.5	29.7	34.6	23.9
8	19	22	29	32	20	34	14
67	12	29	33	10	33	2	41
57.0	70.4	70.8	80.6	63.8	64.1	59.3	41.3
38	58	52	44	55	45	52	25
33	18	27	45	14	30	12	39

Table 4.4. A Comparison of General Aviation Traffic: 1977[a] versus 1967-68[b]

	8 am	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Carlin & Park	10.1	6.0	6.5	9.2	7.5	10.7	11.4	10.8	15.1	16.6	15.0	12.4	9.6	9.6	6.2
CATER 10-7-77	2	2	1	4	2	2	6	9	6	14	12	12	6	5	3
CATER 10-8-77	5	5	3	3	2	5	7	2	6	11	11	7	6	3	0
CATER 9-30-77	0	0	3	4	0	1	7	9	13	14	9	6	8	5	7
CATER AVERAGE	2	2	2	4	1	3	7	7	8	13	11	8	7	4	3
% REDUCTION	80	66	69	57	87	72	39	35	47	22	27	32	27	58	52
Average Reduction = 50%															

[a]Source: [1].

[b]Source: [5, p. 48].

to come. Keep in mind that I have assumed VFR conditions! Lower the ceilings and(or) visibility, add thunderstorms or snow flurries or any type of IFR weather and the runway capacity will get much lower, making it difficult for the airport to accommodate scheduled traffic without delays.

Runway instrumentation has increased and improved since those days, in 1972, three new ILS's were installed on runways 4L/22R and 31L in addition to an approach lighting system on 13L. Improved ILS's were installed in 1974 on 13L/31R and 4R/22L to increase JFK's all weather capability. Installation of an all-weather guidance system on runways at all three airports in the metro area for landings in visibility as low as a quarter of a mile was completed during 1975 [24].

Before closing out this section, one other item is of considerable interest when examined in retrospect in light of its current status. During the initial 16-month period following the implementation of the F.A.A.'s High Density Reservations System (1968-1969), the Airport Reservations Office was able to approve or provide an acceptable alternative reservation for virtually all requests [12]. In other words, carriers had trimmed schedules and were making full or very close to full usage of available slots.

Now, contrast that situation with the one described in Table 4.5. Actual total operations during system hours leave a fairly substantial number of excess slots when compared with the allowable upper limit. Even more striking is the number of unused slots for air carrier operations; with 80 available slots, 70 or more were utilized in only 3.7% of the instances shown, 60 or less were utilized about 68% of the time.

Table 4.5. Actual Operations Counts Compared to Levels Specified by the F.A.A.'s High Density Reservations System at JFK[a]

	Total Operations During HDRS Hours UPPER LIMIT = 90					
	1500	1600	1700	1800	1900	2000
July 1, 1976	49	72	70	74	83	66
2	54	76	81	89	78	75
12	55	77	60	71	71	58
20	50	76	67	74	80	58
28	50	67	70	67	65	67
June 4, 1976	47	72	78	72	75	53
12	51	64	71	70	71	64
20	48	65	66	64	67	70
28	51	71	71	75	82	56
Sept. 30, 1977	66	78	69	85	63	78
Oct. 7, 1977	55	77	74	75	75	68
8	45	66	74	65	72	59
June 1, 1976						
2						
3						
5						
6						
7						

[a]Source: ARINC CATER LOGS.

Air Carrier Operations During HDRS Hours UPPER LIMIT = 80					
1500	1600	1700	1800	1900	2000
42	59	62	65	75	59
38	56	63	67	64	66
46	65	51	60	62	48
44	67	56	65	71	50
41	58	60	57	56	61
42	59	62	59	63	49
45	56	59	60	62	55
43	58	54	53	61	60
42	60	57	61	70	49
49	60	51	67	53	64
43	65	54	58	59	56
42	55	59	51	64	50
32	46	46	56	58	58
45	59	61	59	58	45
43	64	54	62	58	57
45	57	61	60	60	49
41	66	55	58	64	55
34	44	74	55	57	50

The economic theory of congestion, as mentioned earlier, specifies that, if the users of a facility are not required to take into account the cost they impose on others (external diseconomy), i.e., a marginal cost, a facility will be overused [33, p. 34]. The evidence presented in this section demonstrates that in terms of available capacity, JFK's runway facilities are "underused" over 75% of the time.

This conclusion is not meant to preclude the existence of social and private diseconomies among users, but the data and the theoretical principle do create a curious paradox.

Airlines and Airports

In much of the literature of the late 1960s and early 1970s dealing with airport congestion, the scheduled air carriers were treated as both victims of and contributing elements to the problem. Models developed to derive pricing solutions often made various assumptions and statements about airline activity, including their demand for runway usage, scheduling and fares. For these models or derived solutions to be usable or viable as solutions, we must be assured that the assumptions made are either correct or sufficiently approximate reality. In going through studies on this topic, I have noted a number of instances where the writer(s), although unchallenged for their economic expertise, has(have) demonstrated a lack of technical knowledge with respect to some of these topics.

To begin with, demand for runway space, or for that matter airspace, is what is termed in economics as a derived demand. It is derived from the demand for air travel by the general public and is reflected in the schedules which the airlines publish. In a real sense, it is the traveling public that schedules the airlines. It is the job of the schedule planner to interpret the public's desires, and match them as closely as possible with an operationally workable schedule network. In other words, when you look at the timetable for an airline you are looking at proof of the carrier's commitment of capital investment in response to a forecasted pattern of passenger demand with respect to time.[17]

Some writers[18] have stated that this demand for runway space is a function of the user charges in effect at an airport. This suggests a variable schedule of landing charges; however, the Port Authority in their "Schedule of Charges for Air Terminals," specify a minimum user charge for air carrier operations which is invariant over time, plus a per thousand pounds of maximum gross weight charge.[19] The charge does vary for certain hours of the day for aircraft whose seating configuration is for less than 25 passengers, this includes all general aviation and most commuter and air taxi operations.

Looking at this idea from another angle, Jackson [20, p. 199] asserts that hourly capacity utilization is not a function of time of day. This statement does not hold up whether we look at general aviation traffic or

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[17] For all intents and purposes, this may be interpreted as time of day, since seasonal fluctuations in traffic involve an adjustment of that daily pattern.

[18] [22, p. 14; 20, p. 198].

[19] Maximum gross weight means the maximum weight which an aircraft may lawfully have at the time of leaving the ground at any airport in the United States.

scheduled carriers. General aviation users, since they are not on a scheduled basis, will be very responsive to any differential structuring of landing fees, which in turn is usually a function of time of day. The relationship between airline scheduling and passenger demand over time has already been explained. In light of this and personal interviews with controllers at the CIFRR and Kennedy Tower, Jackson's statement is rather puzzling.

Earlier I discussed the F.A.A.'s Reservations or Quota System and its impact on airport congestion. Yance [32, p. 280] makes an interesting point concerning a redistributive drawback of that system. He states that under a pricing scheme, a "slot" in the reservations system would command a scarcity price and revenues earned through flight operations would go to the airport as "scarcity rent." Since the quota is defined by a specific level of operations rather than explicit prices, Yance claims that the quota results in large airport rents going to the airlines. I find this to be a reasonable line of argument, but I also believe that this rent or scarcity price is far lower today than at the time Yance published his work.

My reasoning behind that statement hinges on the fact that I have already demonstrated the existence of a substantial number of excess slots currently available under the HDTA reservations system. Given this "excess supply" of slots or nonscarcity, the price of a slot or reservation should be quite low, possibly even in the neighborhood of current PONYA charges.

Further criticism of the HDTA system was presented by Walters [31, p. 149] in his claim that the main effect of the system was to "keep out" the airlines who did not appear on the scheduling committee under the "grandfather clause."

Most all air carriers in the United States today, transporting the majority of the air traveling public, are Certificated Air Carriers as granted by the Civil Aeronautics Board. The Civil Aeronautics Act provided for the automatic granting of a certificate, in 1938, to those carriers who had been in continuous operation, and in possession of an airmail contract, for a period of 90 days prior to the passage of the Act. This was known as the Grandfather Clause.

As a result of this clause, 16 major domstic airlines were granted Certificates of Convenience and Necessity and became the nucleus of the airline industry. Of this original 16, there are now 11 as a result of mergers during the years.

Current Eleven	Air Carriers at JFK
American	American
Braniff	Braniff
Continental	(not in route structure)
Delta	Delta
Eastern	Eastern
National	National
Northwest	Northwest
Pan Am	Pan Am
Trans World	Trans World
United	United
Western	(not in route structure)

In view of this listing and the conditions specified by the HDTA rulings [12], I fail to see how any airlines were "kept out."

There is one more aspect of the airline industry which has been repeatedly misstated, misinterpreted and erroneously presented: airline fares.

Numerous writers in their development of a theory of airline economics have made assertions such as the following: airlines are not free to choose the fares they wish to charge. . ., regulated airlines competing on a given route usually charge identical fares [7, p. 4]; the CAB specifies the fares for the route [31, p. 151]; (airline) fare level is exogenously determined [14, p. 277]; the CAB has the responsibility . . . of determining the fare [6, p. 309]. These statements are simply not correct.

Insofar as the air traveling public is concerned, control over fares and rates is probably the Board's most important function. Passenger fares and cargo rates are not set by the Board, however, but rather by the air carriers themselves. This is not always understood by the public, but no passenger fare or cargo rate can take effect unless an air carrier files a tariff with CAB. The Board may prefer a different fare or rate, but there is no authority in the Act [21, p. A-46] which permits the Board to require a carrier to charge a particular fare or rate. Even the Board's authority to disapprove a particular fare or rate is somewhat limited, in that the Board cannot summarily disapprove a tariff; it only has authority to suspend it for a limited period of time pending investigation [3, p. 19].

Once a particular far is approved, all carriers are not required to charge that fare. They usually do, due to the competitive nature of the industry [29, p. 39].

Finally, the impression widely exists that airlines bunch flights at a few peak hours, and that airport congestion could be materially eased if the schedules were spread out a bit. This phenomenon is often called "peaking" or "over-scheduling." Rose and Hamilton [28, p. 3] state that in any given time period there is a surplus of flights over and above that which is required to move the demand.

There are many complex factors involved in the scheduling process including airport regulations, and geographic and time zone considerations. Before discussing their importance, let me present some actual airline schedules as contained in the October, 1977, Official Airline Guide. Tables 4.6 through 4.9 illustrate the typical distribution of scheduled flights during the "normal" operating hours of the day. The frequencies shown in Tables 4.6 and 4.7 represent the scheduled operations of all major airlines serving the specific city-pair market; Tables 4.8 and 4.9 provide a breakdown by airline of those schedules.

For the sake of variety and generality, I have also selected various major city-pair markets around the country to demonstrate that the scheduling pattern illustrated for JFK is not particularly different. These data are shown in Table 4.10.

The evidence presented simply does not confirm the notion of peaking and over-scheduling which analysts have supported repeatedly. The schedules are smooth, and for the most part, spread evenly over the day.

Table 4.6. JFK Scheduled Arrivals by City[a]

City	8 am		9		10		11		12		13		14	
Albany						1[b]					1[c]			
Atlanta											1		2	
Baltimore	1									1				
Boston	2				1								1	
Chicago														1
Dallas-Ft. Worth									1					
Denver														1
Ft. Lauderdale								2						1
Los Angeles														
Miami					2	1	2	2	1			1		
Pittsburgh	1												1	
San Francisco														
San Juan							1	1						
Tampa						1	1				1			
Washington, D.C.	1						1					1		

[a]Source: [26].

[b]Indicates arrival during second half of the hour.

[c]Indicates arrival during first half of the hour.

