

## **APPENDIX O**

# **OPERATIONAL ANALYSIS OF MITIGATION OF THE NY/NJ/PHL METROPOLITAN AREA AIRSPACE REDESIGN**

MP070049

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MITRE PRODUCT

# Operational Analysis of Mitigation of the NY/NJ/PHL Airspace Redesign

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## **Abstract**

The Integrated Airspace Alternative with Integrated Control Complex (ICC) has been identified by the Federal Aviation Administration (FAA) as the preferred alternative design for the New York/New Jersey/ Philadelphia (NY/NJ/PHL) Metropolitan Airspace Redesign project. Public comments on the Draft Environmental Impact Statement (EIS) raised concerns about noise, emissions, operating assumptions, and airspace design parameters, many of which comments contained strategies for mitigating their concerns. Where it is consistent with the purpose and need for the airspace redesign, it is the intention of the FAA to mitigate the environmental impacts of the preferred alternative. This document evaluates these mitigation strategies, provides an analysis of the operational impact of each strategy, and describes those mitigation strategies that were selected for inclusion in the Mitigated Preferred Alternative.

**KEYWORDS:** Airspace, Airspace Redesign, New York, New Jersey, Philadelphia, Mitigation



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# 1 Introduction

The Integrated Airspace Alternative with Integrated Control Complex (ICC) has been identified by the FAA as the preferred alternative for the NY/NJ/PHL Metropolitan Airspace Redesign project. This alternative, as described in section 2.5 of the Draft Environmental Impact Statement (EIS),

“...involves full airspace consolidation, as well as modifications to multiple departure gates, additional arrival posts, and additional departure headings. This variation represents a full airspace consolidation and is a new approach to the redesign of airspace from NY to Philadelphia. Where current en route airspace separation rules of five nautical miles are typically used, this airspace redesign alternative would use three nautical mile terminal airspace separation rules over a larger geographical area and up to 23,000 feet MSL in some areas. The ICC airspace would be comprised of the majority of current NY TRACON and NY Center airspace, as well as some sectors from Washington Center and Boston Center. Boston Center could take the high-altitude parts of the current NY Center airspace structure.”

The Integrated Airspace Alternative with ICC makes some relatively high-altitude airspace design changes, as well as some low-altitude changes to maximize the use of the limited runway capacity available in the NY and Philadelphia metropolitan areas. These low-altitude changes caused most of the noise impacts presented in the Draft EIS.

During the public comment period on the Draft EIS, issues were raised about noise, operating assumptions, and airspace design parameters—many with recommended solutions. Many of these issues involved operational changes that would directly affect the performance of the system, as defined in the Purpose and Need for the airspace redesign. These operational changes were studied to assess their effectiveness in addressing the stated concern and their effect (positive or negative) on the safety and efficiency of the operation in the preferred alternative.

The following document discusses these mitigation strategies. It is organized as a set of discrete sections, each of which describes one or more strategies, the methodology for analyzing each strategy, and the operational impact of the strategy. The final chapter of the document provides a description of the Preferred Alternative with those mitigation strategies that were selected for inclusion in the Mitigated Preferred Alternative.

## 2 Assessment of Glide Slope Angles at PHL and JFK

### 2.1 Background

Many of the airports within the NY/NJ/PHL Airspace Redesign study area have at their disposal Instrument Landing System(s) (ILS) for safe operations during periods of inclement weather or reduced visibility. The ILS aligns the aircraft with the runway and provides the pilot with dependable and accurate guidance, both laterally and vertically, allowing the pilot to determine the aircraft's position and navigate the final approach, following the glide slope down to the runway as depicted in Figure 1. The standard angle of descent for a glide slope is 3.0 degrees.

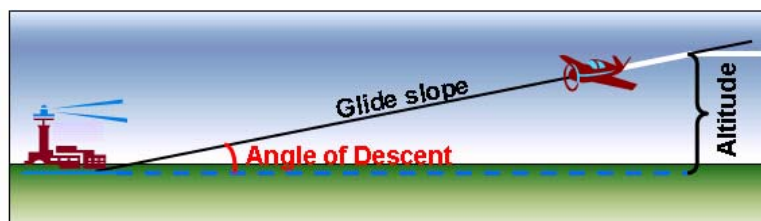


Figure 1. Glide Slope

### 2.2 Affected Area and Proposed Airspace Change

Due to the precise nature of the ILS approach, each flight using the same ILS approach will have exactly the same ground path. This results in arriving flights passing over the same underlying communities. Several comments were received from communities underlying the approach paths to JFK and PHL's runway 09R requesting an increase in the angle of descent in an effort to raise the altitude of the approaching flights and thereby reduce the noise. Currently the glide slope angle for the ILS approaches to PHL's runway 09R and for the JFK runways is 3.0 degrees.

### 2.3 Constraining Factors

The majority of the aircraft arriving at JFK, and the majority of the aircraft arriving to PHL's runway 09R are Category D and E aircraft and may not use more than a 3.1-degree angle of descent. The United States Standard for Terminal Instrument Procedures (TERPS) third edition (8260.3B) document 8260 provides information concerning the maximum authorized glide slope angles by aircraft categories. According to volume 3 section 2.5 of this document, glide slope angles above 3.0

degrees require the approval of FAA Flight Standards Service or the appropriate military authority. Table 1, shown to the left, from 8260.3B, shows the maximum glide slope angles per aircraft category.

Table 1. Maximum Glide Path Angle by Aircraft Category

| Category            |                      | Glidepath Angle |
|---------------------|----------------------|-----------------|
| Helicopter          | A (80 knots or less) | 6.4             |
| Two-Seater Piston   | A (81-90 knots)      | 5.7             |
| Twin Engine Piston  | B                    | 4.2             |
| Business Jet        | C                    | 3.6             |
| Small Passenger Jet | D                    | 3.1             |
| Large Passenger Jet | E                    | 3.1             |
| Heavy Jet           | E                    | 3.1             |

The aircraft categories are defined in Federal Aviation Regulations Part 97 and are based on the aircraft's

referenced indicated approach speed (1.3 times the stall speed in landing configuration) at the maximum certificated landing weight.

## 2.4 Analysis Results

If the glide slope angle were raised from 3.0 degrees to 3.1 degrees, the altitudes of the aircraft would only be raised a small number of feet given the distance of the aircraft from the runway. Table 2 shows a comparison of the distance of the aircraft to the runway, versus the increase in aircraft altitude with a change in the angle of descent from 3.0 to 3.1 degrees. There is an approximate increase of 10 feet for each nautical mile from the runway for each tenth of a degree increase in the glide slope. The reduction in engine-noise exposure from a single event raised by this amount is 0.3 dB, which is generally considered imperceptible.

Against this engine-noise reduction due to greater distance must be set the fact that aircraft descending on a steeper angle tend to gain speed. Maintaining a safe approach and landing speed will therefore require more use of the aircraft's control surfaces, which leads to additional airframe noise that will offset the improvement due to increased altitude.

## 2.5 Conclusions

The instrument approaches at PHL and JFK currently have a 3.0 degree angle of descent. Because the majority of the aircraft that land the runways at JFK and the majority of the aircraft landing runway 09R at PHL are categories D & E, the safe angle of descent at these airports is confined to the lower end of the range of possible angles. Given that the allowable change in altitude for the aircraft is less than 100 feet (when the aircraft is 10 nautical miles or less from the airport); it is recommended that no change be made to the glide slope at these airports.

**Table 2. Ratio of Increase in Altitude by Distance From Runway**

| <b>Distance of Aircraft from the runway (Nautical Miles)</b> | <b>Increase in altitude with Glidepath of 3.1 (feet)</b> |
|--------------------------------------------------------------|----------------------------------------------------------|
| <b>10</b>                                                    | <b>106.4</b>                                             |
| <b>9</b>                                                     | <b>95.8</b>                                              |
| <b>8</b>                                                     | <b>85.1</b>                                              |
| <b>7</b>                                                     | <b>74.5</b>                                              |
| <b>6</b>                                                     | <b>63.8</b>                                              |
| <b>5</b>                                                     | <b>53.2</b>                                              |
| <b>4</b>                                                     | <b>42.6</b>                                              |
| <b>3</b>                                                     | <b>31.9</b>                                              |
| <b>2</b>                                                     | <b>21.3</b>                                              |
| <b>1</b>                                                     | <b>10.6</b>                                              |

### 3 An Evaluation of Arrival Paths to Runways 22L and 22R at JFK International Airport

#### 3.1 Background

In the Integrated Airspace Alternative with Integrated Control Complex (ICC), aircraft from the east and north arriving to JFK's runway 22L fly a considerable distance over Long Island. Residents living under the approach paths to runways 22L and 22R have expressed a desire for noise relief.

Runway 22L serves two roles at JFK. First is as the primary arrival runway in the parallel-22 configuration. In the year 2005, JFK was configured for arrivals to runways 22L and 22R approximately 16% of the time. In today's airspace, flights to runways 22L and 22R arrive along the solid red paths in Figure 2. The northerly red track is for turboprop aircraft, which are fairly rare in today's system and are expected to remain so in the future. The easterly red track is for heavy transatlantic jets and some arrivals from New England. The current tracks are altered in the Preferred Alternative according to the dotted orange lines. Parallel-22 is a low-capacity configuration that causes considerable holding if it must be used without advance warning. In the 2006 radar tracks, shown in blue in Figure 2, oval holding patterns can be seen from the north and west.

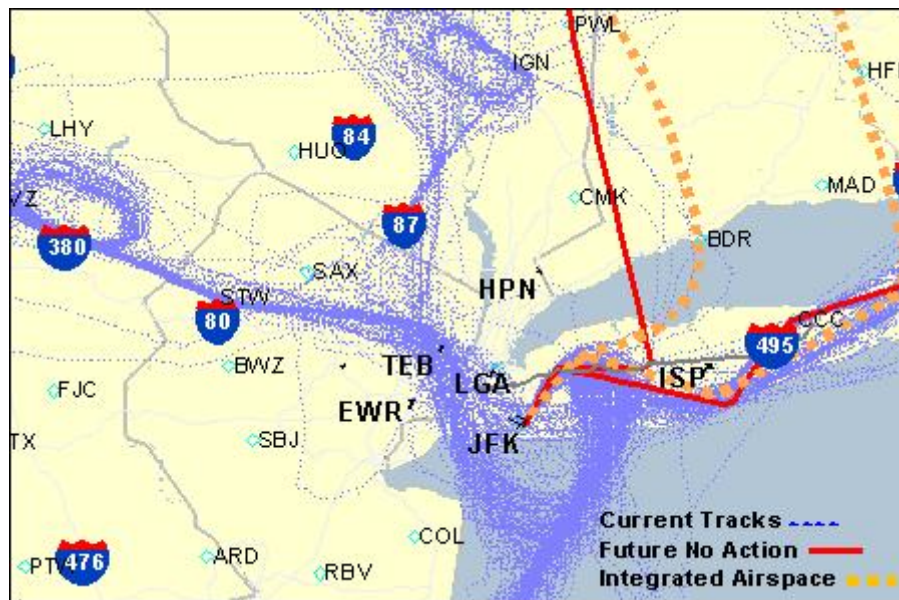


Figure 2. Arrival tracks to Runways 22L and 22R

In its second role, runway 22L is the overflow arrival runway when the airport is landing and departing 13L and 13R. With three runways in use, this is one of the highest-capacity configurations at the airport. Airlines and tower controllers prefer landing on 13L because the end of runway 22L is farther from the terminals, but in the interests of increasing capacity 22L is used on a case-by-case basis.

### 3.2 Proposed Airspace Change

Both currently and in the preferred alternative, as is shown in Figure 3, arriving aircraft from the east dip almost to the south edge of Long Island before turning northwest to intercept the final approach course to the runway. If JFK arrivals could be routed over I-495, an area that is relatively insensitive to aircraft noise, the noise they produce would affect residents of Long Island less than if they flew over areas of higher sensitivity.

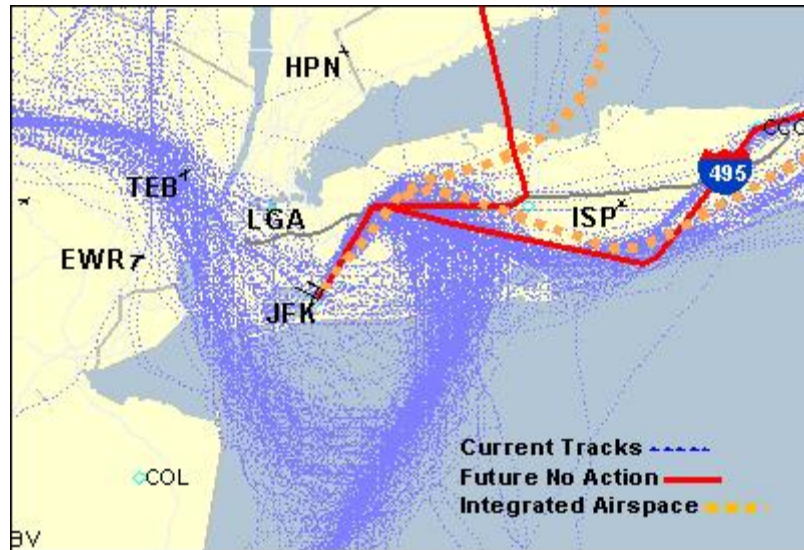


Figure 3. JFK Arrivals to 22R in Reference to the Long Island Expressway (I-495)

### 3.3 Constraining Factors

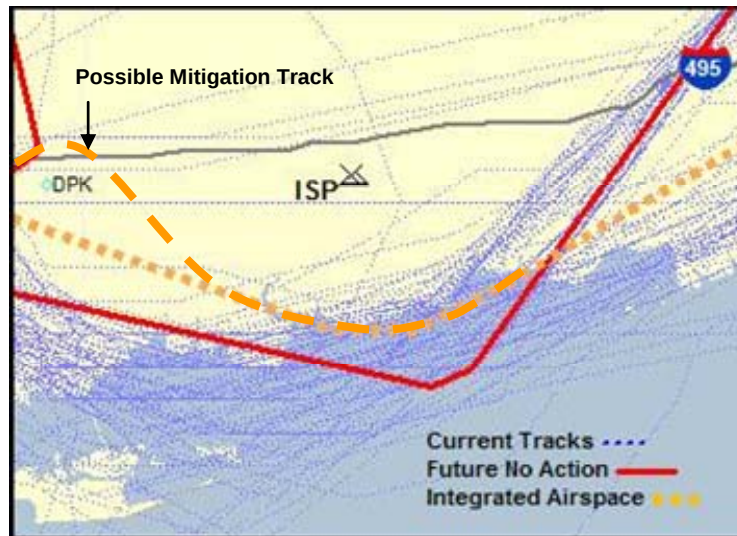
In the terminal environment, aircraft are considered separated if they have at least 3 nautical miles of lateral separation<sup>1</sup>. Figure 3 demonstrates that the most important constraining factor on the JFK flow from the Northeast is the position of Long Island MacArthur Airport (ISP) which, for safety reasons, requires aircraft flows to other airports to remain outside of a circle at least three miles in radius. In practice, air traffic control procedures require an aircraft to stay an additional one and one-half miles away from such an airspace boundary. ISP is less than a mile from the highway, so passing along the north side of the airport along the I-495 corridor is impossible. The procedures in the Preferred Alternative pass 4.5 nautical miles south of ISP, which is essentially the minimum spacing permissible.

### 3.4 Operational Impact

Since runway 22L is less efficient for users and makes the job of the ground controllers more complex, the airport operates best when it is used as flexibly as possible. This requires bringing the aircraft down to the southern shore of Long Island as a single stream before the runway assignment is made.

<sup>1</sup> Aircraft can also be separated in time or in altitude. Separating in time is slow and inefficient, so it is the last resort. Where aircraft are level, altitude separation is used, but this close to the airport almost all aircraft are climbing or descending so the airspace design gives preference to lateral separation.

When JFK is in a parallel-22 operation, the impact of changing the track of the arrival flow would be small. Given the constraints caused by the location of ISP, only a small perturbation of the current track is possible. It will require turns that are sharper than in the current operation, but it may be possible to define them in a way that is consistent with criteria for precision-navigation approaches.



**Figure 4. Notional Modification of the Arrival Track to 22L**

### 3.5 Conclusions

Providing current altitude restrictions remain in place and arriving flights join the newly proposed lateral path only after passing ISP, as shown in more detail in Figure 4, rerouting the current arrivals from the east to follow along the Long Island Expressway should pose no potential conflicts. The benefits are not likely to be large, but since the preferred alternative requires this approach to be redrawn in a precision-navigation version, there is an opportunity for improving the current track. The noise impact will be highly sensitive to the details of the criteria used to draw the new approach, so no estimate is possible at this stage of the redesign. It is recommended that land-use criteria be considered as the new approach is drawn.

## 4 An Evaluation of Arrivals to LGA via the Localizer Directional Aid to Runway 22

### 4.1 Background

Flights arriving to LaGuardia Airport and landing on runway 22 will often use one of two approaches: the Instrument Landing System (ILS) approach or the Localizer Directional Aid (LDA) approach. The ILS approach is advantageous for the pilot in that it aligns the arriving flight precisely with the runway. This approach is required when visibility is poor or for other safety reasons outlined in the Standard Operating Procedures (SOP). The LDA approach is typically used in conditions of good visibility and when safety factors permit. It provides an angled, off-set approach to the runway which results in the arriving flights remaining over the Long Island Sound for much of their approach. (See Figure 5.) Standard Operating Procedures for the New York TRACON specify that the LDA approach is the preferred operation in the midnight shift for noise abatement.

#### 4.1.1 Affected Area and Proposed Change

The ILS approach is very precise. All flights using this approach are focused into a narrow band aligned with the runway. Consequently, each arriving flight will fly the same ground path, and the resulting noise will be tightly concentrated on the communities directly under the flight path.

Comments from communities that lie directly in the path of the ILS approach to runway 22 at LGA, such as Larchmont, NY, request an increase in the use of the LDA approach to runway 22. This would effectively reduce the amount of noise the community is exposed to by moving the affecting flight paths over the Long Island Sound.

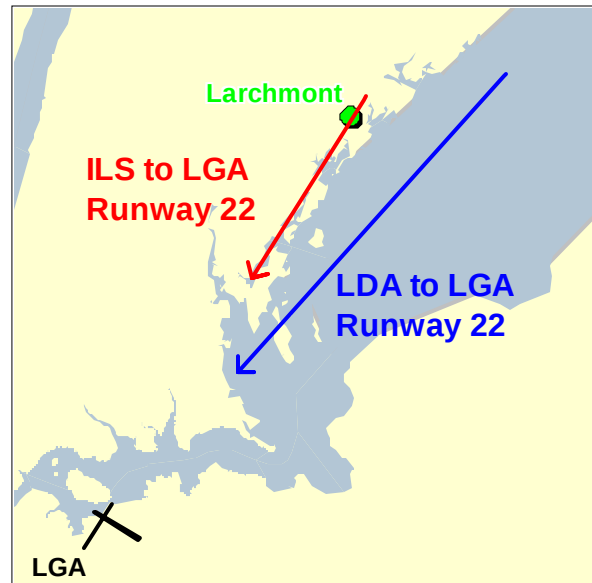


Figure 5. Two Arrival Paths to LGA Runway 22

### 4.2 Constraining Factors

During the last calendar year, 53% of the time arriving flights into LGA landed on runway 22. Part of these arrivals used the ILS approach and part used the LDA approach. Although historical data does not provide us the exact percentage of flights that used each approach, an examination of the constraining factors allows us to establish an upper bound on the percentage of time the LDA approach was available for use. The factors that affect the availability of the LDA approach for arriving to LGA runway 22 are (1) the current landing configuration of JFK and (2) characteristics of the individual flight.

#### 4.2.1 Interaction with JFK

According to the Standard Operating Procedures (SOP) for the NY TRACON, if arrivals to JFK are using the ILS approach to runways 22R or 22L, and arrivals to LGA are landing on runway 22, then the LGA arrivals are required to use the ILS approach as well. This is a safety requirement due to lack of maneuvering room in the airspace. When landing ILS 22's JFK and LGA approaches are parallel and are separated by less than 9 miles. The LDA, therefore, is on a path that would cross the ILS path to JFK. Worse, the close proximity of the two courses leaves little room for LGA departures to maneuver between them. This departure procedure, called the "Whitestone Climb", is favored for high-demand operations.

During the last calendar year, 30% of the time, arrivals into JFK landed on runway 22R or 22L. A comparison of the intersection of arrivals to runways 22 at JFK and LGA shows that 26% of the time both airports were landing 22's. So, assuming no other constraining factors, the LDA approach to LGA runway 22 may have been available and used 27% of the total calendar year (53%-26%).

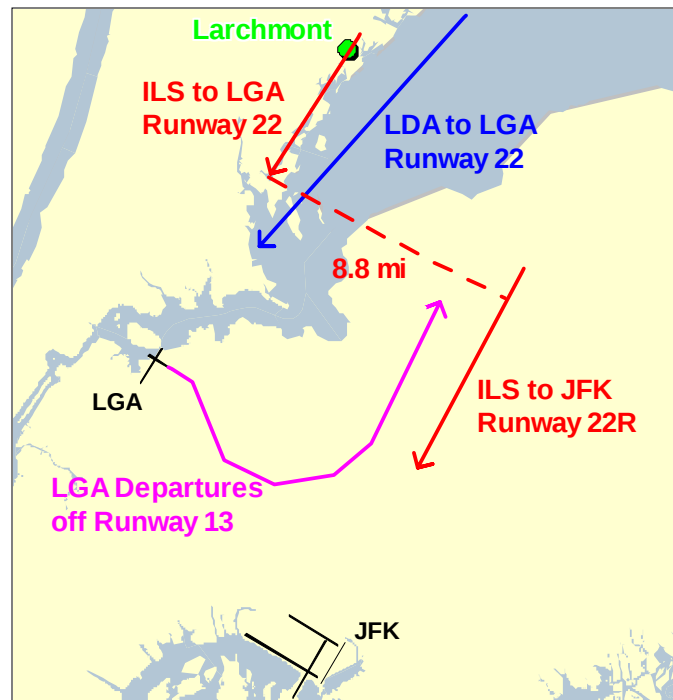
#### 4.2.2 Individual Flight Characteristics

There are a few instances in which the traffic patterns would allow use of the LDA, but the individual characteristics of a particular flight might prevent its use. One such characteristic is the aircraft type. The LDA approach to runway 22 is designed with a 3.6 degree angle of descent. Not all aircraft are capable of approaching the airport from this angle. (See Section 2.) The United States Standard for Terminal Instrument Procedures (TERPS) provides information concerning the maximum authorized glide slope angles by aircraft categories. Some of the aircraft arriving to LGA fall into the category of large jets. Large jets have a maximum designated angle of descent of 3.1 degrees. Consequently, for safety reasons, such flights would be required to use the ILS approach rather than the LDA.

In other instances, a flight's crew may be untrained in the procedures for use of the LDA. In such a case, even if all of the other conditions have been met, the presence of the untrained crew will necessitate use of the ILS approach.

### 4.3 Operational Impact

Required separations between successive LGA arrivals are not dependent on the approach being used. The increased use of the LDA when the constraining factors allow would have little or no effect on any of the operational metrics in the Draft EIS.



**Figure 6. JFK and LGA Interactions when Landing Runways 22**

## **4.4 Conclusions**

In an attempt to minimize noise exposure of the communities that underlie the ILS approach to runway 22 at LGA, the LDA should be used whenever the constraining factors allow. This would include periods of good weather when JFK is not arriving via the ILS to runway 22L or 22R. Based on historical data, this should be possible for approximately 27% of the year.

It is further recommended that the feasibility of an RNP procedure be investigated, for a procedure that will permit the equivalent of the Whitestone Climb for departing aircraft between the two approach courses. Currently under these conditions, only turboprop aircraft are permitted to depart LGA's runway 13 using the Whitestone Climb. Jet aircraft are not certain to stay safely west of the JFK approach course and so must either depart to with a right turn on the Maspeth Climb, which is currently unavailable for use, or depart runway 31, which reduces the efficiency of the airport's operations. A RNP procedure applied to the Whitestone Climb would guarantee that all departing aircraft would remain inside the specified boundaries with no compromise of safety.

## 5 An Analysis of LaGuardia Runway 31 Departures Over Rikers Island

### 5.1 Background

At LaGuardia (LGA) airport, aircraft depart runway 31 for approximately 23% of the annual operations. In the current airspace, flights with destinations to the west and south, which comprise 60% of the departure traffic, use an initial heading of 340. The other 40%, flights traveling north or east use an initial heading of 360. Both of these headings result in LGA departures flying over Rikers Island, outlined in white in Figures 7 and 8. In the Integrated Airspace Alternative with ICC, the number of available headings off of runway 31 is increased from 2 to 3. Those flights traveling north or east, previously on the 360 heading, are shifted east to a heading of 020. The flights traveling south and west, previously on the 340 heading, are divided into two separate streams. Flights to the west are assigned a heading of 005, and flights to the south are assigned an initial heading of 350. The additional heading allows for a more equitable distribution of traffic and results in increased efficiency for the airport.

#### 5.1.1 Affected Area

Rikers Island is located in the middle of the East River less than one quarter of a mile from the end of runway 31. The island hosts 10 separate correctional facilities, identified in Figure 8 by the red circles. Unlike most census blocks, which are typically the size of a city block, the entirety of Riker's Island is contained within a single census block with a single, corresponding point, or centroid, over which to measure changes in noise. As a consequence of this, the entire island is considered subject to a significant noise increase, identified as area PIWB-11LGA-A in the Draft Environmental Impact Statement. In addition, since the population of Rikers Island contains a higher concentration of various minority groups than the surrounding census blocks, the increased noise exposure on the island raises issues of environmental justice.

#### 5.1.2 Proposed Airspace Change

At times of high arrival demand, it may not be necessary to expedite departures with a third heading. LGA may operate with the three headings when arrival demand is low, and revert to two headings at other times. Given the demand profiles in the forecast for 2011, in practice this will mean that three



Figure 7. Characterization of Today's Traffic off LGA Runway 31



Figure 8. Characterization of Proposed Traffic off LGA Runway 31

headings are used for the first hour of the morning departure push. After that, departure controllers will re-combine the western and southern departures, using two headings for the remainder of the day.

## 5.2 Constraining Factors

The proposed airspace change can be accomplished with small changes in the complexity of the departure operation. In place of a single operation in all cases, the departure controller will be instructed to combine traffic onto two headings rather than three during certain periods. Procedures of this type are common; this is not expected to cause an impractical increase in workload.

## 5.3 Operational Impact

According to the forecasts of traffic in 2011, demand at LGA is as high as the airport can accommodate. When an airport is operating this close to its theoretical capacity, any small change in efficiency strongly influences the average departure delay for the airport. Departure headings increase efficiency because they make it possible for the air traffic controllers to use a second dimension of separation (i.e. lateral separation). With a single heading, departing flights must be separated by a minimum distance along the same ground track. When a second or third heading is available, diverging lateral paths of at least 15 degrees can be used to separate aircraft as well. As shown in Table 4, two headings off of LGA's runway 31 results in an average delay savings of 7.5 minutes per flight over the single-heading delay. Adding a third heading, for a total of three headings off of the runway, saves an additional 1.8 minutes per flight—a total average of 9.3 minutes saved per flight.

**Table 3. Average Departure Delay by Number of Headings**

| <b>Number of Runway Headings</b>                                     | 1   | 2        | 3        |
|----------------------------------------------------------------------|-----|----------|----------|
| <b>Number of Departures in 1st Departure Push</b>                    | 41  | 42       | 43       |
| <b>Average Delay Savings Per Flight Compared to a Single Heading</b> | N/A | 7.5 min. | 9.3 min. |

Unlike many airports that have banks of departures and arrivals throughout the day, LGA's operations are relatively steady. The airport typically operates on a one-in-one-out system, so that there are an equal number of departures and arrivals each hour. One hour looks very much like the next, except for the first hour, during which LGA experiences its only departure push. In a steady-flow state such as the forecast traffic at LGA, there are no lulls between periods of departure demand. Therefore, the whole day's delay statistics depend on the number of departures that can be dispatched during that first hour. As shown in the table above, three headings will allow the most departures during the first hour. The one or two extra aircraft that can not depart when a single heading must be used cause ripples of delay through the entire day.

A corollary to the importance of the first hour, however, is that the hours of one-in-one-out operation are less sensitive to the departure headings. Therefore, it is possible to reduce the number of headings for the majority of the day from three to two and without losing the benefit of the third heading. This can be accomplished by operating with three headings for the first hour of the day, during which the number of departures is critical, and then reducing the number of headings to two for the remainder of the day. The difference in total delay between operating with three headings all day and operating with three headings for only the first hour of the day is approximately 20 minutes. Distributed over an entire day of traffic, this increase is negligible.

## 5.4 Conclusions

It is recommended that LGA operate with three headings during hours of low arrival demand and reduce to the current two-heading operation for the remainder of the day. This not only allows for the full benefit of the changes made in the Integrated Airspace Alternative with ICC but also minimizes traffic on the heading that most affects Rikers Island noise exposure.

It should be noted that all currently-available forecasts of LGA traffic in the future maintain the current pattern of a morning departure push followed by 15 hours of balanced arrivals and departures. The operational impacts calculated above were derived from this pattern. If the nature of operations at LGA should change, such that the airport experiences departure banks at times other than the first hour of the day, the third departure heading is recommended during those times in order to control congestion on the taxiways and anticipated escalations in delay.

## 6 An Evaluation of Long Island MacArthur Airport Traffic Over Fire Island National Seashore

### 6.1 Background

Fire Island stretches for thirty-two miles along the southern coast of Long Island. Twenty-six of those miles comprise the Fire Island National Seashore. The island is home to beaches, parks, communities and the Otis Pike Wilderness Area. The population in the vicinity of Fire Island is served by Long Island MacArthur Airport (ISP). Comments on the Draft EIS from residents and visitors show concern that the proposed NY/NJ/PHL Metropolitan Area Airspace Redesign alternatives will increase the number of flights over the island, specifically departures from ISP, and adversely affect not only the Otis Pike Wilderness Area, but the quality of life for the residents of the island. Residents are concerned that an increased number of aircraft would generate increased noise levels, impacting the businesses and communities that are located there. Residents have asked for further clarification to determine the impact those flights would have on Fire Island. Departure tracks for flights departing from the various runways at ISP are shown in Figure 9. There is a wide range of possible ground tracks from each runway, which is characteristic of mid-sized airports like ISP.

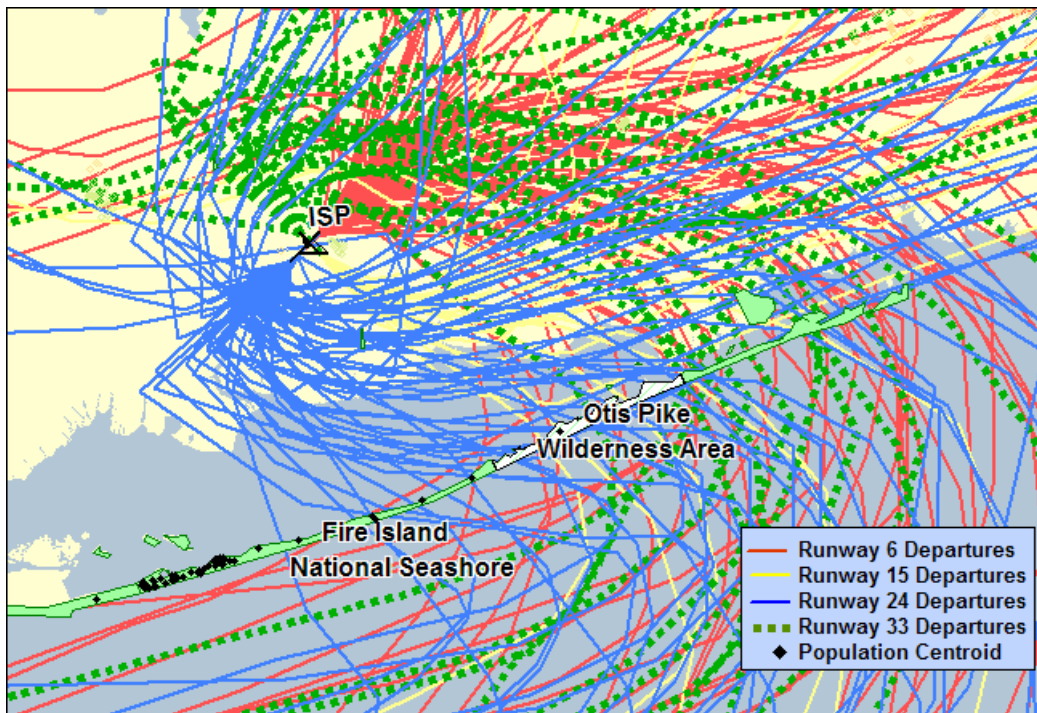
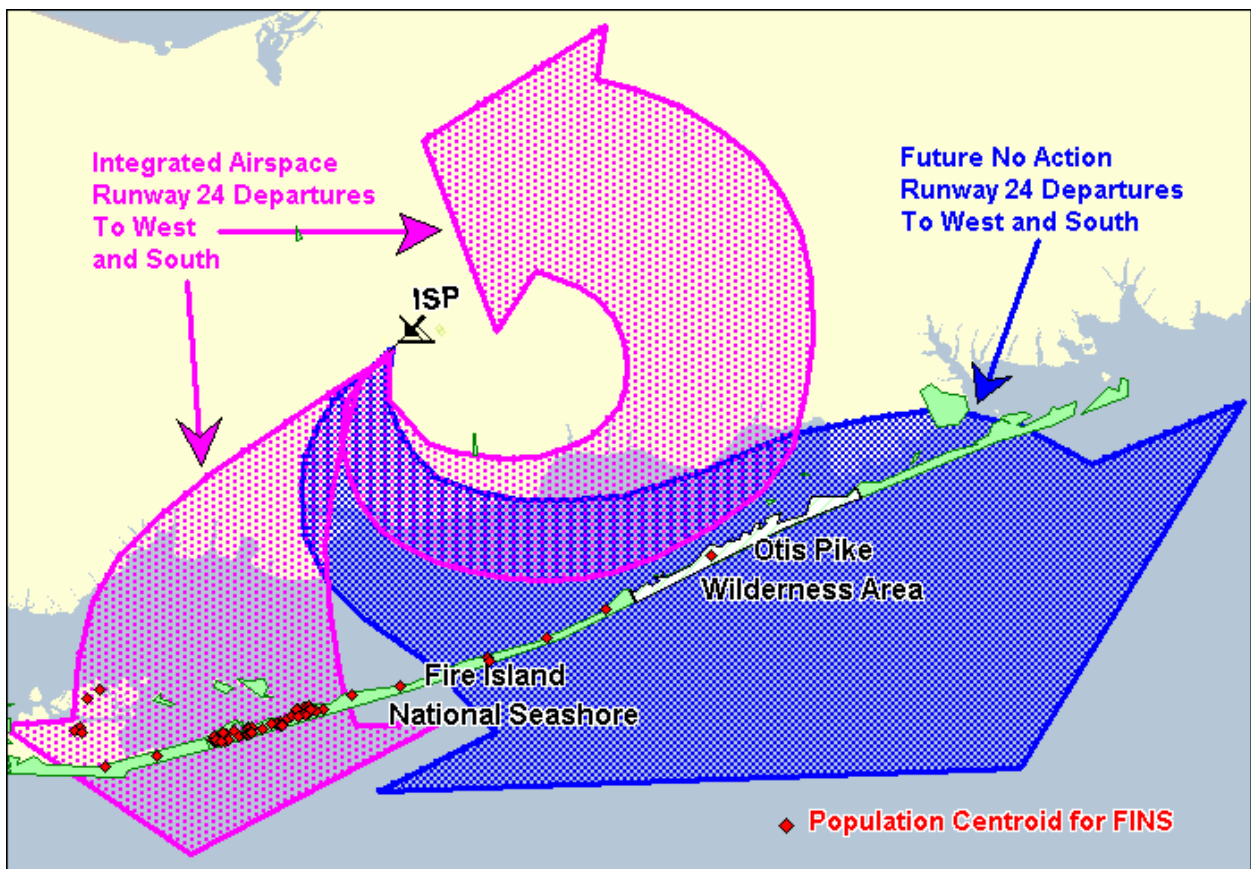


Figure 9. Future No Action Departure Tracks from ISP

## 6.2 Constraining Factors

The most common airport configuration for ISP involves arriving and departing runway 24. Because the runway points toward Fire Island, and the majority of departure traffic at ISP intends to go southwest, departure operations off runway 24 will be the focus of this discussion. Figure 10 shows the runway 24 departures, abstracted into regions for clarity. In the Future No Action alternative, departures off runway 24 traveling south and west depart throughout the blue arrowed region. There is no air traffic control procedure confining the aircraft to a fix, so traffic crosses the Fire Island National Seashore over a fairly wide band including the Otis Pike Wilderness Area.



**Figure 10. ISP Departures in the Future No Action and Integrated Airspace Alternatives**

In the Integrated Airspace Alternative with ICC, the Robbinsville navigation aid (RBV) is no longer used as a departure fix for westbound departures from JFK and ISP. As a result, flights that originally flowed through the blue arrowed region are split into two streams. Those flights traveling to routes in the south still cross the western edge of Fire Island. However, they occupy a

much smaller geographical area of the island and completely avoid the wilderness area. The flights that are bound for western departure airways now circle the airport to the north and continue west without crossing the Fire Island National Seashore at all. These new flows are depicted by the pink regions in Figure 10.

The Integrated Airspace Alternative with ICC actually reduces the number of aircraft traveling over Fire Island by 50% when departing runway 24. It also completely removes these aircraft from traveling over the Otis Pike Wilderness Area. This reduction in traffic over the island is almost entirely due to the west bound departures circling the airport to the north before continuing on a west bound track. This planned reduction in the aircraft departing over the island should alleviate the concerns of some of the residents regarding possible increases in overflight traffic and the subsequent potential for noise increase.

### **6.3 Conclusions**

In today's airspace much of the arrival and departure traffic to and from ISP cross the Fire Island National Seashore. Most important among these, in terms of noise impact, are runway 24 departures. Current operations call for runway 24 departures bound south and west to cross over a large portion of the island including the Otis Pike Wilderness Area. The Integrated Airspace Alternative with ICC splits the combined south and west flow into two flows, rerouting the west bound flights to the north of the airport. This redirection of western traffic results in a 50% decrease in the number of flights crossing the Fire Island National Seashore. The concerns expressed in the public comments on the Draft EIS are addressed by the preferred alternative, and no mitigation is necessary.

## **7 Southwestern Departures from Newark Liberty International Airport**

### **7.1 Background**

In today's airspace, all departures off of EWR's runway 22R take a 190-degree heading off the runway. This constraint of a single heading necessitates increased separation between successively departing aircraft and impairs the ability the tower controller to efficiently move departures from the airport. In order to correct this inefficiency, the Integrated Airspace Alternative with Integrated Control Complex (ICC) provides three departure headings off of EWR's runway 22R instead of the single heading used today.

#### **7.1.1 Affected Area**

The advantage of a single heading off runway 22R lies in the effects of departures on the communities to the southwest of EWR. When the single stream of traffic is split into three flows, the flights are dispersed over a greater area. Communities that before may have been exposed to little or no departure traffic now share in the noise created by the departures. This can be seen by the area PIWB-11EWR-A on the noise impact map of the Draft EIS. Many of the residents of this impact area, such as those of Elizabeth, New Jersey, are concerned with the projected increase in noise for their area associated with the additional departure headings.

#### **7.1.2 Proposed Airspace Change**

Several suggestions for mitigating the noise impacts caused by the increased number of departure headings were received through the public comments on the Draft EIS.

The first suggestion for mitigation involves reducing the number of departure headings from three to two. Furthermore, this option provides for the direction of these headings to overlay non-residential areas: one over I-95 and the other over an industrial corridor.

The second suggestion for mitigating the noise impacts involves allowing for two departure headings, one each off of runway 22L and runway 22R.

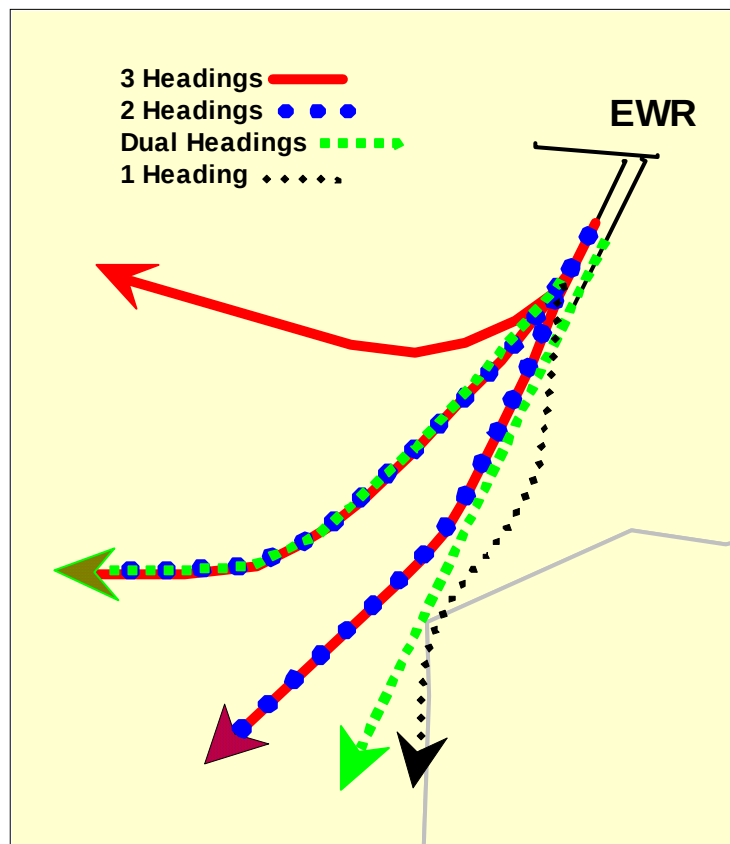
The third suggestion for mitigation involves varying the number of available departure headings off of runway 22R from one to three headings based on the departure demand at the airport throughout the day. When departure demand is low, one departure heading would be used. As the departure demand increased, two or three headings would be used. This approach is referred to as the "123" case in this paper.