15		16		17		18		19		20		21		22	
	1						1						1		
			1	1							1	1			
					1			1			1	1	1		
	1									2			1	2	
			1		1	1				1	1			1	
2			2				1								1
					2							1		1	
		1	1					1							
			1	2		1			1	1		2			
1	1	1		1	1				2	1	1			1	
		1			1	1			1	1					
			2	3				1		3	1	1			
	1		1			2		1				2			
					1			2							
2						1		1		1	1	1		1	1

Table 4.7. JFK Scheduled Departures by City[a]

City	8 a.m.		9		10		11		12		13		14	
Albany		1				1					1			
Atlanta														
Baltimore	1									1		1		
Boston								1						1
Chicago	1					1								
Dallas-Ft. Worth			1			1								
Denver			1				1							
Ft. Lauderdale		1	1		1						1			
Los Angeles			1				1		2	1				
Miami			1	1	1		1		1		1	1	1	
Pittsburgh														1
San Francisco	1	1					1	1	1					
San Juan	1			2						2				
Tampa		1			1			1	1					1
Washington, D.C.	1	1	1				1	2						1

[a]Source: [26].

15		16		17		18		19		20		21		22	
			1						1		1				1
		2		2			1		1			2			
		1				1		1						1	
	1				1					1			1	2	1
		1					1	1			1		1		
1					1	1	1		1						
					1	1									
		1				1						2			
1		1		2		2		1				2		1	
1				1	1	2	2					4		1	
		1	1	1		2	1	1							
		1				3	1	1				1	1		1
					2									1	
			1		1		1	1					1		
1		1	2	1						1		1		1	

Table 4.8. JFK Scheduled Arrivals by Airline[a,b]

City		8 a.m.	9	10	11	12	13	14
ALB	AL			1			1	
ATL	DL						1	1
	EA							1
BA	AL					1		
BOS	AA	1						
	TW			1				1
ORD	NW							
	TW							
	UA							1
DFW	BN							
DEN	TW							
	UA							1
FTL	DL				1			
	EA				1			
	NA							1
LAX	AA							
	TW							
	UA							
MIA	EA			1	1		1	
	DL				1			
	NA				1			
PIT	AL							
	TW	1						1
SFO	AA							
	TW							
	UA							
SJU	AA				1			
	EA				1			
TPA	NA			1			1	
	EA				1			
	DA							
WAS	TW							
	BN			1			1	
	NA				1			

[a]Source: [26].

[b]Restricted to major market carriers.

15		16		17		18		19		20		21		22	
	1						1						1		
			1									1			
				1							1				
		1			1			1					1		
	1													1	1
										1					
											1			1	
			1			1									
					1					1					
2			1				1								1
					1							1			
					1									1	
		1						1							
			1												
			1									1			
				1		1			1			1			
				1						1					
	1			1	1				1						
		1													
1									1		1			1	
					2			1							
		1				1				1					
				1						1					
				1				1				1			
			2	1						2					
	1					1						1			
			1					1				1			
								1							
					1										
								1							
						1						1			
2															1
						1				1				1	

Table 4.9. JFK Scheduled Departures by Airline[a,b]

City		8 a.m.		9		10		11		12		13		14	
ALB	AL	1					1					1			
ATL	DL														
	EA														
BAL	AL	1											1		
BOS	DL								1						1
	TW														
ORD	NW	1													
	TW														
	UA						1								
DFW	BN														
DEN	TW			1											
	UA							1							
FTL	DL					1						1			
	EA		1												
	NA			1											
LAX	AA			1						1	1				
	TW							1							
	UA									1					
MIA	EA			1				1							
	DL					1							1		
	NA				1					1				1	
PIT	AL														1
	TW														
SFO	AA			1	1					1					
	TW							1							
	UA								1						
SJU	AA	1			1						1				
	EA				1						1				
TPA	NA					1			1						1
	EA									1					
	DL		1												
WAS	TW														
	BN			1											
	NA		1						1						1

[a]Source: [26].

[b]Restricted to major market carriers.

15	16		17		18		19		20		21		22	
		1						1		1				1
	1		1								1			
			1			1		1			1			
	1				1		1						1	
				1					1			1		
						1								
	1						1					1		
1				1	1		1							
				1										
				1										
					1						1			
	1										1			
	1				1						1			
1			1		1		1				1			
			1										1	
1			1	1	1	1					1			
											1			
											1			
					2		1	1						
	1		1											
		1										1		
	1				2		1				1			
					1	1								1
				1										
				1									1	
		1					1							
						1								
				1								1		
	1													
1		1	1								1			
										1				

Table 4.10. Demonstration of the Absence of "Peaking" in Airline Scheduling: Scheduled Arrivals[a]

City Pair		8 a.m.		9		10		11		12		13	
ORD - LGA	AA				1	1	1			1	1		2
	TW				1				1		1		
BOS - LGA	EA	1	1		1		1		1		1		
	AA	1		1				1			1		
LGA - DFW	AA						2		1				
DEN - ORD	UA						1					1	1
	CO						1						
ORD - WAS(Nat)	TW			1							1		
	UA				1		1		2	1			
LAS - LAX	WA	1		1			1		1	1		1	
MSP - ORD	NW	1	1	1	1	1			2	2		1	
LGA -ATL	DL			1				2					

[a]Source: [26].

14		15		16		17		18		19		20		21		22	
1	1		1		1		2	2	1			1	2	1		1	
	1		1		2		1		1		1		1		1		
1	1		1		1		1			1		1		1	1	1	
			1			1					1				1		
	1	1	1	1	2	2		1		1		2	1				
	1			1						1				2			
1						1			1			1					
		1					1	1						1	1		
1					1		2	1		1	1					1	
1		1	1	1			1		1	1	1		1	1			
	1		1		1	1		1		1	2			1			
1						2				1							1

The impression of heavy peaking of service is quite understandable. Anyone going to an airport after 5 p.m. will see large numbers of passengers together with their baggage, taxis, friends and relatives. The volume of passengers would logically create the impression that there must surely be a corresponding peaking of flights. Airline service on any given route is, almost always, spread through the day.

The reason for this is simple economics. To intensify schedule activity for a few hours each day would require surplus resources in the form of extra planes, gates, flight and ground crew--over and above the levels required during the rest of the day. This would result in very expensive equipment sitting idle for most of the day, while waiting for a few hours of peak period operation.

Normal airline practice is to put an aircraft into service early in the morning and run it well into the evening. For example:

Delta 245[20]

Fort Wayne	--	Detroit	6:00 a.m. - 6:20 a.m.
Detroit	--	Indianapolis	6:25 a.m. - 6:51 a.m.
Indianapolis	--	Atlanta	7:16 a.m. - 9:32 a.m.
Atlanta	--	Ft. Lauderdale	10:16 a.m. - 11:45 a.m.
Ft. Lauderdale (DL 458)	--	Chicago (ORD)	12:31 p.m. - 2:09 p.m.
Chicago (DL 239)	--	Atlanta	2:26 p.m. - 5:06 p.m.
Atlanta	--	Miami	6:03 p.m. - 7:35 p.m.

[20] Source [26] and telephone conversation with Delta in New York.

The flight number will be changed and the aircraft will resume operations after servicing. Notice that this aircraft will be arriving and departing Atlanta during the rush hour period; the passenger demand determined this, but note that this aircraft is in operation all day and night and not waiting to be used just for the Atlanta peak period.

A similar scenario could be sketched for most JFK operations. Utilization is an economic fact of life for the scheduled carriers, so that any airline's timetable would show a lack of bunching of service on a given route.

Situations do exist, however, in which an involuntary peaking occurs because of geography or time zones, beyond the control of the airline. Traffic arriving from the western United States will not reach the New York area until late afternoon because of the combination of five hours of flight time and three more hours due to time zones.

For example, a flight out of California leaves at 8:00 or 8:30 a.m. The plane will not arrive in New York until late afternoon--about 4:30 or 5:00 p.m. After normal servicing, it will depart within an hour or so. There is no violation of the utilization rule. The equipment is, in fact, in use all day; it just doesn't get into the New York area until late afternoon.

Tables 4.11 and 4.12 reveal a very clear cut case of bunching, in this case, international traffic. International arrivals tend to be heaviest during late afternoon while the departures are distinctively concentrated in the late evening. Even in this situation, the schedules

Table 4.11. JFK Scheduled International Arrivals[a]

	9 a.m.		10		11		12		13		14		15	
Amsterdam														2
Athens										1				
Copenhagen													1	1
Frankfurt								1			1			1
London											1	2		2
Madrid													1	1
Paris									1			1		1
Rome														2

[a]Source: [27].

16		17		18		19		20		21		22		23	
1		1	1					1							
1	2														
1		1	1												
	2					2									
2	3	1					1	1	1						
	1							1							
2						1		1	1	1					
2		1													

Table 4.12. JFK Scheduled International Departures[a]

City	9 a.m.	10	11	12	13	14	15
Amsterdam							
Athens							
Copenhagen							
Frankfurt							
London	1	2					
Madrid							
Paris		1					
Rome							

[a]Source: [27].

16		17		18		19		20		21		22		23	
				1		2	1	1				1			
1			1	1		1			1	1					
				1				2		1					
				1			1		1			1	1		
					1	1		2	3	1	1	1		2	
			1			2			1						
						1	1		1			2		1	
				1			1	1	2	1					

are still at very low hourly levels and relatively spread over the relevant time period.

With the five hours lost going from New York to London (Western Europe), not to mention upwards of eight to ten hours for routes to Eastern Europe, the Middle East and India, many periods are impractical for trans-atlantic departures. A departure from New York at 1500 hours would mean an 0240 hours arrival in London. This is a highly undesirable time when you take into consideration customs, currency exchange, hotel check-in, and so forth. Thus, international departures peak in the evening, when they will permit arrival first thing the next morning.[21]

A cross-section view of Kennedy traffic demonstrates the relationship between major traffic peaking and the presence of long haul service. Figures 4.1 and 4.2 provide an F.A.A.-generated breakdown of traffic according to stage length. The tables are self-explanatory and serve to illustrate the dominant role of long haul traffic in the JFK (New York) market. Figure 4.2 shows that during the evening rush hours, over half of the activity involved flights of over 1,000 miles. Also notice that the short and medium haul flights do show what could technically be called peaking, but that the contribution to overall peak hour activity is very small by comparison with the long haul group.

Taking a composite picture of all types of traffic, there will be in total a peaking of activity, but clearly, this is not a deliberate

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[21] Another factor which constrains international scheduling is that many European airports close after midnight and may not reopen until 0500 or 0600 the next morning.