The fourth suggestion for mitigation involves changing the headings in use by time of day. In practice, this procedure would be identical to the third suggestion in that the times of day that additional headings were used would align with the times that demand was increased. It is possible this approach might eventually be inefficient—for example, if the airlines scheduled their departures differently from the assumed times. This was not modeled separately.

## 7.2 Methodology

The airport configuration in which EWR arrives and departs runways 22L/R for the Integrated Airspace Alternative with ICC was simulated for five cases:

- Three departure headings off 22R, the Integrated Airspace Alternative with ICC;
- One departure heading off 22R;
- Two departure headings off 22R;
- Departures off both runways 22R and 22L; and
- One, two, or three headings (“123” case) based on demand.



**Figure 11. Runway Heading Options for EWR Departures off Runway 22R/L**

Figure 11 shows the various headings available in the simulations. Precise headings are shown in Table 5. The five simulations provide a comparison of the impact of the number of departure headings and number of departure runways on both delay and the ability of the airport to handle dual arrivals.

**Table 4. Simulated EWR Departure Headings**

| <b>Departure Gates</b>  | <b>Three Headings</b> | <b>Two Headings</b> | <b>One Heading</b> | <b>Dual Departures (runway)</b> |
|-------------------------|-----------------------|---------------------|--------------------|---------------------------------|
| <b>North &amp; East</b> | 260                   | 240                 | 190                | 240 (22R)                       |
| <b>West</b>             | 240                   | 240                 | 190                | 240 (22R)                       |
| <b>Southwest</b>        | 240                   | 220                 | 190                | 220 (22L,R)                     |
| <b>South</b>            | 220                   | 220                 | 190                | 220 (22L,R)                     |

The headings used in the analysis for the five simulations are based on the location of the departure fix and are provided in Table 4. The “123” case uses a combination of the one-, two-, and three-headings at different times throughout the day based on demand. The 220, 240, and 260 headings are notional values. These headings may be adjusted within the range of 220-265 to take advantage of noise-insensitive land uses.

### 7.3 Operational Results

Each proposed mitigation scenario was simulated and evaluated for operational impacts. Specifically, these impacts included the impact on delay, departure queue length at the airport, and distance flown. Results were compared across all scenarios.

#### 7.3.1 Delay

**Table 5. Change in Average Delay from the Integrated Airspace Alternative with ICC (Minutes/Flight; positive numbers mean more delay)**

|                        | <b>One Heading</b> | <b>Two Headings</b> | <b>One, Two, and Three Headings</b> | <b>Dual Departures</b> |
|------------------------|--------------------|---------------------|-------------------------------------|------------------------|
| <b>Arrival Delay</b>   | +0.6               | -0.5                | +0.1                                | -0.4                   |
| <b>Departure Delay</b> | +12.0              | +2.2                | +0.3                                | 0.0                    |
| <b>Total Delay</b>     | +6.3               | +0.8                | +0.2                                | -0.2                   |

Reducing the number of available departure headings from the three headings of the Integrated Alternative to a single heading, results in an increase of average departure delay by 12 minutes per flight<sup>2</sup>. Reducing the headings to only two, also results in an increase in average departure delay

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<sup>2</sup> In this section, delays per flight are calculated among EWR departures only. These numbers should not be added or subtracted to the summary metrics in the EIS, which are averages over all traffic in the study area.

of 2.2 minutes per flight. The impact of running dual departures as compared to the three-heading case is minimal. No increase in departure delay is observed with this scenario. With the dual departures case, some flights that would normally depart on runway 29 use runway 22L instead, reducing the delay on 29. A slight decrease in arrival delay is observed. This is due to the use of runway 22R for both arrivals and departures. When varying the number of available headings from one to three throughout the day, based on departure demand, the departure delay is only slightly higher than that of the three-heading case. A comparison of the average delay per flight across the various scenarios with the three headings modeled in the Integrated Airspace Alternative with ICC is provided in Table 6, below.

### 7.3.2 Lineup Queue Length for Departing 22R

At geographically small, cramped airports like EWR, long departure queues can have considerable negative consequences for efficient operations. When too many flights are waiting on the taxiways for their turn on the runway, they frequently back up into the paths of aircraft moving for other purposes. The worst case is when arriving aircraft are unable to reach their gates because the entrance to the appropriate apron is blocked by a long line of departures – gridlock. The tipping point between a smooth flow and a gridlock situation depends on the size of the aircraft in the departure queue, but it is typically between 20 and 24 aircraft. Table 6 shows the maximum observed number of aircraft in line for runway 22R for each scenario under consideration. A flight is considered to be counted in the lineup queue from the time it pushes back from the gate until the time it departs from the runway.

**Table 6. Maximum Lineup Queue by Number of Departure Headings**

| <b>Runway</b> | <b>One Heading</b> | <b>Two Headings</b> | <b>Three Headings</b> | <b>One, Two, and Three Headings</b> | <b>Dual Departures</b> |
|---------------|--------------------|---------------------|-----------------------|-------------------------------------|------------------------|
| 22R           | 36                 | 25                  | 26                    | 24                                  | 25                     |
| 22L           | —                  | —                   | —                     | —                                   | 11                     |

The one-heading case results in the highest maximum lineup queue with a total of 36 flights, considerably higher than is seen in the other scenarios. Additional headings are approximately the same in terms of their impact on the lineup queue. The dual departures case has a maximum lineup queue similar to the two-heading, three-heading, and “123” cases with 25 flights queued for departure on runway 22R, but it also has a maximum lineup queue length of 11 on 22L. The sum is the same as the single heading case, but the queue can build up on different taxiways, so the congestion is not as serious as the single-runway, single-heading case.

### 7.3.3 Distance Flown

Another measure of the efficiency of a particular option is reflected by the additional distance each flight is required to fly in order to join their respective departure route. An option that reduces delay but requires a longer flying distance may not be the optimal choice, because it typically takes an extra minute to fly four extra miles. The one-heading case results in an additional 3.1 nautical miles per flight over the three-heading scenario. The “123 case”, dual departures case, and the two-heading case are all similar, ranging from an additional 0.7 nm per flight to 1.0 nm per flight. The average additional distance flown per flight for each of the cases as compared to the three headings used in the Integrated Airspace Alternative with ICC is provided in Table 8, below. The greatest increase in mileage is found for those flights going to north and east departure fixes when using one heading. Flights to the west and southwest also fly the greatest distance when using one heading. Flights to the south fly the greatest distance in the dual departures case.

**Table 7. Additional Departure Distance Flown By Direction (Nautical Miles / Flight)**

| <b>Departure Gate</b>       | <b>One Heading</b> | <b>Two Headings</b> | <b>One, Two, and Three Headings</b> | <b>Dual Departures</b> |
|-----------------------------|--------------------|---------------------|-------------------------------------|------------------------|
| <b>North &amp; East</b>     | 5.9                | 1.5                 | 1.9                                 | 1.6                    |
| <b>West &amp; Southwest</b> | 1.7                | 0.2                 | 0.5                                 | -0.1                   |
| <b>South</b>                | -0.6               | 0.0                 | -0.2                                | 0.8                    |
| <b>All Departures</b>       | 3.1                | 0.7                 | 1.0                                 | 0.8                    |

## 7.4 Conclusion

The Integrated Airspace Alternative with ICC has two complementary efficiency improvements to EWR in its southwest configuration. It supports dual arrivals to runways 22L/22R to land aircraft more efficiently, and it gives tower controllers three departure headings to expedite departures more efficiently. The airport is physically small, so the two go together – if departures can not be made more efficient, then bringing in arrivals more efficiently can cause congestion on the taxiways that potentially removes all the benefit created by the dual arrivals. However, the three-heading dispersal of departures from runway 22R attracted more negative public comment than any other single element of the redesign. This section has investigated the possibility of changing the departure side of the operation in a way that can reduce noise exposure in such a way that efficiency is not compromised.

A single departure heading off of 22R, as is used in the Future No Action alternative, is impractical. The resulting departure delays are very large (see Section 7.3.1) and the lineup of departing aircraft congests the taxiways. Two departure headings can reduce 80% of the delay penalties of a single heading, but the remainder is still a significant penalty to users of the airspace.

Three headings, as included in the Integrated Alternative, three headings turned on and off according to demand, and dual-runway departures are all shown in the analysis to be viable options for efficiently expediting departures. The differences in delay among these three scenarios are effectively zero, at the limit of simulation accuracy. Likewise, the lineup queue to 22R is similar for these three cases, although the dual departures case also experiences a lineup queue to 22L. In terms of distance flown, these three cases also perform equally well. Therefore, the choice among them can be made on the basis of noise exposure.

Of the three departure headings, the 260 heading affects the most people. Use of this heading is minimized by the use of demand-triggered headings. A simple rule can be based on the number of aircraft wishing to depart: for example, specifying the use of three headings when more than 10 aircraft have pushed back for departure on 22R. A rule like this, with a complementary rule specifying a 190 heading when fewer than five aircraft have pushed back for departure, can reduce the number of aircraft on the 260 heading by 70% without affecting efficiency. As a secondary benefit, the number of aircraft on the 240 heading is reduced by 20%. When the exact directions of the nominal 240 and 260 headings are chosen to send flights over the least-sensitive areas available, the result is an operationally-viable variation of the preferred alternative. The cost of the change to airspace users is negligible; the cost to air traffic control is a small increase in complexity of the departure operation.

The best noise mitigation of the preferred alternative, therefore, is a combination. EWR departures should use three headings only when departure demand requires it; when only one heading is necessary, it should be the current 190 heading; in between, two headings should be used of approximately 220 degrees (near the New Jersey Turnpike) and 240 degrees (near the railroad). Departures off 22L should be kept as an option for the tower when conditions require it, but there is no operational benefit to using 22L continuously for departures.

## **8 Newark Liberty International (EWR) Airport: Evaluation of Night-time Ocean Routing**

### **8.1 Background**

In today's airspace all departures off of EWR's runway 22R take a 190-degree heading off the runway. This constraint of a single heading necessitates increased separation between successively departing aircraft and impairs the ability the tower controller to efficiently move departures from the airport. In order to alleviate this inefficiency, the Integrated Airspace Alternative with Integrated Control Complex (ICC) provides three departure headings off of EWR's runway 22R instead of the single heading used today.

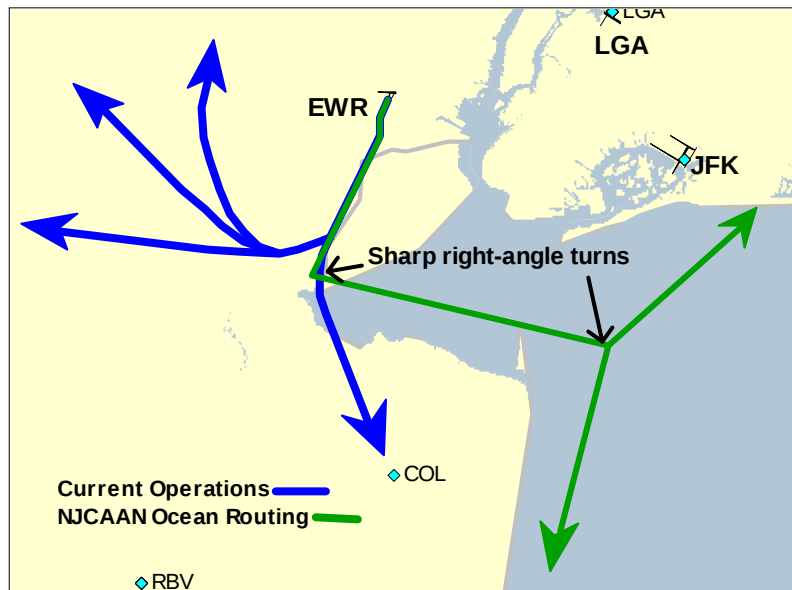
#### **8.1.1 Affected Area**

The advantage of a single heading off runway 22R lies in the effects of departures on the communities to the southwest of EWR. When the single stream of traffic is split into three flows, the flights are dispersed over a greater area. Communities that before may have been exposed to little or no departure traffic now share in the noise created by the departures. This can be seen by the area PIWB-11EWR-A on the noise impact map of the Draft Environmental Impact Statement (Draft EIS). Many of the residents of this impact area, such as those of Elizabeth, New Jersey, are concerned with the projected increase in noise for their area associated with the additional departure headings.

#### **8.1.2 Previous Ocean Routing Proposal**

An ocean routing plan, proposed by the Office of the Governor of New Jersey and originally developed by the New Jersey Coalition Against Aircraft Noise, Inc. (NJCAAN), was modeled as an alternative in the New York/New Jersey/Philadelphia Draft EIS. The objective of the alternative is to reduce noise over inhabited areas rather than increase safety and efficiency of air traffic operations.

In the NJCAAN Ocean Routing Alternative, Newark Liberty International Airport (EWR) departures first fly south and east over the ocean, before turning to their final destination. (See Figure 12.) The aircraft climb over the water until south of John F. Kennedy International (JFK) airport. West departures then turn south for 20 miles and then west to join their jet airways. North-gate departures go east, and then turn north over Long Island, then west. The single stream flow specified in the NJCAAN design requires longitudinal separation between successive departures. In addition, the right angle turns make for inefficient departure flow as different types of aircraft perform differently as they climb out of their departure airport and air traffic control must take into account the performance differences when they space departures. For example, extra spacing is needed in the event the trailing aircraft takes the turn early when the leading aircraft turns late.



**Figure 12. NJCAAN Ocean Routing Alternative for EWR**

Simulation of the NJCAAN Ocean Routing Alternative<sup>3</sup> shows severe departure delays at EWR, much longer flying distances for most EWR departures, and increased airspace complexity. Ocean Routing removes the delay on the west gate out of New York, since this gate is no longer available to EWR departures when departing runway 22R. However, in its place is a new congestion point to the south of New York. The result is a small reduction in airspace delay due to the ocean routing, but a significant increase in airport departure delay. There is an additional complication in the en route airspace, as the proposed routing of EWR and JFK departures passes just north of the main departure fix out of Philadelphia. As EWR departures are pushed later in the day by the airspace capacity limits, they coincide with the evening departure push out of Philadelphia. The result is increased complexity in the en route airspace to the southwest of New York, which is already a bottleneck in the en route system. For these reasons, the NJCAAN Oceanic Routing Alternative was determined in the Draft EIS not to meet the purpose and need of the airspace redesign.

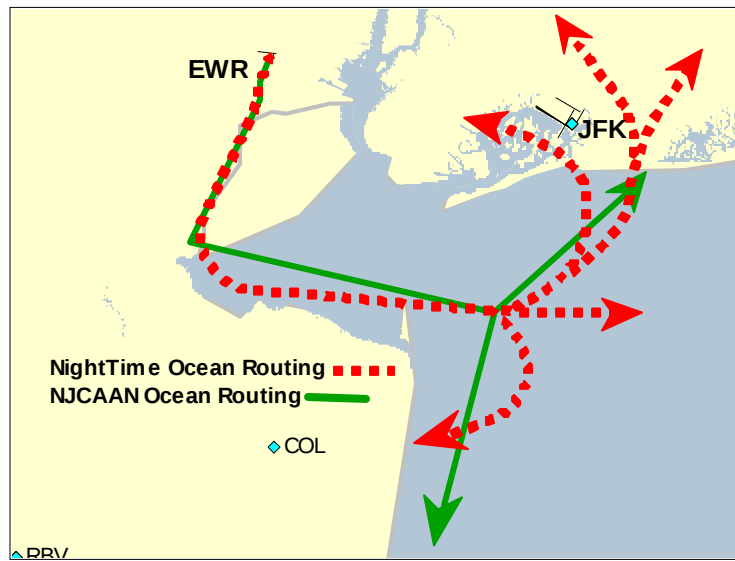
### **8.1.3 Proposed Airspace Change**

One possible approach to mitigate the noise associated with the three headings off 22R, while still obtaining some of the operational benefits of fanned headings, is to use the fanned headings during daytime hours and ocean routing for nighttime operations. The ocean routing would use

<sup>3</sup> Federal Aviation Administration, *New York/New Jersey/Philadelphia Airspace Redesign, Draft Environmental Impact Statement*, December 2005, Appendix C.

one departure heading off of 22R and send the flights out over the ocean as they climb so that the associated noise would be reduced over residential areas. Once the flights were at high enough altitudes so that they could not be heard from below, they would be routed back to their departure fixes.

In the noise mitigation approach for nighttime operations, routes may be modified to eliminate the bottlenecks associated with the NJCAAN design. The routes in the noise mitigation approach eliminate the right-angle turns and departures turn over the ocean sooner and fan out more than the NJCAAN design, thus allowing for a better flow of the traffic. (See Figure 13.)



**Figure 13. Comparison of NJCAAN Ocean Routing with Mitigated Approach**

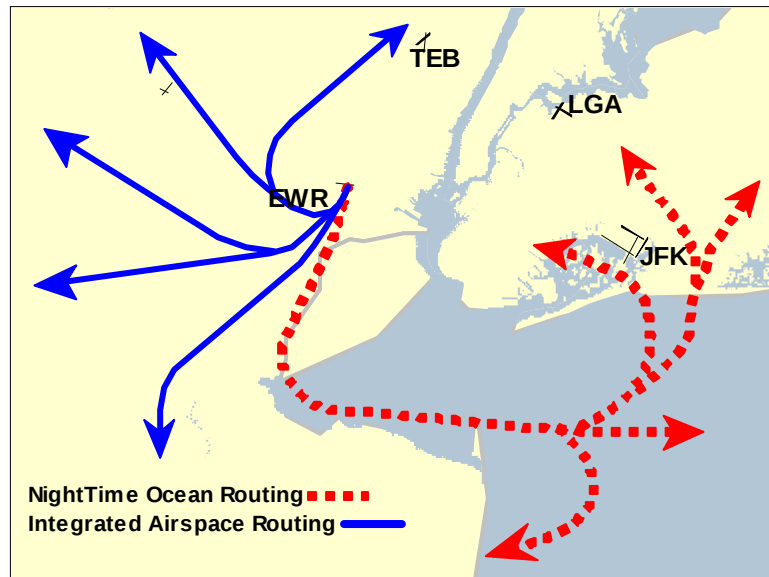
## 8.2 Methodology

EWR departures off of runway 22R during nighttime operations were simulated for both the Integrated Airspace Alternative with ICC, using three headings off 22R; and the noise mitigation approach, using one heading off 22R. Nighttime ocean routing was used between the hours of 0230 and 1000 GMT. These hours of operation were selected such that they would have minimal impact on delay, while still reducing noise during critical nighttime hours. The airport configuration used in this analysis is the same as was modeled for the NY/NJ/PHL Operational Analysis.

In the Integrated Airspace Alternative with ICC, departures to the south head straight (220-degree heading) off the runway. Departures to the west take a 240-degree heading off the runway. Departures to north and east fixes take a 260-degree heading off the runway.

For the noise mitigation approach, there is only one heading off the runway, the 190-degree heading. This matches the current procedure for south departures, up to about 4,000 ft. The

aircraft climb over the ocean until they are south of JFK airport. The flights to the east, north, and west head northeast and gradually turn and fan out in the direction of their respective fixes. The flights to the southwest and south head southeast and gradually turn and fan out in the direction of their respective fixes. The difference between this approach and the NJCAAN design is that the flights in the noise mitigation approach do not make the sharp 90-degree turns that the NJCAAN design uses. The departures in the noise mitigation approach fan out and turn back to land sooner and, consequently, are in-trail for a shorter distance than in the NJCAAN design. (See Figure 14.)



**Figure 14. Simulated Departure Routings**

### 8.3 Constraining Factors

With the rerouting of EWR departures over the ocean, there are three areas of potential conflict with other airports' traffic.

The first instance concerns the JFK arrivals via CAMRN. These flights have a lateral intersection with the EWR ocean departures approximately two miles northwest of FATHO. However, the JFK arrivals are at 4,000 feet and stay below the EWR departures, which are either at or above 9,000 feet and climbing at that point. These flows are altitude separated and pose no problems.

The second possibility for a conflicting flow involves the LGA arrivals via RBV. During the daylight hours, when LGA is busy, these arrivals cross the proposed EWR departures at 7,000 ft. EWR departures must therefore be held to 6,000 ft until three miles west of the crossing point, which is another source of inefficiency. After local midnight, however, LGA arrivals are rare. This stream does not exist, and there is no conflict.

The third potential area for conflict involves JFK departures via WHITE and WAVEY. These flights would conflict with the EWR ocean departures approximately four miles northeast of FATHO where both airports' departures are at about 10,000 feet. This area of conflict could be

avoided by rerouting the JFK departures to WHITE and WAVEY farther east and then merging them with the EWR departure flow. This would allow the JFK departures a more direct route to their respective fixes (as shown in the figure to the right). The rerouted JFK flights would fly 0.95 fewer miles per flight.

Since there are so few JFK flights affected during the nighttime hours between 0230 and 1000 GMT, these changes would not have an impact on the operations.

## 8.4 Operational Impacts

The results of the simulation include the impact on delay, departure queue length at the airport, and distance flown.

### 8.4.1 Delay

Given the low number of operations during the nighttime hours for which this mitigation scenario was evaluated, no discernable difference in average delay was found between the mitigated alternative and the Integrated Airspace Alternative with ICC. Delay was not affected by the reduced number of departure headings off the runway.

### 8.4.2 Lineup Queue Length for 22R

One way to measure of the efficiency of the number of headings off the runway is to observe the number of flights waiting on the ground to take their turn on the departure runway. A flight is considered to be counted in the lineup queue from the time it pushes back from the gate until the time it departs from the runway. During nighttime operations, both the Integrated Airspace Alternative with ICC and the noise mitigation approach have a maximum of eight flights in the lineup queue. Again, with the decreased number of flights during these hours of operation, the lineup queue was not affected.

### 8.4.3 Distance Flown

A comparison of the distance flown using the Integrated Design with ICC and the noise mitigation approach shows that the EWR aircraft departing between 0230 and 1000 GMT fly approximately 37 additional miles per flight in the noise mitigation approach. This increased distance flown affects 73 flights.

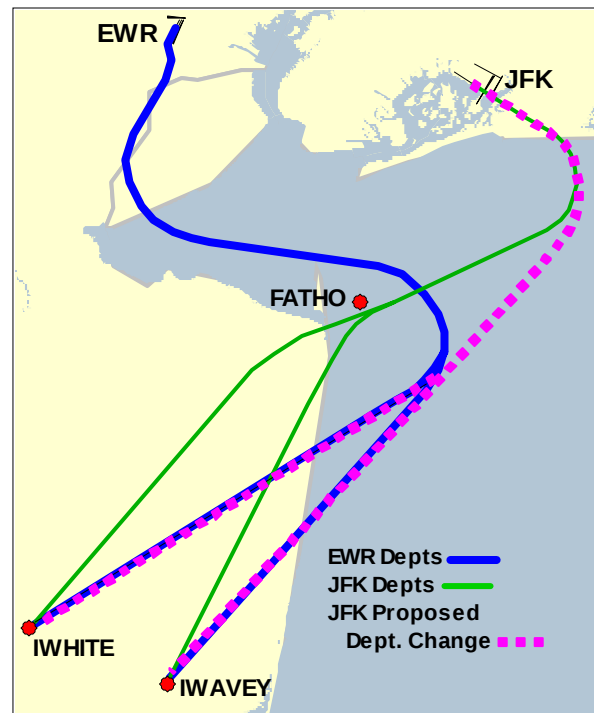


Figure 15. Illustration of Proposed JFK Reroute to the Southern Fixes

## **8.5 Conclusions**

The use of nighttime ocean operations has no impact on delay and lineup queue at the airport. These departures are required to travel an additional 37 miles each on average. However, only 73 departures are affected by this additional distance. Given the anticipated benefit (reduction in noise impacts) to the residential areas southwest of EWR airport during the nighttime hours, the penalty of additional flying distance for 73 flights is an acceptable tradeoff. The nighttime ocean routing is a viable noise mitigation option. This option dovetails with the recommendation that the number of departure headings be triggered by departure demand (see Section 7). The nighttime period is a single-heading operation in all available demand forecasts.

## 9 Can Precision Navigation Increase the Efficiency of Newark Ocean Routing?

### 9.1 Background

An ocean routing plan, proposed by the Office of the Governor of New Jersey and originally developed by the New Jersey Coalition Against Aircraft Noise, Inc. (NJCAAN), was modeled as an alternative in the New York/New Jersey/Philadelphia Draft Environmental Impact Statement (EIS). The objective of the alternative is to reduce noise over inhabited areas, rather than increase safety and efficiency of air traffic operations. In the NJCAAN Ocean Routing Alternative, Newark Liberty International Airport (EWR) departures first fly south and east over the ocean, regardless of their final destination. The aircraft climb over the water until they are south of John F. Kennedy International (JFK) airport. West departures then turn south for 20 miles and then west to join their jet airways. North-gate departures go east, and then turn north over Long Island, then west. The single stream flow specified in the NJCAAN design requires longitudinal separation between successive departures. In addition, the right angle turns make for inefficient departure flow as different types of aircraft perform differently as they climb out of their departure airport and air traffic control must take into account the performance differences when they space departures. For example, extra spacing is needed in the event the trailing aircraft takes the turn early when the leading aircraft turns late.

Simulation of the NJCAAN Ocean Routing Alternative<sup>4</sup> shows severe departure delays at EWR, much longer flying distances for most EWR departures, and increased airspace complexity. Ocean Routing removes the delay on the west gate out of New York, since this gate is no longer available to EWR departures when departing runway 22R. However, in its place is a new delay point to the south of New York. The result is a small reduction in airspace delay due to the ocean routing, but a significant increase in airport departure delay. There is an additional complication in the en route airspace, as the proposed routing of EWR and JFK departures passes just north of the main departure fix out of Philadelphia. As EWR departures are pushed later in the day by the airspace capacity limits, they coincide with the evening departure push out of Philadelphia. The result is increased complexity in the en route airspace to the southwest of New York, which is already a bottleneck in the en route system. For these reasons, the NJCAAN Oceanic Routing Alternative was determined in the Draft EIS not to meet the objectives of the airspace redesign.

During the period for public comment on the Draft EIS, NJCAAN suggested that Area Navigation (RNAV) overlays of their proposal for ocean routing would reduce the need for additional space between departures and reduce the associated penalties to users of the airspace. This section investigates their suggestion for feasibility and efficiency.

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<sup>4</sup> Federal Aviation Administration, *New York/New Jersey/Philadelphia Airspace Redesign, Draft Environmental Impact Statement*, December 2005, Appendix C.

## 9.2 Approach

Precision navigation causes an aircraft to adhere more closely to its intended path, but it does not change the performance of the aircraft. For example, all B737-800 of the same weight will fly the same track, and all E145 regional jets of the same weight will fly the same track, but the tracks of the E145 and the B737-800 will usually not be the same.

The operational efficiency estimate in the Draft EIS was based on separations calculated<sup>5</sup> using conventional navigation. The variability of aircraft tracks in that sample of terminal radar data led to the conclusion aircraft departing EWR runway 22R would need five miles of separation in trail to prevent them from coming too close together in the airspace. This analysis replaced the aircraft with simulated RNAV aircraft, and treated the spacing between departures as a variable parameter. The minimum value of the parameter that maintained spacing between successive aircraft was then compared to the 5-mile standard.

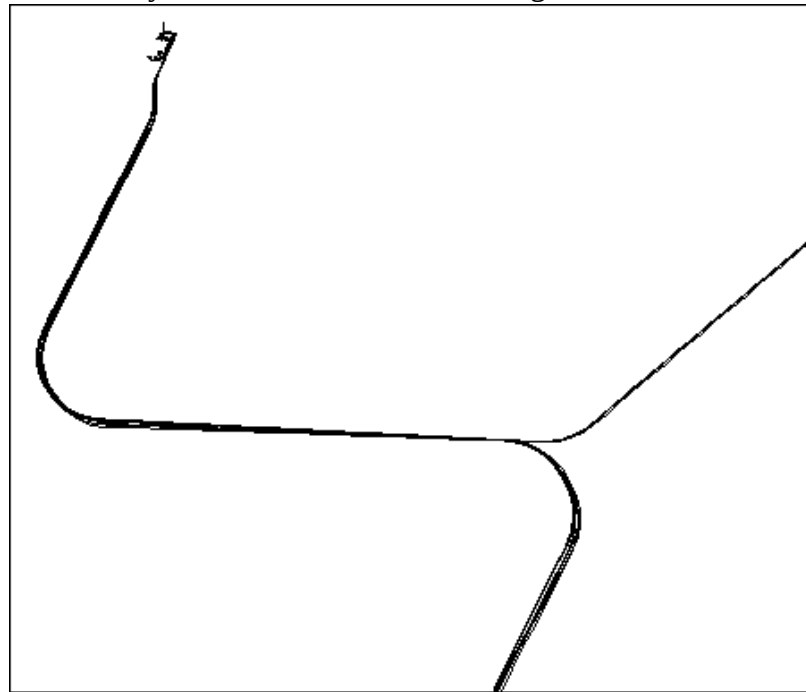
### 9.2.1 Simulation

The correct magnitude of the departure separation between successive ocean-routed aircraft is essentially a safety question, so a full-day simulation was not needed. The simulation of the Ocean Routing Alternative for EWR and its associated airspace was extracted from the suite of simulations used for the original operational analysis. Aircraft were flown through the simulation in pairs, according to each common combination of leading and following aircraft types.

The simulation was used to create artificial radar data, which was used to compute the instantaneous separations between successive aircraft as they climbed from the airport along the oceanic route.

## 9.3 Results

Aircraft with RNAV capability adhere much closer to their specified paths than do conventional aircraft. The simulated tracks of EWR oceanic departures are shown in Figure 16. Dispersion is caused by aircraft performance only; no navigation



**Figure 16. Dispersion of Ground Tracks of EWR 22R RNAV Departures**

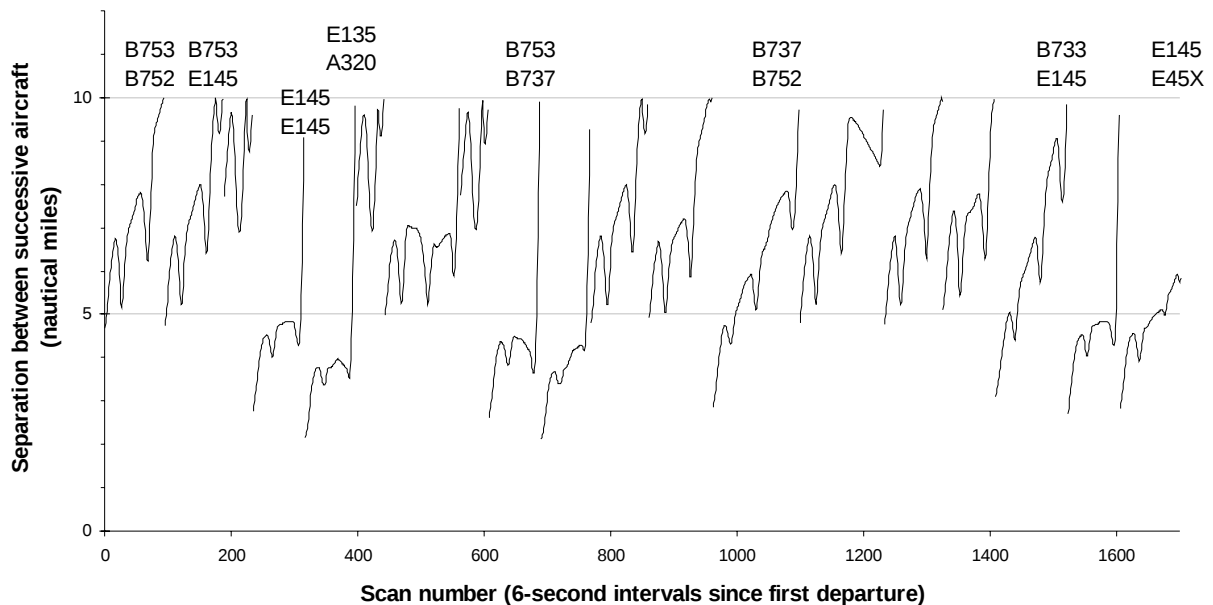
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<sup>5</sup> Leigh-Fisher Associates, *Evaluation of Proposed Ocean Routing Procedures*, May 1994.

error is included. This figure shows the effect of turn radius and rate of climb. The effect of airspeed differences is not visible here.

To include the effects of airspeed, we must look at separation distances between aircraft. Departures naturally separate themselves in trail, as the lead aircraft accelerates before the trailing aircraft.

Simulated separations between successive aircraft, as a function of time, are shown in Figure 17. Time is represented by a simulated radar scan that returns one hit each six seconds. The graphs end when the aircraft reach a separation of 10 nautical miles. An exemplar of each pair of aircraft is called out explicitly. Similar curves belong to similar aircraft types of different weights. B757 variants used were the B757-200 and -300, designated by “B752” and “B753” respectively. B737 variants used were the B737-300 and -700, designated by “B733” and “B737” respectively. Embraer regional jets are the “E135”, “E145” and “E45X”. The Airbus 320 is designated by “A320”.



**Figure 17. Inter-aircraft Separation of EWR 22R Departures**

An immediately-obvious feature of these curves is a pair of cusps where separation between aircraft decreases. This occurs at the right-angle turns in Figure 17, where the lead aircraft’s natural acceleration is diminished by the geometry of the turn. Some curves have a third cusp, when the successive flights share a third turn back over land, south of the area shown in Figure 16.

### 9.3.1 Separation Requirements

Terminal controllers must never permit aircraft on the same course and altitude to approach within three nautical miles of each other. As required, all the aircraft pairs quickly reach a 3-mile

separation. (At the beginnings of the curves, the trailing aircraft is still on the runway). When the leading aircraft is a B757 or heavier, the curves begin with 5 or more miles of separation to account for wake turbulence.

A terminal departure controller must not have aircraft at a separation of less than five nautical miles when handing them off to the en-route center. To provide a margin of safety in the event of unexpected winds or traffic, eight to ten nautical miles is the customary minimum spacing at handoff.

### **9.3.2 Findings**

The curves in Figure 17 were generated with the minimum spacing necessary to keep the cusps above 5 nautical miles. This is the limit of a viable operation. An unexpected event at one of those cusps can lead to an operational error, and in the worst cases safety may be compromised. Therefore, this simulated separation off the runway is the minimum acceptable. The separation rule that generated these curves was a requirement of 90 seconds between departures any time wake turbulence was not a factor. This translates, for example, to 4.67 nautical miles between successive B737 departures. Spacing requirements can not be specified so precisely, so this value must be rounded to 5 nautical miles, which is the same as specified in the 1994 Leigh-Fisher study.

## **9.4 Conclusion**

If the ocean-routing departure procedures in the NJCAAN-proposed alternative were replaced with RNAV overlays, the random part of the side-to-side variation in departure tracks would be greatly reduced. As a result, ground tracks of flights using the hypothetical RNAV ocean route will form a few tight bundles, not a continuous spread as they do with conventional navigation. However, the extremes of the tight bundles at the sharp turns will match the extremes of the conventional spread because the longitudinal speed profile and turn radii of each individual aircraft's track are determined by the aircraft's performance envelope, not by random variations in navigation accuracy. The same extra space will be needed between departures. Precision navigation will not reduce the departure-delay penalties associated with ocean routing of EWR departures during busy hours.

## 10 An Analysis of the Lateral Path and Downwind Altitudes of EWR Arrivals to Runways 04R and 22L

### 10.1 Background

Aircraft approaching EWR on the opposite side from the final approach course enter the New York TRACON at the arrival fix at a low altitude, typically 8,000 feet. These flights then fly a very long downwind of approximately 50 miles before turning east to continue their descent to the runway. The altitude of flights on the downwind is constrained to 6,000 feet

(Figure 18.) This is due to the need to keep departures out of approach airspace. Departing flights from EWR, TEB, and MMU that cross the path of the EWR arrivals must climb

above the arrivals. The altitude constraint keeps EWR arrivals separated from the departures above them. In the Integrated Airspace Alternative with ICC, the lateral path of these arriving flights is altered from Future No Action (Figures 19 and 20) but the vertical profile is unchanged.

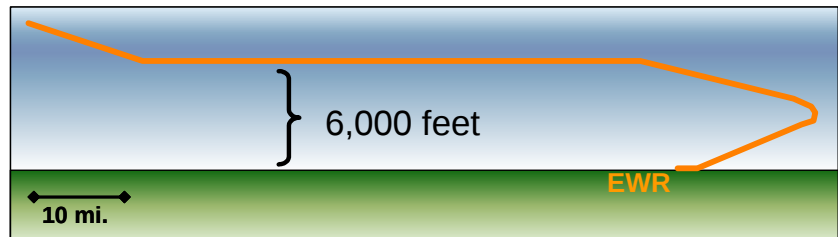


Figure 18. Vertical Profile of EWR Arrivals

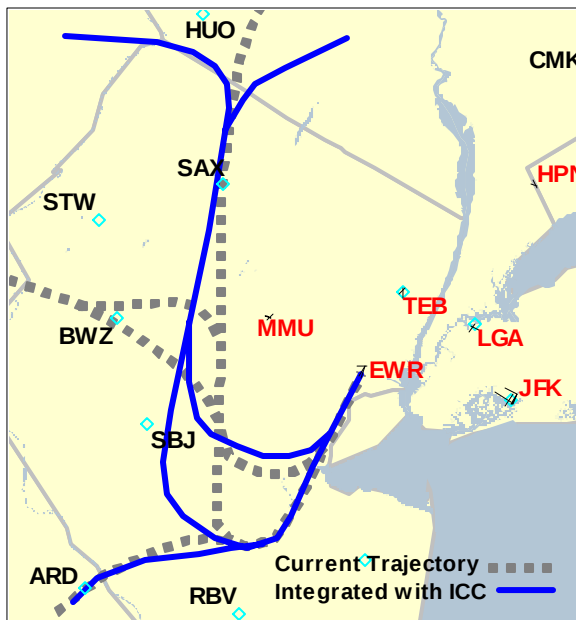


Figure 19. EWR Arrivals to Runway 04L/R

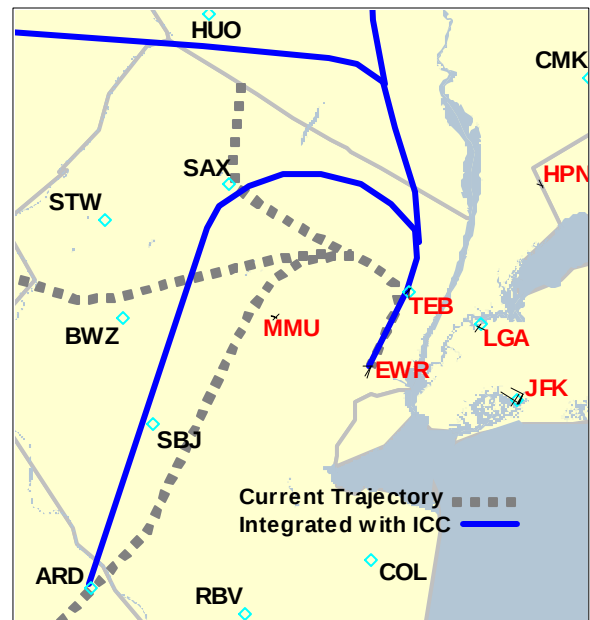


Figure 20. EWR Arrivals to Runway 22L/R

### **10.1.1 Affected Area**

Part of the area under this approach is exposed to a marginal increase in noise, identified in the Draft Environmental Impact Statement<sup>6</sup>. Numerous public comments have been received from residents of the affected counties in New Jersey, expressing disapproval of low-flying aircraft.

### **10.1.2 Proposed Airspace Changes**

Two mitigations were proposed to alleviate the noise caused by the changes in the Integrated Airspace Alternative with ICC.

The first scenario (Vertical Only), the proposal consists of raising the downwind segment of EWR arrivals in both configurations from 6,000 ft to 8,000 ft MSL, while the lateral path remains unchanged. This will have very little effect on the user-oriented metrics used to establish the degree to which alternatives meet the purpose and need of the airspace redesign.

In the second scenario (Vertical and Lateral), the proposal included both raising the altitude of the downwind segment of the EWR arrivals in both configurations from 6,000 ft to 8,000 ft MSL, as well as moving the lateral path so that the downwind passes within a few nautical miles of the airport. This proposal decreases the length of the track some aircraft must fly, so in addition to whatever noise benefits it can provide, it can improve metrics such as the distance and time flown below 18,000 ft.

## **10.2 Constraining Factors of Vertical Move Only**

In order to verify the necessity of maintaining the 6,000-foot vertical constraint in the Integrated Airspace Alternative with ICC, crossing traffic must be identified and the respective crossing altitudes established. Then, all must be evaluated in the context of the approach airspace, newly designed for the Integrated Alternative.

### **10.2.1 Crossing Traffic**

Two flows of traffic were identified as crossing the EWR arrivals to runway 22L in the high capacity configuration and the arrivals to runway 04R in the low capacity configuration: departures and overflights.

#### **10.2.1.1 Departures**

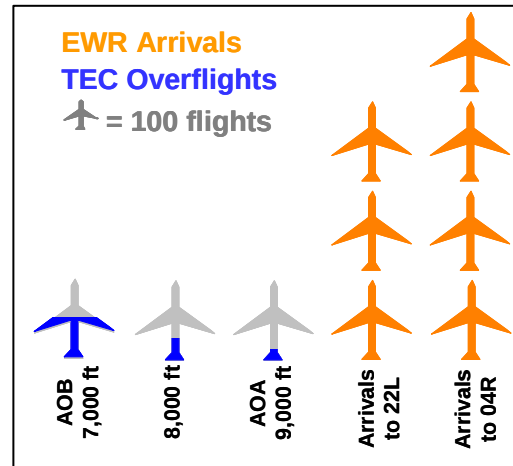
The first type of crossing traffic consists of departures to the west from EWR, TEB, and MMU. With rare exceptions, these flights cross the location of the downwind arrival path at or above 10,000 feet in current radar data, leaving ample room to raise the downwind for the arrivals to an altitude of 8,000 feet. In the Integrated Airspace Alternative with ICC, several important climb restrictions have been removed from the departures, which will improve the vertical separation between these two flows.

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<sup>6</sup> This area is labeled PIWB11EWR-D in Figure ES.5.