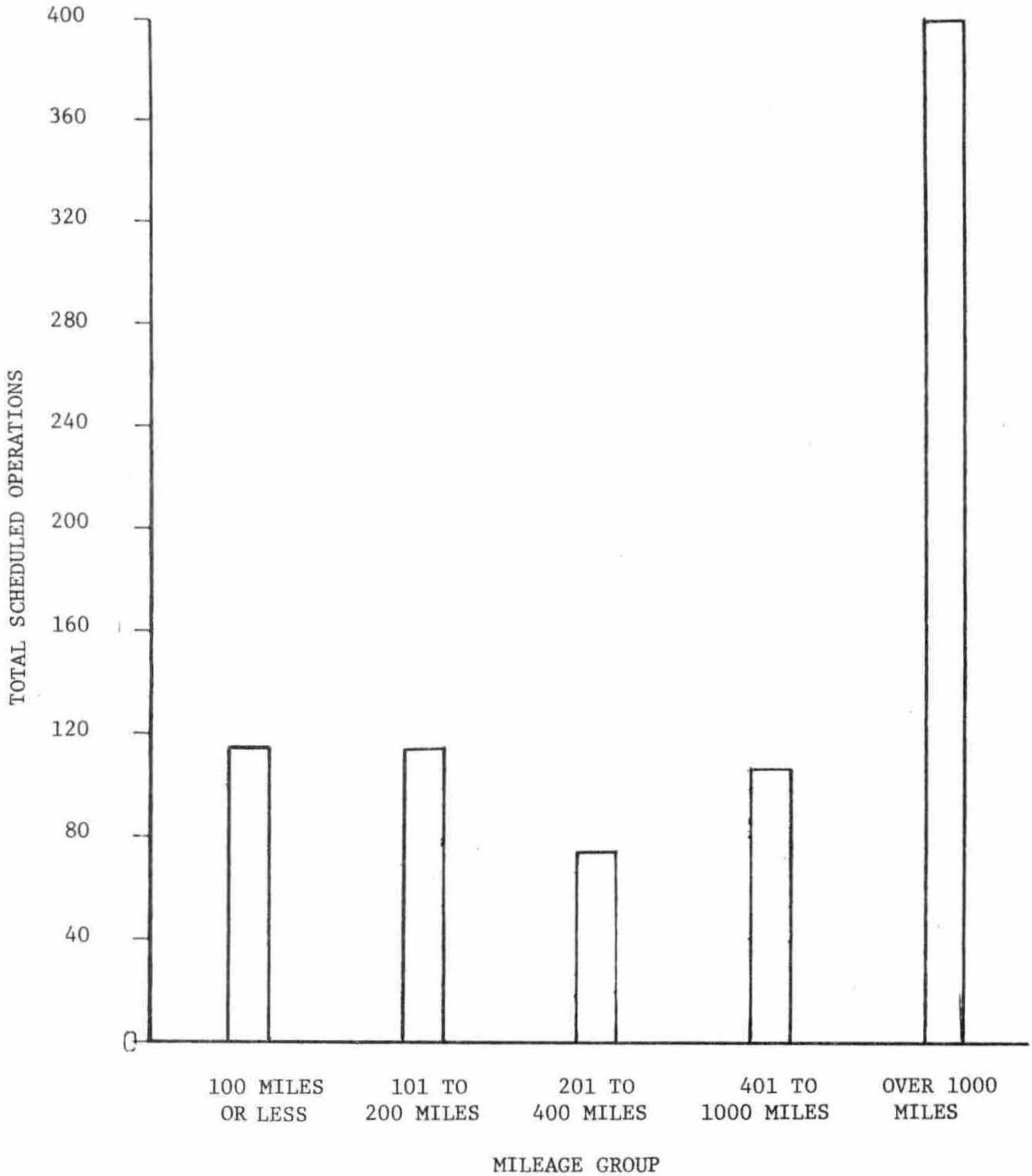

Figure 4.1. Scheduled Operations by Mileage Group (Source: [1], [26])

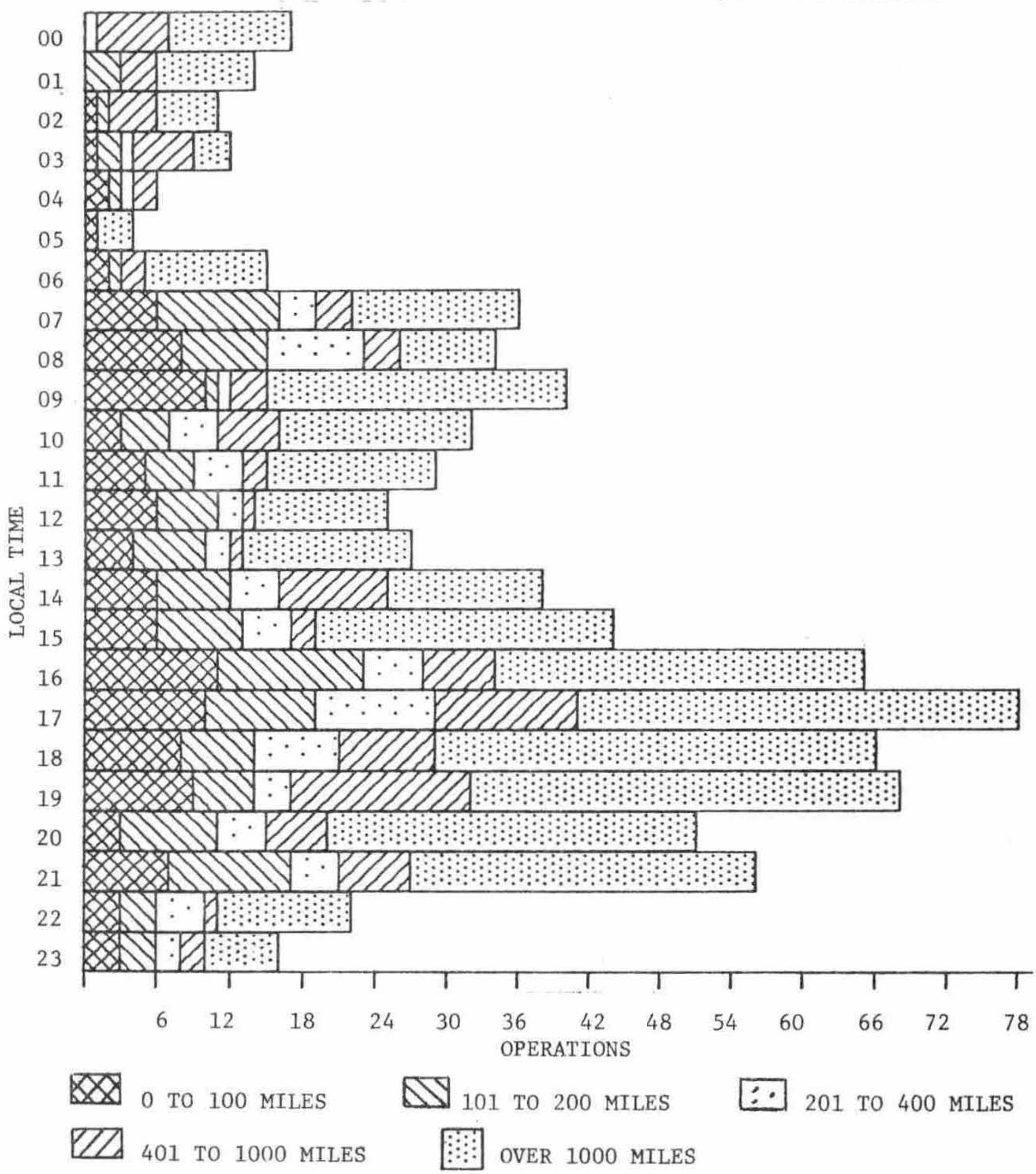

Figure 4.2. Stage Lengths and Time of Day (Source: [1], [26])

managerial decision. It is not a case of holding planes idle all day in readiness for the peak hour. The planes are in use all day, some of them just don't get into New York-JFK area traffic until late in the day because of time zone problems.

In summary then, airline schedules are spread throughout the day and are not bunched during peak hours as economic analysts and much of the traveling public have assumed. Economic rationality dictates utilization of aircraft during as many hours of the day as possible.

The peaking which I have detected at JFK is a function of the long-haul nature of over half the airport's operations. Combining this fact with our concept of scheduling and passenger demand, and the all-important geographic time zone element, an involuntary peaking occurs which is essentially beyond the control of the airline scheduler.

Before closing, let me reiterate my introductory remarks as a qualification at this point: the preceding analysis is designed to show the pattern of scheduling by the airlines and as such does not preclude the possiblity that many of these flights have generated various social costs during their operations on a given day to and from Kennedy. Airline reaction to any alteration of existing price structures in response to these costs would hinge on the elasticity of demand for runway usage at specific times; to predict this response to a time varying price structure at a particular airport, the repercussions of each possible change on the complete schedule must be considered (see Appendix I). It is unlikely that an airport planner or economist could make these estimates accurately [30, p. 32].

Air Traffic Control

Previously, I have dealt with two components of the airside system: runway capacity and airline flight scheduling, the remaining component is one of the most interesting, complex and volatile of all--the airspace.

The airspace layout in the New York metro area is probably one of the most complex in the country. A unique situation exists here which demands a special configuration of arrival and departure routes: JFK lies southeast of LGA by only 9 miles (measured from departure end of 13R-JFK to 4-LGA) and east of EWR (Newark Airport) by only 19 miles (measured similarly). With three high density airports operating in such close proximity, special procedures are required.

It was the recognition of this fact which prompted the F.A.A. to define the concept of a "terminal control area" in September, 1969. Specifically, they defined a "Group I Terminal Control Area," composed of 10 of the busiest airports in terms of aircraft operations and passengers carried, where it was considered necessary for safety reasons to have stricter requirements for operations within TCA than at other locations.

In a study on Midair Collisions [12, p. 8], it was found that 97% of terminal area accidents occurred below 8,000 feet AGL (above ground level), and that the vast majority involved conflict between general aviation and either an air carrier, military or another general aviation aircraft. Of particular note was that the mix of uncontrolled VFR and controlled IFR aircraft was cited as a basic causal factor of the air traffic conflicts.

In light of the fact that the density of air traffic is greater in Group I TCA's, and over 60% involves air carrier operations--just over 90% at JFK--conflicts resulting from the above traffic mix have a great potential for a major catastrophe. Thus, the F.A.A. deemed it essential to impose maximum safety requirements at Group I locations. Traffic was to be separated based on more stringent equipment and piloting requirements at the designated TCAs.

In order to design a safe and efficient terminal control area, it was necessary to tailor the airspace configuration to the particular needs of the area, factors such as aircraft types, facilities at the airports within TCA, navigational aids available and the air traffic capability to meet the TCA concept's needs had to be considered.

The New York Air Route Traffic Control Center (ARTCC) controls IFR traffic arriving and departing the New York metropolitan area with the exception of tower enroute operations.[22] The ARTCC operates in conjunction with the New York Common IFR Room (CIFRR) which is responsible for the terminal area portion of the flight. Overflights, i.e., aircraft with destinations outside the metro area, are generally routed east or west of the terminal areas and adjoining low altitude sectors to reduce congestion in the transition sections.

Each arriving aircraft must be transitioned from the enroute phase to the terminal phase and sequenced with other arriving traffic before handoff to the CIFRR approach controller. The transition function consists

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[22] The control of IFR enroute traffic within delegated airspace between two or more adjacent approach control facilities.

of positioning the arrival flights so that they arrive at the handoff point in an orderly sequence, with adequate spacing, and at specified altitudes and speeds.

The ARTCC sectors adjoining the CIFRR are responsible for the transition and handoff of aircraft to the appropriate approach controllers. In general, the preferred routes for arriving traffic terminate in a common enroute segment and approach fix or clearance limit depending upon the direction from which the flight comes. The CIFRR services a total of 20 airports, including LGA, JFK and EWR. Tower enroute services are provided between the CIFRR and Philadelphia, Allentown, Wilkes-Barre, and Westchester towers, and McGuire Air Force Base.

Kennedy and its satellite airports are served by the Bohemia (BOHLO), Southgate (SATES), Empire (ELLIS), and Shrimp holding/arrival fixes. Traffic arriving over these fixes is descended to specific altitudes (depending upon fix and runway in use), and then sequenced at intervals of five miles or more before being handed off to Kennedy approach at the CIFRR, except when holding is required. Holding aircraft are provided 1,000 feet of altitude separation and then turned over to approach control. Vectoring from these fixes to final approach takes place, for the most part, in the area east of JFK. Handoff to the tower is accomplished at a point eight miles from the runway.

For departure traffic, Standard Instrument Departure (SID) routes have been developed to accommodate JFK traffic. Departures are normally radar identified within one mile of the runway and, after noise abatement turns have been made, vectored through the Metroplex until handed off to

ARTCC. The designated handoff points are located between 20 and 35 miles from the airport.

The proximity of the three airports, especially JFK and LGA, requires that a highly structured system of route and altitude restrictions be used to separate traffic between the airports as well as activity to and from the same airport, due to high traffic density and limited airspace. The flow of traffic through this network has a very direct impact upon runway utilization rates and delay patterns. In the initial chapter, mention was made of certain "factors" which profoundly affected the air-side operation of the airport, one of which was aircraft mix.

The mix of traffic has a direct effect upon capacity utilization in one very important way: size and wake turbulence.[23] Increased radar separation must be used when smaller and(or) lighter aircraft are in-trail behind a heavy jet. Current landing procedures in conjunction with heavy jet traffic may be a contributing factor to the subcapacity utilization of the runways at JFK.