### 10.2.1.2 Overflights

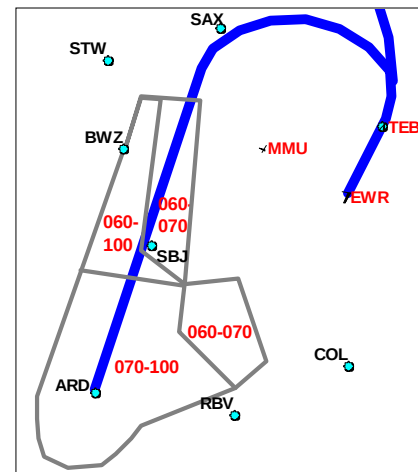
The second type of crossing traffic consists of those flights operating under Tower En Route Control (TEC) and crossing the Solberg (SBJ) VOR. In the current airspace, these flights cross SBJ at a range of altitudes from 2,000 feet up to the ceiling of the TRACON. As illustrated in Figure 21, the number of TEC flights crossing the SBJ VOR is relatively small compared to the 300 EWR arrivals to runway 22L and the 400 EWR arrivals to runway 04R that cross this same point. Only 21 flights a day cross at the altitude of 8,000 feet. This is a small number of flights in need of altitude adjustments necessary to raise the downwind altitude for the EWR arrivals. In the Integrated with ICC alternative, several of the TEC flights currently originating in the NY TRACON and crossing the SBJ VOR already have redefined routes that no longer include this point. However, there are other TEC routes defined in the current Airport and Facilities Directory which include crossing SBJ at 8,000 feet, but are not directly addressed by the Integrated Airspace Alternative with ICC.



**Figure 21. A Comparison of the Number of TEC Flights and EWR Arrivals Using the SBJ VOR**

### 10.2.2 Airspace Boundaries

In the Integrated Alternative, the approach airspace for the ARD position (sketched in Figure 22 to the right) is reserved up to a ceiling of 10,000 feet between ARD and SBJ. Portions of the airspace between SBJ and BWZ, the segment to the west, continue with the 10,000 feet ceiling. Given that the departures from EWR, TEB, and MMU have all climbed to suitable altitudes above this airspace, reassignment of the shelves for the eastern segment of the airspace between SBJ and BWZ may be possible. This raised ceiling for the approach airspace should allow the EWR arrivals on the downwind to be raised to an altitude of 8,000 feet. However, without the reassignment of the airspace shelves between SBJ and BWZ, raising the downwind altitude from 6,000 to 8,000 feet will not be possible.



**Figure 22. ARD Approach Control Position Design for the Integrated with ICC Alternative**

### 10.2.3 Operational Impact

This change will have little or no effect on any of the operational metrics in the Draft EIS.

### 10.3 Constraining Factors of Vertical and Lateral Move

In order to evaluate the viability of both moving the lateral path of the arrivals as well as adjusting the vertical profile, a new lateral path must be defined for each of the arriving flows (the flow to runway 04R and to runway 22L), crossing traffic must be identified, and the respective crossing altitudes established. Then, all must be evaluated in the context of the approach airspace. As these approaches, which are substantially different from the Integrated Airspace Alternative with ICC, do not lie within the redesigned approach airspace for the Integrated Alternative, they are evaluated with regard to the current approach airspace.

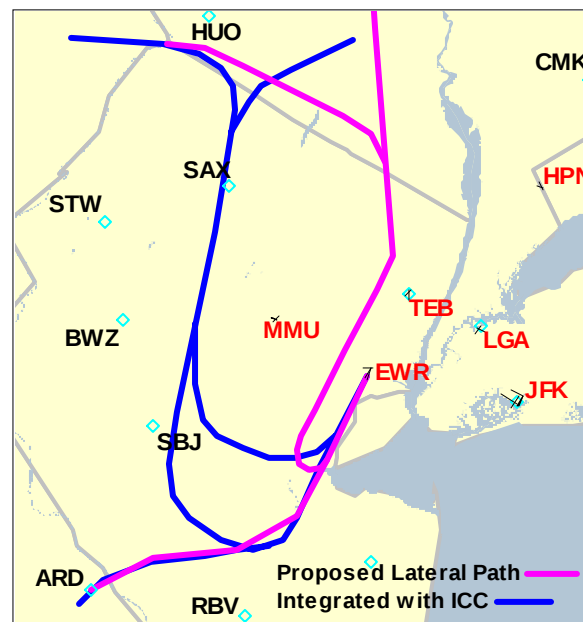
#### 10.3.1 Arrivals to Runway 04R

A new lateral path was developed for the arrivals to EWR's runway 04R, shown in pink in Figure 23. Flights arriving from the north on this new lateral path cross their respective arrival fixes at 8,000 feet. This altitude is then maintained until the flights are directly west of EWR airport, at which point they begin a steady descent to begin their final approach to the runway.

##### 10.3.1.1 Crossing Traffic

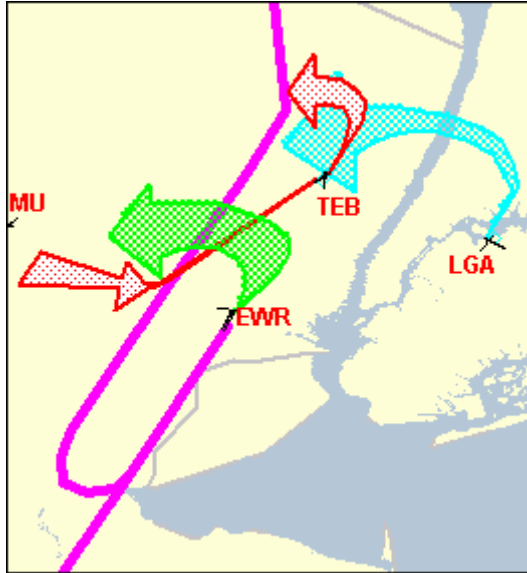
A number of both arrival and departure flows have a lateral intersection with the newly proposed path to runway 04R. Some of these flows, such as the JFK departures to the west, reach sufficient altitude by the time they cross the EWR downwind that vertical separation is maintained. Other flows, such as the arrivals to TEB, descend to sufficient altitude that they can easily maintain vertical separation while tunneling under the EWR downwind. There are, however, some flows that may have potential interaction with the newly proposed arrival downwind, both laterally and vertically. One of these concerns the EWR departures.

Several of the departure flows off of EWR's runway 04L climb north and then turn back to the west, laterally intersecting the downwind stream. These departures are illustrated by the green arrow in Figure 23. There is the potential that in an unrestricted climb, some of the departing flights may cross the lateral path of the arrivals at an altitude around 8,000 feet. In order to maintain safe separation, a restriction is placed on the EWR departures such that they may not climb above 7,000 feet until they have crossed underneath and cleared the arrival stream.



**Figure 23. Comparison of Integrated Arrival Path to Runway 04R with Proposed Mitigated Path**

Another conflicting flow concerns the LGA departures (depicted by the blue arrow in Figure 24). The proposed path for the EWR arrivals crosses through airspace currently delegated to LGA.



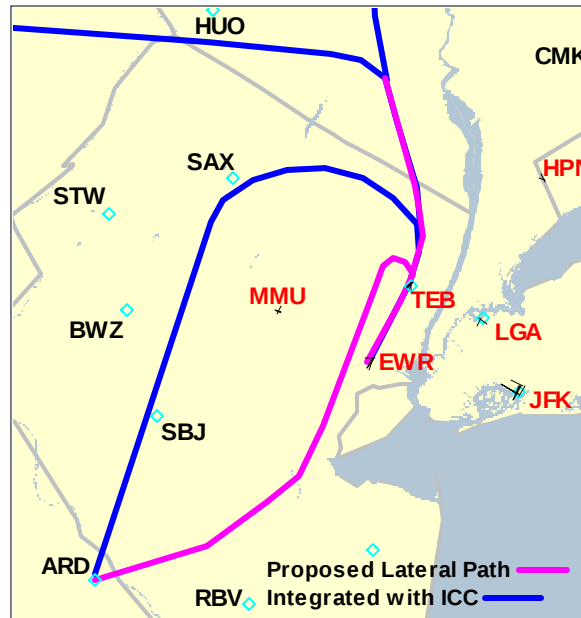
**Figure 24. Proposed EWR Arrivals to Runway 04R and Conflicting Flows**

altitude of 5,000 feet until clearing the EWR arrivals. If we in turn push down the EWR departures, restricting them to an altitude of 5,000 feet, then there is a conflict with the TEB arrivals which are crossing the downwind at that same altitude.

If we continue to lower the altitudes of conflicting flows until adequate vertical separation can be achieved, we then find that we have substantially increased the number of flights at lower altitudes than exist even today. We can be fairly confident this would result in an increase in noise rather than achieving the desired, intended effect of the mitigation proposal.

LGA owns the altitudes from 5,000 feet to 12,000 feet. Although EWR arrivals currently use this airspace at the lower altitudes, a downwind altitude of 8,000 feet conflicts with many of the LGA western departures, which cross through the airspace at a range of altitudes from 6,000 to 12,000 feet. As not all of the LGA departures can clear the 8,000 foot downwind, and it is unrealistic to require the LGA departures to tunnel under the EWR arrivals, we must consider lowering the altitude of the EWR arrival downwind. This, in turn, creates additional problems.

In order to avoid the LGA departures, the downwind altitude would need to be lowered from 8,000 feet to 6,000 feet. This creates a conflict with the EWR departures, which are concentrated at an altitude of 6,000 feet. It also creates a problem for the TEB departures which would need to be restricted to an



**Figure 25. Comparison of Integrated Arrival Path to Runway 22L with Proposed Mitigated Path**

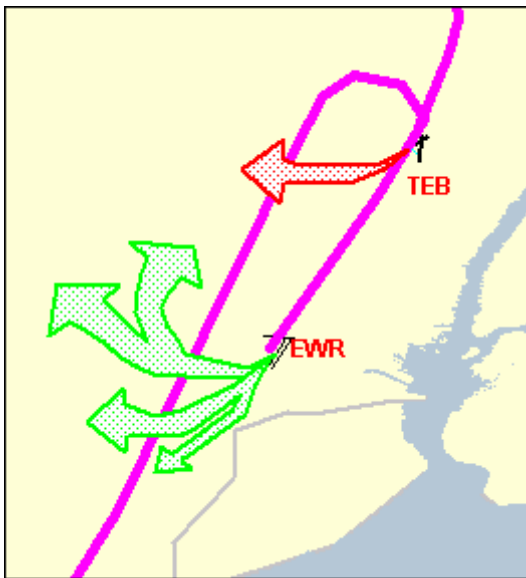
### 10.3.2 Arrivals to Runway 22L

A new lateral path was developed for the arrivals to EWR's runway 22L, shown in pink in Figure 25. Flights arriving from the south on this new lateral path cross the arrival fix at 8,000 feet. This altitude is then maintained until the flights are directly west of EWR airport, at which point they begin a steady descent to begin their final approach to the runway.

#### 10.3.2.1 Crossing Traffic

Like the arrivals to runway 04R, described above, there are a number of flows into and out of the NY TRACON that laterally intersect the newly defined arrival path to runway 22L. Most of these flows have ample vertical separation with the suggested 8,000 feet downwind altitude. There are only two flows that may conflict.

The TEB departures, as shown by the red arrow in the figure below, cross underneath the EWR arrivals after they have begun their descent. In order to maintain separation, the EWR arrivals should not descend below 5,000 feet until beginning the turn east onto the base leg. The TEB departures should be restricted to 4,000 feet until clearing the EWR arrival flow.



**Figure 26. Proposed EWR Arrivals to Runway 22L and Conflicting Flows**

The second flow that may create a conflict consists of the EWR departures, depicted by the green arrows in the picture to the left. With the exception of those to the south, all of the departures off of runway 22R turn to the west and intersect the downwind of the arrivals. The flights departing back to the east cross the arrivals a second time. In order to ensure vertical separation, the EWR departures must not climb above an altitude of 7,000 feet until they have cleared the arrivals. Those arrivals headed to eastern departure fixes should continue with the northern flow until an altitude of 9,000 feet is reached, at which point they may turn back east to climb over the top of the EWR arrival stream.

### 10.3.3 Airspace Boundaries

The arrival path to runway 22L as drawn in Figure 25 above does not fit within the current design of the approach airspace, nor does it fit within the design for the Integrated Airspace Alternative with ICC. Consequently, adoption of this mitigation proposal would necessitate an evaluation and redesign of the boundaries of the approach airspace.

## **10.4 Operational Impact**

One of the benefits of the Integrated Alternative is the unrestricted climb afforded to the departures from the NY TRACON. Adopting a scenario with both vertical and lateral moves strips both EWR and TEB of this efficiency as both have restricted climbs until beyond the EWR arrival flow. Worse, holding departures down low may negate the noise-exposure benefits of raising the arrivals, since departing aircraft produce more noise than arrivals.

## **10.5 Conclusions**

In the Integrated Airspace Alternative with ICC, the downwind of the EWR arrivals to runway 22L and the downwind of the EWR arrivals to runway 04R are moved west from the current track. This western move of the downwind puts the arriving flights over communities that previously had little or no arrival traffic. The public comments on the Draft EIS generated two scenarios for alleviating this increase in noise.

The Vertical Move Only scenario consists of raising the downwind altitude of the arrivals to both runways from 6,000 feet to 8,000 feet while maintaining the lateral profile. In this scenario, the crossing traffic from the EWR, MMU, and TEB departures, which have unrestricted climb in the Integrated Airspace Alternative with ICC, cross the downwind at or above 10,000 feet. This allows additional airspace for the approach positions and consequently, no longer necessitates the aircraft on the downwind to immediately descend and maintain 6,000 feet for the duration of the 50 miles of downwind track. It is recommended that the downwind altitude of the arrivals crossing ARD and landing 22L be raised to 8,000 feet for the duration of the downwind and descending to 6,000 feet for the turn back to the east. It is, likewise, recommended that the downwind altitude of the arrivals crossing FLOSI and landing 04R be raised to an altitude of 8,000 feet for the duration of the downwind and descending to 6,000 feet for the turn to the base leg. Overflight traffic on V249, level at 8,000 ft, should be lowered to 6,000 ft.

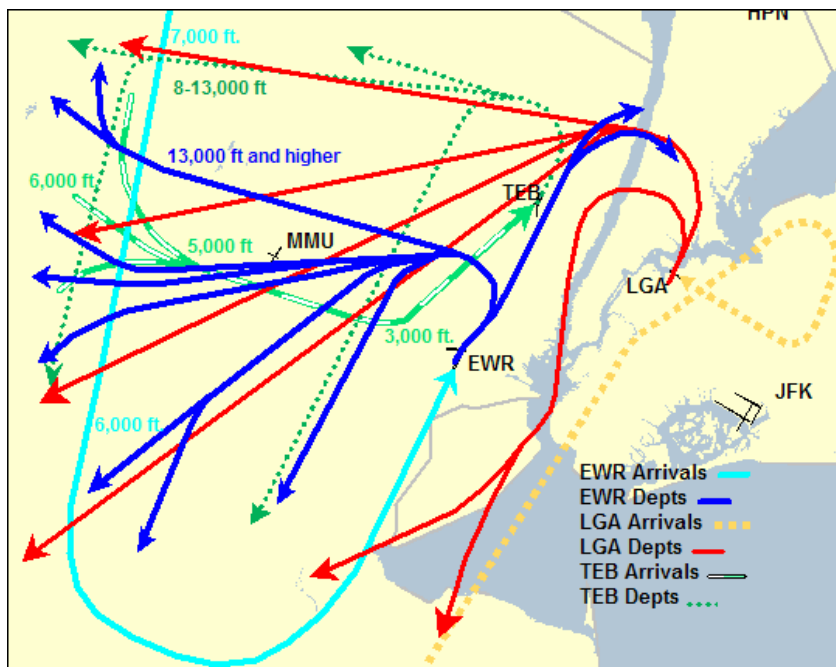
The Vertical and Lateral Move scenario consists of moving both the lateral and vertical profile of the arrivals to both runways. As was described above, this is not feasible for the arrivals to runway 04R as there are not sufficient altitudes for dealing with conflicts. The proposed approach is feasible for the arrivals to 22L. However, it would require holding down both the TEB departures to 4,000 feet and the EWR departures to 7,000 feet until they had cleared the EWR arrival stream. This scenario would also require extensive revisions to the boundaries of the approach airspace. Moving both the vertical and lateral profile is not recommended.

# 11 Newark Liberty International (EWR) Airport: An Analysis of Right Turns off of Runway 04R

## 11.1 Background

Dual 04 departures at EWR are a long-standing suggestion of the Port Authority, which arose again in the public comments on the Draft EIS. Implementing dual departures during times of high departure demand can balance the airport operation, since dual arrivals are planned at times of high arrival demand. In addition, they hold the possibility of reducing the noise exposure in Bergen County, NJ.<sup>7</sup>

Because runways 04L and 04R are so close together, departures from 04R will not bring about an efficiency increase without independent departure headings. Therefore, the first stage in enabling dual departures is to find a way to establish 15 degree divergence between the departure streams. If the two flows can be separated with headings, then the dependency between 04L and TEB would be broken. Dual departures would then be a possibility. Dual departures would help balance EWR operations when dual arrivals are implemented with the Preferred Alternative.



**Figure 27. Interaction of EWR, TEB, and LGA Traffic in the Preferred Alternative**

The airspace through which 04L/R departures must fly is tightly constrained on both sides. Less than four nautical miles to the west is the ILS to Runway 06 at TEB. The separation minimum is three miles. EWR departures must therefore turn east to a 60-degree heading, parallel to the ILS, until they reach an altitude of 2500 ft. Then they can turn west, because they are separated in altitude from the TEB arrivals.

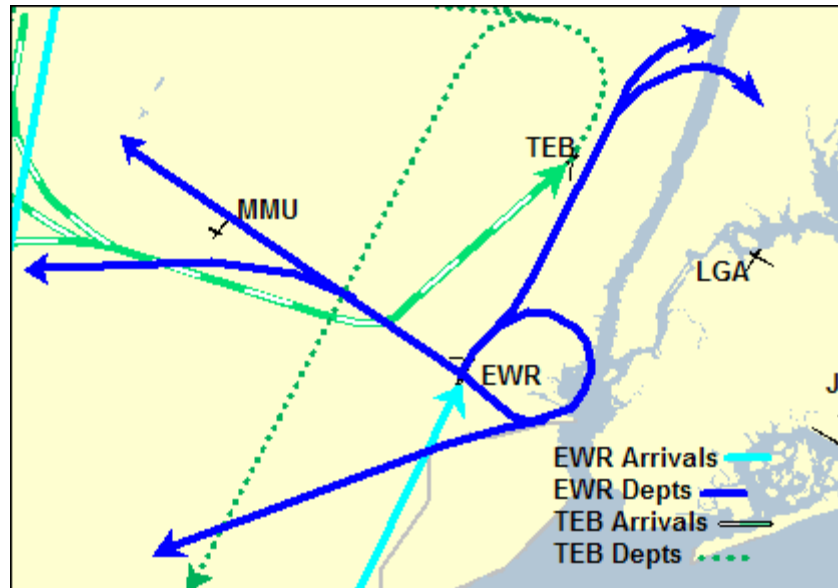
Almost exactly three miles to the east is the Special Use Line, on a 40-degree heading, which forms the

<sup>7</sup> The increased noise exposure in Bergen County due to the Integrated Airspace with ICC Alternative is area PIWB-11EWR-E in Figure ES.5 of the Draft EIS.

boundary of EWR and LGA airspace. EWR departures must turn away from this line by 2500 ft, or their flight path must be coordinated with LGA controllers. Coordination across this line causes extra workload for both EWR and LGA controllers, which will quickly turn into a decrease in departure throughput unless it can be prearranged. Procedures that simplify this coordination are the key to enabling the second heading.

#### 11.1.1 Proposed Airspace Changes

There are two separate conditions to study. First to be examined was the impact of changing the EWR departures to turn in a right clockwise circle over the airport (as shown in Figure 28) before turning to the north, west or south. This maneuver would allow EWR departures to gain more altitude before crossing the EWR arrivals, and also would raise the EWR departures above the TEB arrivals. This will be called the “circling scenario”.



**Figure 28. Circling Scenario for EWR Departures**

In another option, a right turn off of runway 04R was developed for the departures to the fixes of the south gate: IWHITE, IWEAVEY and DIXIE. (Figure 29.) (IWHITE and IWEAVEY represent the slightly shifted positions of the current WHITE and WAVEY) This procedure has an initial runway heading of 75 degrees which allows for 15 degree divergence from the east-, north- and west-bound EWR departures for lateral separation. It will be called the “Hudson River scenario”.