Table 4.13 and Figures 4.3 through 4.5 demonstrate the tremendous proportion of heavy jet aircraft at JFK during most of the day. As mentioned earlier, Kennedy airport is regarded as the "heavy jet airport of the world." This title is certainly well-illustrated in Figures 4.3-4.5.

Closer examination of Figures 4.3 and 4.4 further confirms a point made at the end of the previous chapter. Notice how heavy departures peak toward the late evening hours--international departures--and in the earlier

[23] See Chapter II for a review of this relationship.

Table 4.13. Aircraft Category Analysis[a]

TIME \ CATEGORY[b]	% HEAVY A	% HEAVY D	% HEAVY TOTAL	% LARGE/SMALL A	% LARGE/SMALL D	% LARGE/SMALL TOTAL	% LIGHT A	% LIGHT D	% LIGHT TOTAL	% LIGHT THAT ARE SCEDULED AIR TAXI
8 - 9 a.m.	54	40	46	38	47	43	8	13	11	100
9 - 10	60	68	67	20	20	20	20	4	7	100
10 - 11	14	74	51	71	17	32	29	9	16	50
11 - 12	20	47	36	50	27	36	40	20	28	57
12 - 13	29	50	44	71	45	52	0	5	4	100
13 - 14	63	62	62	31	46	38	13	0	7	50
14 - 15	42	18	33	26	45	33	32	36	33	30
15 - 16	40	25	36	32	44	35	26	25	26	47
16 - 17	60	36	51	24	29	26	18	32	23	28
17 - 18	57	34	46	24	31	28	22	31	26	22
18 - 19	58	44	51	26	31	29	16	22	19	44

19 - 20	56	52	54	31	26	29	13	19	16	40
20 - 21	49	63	55	30	17	24	19	17	18	43
21 - 22	64	50	55	28	36	23	8	14	12	25

[a]Source: CATER LOGS, September 30, 1977.

[b]HEAVY JET category (greater than 300,000 lbs.): DC-8 (all series), DC-10, 707-320B, 747, L-1011, VC-10, IL-62.

LARGE/SMALL JET category (12,500-300,000 lbs.): DC-9 (all series), 737, 727, 720B, 707-120B, BAC-111, CV-580.

LIGHT AIRCRAFT category (less than 12,500 lbs.): Piper Aztec, BE-99, DHT (despite gross weight the DHT was included under light aircraft due to its comparability with respect to speed and weight; more so than the planes in the LARGE/SMALL category).

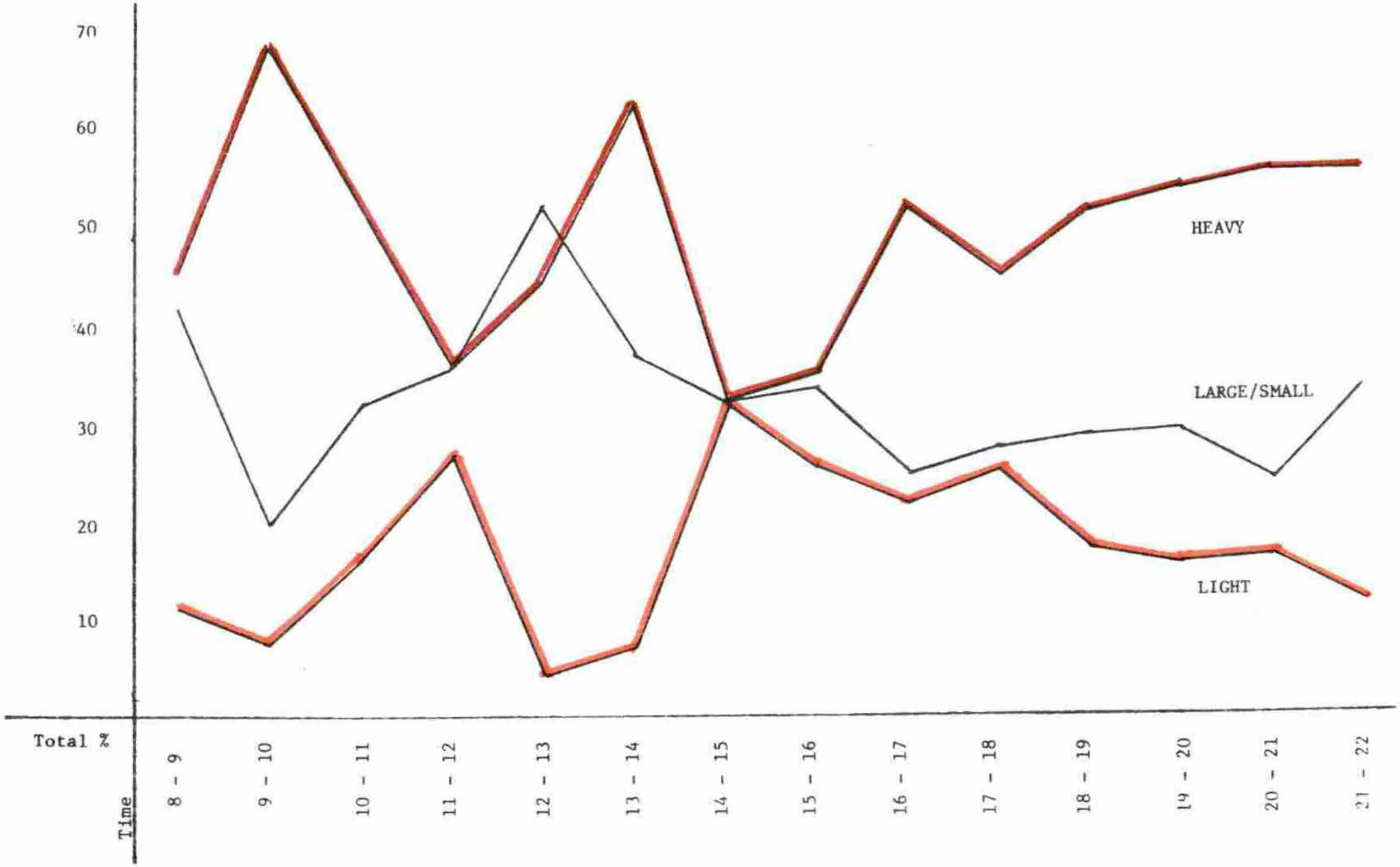

Figure 4.3. John F. Kennedy International Total Traffic by Category of Aircraft

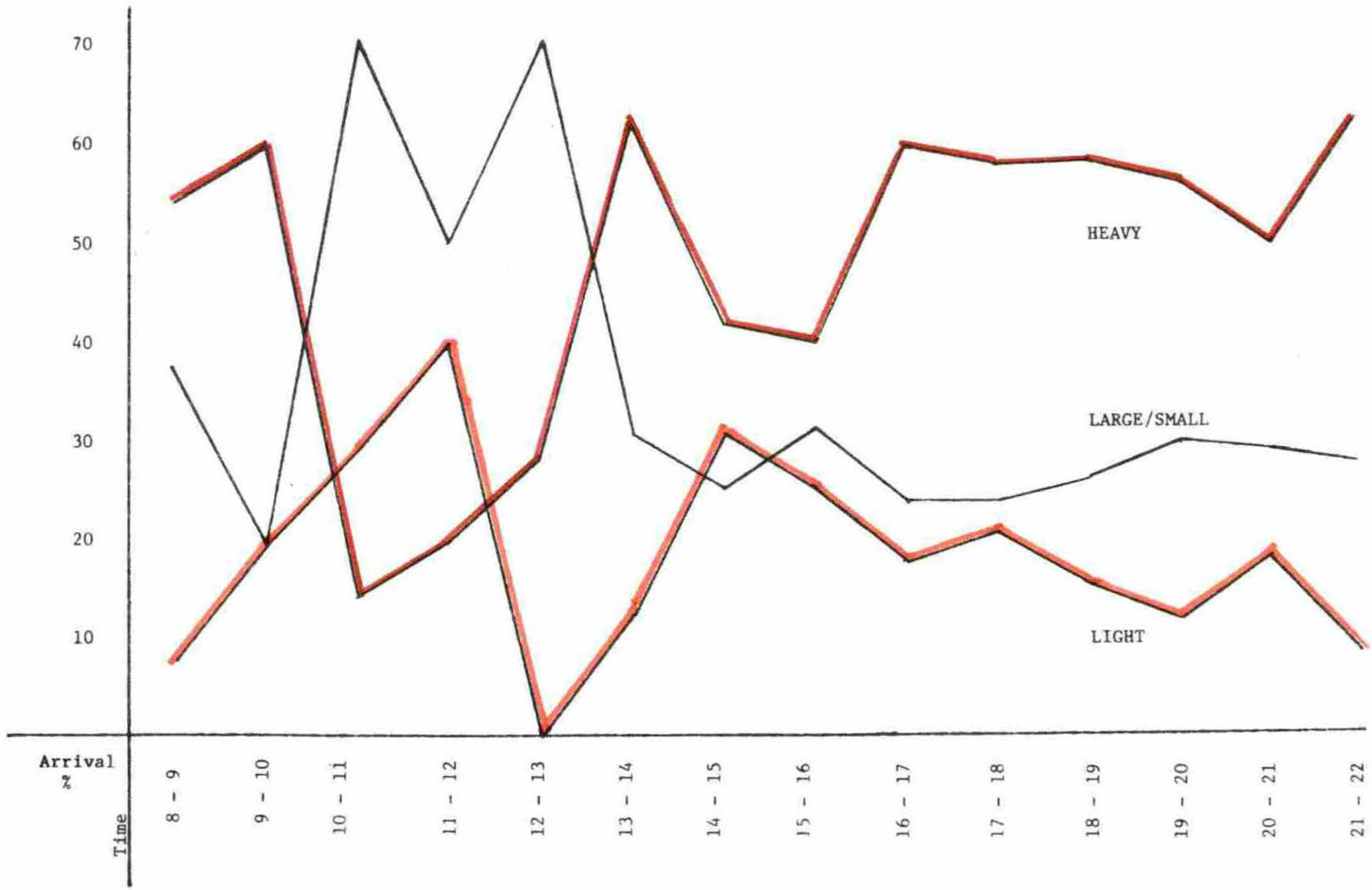

Figure 4.4. John F. Kennedy International Arrival Traffic by Category of Aircraft (Source: Table 4.15)