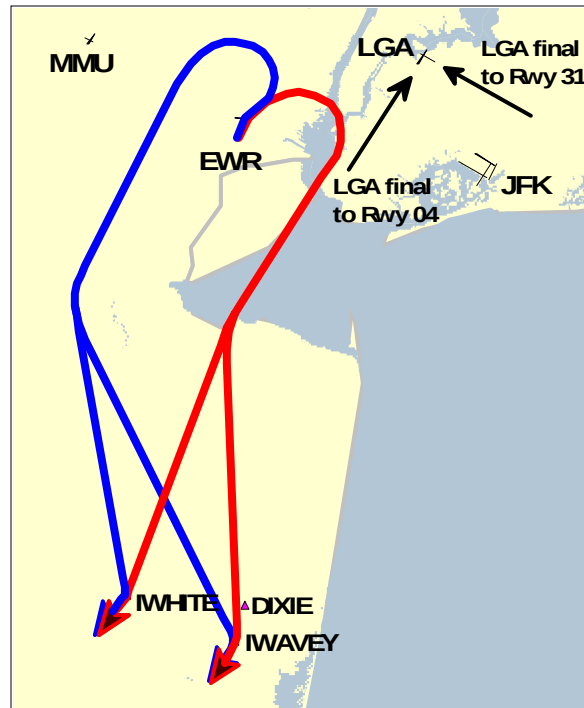


Figure 29. Hudson River Scenario for EWR Departures

## 11.2 Approach

Developing a concept for a mitigation scenario in which EWR departures may use runway 04R is a two-step process. Each move of the EWR departure flow necessitates the analysis of all other interacting flows for conflicts. Sometimes the conflicts cannot be resolved and the scenario must be abandoned. When a scenario is identified that has no irresolvable conflicts, then the second stage evaluates it for efficiency.

These proposals involve the most intricate parts of the complex, congested airspace surrounding the NY metropolitan area. Arrival and departure patterns for five other airports in the redesign study are considered as well as those in Figure 27 to accurately represent traffic flows through the airspace. It is assumed that tower en-route traffic crossing through the airspace is of secondary importance and can be rerouted away from any critical areas.

The first step in the analysis was to resolve any conflicts between the procedure in question and other flows in the vicinity by changes to altitude or vector pattern. The impacts of these changes are evaluated. If the efficiency cost of the altered flows is not too great, the procedure is passed on to the second step, in which EWR and LGA operations were simulated under the same assumptions as the Integrated Airspace Alternative with ICC. Since the runway configurations at EWR and LGA are not strongly correlated, the configuration of LGA was chosen that most conflicted with the proposed EWR procedure. The projected 2011 90<sup>th</sup> percentile day for EWR and LGA traffic drove the simulated airspace, exactly as in the original operational analysis.

## 11.3 Results

### 11.3.1 Operational Feasibility

#### 11.3.1.1 Circling Scenario

The circling scenario when LGA is departing 04 has less conflict with those departures. This proposal has the beneficial features of allowing TEB altitudes (crossing underneath the EWR arrivals) to be raised to 6000 feet and the TEB final to be raised to 4000 feet, but it also added an additional nine nautical miles to the EWR flights to the west and north.

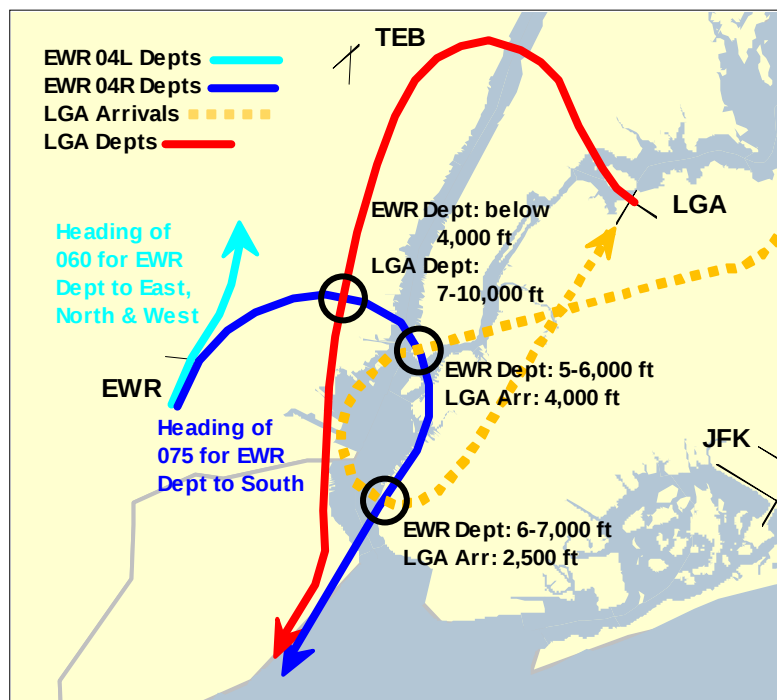


Figure 30. Conflicts between EWR Right-turn Departures and LGA 04 Arrivals

In the circling scenario when LGA departs runway 31 and lands runway 04, while EWR departs any flight from runway 04L and allows southbound departures from runway 04R. Figure 30 shows the interactions among EWR southbound departures, LGA southbound departures, and LGA arrivals. In this scenario, the EWR departures are not able to gain sufficient altitude to top the LGA flows. Vertical separation cannot be achieved, so LGA traffic would have to be rerouted. (See Figure 30.)

### 11.3.1.2 Hudson Scenario

In the Hudson scenario, LGA departs runway 04 and lands runway 31, while EWR departs via runway 04L and allows southbound departures via runway 04R. Two options were analyzed for the LGA departures off of runway 04. In option 1, LGA 04 departures are not changed (resulting in the need to merge the EWR 04R departures into the LGA southbound departure stream). In option 2, the LGA 04 southbound departures are moved away from the EWR southbound departure stream. These two options are shown in Figure 31.

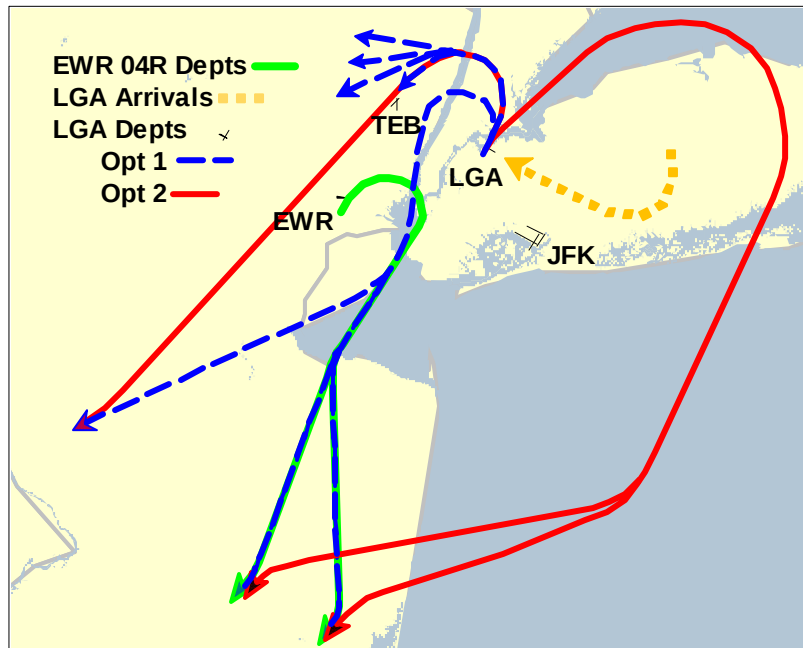


Figure 31. Two Options for LGA 04 Departures

For the scenario in which LGA

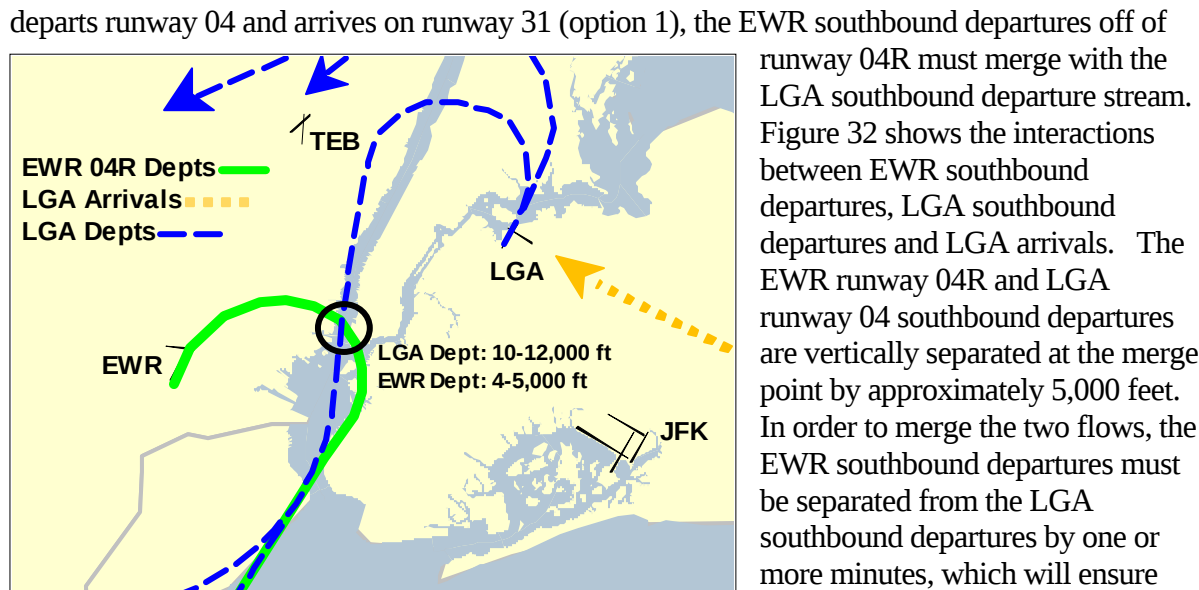
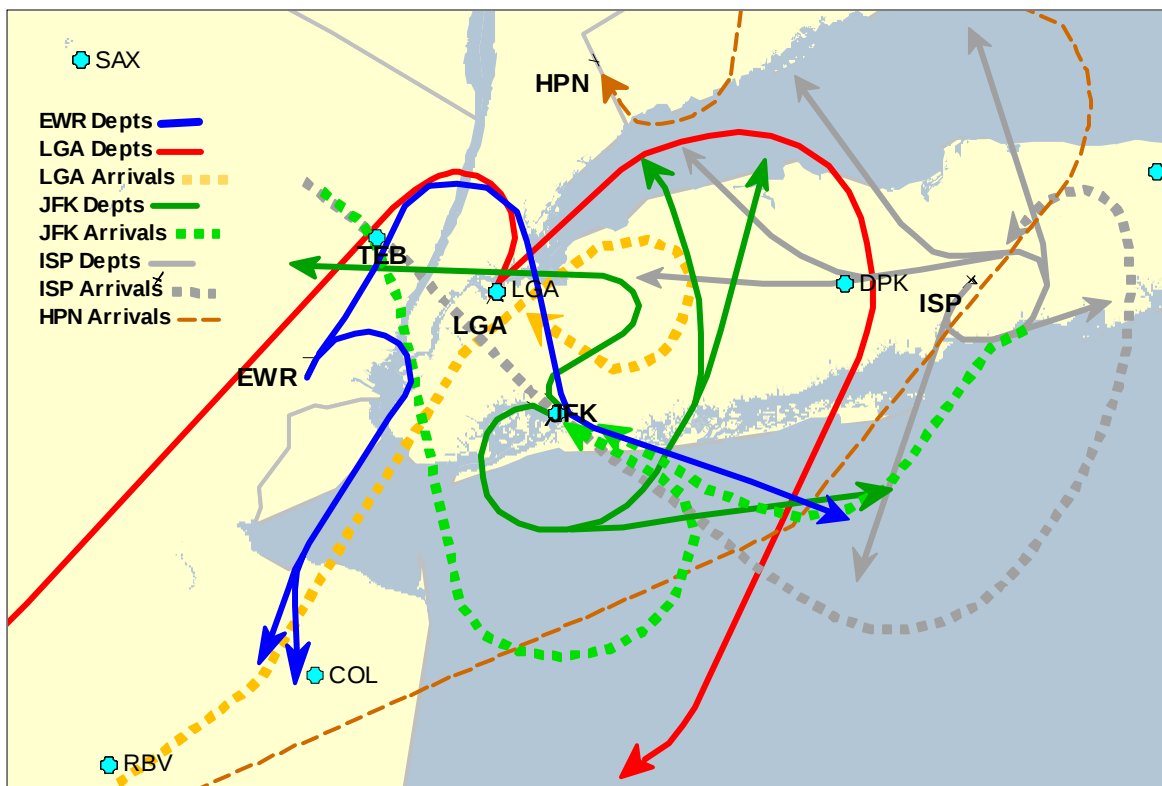


Figure 32. Interactions between Departures from Runways EWR 04R and LGA 04

departs runway 04 and arrives on runway 31 (option 1), the EWR southbound departures off of runway 04R must merge with the LGA southbound departure stream. Figure 32 shows the interactions between EWR southbound departures, LGA southbound departures and LGA arrivals. The EWR runway 04R and LGA runway 04 southbound departures are vertically separated at the merge point by approximately 5,000 feet. In order to merge the two flows, the EWR southbound departures must be separated from the LGA southbound departures by one or more minutes, which will ensure adequate distance between the EWR and LGA flights in the southbound flow. To space the EWR

southbound departures with the LGA southbound departure flow, the EWR departures must be held on the ground until adequate separation can be achieved. It is important to note that during the hours of peak southbound departure pushes (from 21 to 23 GMT), EWR southbound departures were modeled to use runway 04L due to the high ground delays associated with waiting for adequate separation in the LGA southbound departure stream.

For the scenario in which LGA departs runway 04 and arrives on runway 31, option 2, the LGA southbound departure paths are moved away from the EWR southbound departure stream. First, the departures to IWHITE and IWAYEY are changed to turn to the northeast before turning southbound. These departures must be held down to 10,000 feet until they cross underneath the JFK northbound departures and fly above the ISP westbound departures. At that point they are allowed a maximum altitude of 15,000 feet until crossing underneath the JFK eastbound departures. After clearing the JFK eastbound flow, they are cleared to continue their climb to join the southern departure route. The LGA departures to jet airway J75, the flow to the southwest, are also changed to fly further north and west before turning south, similar to the LGA departures to the west. The interactions among LGA, JFK, ISP and EWR are shown in Figure 33.



**Figure 33. Flows That Must be Avoided by Rerouted LGA Departures**

When LGA departs runway 31, the same congestion issues arise as for the circling departures, so this configuration is not viable.

### **11.3.2 Delay**

Circling EWR departures to the north and west gates causes a large improvement in departure efficiency at EWR. Airport departure delay decreases by 1.7 minutes per flight, if LGA departures are moved to non-conflicting airspace. If LGA departures must be delayed to fit the two departure flows into a single stream, EWR departure delays increase significantly and LGA departures are essentially paralyzed. Simulation results show 71 minutes per flight of extra delay, but this does not represent a viable operation at LGA because the airport does not have the ground infrastructure to support such large delays on a regular basis. EWR departure throughput is not increased over the baseline case. LGA departure throughput loses 3 to 4 aircraft per hour.

Sending EWR south-gate departures on a right-turn path down the Hudson River reduces departure delay at EWR by 0.8 minutes per flight, if LGA departures are moved to non-conflicting airspace. This is less than the benefits of the circling metric because fewer flights are involved in the right turn. If LGA departures must be delayed to form a single stream with the EWR departures, departure throughput decreases by 1 to 2 per hour, with a resulting large increase in departure delay of more than 16 minutes per flight. Again, EWR departure throughput is not increased.

### **11.3.3 Distance**

In Option 1, the EWR departures to the south were allowed to turn right off runway 04R. This resulted in a reduction of distance flown by EWR flights to IWHITE by approximately 7 nm and to IWAVEY by approximately 9 nm.

In Option 2, the EWR departures to the south were allowed to turn right off runway 04R, and the LGA departures of runway 31 to the south were modified to fly east before turning south. This resulted in a reduction of distance flown by EWR flights to IWHITE by approximately 7 nm and to IWAVEY by approximately 9 nm. However, the distance flown by LGA departures to IWHITE increased by an average of 66 nautical miles and the distance flown by LGA departures to IWAVEY increased by an average of 51 nautical miles.

### **11.3.4 Net Benefit or Penalty**

The net effect of these increases and decreases in flying time is shown in Table 8. Positive numbers are penalties to users of the airspace; negative numbers are benefits. The delay metrics include time waiting for the departure runway plus pauses while waiting for proper separation behind a flight from another airport using the same departure track. Distance is a weighted average of the extra flying miles on each flow. Distance was converted to flying time by assuming an average speed of 300 knots for jet departures up to 20,000 ft.

**Table 8. Net Impact of EWR Right-Turn Possibilities**

|            | Metric                             | Circling          |                  |                   |                  | Hudson River      |                  |                   |                  |
|------------|------------------------------------|-------------------|------------------|-------------------|------------------|-------------------|------------------|-------------------|------------------|
|            |                                    | Delay LGA         |                  | Reroute LGA       |                  | Delay LGA         |                  | Reroute LGA       |                  |
|            |                                    | impact per flight | flights affected | impact per flight | flights affected | impact per flight | flights affected | impact per flight | flights affected |
| <b>EWR</b> | Departure Delay                    | 13.9              | 821              | -1.7              | 821              | 7.6               | 821              | -0.8              | 821              |
|            | Distance (n.mi.)                   | 9                 | 295              | 9                 | 295              | -7                | 101              | -7                | 101              |
| <b>LGA</b> | Departure Delay                    | 71.6              | 668              | 0                 | 668              | 16.8              | 668              | 0                 | 668              |
|            | Distance (n.mi.)                   | 0                 | 0                | 59                | 114              | 0                 | 0                | 59                | 114              |
| <b>Net</b> | extra minutes, 90th percentile day | +59772            |                  | +481              |                  | +17321            |                  | +547              |                  |

From the table it is obvious that merging the EWR and LGA flows into a single stream is not efficient. Rerouting LGA southbound departures is the only way to use that airspace for EWR traffic. Unfortunately, the only available airspace for LGA departures to use in that case adds so much distance to the flights that the net effect is a penalty to airspace users.

## 11.4 Conclusions

EWR runway 04R southbound departures were examined for EWR and LGA for the Integrated Airspace Alternative with ICC. When LGA is departing runway 31 and arriving runway 04, EWR departures turning right cannot gain sufficient altitude above LGA arrivals. When LGA is departing runway 04 and arriving runway 31, there are two possible ways to organize the airspace. Apart from user benefits or penalties, this fact increases the dependency between EWR and LGA operations, which increases coordination between the facilities and increases the complexity of the airspace. In situations like this where air traffic control is made more complex, only large user benefits would be worth an implementation.

Forming a single stream out of EWR and LGA departures is not an efficient operation. Because there is no room to maneuver the flights side to side, the single stream causes immediate backups onto the ground at airports where there is very little room to accommodate the delays without interfering with other operations. Routing LGA departures out of the stream and giving the airspace to EWR is efficient for EWR, but when LGA traffic is included, all cases show that extra flying mileage cancels out the delay benefits of the right turn at EWR.

## 12 An Analysis of Philadelphia International Airport Departure Headings off Runway 27L

### 12.1 Background

Current operations from Philadelphia International Airport (PHL), and those in the Future No Action Alternative, require traffic to depart Runway 27L on a heading of 255 degrees. When only one departure heading is available, flights going different directions must still be separated by three miles as they lift off. This limits efficient use of the departure runway. In the Integrated Airspace Alternative with Integrated Control Complex (ICC), planes departing runway 27L at Philadelphia International Airport (PHL) have a choice of six different runway headings including a river departure heading. The additional headings were proposed during the NY/NJ/PHL Metropolitan Area Airspace Redesign project to relieve congestion and delay at PHL. The departures off 27L and their respective headings are depicted in Figure 34.

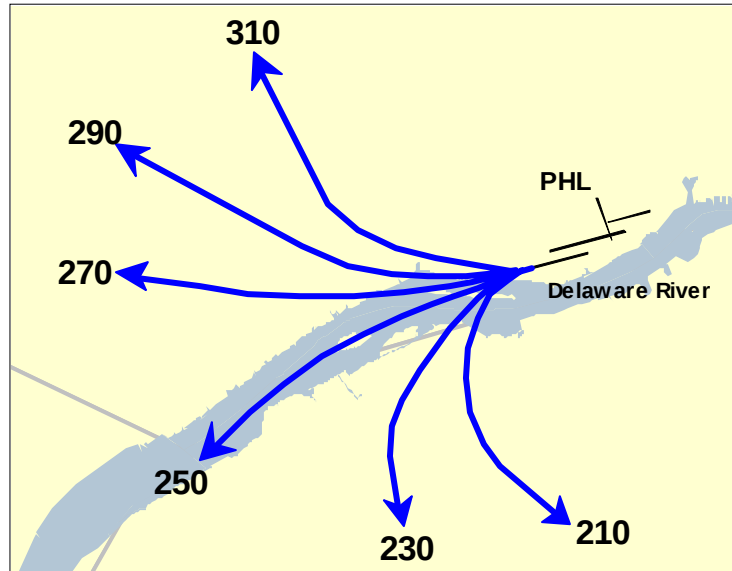


Figure 34. PHL Runway 27L Proposed Departure Headings

#### 12.1.1 Affected Area

The increased number of departure headings resulted in noise impacts to some residents of Pennsylvania living northwest of the airport, as well as for the residents of New Jersey living directly south of the airport<sup>8</sup>. An area of New Jersey to the southwest of the airport, beneath the current single heading saw a decrease in noise exposure. Several comments were received from these residents in response to the Draft EIS requesting noise relief from the proposed changes.

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<sup>8</sup> Draft Environmental Impact Statement, New York/New Jersey/Philadelphia Metropolitan Area Airspace Redesign, Figure 4.25.