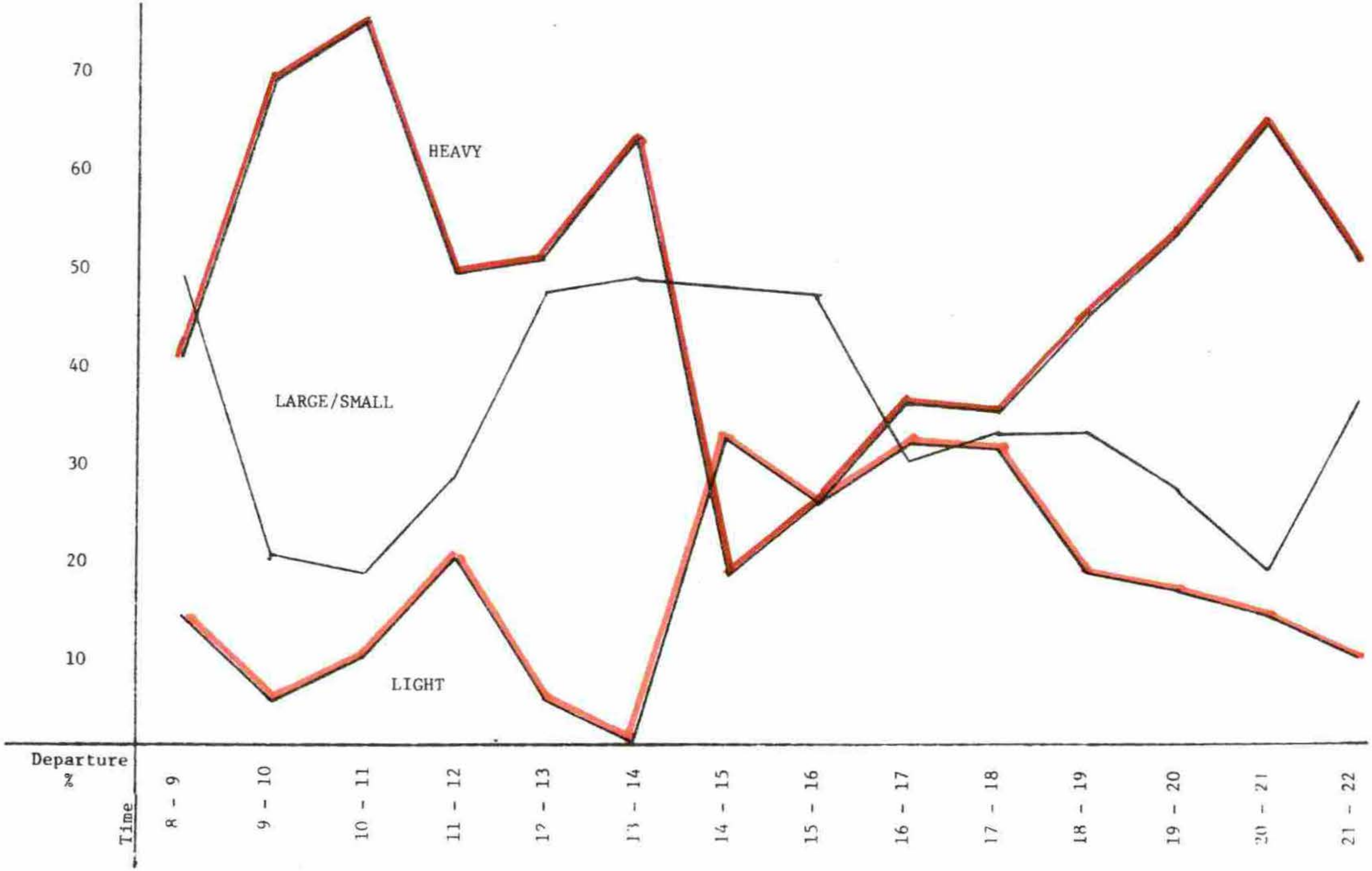

Figure 4.5. John F. Kennedy International Departure Traffic by Category of Aircraft (Source: Table 4.15)

part of the morning--transcontinental traffic, and also how heavy arrivals peak in the evening--transcontinental and international arrivals. Since it is the large, long-range aircraft which fly these routes, the long haul nature of the majority of Kennedy's traffic demonstrates itself again, this time through analysis of air traffic composition.

I believe it would be safe to say that the disadvantages of increased separation are, in part, offset by the effect that the jumbo or wide-body jets have had on the level of traffic activity. Given the tremendous passenger and cargo capacity of the heavy jet aircraft, more passengers and cargo can be carried using fewer aircraft. For example, in terms of passenger capacity as listed in the O.A.G. [26, p. 28], the following aircraft equivalents show the reduction in traffic a 747 might generate:

Approximate 747 Equivalents

Number	Type of Aircraft
2-4	707
3-4	727
2-3	DC-8
1-2	DC-8 (series 60)

One of the more interesting statements about this aspect of TCA operations was made by Walters in regard to landing fee discrimination across classes of aircraft: "A small aircraft on a duty runway occupies as much airspace and runway as a 747" [31, p. 145]. In an associated footnote, he clarifies this by stating that "it may be claimed" that the smaller aircraft (prop driven) occupies more airspace due to approach speed differentials.

For some of the aircraft using Kennedy, the speed differential element is significant, but for most of the operators of prop driven or small corporate aircraft, wake turbulence is the dominant factor. Controllers handling Learjets, Swearingens or DHTs will base separation distances mainly on the wake turbulence consideration. Certain speed limits applicable to TCA and beneath TCA also help to reduce the difference in actual speeds among different aircraft.[24]

In terms of marginal effects, a small plane has a much greater in-trail impact than a larger jet in terms of economic costs. The marginal impact of a Piper Aztec in-trail behind a heavy 747 (or any wide-body or jet aircraft) is to spread aircraft out far more than were the Piper not there. Not only must the Piper be placed well-behind the jumbo, but following jet liners must be "over-separated" to prevent overtake in-trail. If this following aircraft was another 747, it would have to be placed possibly as far as 12 miles back. The Piper has generated a delay upon traffic flows by causing increased separation ahead and behind, resulting in relatively longer TCA flying time. Increase this to three or four general aviation operations during busy periods and the domino effect or marginal impact on costs to passengers and airlines becomes substantial.

Finally, runway service times for the two classes of aircraft are not even close. Runway time requirements for heavy jets are far greater due to weight and extra separation required behind them, A small plane, however, can be clear of a runway very quickly, especially in the landing operation and thus, a much shorter service time.

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[24]This is not to say they totally disregard speed.

Walters goes on to say that through a reduction in the general aviation component overall delays would be reduced to an average 10 minutes instead of the much higher values of greater than an hour experienced during bad IFR conditions in 1967-68.

The author does not reveal where the figure 10 minutes comes from, but more importantly, average delays in bad IFR will not be 10 minutes as we shall see in a subsequent chapter dealing with weather in the terminal and enroute areas around New York. Bad IFR, more often than not, involves conditions which are extremely conducive to very high delay levels. The C.A.B. designates a flight as being "on-time" if it operates within 15 minutes of its published schedule. An average delay of 10 minutes would convey the notion that most flights are operating close to schedule; this simply is not the case under severe meteorological conditions.

Furthermore, eliminating G.A. traffic during bad IFR will not significantly affect TCA delay levels since most general aviation pilots (the rational ones) will not be flying under these conditions anyway.

Along a similar line, Grampp states that space in the air has a zero price due to its abundance [16, p. 23]. I have already illustrated a situation where location in space may involve certain economic penalties, being 16-20 miles back from the preceding airliner rather than 3-5, due to the presence of a small aircraft in between, represents an additional cost incurred by the trailing jet. In this sense, the airspace does have a price, the potential marginal cost imposed upon commercial airliners by G.A. operators by their presence in TCA traffic flows.

The airspace also has a price in terms of airway availability and fuel consumption. Space in the air appears abundant until we examine navigation charts for high and low altitude routes in the transport-intense Northeast Corridor. Resembling an intersecting network of highways, the airspace for this area is probably one of the most intensely used in the country. This means that certain routings and(or) altitudes which would ensure more economical operation of the aircraft may not be available to a particular flight.

Because of the relationship between aircraft speed, altitude and fuel consumption rate, the overall flight profile flown by an aircraft is an important factor in determining fuel burn. For instance, an aircraft can adopt a high rate of climb, a cruise climb, or something in between these two extremes. The actual climb profile performed by departing aircraft depends partly upon company regulations and also the ATC departure clearance in effect for the routing.

In the cruise mode, flight may be performed at a constant flight level, or the aircraft may take advantage of the continual reduction in aircraft gross weight (resulting from fuel consumption) and perform a "gradual climb" profile to increase altitude to maintain an optimum rate of fuel burn.

If the aircraft cruises at constant altitude, at some point in this level cruise, because of reduced weight, the aircraft is in effect being operated at a lower altitude than optimum for a given weight and airspeed and, hence, begins to consume fuel at a faster rate. A gradual climb profile may not be possible because of conflicts with other traffic. In congested airspace such as the Northeast Corridor, with aircraft operating in both directions, the gradual climb profile would require considerable "sterilization" of airspace between requested and operating altitude. In other words, in congested or heavily used airspace where altitude flexibility may not be readily available, aircraft may incur a fuel burn penalty because of ATC traffic considerations.

In summary then, we have seen that the presence of heavy jet aircraft in the traffic pattern can result in somewhat less than full-capacity capability utilization due to wake turbulence considerations and the subsequent radar separations. On the other hand, we saw that these jumbo or wide-body aircraft permit the airlines to carry greater payloads using fewer aircraft, resulting in a reduction in air traffic.

The deviation from full capacity utilization is minimized (given current usable technology) with an all jet traffic lineup but becomes significantly large with a jet-general aviation mix. Certain techniques and procedures are currently used or are being developed to reduce this deviation in the future.

CHAPTER V. "ON A CLEAR DAY. . ."

Traffic Analysis

In this chapter I intend to show that Kennedy International can run traffic with very low average levels of delay and that the primary cause of delay in the New York area is not inadequate facilities, airline scheduling or heavy jets, but something over which our control is, at best, indirect.

Initially, flight strips[25] and CATER LOGS covering three days[26] of operations at JFK were obtained (see Table 5.1 for examples of each). Through the use of this data in conjunction with the Official Airline Guide for that period, delay estimates were calculated for Kennedy arrivals. During the hours for which data were collected, a number of flights had to be left out of the tabulations since they were not listed in the O.A.G. and no scheduled arrival times could be determined. Table 5.2 contains a sample page[27] from the data compiled; certain flights are listed in the table with a square around their approximated delay times (for example, NW 222, 8-9 a.m.), these were exceptionally large by comparison with the

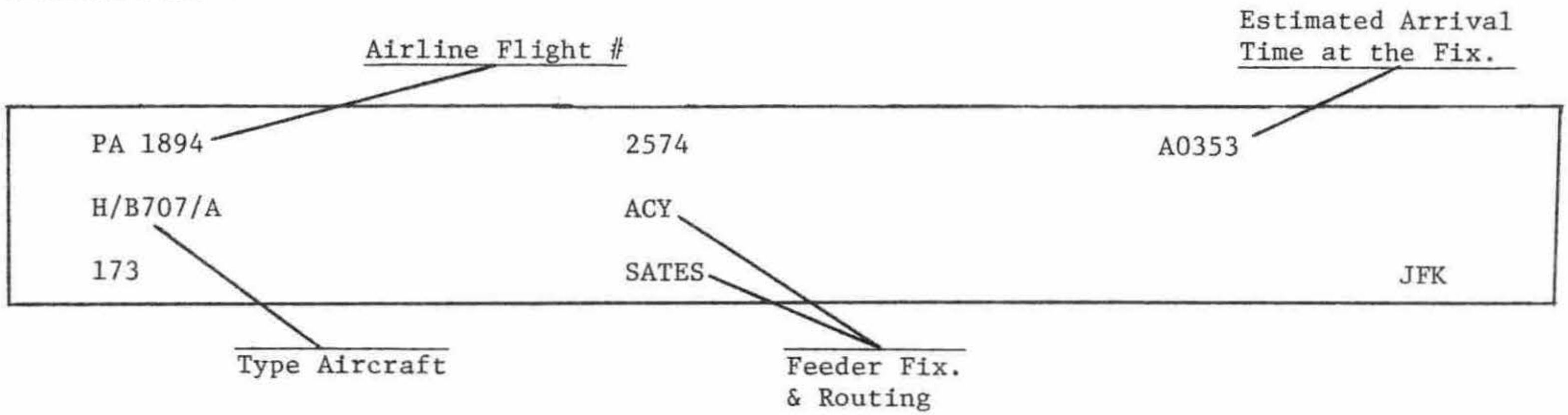
[25] Flight strips were courtesy of the New York Common IFR Room.

[26] Three days were used instead of one because of certain fluctuations in delay time. For instance, EA 191 was 4 and 2 minutes early on 9/30/77 and 10/7/77, respectively, but was 31 minutes late on 10/8/77. It seemed more appropriate to average the days together to compensate for odd combinations such as that rather than just use one.