### 12.1.2 Proposed Airspace Changes

Although additional headings will reduce delay, it may be possible to identify a subset of departure headings that would balance the need to acceptably reduce departure delay and the need to provide relief from the expected noise impacts.

## 12.2 Approach

The airport configuration in which PHL departs runway 27L was one of the scenarios operationally modeled during the NY/NJ/PHL Metropolitan Area Airspace Redesign project. Using the PHL simulation model of the Integrated Airspace Alternative with ICC, the proposed runway 27L headings were eliminated one at a time and the subsequent delays measured to evaluate the impact of reducing the number of available runway headings. From this, the number of runway headings required to maintain delay reduction could be ascertained.

Although when departing runway 27L departures are also allowed to use runway 35, this analysis only considers the reduction of headings for departures off of runway 27L. Arrivals were not affected by the departure heading changes and showed no difference in delay.

## 12.3 Results

Reducing the number of headings from six to five has no effect on the average delay. Reducing the headings to four increases the delay by little more than 4%. A further reduction to three headings reveals no change in average delay from the four heading case. It is not until the number of headings are reduced to only two headings that a considerable increase in average delay is observed, a 21.9% increase. The single heading case results in a 35.6% increase in average departure delay.

**Table 9. Average Departure Delay by Number of Departure Headings**

|                                              | <b>6<br/>Headings</b> | <b>5<br/>Headings</b> | <b>4<br/>Headings</b> | <b>3<br/>Headings</b> | <b>2<br/>Headings</b> | <b>1<br/>Headings</b> |
|----------------------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| <b>Average Delay<br/>per Aircraft</b>        | 16.23                 | 16.23                 | 16.91                 | 16.91                 | 19.78                 | 22.0                  |
| <b>Increase in Delay<br/>Over 6 Headings</b> |                       | 0%                    | 4.2%                  | 4.2%                  | 21.9%                 | 35.6%                 |

The departure delay increase when the number of headings is reduced is small until the headings are reduced beyond three headings, which can be attributed to careful assignment of departure flows to the remaining headings. Departure traffic is assigned a heading based on the ultimate direction the departure will travel. Under-used headings were the first to be consolidated as the number of headings was reduced. Consequently, there is little impact on delay when removing

those headings. If traffic volumes significantly increase on these underutilized headings, like the 210 heading, the results may change.

The following table shows the change in the total number of aircraft on each heading as the headings are reduced.

**Table 10. Number of Aircraft Assigned to Each Heading**

| <b>Headings</b>    | <b>All Headings</b> | <b>5 Headings</b> | <b>4 Headings</b> | <b>3 Headings</b> | <b>2 Headings</b> | <b>1 Heading</b> |
|--------------------|---------------------|-------------------|-------------------|-------------------|-------------------|------------------|
| <b>310</b>         | 152                 | 152               | 0                 | 0                 | 0                 | 0                |
| <b>290</b>         | 168                 | 168               | 320               | 320               | 320               | 0                |
| <b>270</b>         | 143                 | 143               | 143               | 154               | 390               | 0                |
| <b>250</b>         | 11                  | 11                | 11                | 236               | 0                 | 0                |
| <b>240 (River)</b> | 0                   | 0                 | 0                 | 0                 | 0                 | 710              |
| <b>230</b>         | 230                 | 236               | 236               | 0                 | 0                 | 0                |
| <b>210</b>         | 6                   | 0                 | 0                 | 0                 | 0                 | 0                |

## 12.4 Conclusions

It is possible to find a balance between the reduction of departure delay at PHL and the mitigation of noise impacts to the residents of communities surrounding the airport. Reducing the number of available departure headings at PHL from six headings to three headings would allow for some relief of the expected noise impacts while minimizing the loss of operational efficiency. The fourth heading may be maintained for use in peak departure periods should the balance of traffic shift.

At night, the expected departure demand is light enough to consolidate the flow into a single heading down the river. Flights could remain over the river long enough to gain sufficient altitude before turning over land to join their respective departure routes. This would provide additional relief from noise impacts to the residential areas.

## 13 An Analysis of Philadelphia International Airport Departure Headings off Runway 09L

### 13.1 Background

In the Integrated Airspace with Integrated Control Complex Plan, planes departing runway 09L at Philadelphia International Airport (KPHL) have a choice of seven different runway headings. The additional headings were proposed during the NY/NJ/PHL Metropolitan Area Airspace Redesign project to relieve congestion and delay at KPHL. The proposed departures from 09L and their respective headings are depicted in the Figure 35.

Although additional headings will reduce delay, there is a potential noise increase that often accompanies them. In this case, the noise exposure is area PIWB-11PHL-B in Figure 4.25 of the Draft EIS. If efficiency permits, reducing the use of the headings that are farthest from the current procedure may mitigate the noise impacts of the procedures in the preferred alternative.

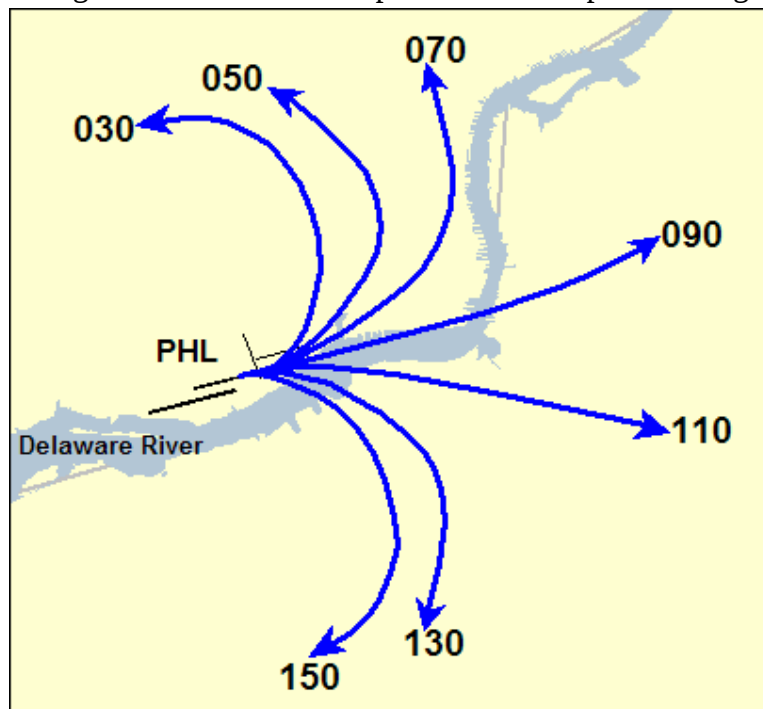


Figure 35. Departure Headings in the Preferred Alternative

### 13.2 Approach

Using the Integrated Airspace with Integrated Control Complex Alternative (ICC) PHL airport simulation model, headings were eliminated one at a time, traffic was reassigned among the headings, and the delays measured to capture the impact on users of each number. In the east flow configuration, departures are allowed to use runway 09L, 08 or 35. Reducing the headings was only analyzed for departures off of runway 09L. Runway 08 departures will have to be modified accordingly, but this will have no effect on large-aircraft departures off 09L. Runway 35 departures have their own headings that are tightly constrained by the main runways, so they were assumed the same in all cases. Arrivals are not affected by departure heading changes (as long as throughput is maintained) and showed no difference in delay.

### 13.3 Results

Efficiency is not necessarily reduced when the current seven headings are reduced to four because several southern headings are not as heavily traveled as the northern headings. If only 3 headings are allowed, delays increase by 4% and one additional minute per aircraft. When two headings are available, delay is further increased by less than two minutes per aircraft or an additional 9% over having three headings available. Table 11 shows the numbers of aircraft on each heading as the headings are reduced.

**Table 11. Use of PHL East Departure Headings**

| <b>Headings</b> | <b>All Headings</b> | <b>6 Headings</b> | <b>5 Headings</b> | <b>4 Headings</b> | <b>3 Headings</b> | <b>2 Heading</b> |
|-----------------|---------------------|-------------------|-------------------|-------------------|-------------------|------------------|
| 30              | 286                 | 286               | 286               | 286               | 286               | 441              |
| 50              | 19                  | 19                | 19                | 0                 | 0                 | 0                |
| 70              | 136                 | 136               | 136               | 155               | 155               | 0                |
| 90              | 3                   | 0                 | 0                 | 0                 | 0                 | 0                |
| 110             | 74                  | 77                | 0                 | 0                 | 0                 | 0                |
| 130             | 18                  | 18                | 95                | 95                | 0                 | 0                |
| 150             | 101                 | 101               | 101               | 196               | 196               | 196              |

If headings are assigned carefully, removing some of the headings off of 09L produces little change in average delay. Delay increases only start to appear after the seven headings have been reduced down to three headings. From four to three headings, the delay increase is at the limit of simulation sensitivity. These results can be seen in Table 12.

**Table 12. Delay Impacts of Reduced Headings at PHL**

|                            | <b>7 Headings</b> | <b>6 Headings</b> | <b>5 Headings</b> | <b>4 Headings</b> | <b>3 Headings</b> | <b>2 Headings</b> |
|----------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| Average Delay per Aircraft | 17.8              | 17.8              | 17.8              | 17.8              | 18.8              | 20.4              |
| Percent Increase in delay  |                   | 0%                | 0%                | 0%                | 5.6%              | 14.6%             |

### **13.4 Conclusion**

Assigning a separate departure heading off runway 09L at PHL produces the simplest airspace, but also the largest changes in noise exposure. Given the limitations of the runway configuration at PHL, seven separate headings are not necessary for user efficiency, so in the interest of mitigating noise exposure the headings in the preferred alternative can be reduced to four without noticeable effect, or three with minimal effect on users.

## 14 An Evaluation of the Use of Visual Approaches for Noise Mitigation at PHL

### 14.1 Background

Philadelphia International Airport has three published visual approaches. Two of them, the Liberty and River Visual Approaches, make use of the airspace over the Delaware River to reduce the amount of traffic over noise-sensitive areas. During the period for public comment on the Draft EIS, several correspondents suggested that the use of these approaches be expanded to mitigate increases in noise exposure in the areas beneath the current ILS approaches.

Figure 36 shows the ground tracks of the two approaches of interest. Visual approaches do not have precise ground tracks, since the pilot is navigating by landmarks. The paths indicated are a representation of the instructions in the approach plate, which are more or less followed by each aircraft.

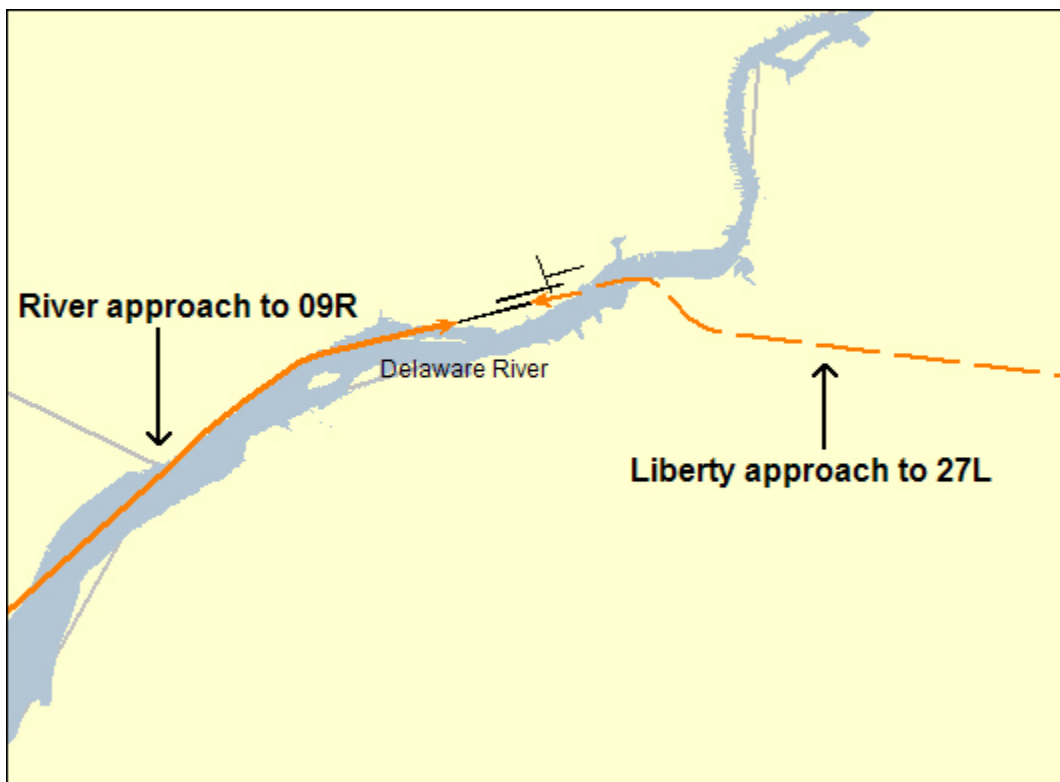


Figure 36. Ground Tracks of Two Visual Approaches to PHL

Visual approaches are usable only when the weather is good. The Liberty Visual requires the cloud cover to be more than 3000 ft above the ground, and visibility must be at least 3 miles. The River Visual requires cloud cover to be more than 4500 ft above the ground, and visibility must also be at least 3 miles.

## **14.2 Proposed Airspace Change**

An RNAV overlay of the existing visual approaches could be generated that would permit their use in inclement weather, and would minimize the uncertainty in the path of each individual aircraft. Adding predictability to the visual approaches would make them more usable during busy hours at the airport.

## **14.3 Constraining Factors**

The use of the River and Liberty visual approaches is not common in the current system, nor under the Future No Action alternative, for reasons of airport configuration, weather, and arrival efficiency.

### **14.3.1 Airport Configuration**

According to the FAA's Aviation System Performance Measures database, the most-common configuration for PHL in good weather was to use 27R, 26 and 35 for arrivals. This occurred approximately 80% of the time when the weather permitted visual approaches in 2005. Since runway 27L is not typically used for arrivals (only 11% of the time), use of the Liberty visual is not frequent. Its primary use was intended to be for dual arrivals to 27L and 27R, but runway 27L is sufficiently far from the terminals and gates that few airlines want to land there. The exception may be UPS, which has facilities on the south side of the airport. A UPS aircraft landing 27L would be much closer to its cargo facility than one that landed on 27R.

An RNAV overlay of the Liberty Visual approach exists, but it is not widely used. It is a special procedure, usable only by USAirways. Modern criteria, possibly including precision navigation, may make another overlay, using different design criteria, more widely available.

### **14.3.2 Weather**

PHL operated in the 09L and 09R configuration 19% of the year. When PHL is in instrument meteorological conditions (IMC), arrivals land on runway 9R 60% of the time. Since it is rare to operate in East configuration in good weather, use of the River Visual approach is not frequent.

### **14.3.3 Arrival Efficiency**

Use of a charted visual approach procedure is not recommended at times of high arrival demand at PHL. When controllers are working to land the most aircraft possible during an arrival bank, predictability is of primary importance. The position of aircraft on an ILS approach is highly predictable, so the smallest separation minima apply<sup>9</sup>. Between two aircraft established on an

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<sup>9</sup> FAA Order 7110.65P, *Air Traffic Control*, Section 5-5-5.g.3

ILS, when runway exits are visible from the tower (and several other criteria are met), the separation minimum is 2.5 nautical miles. Between two aircraft on any other approach, three nautical miles are needed. For an aircraft on a visual approach, given the variations in pilotage, several miles of buffer space are typically used by air traffic controllers to ensure that the three-mile minimum is protected. The result of all these constraints is that the River Visual approach is less efficient than other approaches to 09R.

#### 14.4 Operational Impact

Figure 37 shows the process of merging aircraft on the ILS with aircraft on a notional RNAV overlay of the River Visual approach. Arrivals from the southern fixes are cleared on the river approach. Arrivals from the north and west are vectored to the ILS because sending aircraft from the north down to the river would increase noise exposure, not decrease it.

The greater spacing on final approach that is needed when some traffic is not on the ILS will cause a decrease in throughput on 09R, the main runway for arrivals. Approximately 2 arrivals per hour are lost, which can cause large increases in delay during peak hours. At other times, or when 2.5-mile separations are not available, a River RNAV approach should be practical.

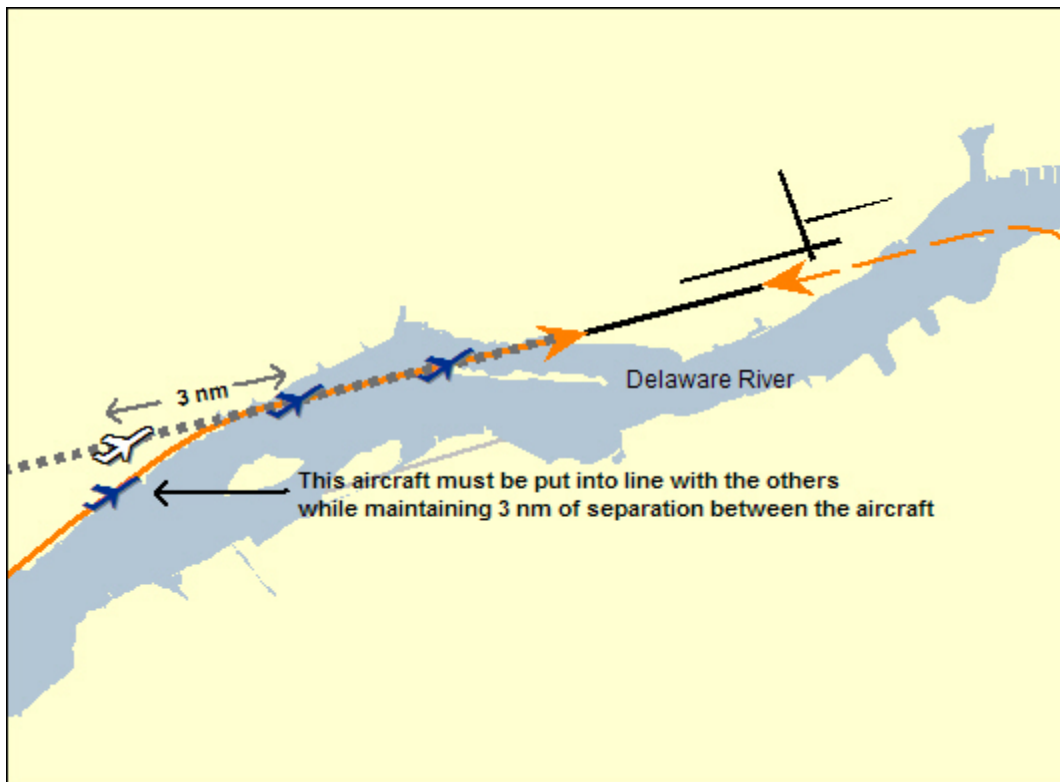


Figure 37. Spacing Arrivals on the River Approach

## **14.5 Conclusions**

There is no reason why RNAV versions of the River Visual and Liberty Visual approaches should not be made available to pilots and controllers. The use of these approaches will likely be limited, but it can provide some noise mitigation.

When arrival demand is high, the River RNAV approach can cause a two-arrival per hour loss in throughput. This may be too expensive for users and may increase complexity of the arrival operation beyond efficient levels. However, when the traffic has a large component of heavy or 757 aircraft, and 2.5 mile separations are not used on final approach, the penalty is minimal. Therefore, the use of the River RNAV approach should be optional for controllers.

A Liberty RNAV approach may be attractive to UPS, whose facility locations make use of 27L favorable. Many UPS operations take place at night; thus, if this RNAV approach can be used at night, when noise is particularly of concern, it will have maximum benefits.

## 15 Westchester County: An Assessment of Departure Flight Paths

### 15.1 Background

In current operations and the Future No Action Alternative, departures from Runway 34 at Westchester County use airspace that is not tightly constrained. The primary complexity concern is the frequency of LGA departures with which HPN traffic must share the airspace. In the Preferred Alternative, expanded final approach airspace is needed for EWR's dual arrival streams, so an airspace boundary to the south of HPN-34 departures becomes a factor for air traffic control.

Under conventional departure procedures, if the departure controller turns an aircraft towards the boundary, the controller must deliver a second turn instruction away from the boundary at exactly the right time. That time depends on winds and aircraft performance, so it is not exactly the same for any two flights. This means the controller must watch that particular aircraft closely, which adds to controller workload. The pilot is anticipating this instruction, but does not know exactly when it will come, which adds to pilot workload. An FMS/RNAV departure procedure, in effect, gives the second turn instruction in advance, so there is no additional workload associated with a turn towards a boundary.

### 15.2 Affected Area

The dispersal of the departure tracks from runway 34 at Westchester County Airport results in a borderline change in noise for a single point located in the yellow area of Figure 38. This area was not large enough to be given a catalog number in the Draft EIS.

### 15.3 Proposed Airspace Change

In the Preferred Alternative, the simplest departure path was chosen for HPN 34 departures. A path that runs parallel to the EWR airspace boundary, after the heading off the runway contained in current noise abatement guidelines, keeps aircraft clear of EWR airspace. However, this brings aircraft further north of where they fly today.

It may be possible to mitigate this noise change by developing an RNAV procedure for the departures. An RNAV procedure would focus the departures into a narrow band, eliminating the dispersal due to aircraft performance variations. As a result, it will be possible to guide aircraft on a path closer to the airspace boundary with less concern that unexpected events could lead to an operational deviation.