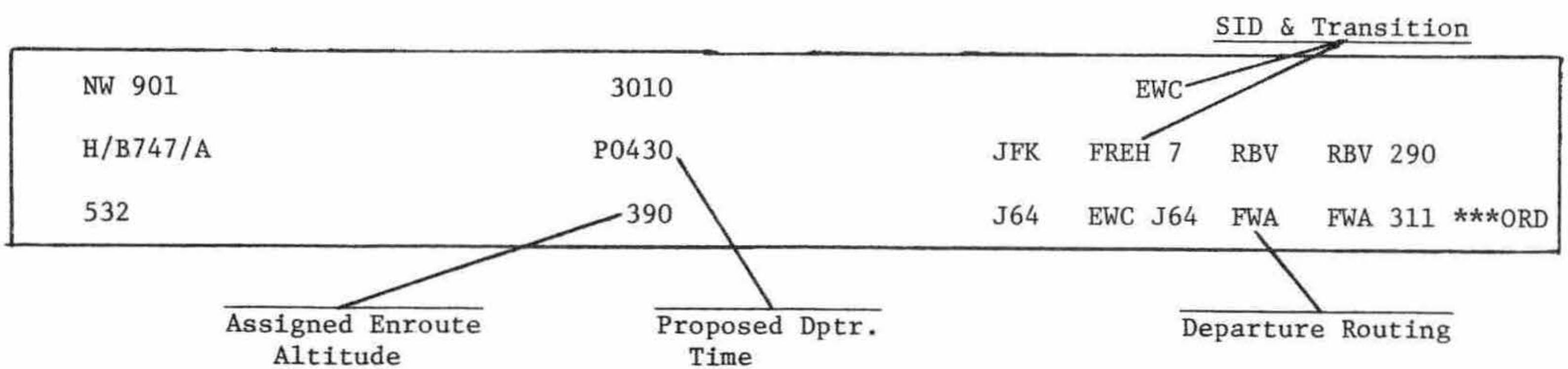
[27] The remainder of the data was omitted due to the unnecessary amount of extra time and cost (218 flights listed) involved in preparing it for incorporation into the study.

Table 5.1. Example of Flight Strips and CATER LOGS

ARRIVAL STRIP:



DEPARTURE STRIP:



CATER LOG ENTRIES:

Date and Time (GMT)	Flight I.D.	Aircraft	Type Operation	Arrival or Departure	Flight Rules	Runway	Requested Taxi Time
071203	DL 441	B727	A	D	I	31L	1159
071205	AA 59	B707	A	A	I		
071207	TW 702	B707	A	A	I		

Table 5.2. Sample from Arrival Delay Data

	Equipment	Origin	Feeder Fix	A.G.A.[a] 10-7-77	A.G.A.[a] 10-8-77	A.G.A.[a] 9-30-77	S.G.A.[b]	S.G.A. - A.G.A. 10-7-77	S.G.A. - A.G.A. 10-8-77	S.G.A. - A.G.A. 9-30-77	Average Delay
0800 - 0900											
AA 59	707	BDL	B	1215	1226	1225	1216	1	(10)	(9)	(6)[c]
TW 702	707	PHL	PHL	1217	1210	1216	1213	(4)	3	(3)	(1)
AA 645	727	PVD	B	1221	1222	1220	1218	(3)	(4)	(2)	(3)
EA 191	727	YUL	E	1224	1257	1222	1226	2	(31)	4	(8)
AA 117	H07	BOS	B	1226	1228	1232	1224	(2)	(4)	(8)	(5)
NA 482	727	ORF	S	1230	--	1230	1229	(1)	--	(1)	(1)
AA 608	H07	YYZ	E	1234	1233	1234	1230	(4)	(3)	(4)	(5)
NW 222	H47	DTW	E	1238	1137	1133	1134	1:04	(3)	1	(1)
EA 923	L011	BDL	B	1246	1251	1247	1250	4	(1)	3	2
AC 740	9	YUL	E	1254	1306	1303	1300	6	(6)	3	1
NA 61	727	PVD	B	1257	1305	1254	1254	3	11	0	5
0900 - 1000											
AC 770	9	YYZ	E	1331	1334	1335	1330	(1)	(4)	(5)	(3)

<u>1000 - 1100</u>											
TW 7	H011	BOS	B	1425	1424	1415	1412	(13)	(12)	(3)	(9)
EA 884	727	PBI	S	1435	1422	1420	1420	(15)	(2)	0	(6)
AA 625	727	PVD	B	1452	--	1450	1453	1	--	3	2

[a] Approximate Gate Arrival equals CATER LOG touchdown time plus 10 minutes taxiing time.

[b] Scheduled Gate Arrival equals the time the flight is listed for in the O.A.G.

[c] ( ) number in parentheses indicates positive levels of delay.

others. In view of the fact that no major delays were recorded in New York airspace, these exceptional delays were assumed to have occurred at the originating airport or enroute outside the NYARTCC area, as such they were ignored to avoid distortion of the delay picture for the Kennedy-New York area.

The actual calculation of the delays involved a comparison of approximate and scheduled arrival time at the gate. Approximate gate arrival was figured by taking the landing or touchdown time for each operation (CATER LOG) and adding on another 10 minutes for taxiing time to the gate position. At an airport the size of Kennedy, the amount of time from landing until reaching the gate averages 10 minutes.[28] This time will actually vary as a function of an airline's terminal location with respect to the landing runway[29] in use at a specific time (see Table 5.3). The 10 minute figure is also used by Kennedy Tower personnel in determining delays for both arrivals and departures.

This procedure was performed for each flight and then compared with the arrival times published in the O.A.G., which are times at which the aircraft should arrive at the gate. The differences calculated for each of the three days were then combined to provide an "average delay" for each operation listed.[30]

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[28]Information provided by Chief, Kennedy TRACAB through personal communication, December 14, 1977.

[29]For example, taxi times for Eastern and Delta arrivals will vary greatly if landings are being conducted on 13R (short) as opposed to 4R (long).

[30]To make the numbers a bit more realistic, I have assumed that any minor delays at the airport of origin were made up for enroute and that the constant taxi time will offset any actual ground delays at JFK.

The final step was then to compress the "average delay" into an "average hourly delay" as shown in Table 5.4, along with a distribution of the flights according to specific levels of delay.

Table 5.3. Taxiing Distance Information

Given a specific arrival runway the following major airlines may experience above average taxiing times:

4R	13L
United	Northwest
Braniff	World
Dominicana	Delta
Eastern	Eastern
American	Air Panama
Olympic	Pan Am
	Allegheny
	International Arrivals Building

22L	31R
National	Eastern
BOAC	Air Panama
Air Canada	Northwest
American	World
Olympic	Delta
United	United
Braniff	Dominicana
Dominicana	American
	Olympic
	Braniff

The significance of this information can be seen by examining the average hourly figures: they are very low and in some instances, almost negligible. In other words, under favorable conditions, normal arrival traffic at Kennedy can be accommodated with very low, almost insignificant levels of average delay. A look at the distributional data in the lower

Table 5.4. Arrivals

Hour	Average Hourly Delay (Minutes)	Number Late	Number Early	Number On Time
0800-1000[a]	(2.08)	9	3	--
1000-1200[a]	(4.98)	10	3	1
1200-1400[a]	(7.53)	14	1	--
1400-1600[a]	(4.06)	19	10	2
1600-1700	3.07	17	18	--
1700-1800	(8.90)	16	5	--
1800-1900	(5.21)	12	2	--
1900-2000	(4.81)	13	7	1
2000-2100	(5.87)	16	7	--
2100-2200	.92	6	6	--
2200-2300	(1.73)	7	3	1
		139	64	5

Total = 208

OVERALL AVERAGE DELAY = (3.74)

Late (Minutes)	# Aircraft	% of Total
1- 5	40	28.8
6-10	40	28.8
11-15	29	20.8
16-20	13	9.4
21-25	8	5.7
over 26	9	6.5
	139	100.0

[a]These hours combined due to the small number of arrivals during these hours.

half of Table 5.4 reveals that roughly 57% of the recorded flights were within 10 minutes of their schedule, and if we use the CAB's on-time criteria,[31] 78.4% of the flights would be regarded as on time.

Weather

This section probably represents the most striking departure from the standard approach previoualy employed by economic analysts in the discussion of airport congestion (not that my previous chapters have taken the traditional route, either). As far as I have been able to find, no section on weather has ever been included in an economic analysis of this topic;[32] yet, as you shall see, weather is probably the dominant factor in congestion and delay situations.

Eakin and Bear, National Weather Service meteorologists with the Central Flow Control section of the Air Traffic Systems Command Center, have stated that major delays are almost always caused by weather phenomena of some sort [8, p. 13]: an airport closed or hampered by dense fog, runways blocked by deep snow, thunderstorms overhead, or by strong, gusty surface winds discouraging use of the most advantageous runways.

Thunderstorms that develop to heights above most aircraft ceilings (about 40,000 feet), forming extensive and essentially solid lines, are one of the main problems for air traffic controllers. Circumnavigating individual storms causes no difficulty, but, if aircraft are forced to divert across different ARTCC boundaries, contact and control can be

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[31] Within 15 minutes of scheduled time.

[32] Carlin and Park [5] included various weather categories as dummy variables in their regression analysis, but even here it was reduced to a quantitative element and not treated with the degree of importance that it warrants.

temporarily lost, and workload capacities can become strained. Thunderstorms present a special problem to the New York Center area. Airspace is so limited that a single thunderstorm can disrupt the flow of traffic, and a line of any extent causes a near catastrophe. Reroutes and stops on traffic are not unusual during severe weather.

Aircraft delays due to weather are also likely to depend upon rather small increments of the element involved. Surface wind winds of only 20 to 30 knots, if from a certain direction, will cause large delays; yet, a change in the wind of only a few degrees or knots will make possible an immediate improvement of the situation.

The ARTCC's are also very interested in the location of the jet stream, because it may affect the number of long distance flights traversing their areas and thus, affect the complexity of their tasks. Clear air turbulence (CAT) is also of interest because it often causes deviations from established routes, thus disrupting Center operations.

Analysis of delays for this phase of the study was developed from NASCOM reports which list by hour the number of aircraft delayed, average delay in minutes and the cause of the delays broken down by facility (NYARTCC, CIFRR, JFK TRACAB).[33] April, July, October, and December, 1977, are shown in Tables 5.5b-f (with abbreviations given in Table 5.5a).

A careful examination of the information presented in Tables 5.5b-5.5f (tedious though it may seem) reveals one very distinct and unmistakable element in so many of the explanations of delays to Kennedy (in some

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[33]NASCOM reports average delays greater than or equal to 30 minutes.

Table 5.5a. Abbreviations Used in Tables 5.5b-5.5f

A/C	Aircraft
MAPS	Missed Approaches
RVR	Runway Visual Range
SWAP	Severe Weather Avoidance Procedures
TRW	Thunderstorm, moderate rain shower
20 MiiT	20 miles in trail
TSTMS	Thunderstorms
VAPS	Visual Approaches
Wx	Weather
ZNY	New York ARTCC
JFK	Kennedy Tower
7/3 and 3/11	Shift during which delays occurred

Table 5.5b. NASCOM Delay Cause Analysis--August 1977

Date		Time	Delay Max	Delay Avg	# A/C	Cause
8-02-77	Arv	1434 - 2030	72	40	68	Severe weather, deviations and A/C inability to hold primary patterns.
	Dpt	1711 - 2415	117	71	153	SWAP, TSTMS, ZNY-CIFRR stops, reroutes due to severe Wx.
8-04-77	Arv	1656 - 2000	52	39	25	Weather, volume and rwy change.
8-05-77	Arv	1529 - 1828	73	44	59	Severe weather, increased spacing, deviation and rwy changes.
	Dpt	1513 - 1546 1614 - 1745 2129 - 2200	 58 34	33 49 31	1 4 11	Weather, rwy changes and closure, Dptr restrictions and stops, pilot deviations due to weather.
8-06-77	Arv	1805 - 2127	53	38	18	Severe weather, pilot refusal to make aprch, and deviations.
	Dpt	1721 - 2341	92	59	177	Severe weather, SWAP TSTM ovhd, pilots refusal to depart, ZNY and CIFRR stops and reroutes.
8-12-77	Arv	1715 - 1804	40	31	11	Volume and inability to conduct visuals to overflow runway.
8-13-77	Arv	1720 - 2040	65	38	46	Wx below VAPS minimums and 1 arv rwy.
8-14-77	Arv	1543 - 1600	33	32	4	Unable to hold at SATES due to Wx, tfc to BOHLO.
		1653 - 1830	68	42	25	1 Arv rwy due to Wx below VAPS minimums, arv tfc from the South rerouted due to adverse Wx @ SATES.

8-17-77	Arv	1700 - 1806	47	40	7	Demand greater than acceptance rate, unable VAPS to overflow rwy due to reduced vsblty.
8-31-77	Dpt	1709 - 1921	132	119	3	PHL low level stopped due to Wx.
		1936 - 2053	57	34	25	Volume and backlog.
		2245 - 2316	50	50	2	Nonconforming runway.

Table 5.5c. April NASCOM

Date			Cause
4-02-77	3/11	CIFRR	Arv dly, due to Wx, demand, missed approaches, two acft requiring priority handling.
		JFK	No dlys.
4-03-77	7/3	ZNY	Arv dly due to low RVR conditions.
		CIFRR	Dpt dly, stops due to interference on primary and secondary departure frequencies originating from Con Ed.
4-04-77	3/11	ZNY	Adverse Wx of mdt-svr turbl at all flight levels up to FL 360 necessitated ZNY 20-Miit restriction.
		CIFRR	Arv dly, demand exceeding capacity, for one rwy arv ops.
		JFK	Demand, acft on nonconforming rwy.
4-23-77	7/3	ZNY	Dpt dly, equipt. failures, emergency returnee.
	3/11	ZNY	Single rwy ops, Wx, 4R/22L closed.
		CIFRR	Increased spacing for dptrs and alternating approaches with LGA. Use of 13L/R at JFK periodically to equalize delays at both aprts and minimize total dly impact.
		JFK	Wx IFR, single rwy, dptrs required to hold short of ILS critical area.

4-24-77	7/3	ZNY	Dptr dlys, emergency acft returning, ILS critical area.
		JFK	Wx IFR.
	3/11	CIFRR	One rwy ops, backlog, Wx, and spacing for dptrs.
		JFK	One rwy ops., IFR Wx.
4-26-77	3/11	CIFRR	Arv dlys, single rwy, IFR Wx, rerouting around Wx by ZNY.

Table 5.5d. July NASCOM

Date			Cause
7-01-77	7/3	CIFRR	Dptr dlys, stop due to acft blocking frequency, returning airliner with engine failure resulted in 8 min closure of airport.
	3/11	JFK	15 acft taxied simultaneously plus those already at the dptr rqy; brief stops due to rubber reported and removed from dptr rwy.
7-02-77	3/11	CIFRR	Rwy change, acft returnee, nonconforming JFK dptr.
7-07-77	3/11	ZNY	SWAP implemented, TSTMS, dlys due to CIFRR restrictions to towers.
		CIFRR	Volume, one rwy, unable to use overflow due to Wx.
7-11-77	7/3	CIFRR	CIFRR/ZNY stops sue to Wx and reroutes, acft refusing to depart due to Wx.
		JFK	TRW off dptr end of rwy, turbl reported mdt-svr, acft requested reroute, reluctant to dprt into TRW.
7-16-77	3/11	ZNY	SWAP implemented, severe Wx, Metro dptrs rerouted, JFK arv dlys due to volume, rwy config., and unable to hold at ELLIS due to Wx.
		CIFRR	Arv dlys, volume, one arv rwy, restricted vsblty precluded visual approaches.
		JFK	No delays.
7-17-77	3/11	CIFRR	Arv dlys due to volume, inability to conduct VAPS due to poor vsblty. Dptr dlys volume, Wx requiring ZNY reroutes during SWAP stops and restrictions on account of Wx.
7-19-77	3/11	CIFRR	Dprt dlys due to ZNY stops, restrictions due to Wx.

7-21-77	7/3	CIFRR	Dptr dly, ARTS handoff malfunction.
	3/11	ZNY	SWAP implemented due to line TRWS, westbound routes unpenetrable, inbound tfc unable to traverse certain jet routes. JFK dptr dly due to ZNY HUO stops and subsequent HUO 20 MiiT rstn. ZNY SARDI rstn. JFK arv dly, demand exceed acceptance rate, reduced vsblty, limited VAPS.
		CIFRR	2 rwy changes, 1 arv rwy, unable VAPS to overflow due to reduced vsblty, conflicting flow at LGA, and winds above 15 knots. Stops on SW dptrs due to Wx.
7-25-77	3/11	CIFRR	Arv dlys due to demand exceeding arv capacity, Wx precluded the use of more than one arv rwy. Dptr dlys due to rwy change and windshift.
7-31-77	3/11	CIFRR	Arv dlys, 15-26 mins demand exceeded capacity.
		JFK	No dlys.

Table 5.5e. October NASCOM

Date			Cause
10-01-77	3/11	ZNY	Arv dlys, low ceilings, vsblty limiting arvs to one rwy, demand exceeding acceptance rate.
		CIFRR	Volume, single rwy due to high winds, no VAPS.
		JFK	No dlys.
10-14-77	3/11	ZNY	Low ceilings, vsblty, heavy rain, strong winds, svr turbl. Reports of svr trub at SATES, ELLIS, 20 MiiT, reduced holding capacity for Metro area, JFK had reduced acceptance rate.
10-16-77	3/11	ZNY	Wx in vicinity increasing in intensity during the shift, JFK dptr delays due to Wx reroutes and stops.
		CIFRR	Svr Wx, dptrs refusing release.
		JFK	TSTM overhead, xvr turb.
10-19-77	3/11	ZNY	Wx affecting ops from Metro area. JFK TSTM overhead, 20 MiiT.
		CIFRR	6 MiiT, due to poor to nil braking action.
		JFK	No delays.
10-28-77	3/11	CIFRR	Dlys due to volume.
		JFK	No delays.
10-29-77	3/11	ZNY	Demand exceeds capacity, IFR Wx, no VAPS, MAPS.
		CIFRR	Wx below VAPS, rwy change, dptr dlys when CIFRR stops due 6 arvs overflying when they lost visual contact.

Table 5.5f. December NASCOM

Date			Cause
12-01-77	7/3	ZNY	Fog, vsblty caused MAPS, some acft diverted.
	3/11	JFK	No delays.
12-05-77	3/11	ZNY	Rain showers, low ceilings and vsblty, mod-svr turb at all arv fixes.
		CIFRR	High winds heavy rain, wind shear, mod-svr turb, increased separation, temporary suspension of operations at JFK, LGA.
12-13-77	3/11	CIFRR	Arv dlys due to Wx conditions which precluded use of multiple landing rwys.
12-14-77	7/3	ZNY	Low ceilings and vsblty, at all Metro airports.
		JFK	Nonconforming ops, accoutn of 40 knot tailwind down to 500 ft on duty rwy.
	3/11	ZNY	Low ceilings, vsblty, rain and fog, JFK arv dlys due to Wx, spacing account of wind shear.
		CIFRR	IFR Wx, wind shear, high winds aloft, poor braking action.
12-18-77	3/11	ZNY	Wx throughout Metro area, low ceilings and vsblty, freezing rain, ice pellets and snow. Braking action fair to poor. Demand exceeding capacity.
12-19-77	3/11	ZNY	Wx/demand caused dlys in Metro area, single rwy at JFK.
12-21-77	7/3	ZNY	IFR Wx throughout area with mod-svr turb for flts negated use of some holding areas.
	3/11	ZNY	Low ceilings and vsblty prohibited VAPS, one rwy, rwy change.
		JFK	No delays.

cases, the Metro area in general) flights: weather phenomena of some sort were the cause of the delays in nearly every instance. Elaboration or any extensive text dealing with this conclusion would be, at best, useless reiteration of what these tables already demonstrate so clearly and dramatically.

In conjunction with this, there is one other item which I neglected to mention during my traffic analysis of the preceding section; it seemed more appropriate to present it now in light of the above results from NASCOM. The weather for the three sample days from which I derived JFK arrival delays, was very good VFR,[34] which means excellent visibility and clear skies or unrestricted ceilings.

In summary, we have seen that the airspace in the New York area (TCA and neighboring Center areas) is a very highly organized and controlled entity which is designed with the purpose of providing a safe and efficient flow of air traffic to and from the New York airports. With good meteorological conditions (VFR), this system operates extremely well, with delays to flight operations well within a tolerable range, but given unfavorable winds or adverse weather of varying intensity or severity, traffic flows will be disrupted (the extent of the disruption will be a function of the level of severity of the weather) and alternate routings and(or) special procedures may be required culminating in large delays and some disgruntled passengers.

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[34]Information provided by Kennedy Tower Chief in personal communication, December 14, 1977.

CHAPTER VI. TEN YEARS AFTER: SUMMARY AND CONCLUSIONS

The contributing factors to the airport congestion crisis fall under two general headings:

1. Bunching of schedules by airlines creating critical levels of traffic during peak periods; excessive levels of scheduling putting a strain on airport capabilities; and
2. Inadequate runway capacity in combination with the above, resulting in overused facilities and delays.

These were the targets at which a marginal cost-based user charge was to be aimed. The objective of such a policy was to require the marginal user to take into account the total extra delay caused by his(her) operation, including the delay the user incurs plus that imposed on others. Landing fees seem generally to be based on the average cost of the landing area. For efficient use, fees would be equal to marginal cost, which Yance says are likely to be less than average cost, plus the congestion toll equal to the marginal external delay. In addition to this rationing function, the new system was promoted as an aid to economic logic in decision making since it would give airport planners a more economically sound and efficient basis upon which to make expansion decisions. Value of service pricing was soundly criticized on the grounds that since it did not reflect real user valuation of the airport, expansion decisions based on it would be economically meaningless.

So there you have the two characteristics or causes of the problem as determined by previous economic analysts and the general solution which they believed would put the airports and airlines on a more efficient operating basis.

In nearly complete contrast, here are the conclusions drawn from my own analysis:

1. Bunching of scheduled flights by airlines simply does not exist. Schedules examined in this study for Kennedy traffic show a very smooth distribution of activity over the day. Levels of scheduling per hour per airline are by no means excessive in terms of sheer numbers. An involuntary peaking occurs at Kennedy, but this is strictly due to the long haul nature of the traffic in conjunction with geography and time zone considerations, not a result of managerial policy.
2. Runway capacity utilization at Kennedy indicates the existence of excess capacity the majority of the time; excess slots also exist under the HDTA Reservations system.
3. The primary cause of major delays to JFK flights in the New York area is the weather. Major delay occurrences in the Center, Terminal and Tower areas were attributed to weather phenomena of some sort in nearly every instance on record from the five month sample for 1977.

This evidence describes a situation which is as different as night and day in comparison with the 1968-70 scenario. The conditions which so detrimentally characterized Kennedy in those congestion-riddled late 1960s, as identified in the literature, no longer seem to exist to the extent previously described.

It is on the basis of this evidence that the use of full marginal cost pricing should be questioned. There are four reasons for this. First, if a marginal cost schedule was devised, say, based on delay levels for the three-day sample I used for estimating arrival delays at JFK, the total delay cost would probably not be too much different from the weight-based charge in effect now. If we can assume economies of scale in the operation of JFK airside facilities, then marginal cost will be less than average (as Yance said) and the additional "delay charge" will be very small.

Second, the most likely time for large traffic-related delays to occur (other things being favorable) will be during the evening rush hours. I have already demonstrated the involuntary peaking which occurs at Kennedy during those hours due to the activity involving transcontinental and trans-atlantic flights. This traffic operates under a twofold constraint: passenger demand within a time zone-oriented framework and alterations of flight schedules resulting from higher fees might cost the airline much of its passenger traffic unless the carrier is able to induce travelling at "awkward hours" through monetary incentives. In the case of international carriers, economic policy changes must be tempered with the very real and powerful element of diplomatic complications. In light of Kennedy's (New York's) role as a major international gateway, such complications could be very extensive and eventually prove to be more persuasive than economic considerations. Therefore, marginal cost landing fees might be a difficult policy to impose on this group due to their operational nature, diplomatic involvements and levels of scheduling.

Third, major delays to Kennedy traffic may almost always be linked to weather conditions. Where there are delays (whatever the cause), there are social costs, and with some of the major tie-ups the weather can induce, these costs can be substantial. My question is: How and to whom do we charge these costs? Let us assume that between 1700-1800 hours inbound traffic from various cities is approaching the New York TCA with all flights on schedule. Now, suppose that a large mass of unstable warm air in the New York area has finally blossomed into an area of severe weather: poor visibility, moderate to severe turbulence, aircraft refusing to depart due to thunderstorm off departure end of runway, reroutes, in-trail restrictions--EXTENSIVE DELAYS. All of our inbound traffic will probably experience delays of 30 minutes or more. The costs involved here are substantial, but who is responsible and who shall be penalized according to our theory of congestion pricing?

The point being made is that when an airport or airspace (TCA, ARTCC) is in a delay posture, it will not always be clear how we should measure the delay, whom should be charged and for what reason. Situations do exist wherein the economic theory does not provide a very applicable solution.

Fourth, certain decisions with respect to capacity expansion at JFK <u>were</u> made on the basis of economic criteria. In December of 1969, the

Port of New York Authority approached the Environmental Studies Board[35] about undertaking a study of the environmental impact an extension of runways at Kennedy International would have on Jamaica Bay and its surrounding communities [23].

One of the conclusions was that any runway construction would damage the natural environment of the Bay, and reduce its potential use of conservation, recreation and housing. The degree of that impairment would be dependent upon the amount of Bay area taken. To the extent that use of some Bay area for runways reduces the recreational potential of the Bay, the future opportunity for recreation of some New York City residents would be lost (an opportunity cost) so that others might have the benefits of air travel. But because the airport land and the Bay are owned by the City, there would be no direct charge to the air traveler for use of the Bay land if there was an expansion, as there would be no charge to recreational users if the airport is not expanded. Any public decision to use the Bay for expansion would have involved a transfer of social cost from one segment of the community to the other without any compensation from the users who benefit directly.

Analysis such as this in conjunction with environmental and ecological impact statements in a cost-benefit framework was used to provide an economic-enviromental case against the City's plan for runway expansion into Jamaica Bay.

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[35] Representing a combination of the National Academy of Sciences and National Academy of Engineering.

As a result, the City of New York and the Port Authority elected to postpone any expansion plans for the Kennedy runway system in the near future.

During this study, I have repeatedly made reference to the sizable reductions in the level of scheduling by the commercial air carriers since 1968. Economic history provides much insight into some of the changes which have taken place in the industry during the last several years, and which have altered the scenario since the late 1960s.

Powerful economic forces in 1970 gave the scheduled airlines the worst financial results in their history. The national economic recession that began in 1969 and continued into 1970 slowed domestic passenger traffic growth almost to a halt in 1970. Inflation continued to plague the industry at a rate of about 9 percent in 1970 over 1969, almost double the national rate. The major portion of this pressure came from labor settlements which increased airline wages by some 15 percent in 1970.

In response to these and other adverse forces, many carriers cut flight schedules to eliminate unprofitable flights and reduce uneconomic competition (capacity agreements). This began in the second half of 1970 and by May, 1971, there were 5.2 percent fewer domestic flights scheduled than the same month of the prior year.

Cost inflation continued to be a serious problem for the airlines in 1971. Over the prior five years, inflation for the industry had grown at an average annual rate of 6.7 percent while that for the nation as a whole had been 4.4 percent. The single most important reason for this was that airline wage rates continued to be among the highest in private industry. Landing fees, which account for one of the largest portions of airline airport costs had, in the prior ten years, risen more rapidly than the number of operations. This caused the cost per landing to more than triple in just a decade.

By 1974, the scenario of growing inflation and deepening recession appeared again and had a severe impact on airline finances. With the Consumer Price Index showing an 11 percent increase for the year, the Airline Cost Index for 1974 showed an estimated increased of 18 percent over the year earlier. The principal cost item in 1974 was fuel. In 1974, the increase in the price of fuel cost to the airline industry was more than $1 billion in added costs.[36]

In the final analysis, the reduction in schedules of commercial airlines was brought about by economic factors. The combined trends of declining traffic growth resulting from an overall economic slowdown, increased unused passenger capacity, and increased labor and fuel costs forced the airlines to become much more efficient in terms of scheduling and aircraft capacity utilization.

In summary then, I feel that there is a very strong case against immediate implementation of an unadjusted or unmodified marginal cost pricing policy. A middle ground exists between a situation where marginal cost pricing is strictly inappropriate and one in which we have full and immediate activation of such a policy. It would be difficult to justify

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[36] Statistical data derived from the annual report of the U.S. scheduled airline industry.

the latter extreme in terms of administrative costs, ripple effects upon scheduled service, and overall political, economic and system disruption. One commonly offered suggestion in this respect is the use of a trial and error technique for gradually introducing the new pricing policy and making adjustments accordingly. Although a cautious approach, such a technique may be more bureautic and political exercise than some airport managers and authorities are willing to deal with, given the very reactionary nature of powerful aviation interests groups.

On the other hand, trying to prove that congestion tolls are strictly inappropriate is an exercise in futility in terms of major hub airports. Delays do occur, no doubt exists on this point; to completely negate the need for congestion tolls the analyst would have to prove that there are no marginal or "interaction" effects among aircraft. The only period for which the analyst might be able to develop a case for this would be between the hours of 11 p.m. and 7 a.m., during these hours marginal delay costs are equal to zero for all practical purposes [30, p. 26]. During "normal" operating hours it would be very difficult to prove the absence of interactions among aircraft. These interactions are caused by traffic levels, airspace structure,[37] and other major factors which have been examined in this study.

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[37]For example, for most departing flights from JFK there is a climb restriction to 5,000 feet out to an intersection or VORTAC in the TCA after which they are cleared to the assigned route and altitude. This restriction puts a limitation on the aircraft's climb out and it may be said that this represents a fuel burn penalty in that the aircraft is not able to more rapidly reach a more efficient altitude. This restriction, however, is imposed due to Kennedy arrivals and LaGuardia traffic also operating in TCA and its purpose is to ensure safe and efficient flow of aircraft.

The theory of the marginal cost pricing policy is one which, although subject to much qualifying discussion in the literature, is correct and economically appropriate for airport landing charges. The exact level and method of implementation is an immediate issue with which airport authorities, planners and economists must come to grips. Although such a policy would establish a more economically efficient measure of capacity expansion in the long run, it might also result in traffic pattern changes at effected airports in the form of some traffic diversion or simply changes in the quality of service, as well as possible changes in airline passenger fares reflecting new airport policy.

In terms of noneconomic changes, new aircraft and air traffic technology[38] are becoming realities which over the next 5-10 years will do much to improve the operational efficiency of the airspace/airport system and, as such, will help lessen the magnitude and impact of a new pricing policy.

Simply put, more must be known about airline reaction to the imposition of marginal cost pricing. Before any airport authority or planner could be expected to put such a strikingly new policy into action,

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[38]Microwave Landing Systems will eventually replace the narrow beam ILS systems employed at commercial airports with ones that provide a much more flexible and larger landing approach area. Planes on an ILS course are now brought through the approach area to the runway one at a time in a long single file. The MLS lets planes head into what is, in effect, a huge electronic funnel whose mouth is 80° wide and 20° high. With MLS, arriving aircraft can enter from several directions at different speeds, flying various curved approaches toward separate electronic gates. MLS will thus permit more efficient use of runways by different types of aircraft and will give controllers greater choice in routing planes away from built up areas. It is estimated that in a decade or two all major airports will be served by this system.

they must have some idea of the repercussions that such a change will have on traffic levels, services and community-airport relations. Further study of approaches that contribute to efficient utilization of existing airport capacity should be encouraged and supported. To evaluate the potential economic (and political) risks and the possible benefits of peak hour pricing, actual experience and not theory is needed.

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APPENDIX[39]

Suppose the routing of Flight 101 is as shown in Table A.1. It may be a useful exercise to investigate the implications of a minor change in the departure time at Chicago. A departure at 6 p.m. instead of 5 p.m. would eventually land the aircraft at Honolulu after midnight. Not only is this in itself undesirable, but the flight would break connections from three other flights, and a change in each of these would have its own repercussions. In addition to other problems caused by this extremely late arrival, the aircraft could also not leave Honolulu at 8 a.m. the next morning because the flight crew layover limits would be violated. On the other hand, the flight could not be scheduled to depart Chicago at 4 p.m. because this would mean a 9 a.m. departure from London. This is unrealistic because the flight is a turn-around and requires two hours on the ground after arriving from New York the previous night. In addition, two flights, one from Frankfurt and the other from Paris, arrive in London at 9:30 a.m. and make a connection with Flight 101.

The flight cannot arrive at Chicago between 4 p.m. and 5 p.m. because of the quota on the number of flights arriving in Chicago during this hour. In any case, Flight 101, because of the unavailability of a gate position, cannot arrive in Los Angeles before 7 p.m. In order to free a gate for Flight 101, flights have to be changed at San Diego, Phoenix, and Dallas. Even if a gate were available, the flight could not depart Los Angeles

[39] Source: [29, pp. 110-111].

until 8 p.m. because no flight crew is available until then. Due to federal flight time limits, 8 p.m. is the earliest departure time the available crew can take out the flight; it would not be economical to have an additional crew based in Los Angeles.

Table A.1. Routing of Flight 101

Station		Local Time	Connecting Flights
London	LV	10:00 a.m.	Frankfurt, Paris
New York	AR	12:00 noon	Boston, Providence, Hartford
	LV	2:00 p.m.	
Detroit	AR	3:30 p.m.	Toronto, Cleveland, Toledo
	LV	4:00 p.m.	Syracuse
Chicago	AR	4:00 p.m.	Indianapolis, Columbus
	LV	5:00 p.m.	Washington, Oklahoma City, St. Louis
Los Angeles	AR	7:00 p.m.	New York, Denver
	LV	8:00 p.m.	
Honolulu	AR	11:30 p.m.	

Flight 101 cannot leave Detroit earlier than 4 p.m. because it connects with flights from Toronto, Cleveland, Toledo, and Syracuse. Moving back a little to New York, although the minimum ground time is only 75 minutes for an international arrival, the flight is scheduled to depart at 2 p.m. because there are three flights that arrive in New York at 1:15 p.m. and would connect with Flight 101. In order to accommodate an earlier departure, changes would have to be made to flights from Boston, Providence, and Hartford. Although there is another potential connecting flight at 1:45 p.n., Flight 101 cannot be delay any longer because this would leave the through-passengers to Detroit and Chicago dissatisfied enough to switch to the competitor's flight from London to Detroit and Chicago via Boston. Because of a highly competitive environment, the amount of flexibility available to the schedule planner is very limited. Even though it may be very costly from every aspect, flights are scheduled to meet competition.

These considerations are only a few of the problems that would occur if Flight 101 were changed in (on the surface) a seemingly insignificant way. This hypothetical example illustrates the interrelationship and chain reactions that can take place to accommodate a change in arrival or departure time of as little as 30 minutes. In analyzing the costs involved in making a change to the schedule, one must remember to also consider the administrative costs of publications, promotion, and notification. If a number of small changes have been made, it may become necessary to publish a new system timetable. The publication and distribution costs of the revised timetable can be quite substantial. Advertisement and promotion affected by these revisions may also be changed. Finally, the new changes must also be filed with the appropriate government agencies, such as the Board and the Post Office Department.