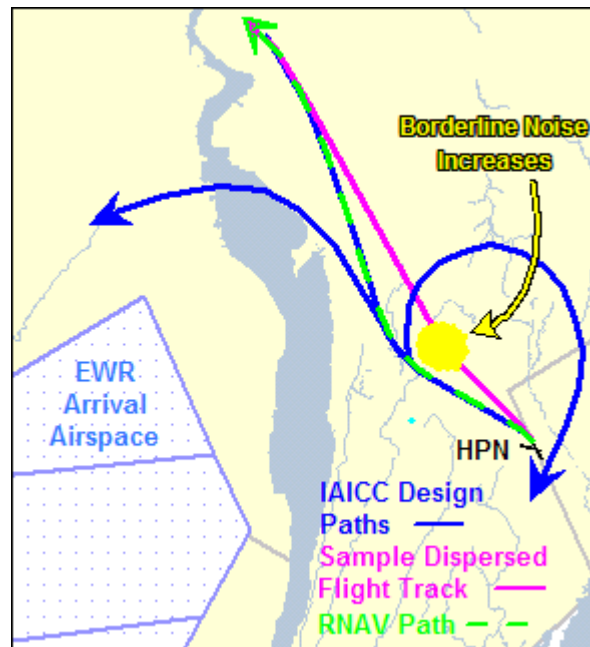


Figure 38. HPN Runway 34 Departures

## **15.4 Constraining Factors**

HPN departures must stay 1.5 miles away from the boundary with EWR arrival airspace until they are high enough to pass over the top. If this is not possible, then the departures must be coordinated with the EWR arrival controllers. HPN departures to the west gate must merge with LGA departures to the same fixes, and cross LGA departures to the north gate.

## **15.5 Conclusion**

The application of an RNAV departure procedure for westbound flights departing runway 34 at Westchester County Airport would ensure that flight tracks were focused and followed a predictable, predetermined path. Such a change would have no operational impact, since the extra mileage flown is negligible.

## **16 Continuous-Descent Arrivals**

### **16.1 Background**

Traditional airspace designs assign vertical paths to arrivals that are qualitatively different from the vertical paths assigned to departures. Departures are given uninterrupted climbs wherever possible. Arrivals, on the other hand, are instructed to descend in a series of steps and fly level segments between descents. In a system built upon ground-based navigation aids and manually-piloted aircraft, this arrangement has benefits for airspace users, air traffic control, and surrounding communities.

First, pilots benefit from simplified routing. Outside the terminal airspace, the same airway can be used for arrivals and departures because the arrivals are safely below the departures. Bi-directional airways simplify airspace charts and air traffic control instructions. Second, air traffic control is more efficient because crossing flows of traffic are most easily separated when at least one flow is level. With proper choice of level segments, arrivals are at one altitude, the crossing flow is at a safely-separate altitude, and only departures need the horizontal directions to stay clear of the crossing traffic flow. Finally, surrounding communities benefit because departures are noisier than arrivals. Expediting departure climbs removes the noisiest aircraft from the noise sensitive areas soonest. Arrivals are quieter than departures, so it is relatively less beneficial to keep them at higher altitudes.

#### **16.1.1 Effects of Modernization of the Air Traffic Management System**

The air traffic management system is changing. Satellite-based navigation is more common and newer aircraft are gaining the ability to control their positions in altitude and time as precisely as they can in the lateral dimensions. The preferred alternative airspace design takes advantage of these trends to change many of the conditions that constrained traditional airspace designs.

In high-density airspace like the New York/New Jersey/Philadelphia area, bi-directional airways are now rare. One-way airways can be more efficient for handling high volumes of traffic, so the bi-directional sharing argument no longer applies. In an air traffic control system where precision satellite-based navigation is the rule, dedicated airways will be more common, laterally separating arrival from departure traffic. The complexity of this airway system is manageable because of sophisticated flight management computers aboard the aircraft. When departure traffic is laterally separated from arrival traffic, altitude separation between arrival and departure routes in the en-route airspace is less-often necessary. Altitude separation between arrivals and crossing traffic is still important, but modern aircraft have improved navigation in the vertical dimension as well. When descending aircraft can reliably stay within predictable altitude bands at future positions, crossing traffic can frequently be cleared over the same waypoints at altitudes outside the band reserved for arrivals. Finally, future concepts for operation of the Next Generation Air Traffic System envision advance planning of traffic flows that make it less necessary for controllers to make last-minute maneuvers of arriving aircraft, so vertical and lateral positions of aircraft will be closely connected.

In recognition of this changing environment, researchers have developed the idea of the “Continuous Descent Approach” (CDA), which eliminates to a certain extent the need to force arriving aircraft to low altitudes early in their flights. Though they are still in the research stage, FAA has made it official policy<sup>10</sup> eventually to develop such arrival procedures. Prototypes have already been tested, notably at Louisville International Airport<sup>11</sup>.

### **16.1.2 Definition**

According to the consensus of a large group<sup>12</sup> of airlines, aircraft manufacturers, and air navigation service providers, “a Continuous Descent Approach is an unimpeded (and consequently low thrust engine powered) vertical descent profile from an appropriate intermediate altitude above the aerodrome elevation and within an appropriate distance from the landing runway threshold until the aircraft is configured for landing.”

When the appropriate intermediate altitude is close to the typical cruise altitudes of the traffic, the term “continuous descent arrival” is also used.

### **16.1.3 Benefit Mechanisms**

When new technology makes obsolete the traditional needs for level arrival segments, new types of benefits become possible.

A descending aircraft has its engines running at low power. In level flight, engine power is higher. If it is possible to remove level segments from an arrival procedure, the engines burn less fuel, which reduces the direct operating cost of the aircraft. When the engine power is lower, the noise produced by the engines is lower, which benefits the communities under the flight path. In many cases, removing level segments means the aircraft is higher above the ground in a continuous-descent approach than it would be in a conventional approach. This further reduces noise exposure of the areas below the approach path, if the approach path is held constant. Both types of noise benefit are limited to the phases of flight where the aircraft is low enough to be audible, but high enough that its altitude is not dictated by landing-system requirements. This means that the aircraft is below 14,000 ft and above 3,000 ft, which in this study will mean benefits to areas exposed to a DNL of less than 60 dB. CDA can therefore mitigate slight-to-moderate noise increases.

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<sup>10</sup> [http://www.tc.faa.gov/acf/FAA\\_Flight\\_Plan.pdf](http://www.tc.faa.gov/acf/FAA_Flight_Plan.pdf)

<sup>11</sup> J. P. Clarke et al., *Development, design, and flight test evaluation of a continuous descent approach procedure for nighttime operation at Louisville International Airport*, Partnership for Air Transportation Noise and Emissions Reduction, Report No. PARTNER-COE-2005-002, January 2006.

<sup>12</sup> International Air Transport Association, *One Sky ATM Implementation Roadmap—Short and Medium Term* v.2, October 2004.

Some previous studies of CDA<sup>13</sup> have included in their benefits analyses the benefits of the combined system of CDA and all its enabling technologies, most notable among which is some form of en-route metering for an arrival runway. En-route metering lets aircraft absorb necessary delays early in their flights, where speed control provides aircraft an inexpensive way to meet a required time over a specified fix. Traditional approaches rely on vectoring at low altitudes for spacing on final approach, which leads to higher direct operating costs for the same number of minutes of delay. The operational analysis of the alternative airspace designs in Appendix C already includes the benefits of en-route metering, since en-route metering can be implemented without CDA and it functions differently in the various alternatives. Therefore, those benefits will be excluded from the analysis here.

## **16.2 Affected Airspace**

Continuous-descent approaches can be used to mitigate noise impacts of the preferred alternative in the New York/New Jersey/Philadelphia area in two ways. First, where an arrival path has moved so its ground track is over a more noise-sensitive area, using a continuous descent profile can reduce the noise changes. This is the case around Newark Liberty International Airport, in the areas labeled PIWB-11EWR-D and PIWB-11EWR-E in Figure ES-5 of the EIS. Second, where arrivals and departures use the same airspace (at different times), noise due to changes to the departure pattern can be mitigated by reducing the contribution of arriving aircraft to the day-night average noise level. This is the case around Philadelphia International Airport, in the areas labeled PIWB-11PHL-A and PIWB-11PHL-B in Figure 4-25 of the EIS.

## **16.3 Constraining Factors**

The practical application of CDA will be limited by several factors: the presence of crossing traffic; the presence of traffic in trail that is subject to different speed requirements; the ability of aircraft to comply with the instructions; and the uncertainty of operations that may require aircraft to deviate from their ideal approach profile.

### **16.3.1 Crossing Traffic**

It is most efficient to separate crossing flows of traffic by altitude. Where flows must be crossed, the altitude flexibility that makes CDA effective can be restricted, so CDA applications may be limited. Crossing flows of concern are different in the different altitude strata. Below 14,000 ft, departure flows from the destination airport and arrival and departure flows from satellite airports are most likely to cross the approach. Above 14,000 ft, the primary concern is overflight traffic to other, unrelated airports.

There are three distinct areas to consider. Low altitude crossing traffic at EWR, low altitude crossing traffic at PHL, and en-route crossing traffic for the whole study area.

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<sup>13</sup> J.P. Clarke, *et al.*, *op. cit.*

#### **16.3.1.1 Low Altitude: EWR**

When aircraft are approaching from the northwest and landing southwest, or approaching from the southwest and landing northeast, the only crossing flows are arrivals and departures at satellite airports and tower en-route control flights, which are also typically going to smaller satellite airports. This traffic is unpredictable, but is very sparse at night. Continuous descents to EWR are possible from the arrival fix to the runway when satellite traffic is not present. The ideal altitude for a continuously-descending aircraft at these downwind fixes is only a few thousand feet above the arrival fix altitude, so the loss of flexibility for the controllers is minimal.

When traffic are approaching from the northwest to land northeast, or approaching from the southwest to land southwest, the aircraft must fly long downwind segments to a base leg and then final approach. Conflicting traffic for these flights is primarily westbound departures from EWR, TEB and satellite airports<sup>14</sup>.

#### **16.3.1.2 Low Altitude: PHL**

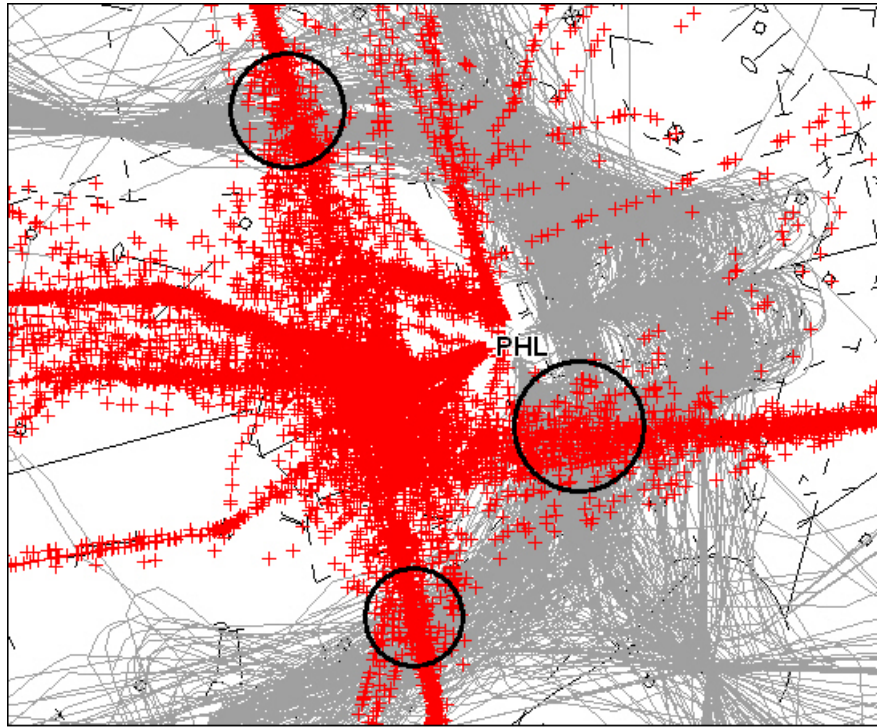
Many conventional approaches to Philadelphia involve two or more extra turns before the downwind and base legs. Philadelphia approach control airspace is wedged between New York TRACON to the northeast and Potomac TRACON to the southwest, so arrival and departure operations must share a limited space. Overflight traffic on Victor airways creates additional complexity. Aircraft descend rapidly, with level segments at 4,000, 6,000, or 7,000 ft.

The reasons for the level segments are visible in Figure 39, which shows radar tracks<sup>15</sup> for PHL arrival and departure traffic. Arrival tracks are shown with grey lines, departure radar returns are shown with red crosses. The airport is in west configuration, with arrivals to runways 27R, 26, and 35. Departures are using runways 27L and 35. The three most important crossing situations for Runway 27 arrivals are marked with black circles.

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<sup>14</sup> The airspace geometry is described in detail in Sections 10 and 11 of this document, especially Figure 27.

<sup>15</sup> PHL Tracon ARTS data for August 18, 2006. These data are valid for comparison with CDA in the preferred alternative because the lateral displacements of departures proposed in the redesign imply changes in altitude at crossing points that are within the range of variability of current climb performance.

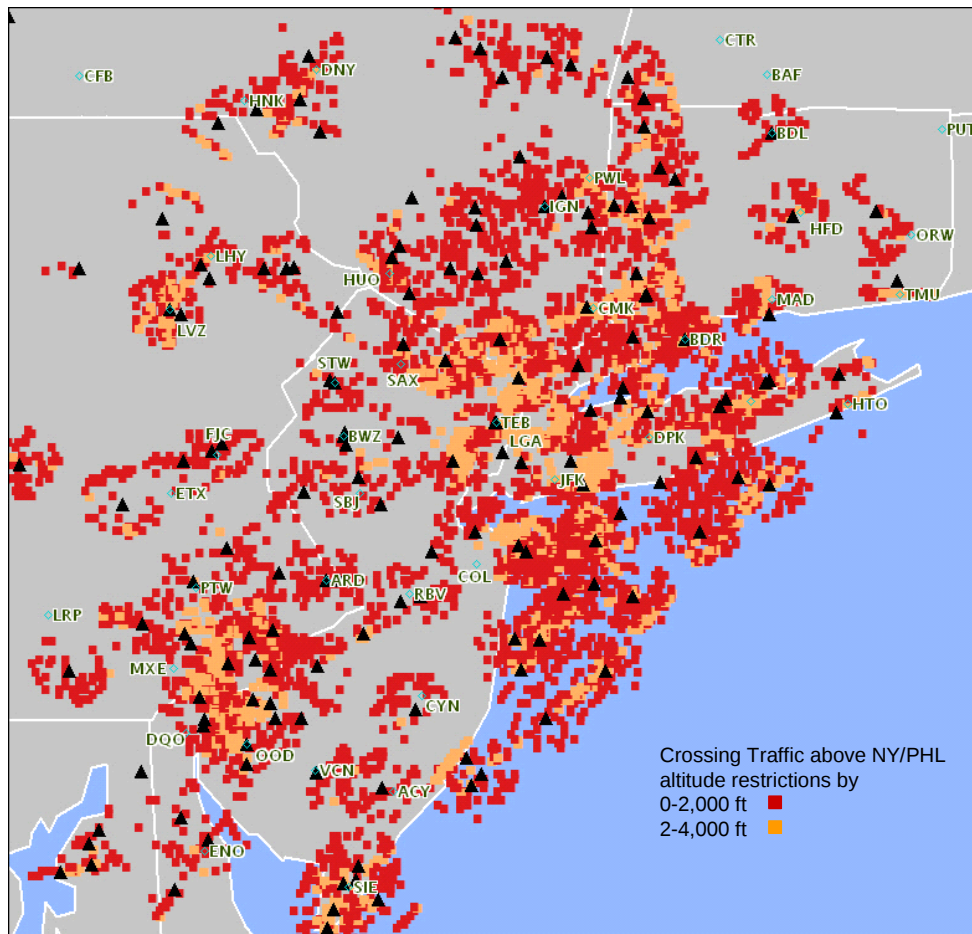


**Figure 39. Crossing Points of PHL Arrivals and Departures**

### **16.3.1.3 En-Route Altitudes**

Arrivals to New York and Philadelphia begin to step down from their cruise altitude as far as 200 nm from their destinations in both the Future No Action and preferred Alternatives. In situations where the low altitude airspace permits continuous-descent approaches, the en-route traffic flows determine whether the approach can be extended upward and outward to create a continuous-descent arrival.

Figure 40 shows that the airspace in the study area is tightly constrained. Each point where an arrival altitude restriction was used in the Integrated Airspace Alternative with ICC is marked with a black triangle. Traffic in the vicinity (except arrivals to modeled airports and low-altitude flights beneath them) is compared to the altitude restriction.



**Figure 40. Use of Airspace above Altitude Restrictions**

Where the 25<sup>th</sup> percentile of the crossing traffic altitudes is less than 2000 ft above the altitude restriction, the point is marked red. If there is a gap of 2000 to 4000 ft between the restriction and the 25<sup>th</sup> percentile of crossing altitudes, the point is colored orange. If the crossing traffic is more than 4000 ft above the arrivals, the point is not marked.

Opportunities for raising restriction altitudes would be seen as black triangles without nearby red points. These are almost nonexistent in the chart. Where altitudes are not tightly constrained from above, such as southwest of DQO or west of LVZ, there are other places closer to the destination airport where crossing traffic requires the altitude restriction in the preferred alternative. To lift one altitude restriction while leaving restrictions before and after that point on the flight's path would not facilitate creation of a CDA.

### **16.3.2 Collinear Traffic**

Most airways are used by flights to many different destinations. An en-route controller separates aircraft “in trail” along the airways, matching speeds between flights at the same altitude to create orderly flows of traffic. Once a flow has been set up, the aircraft will maintain proper separation because their speeds are the same. En-route controllers are frequently called upon to put extra spacing between two arrivals to the same airport for flow management purposes; they accomplish this by putting the appropriate number of aircraft bound for other airports (if such flights are in the sector) between two flow-managed aircraft. Since the operating conditions at the different destinations are unrelated to each other, it is common for several different spacing requirements to be in force at any given moment. For example, the controller may need to space PHL arrivals 20 miles apart while EWR arrivals must be 10 miles apart and TEB arrivals can flow freely. This is a highly complex situation. More than one controller shares the responsibility for spacing in situations like this.

In the current system, where arrivals step down early, the different destinations can be stratified by altitude. That is, flights bound for the closest airport are put at the lowest altitude stratum; flights bound for the furthest airport are kept highest, and so forth. When the traffic is arranged this way, the airspace can be split into air traffic control sectors by altitude. The controller of the low-altitude sector has responsibility for spacing aircraft to the closest destination; the traffic to other airports is handled by other controllers in higher sectors.

When aircraft are cleared on CDA at cruise altitudes, the controller’s job becomes more complex in three ways. First, the necessary spacings between aircraft are more complicated. Wake turbulence separation on final approach is not typically a problem for en-route controllers in today’s system because the spacing can be increased in approach control airspace if necessary. Aircraft on CDA are not to be maneuvered by approach controllers, so spacings that protect wake turbulence separation must be applied in the en-route airspace. Second, altitude stratification is no longer possible after the CDA begins. Third, aircraft speeds are no longer at the controller’s discretion. Instead of matching the speeds of the aircraft in front and behind, the aircraft speed is set for efficient descent. (Note that a bare-bones CDA doesn’t have the time-at-the-runway part of the SDF concept.)

A single controller is now responsible for making a single, well-separated flow out of aircraft which may have high speeds to compress spacing to one airport, mixed with others that need low speeds for delay absorption at another airport. Before CDA can be used to more than one airport, it must be proven that this situation is never severe enough to present the en-route controller with an insolvable problem.

#### **16.3.2.1 From the South**

Flights from Atlanta, Charlotte, Tampa, New Orleans, Houston, and points in between use an airway called J51 as they fly across Virginia on their way to Washington Dulles, Baltimore, Philadelphia, Newark, Teterboro, and their respective satellites. This airway serves the same purpose in the preferred alternative.

### 16.3.2.2 From the West

PHL arrivals along J152 from the west share that airway with a few dozen flights per day (2006 traffic) to Harrisburg, Allentown, and PHL satellites. Flights to Harrisburg and Allentown are restricted to lower cruising altitudes, so they will not interfere with CDA aircraft. Flights to the satellite airports can be matched in speed with the closest CDA arrival to PHL. This is not an important difference from the operation without CDA. There is no reason that this traffic will interfere with CDA efficiency.

All the major airports around New York City have dedicated arrival airways on the west side, so there is no interfering traffic that might limit applicability of CDA.

## 16.4 Modeling

### 16.4.1 CDA Development

Candidate CDA were developed for five approaches into EWR and PHL, for an assortment of narrowbody and widebody transport aircraft<sup>16</sup>. There were two stages of development. First, a continuous-descent arrival was created and altitudes of contention with other major flows were identified. Second, a continuous-descent approach was developed that began at the arrival fix, beneath constraining flows. Arrival fix altitudes obtained from this process are shown in Table 13.

**Table 13. Restricted and Unrestricted Altitudes at Arrival Fixes (1000 ft)**

|                   | EWR   |     |       |     | PHL  |     |           |     |           |     |
|-------------------|-------|-----|-------|-----|------|-----|-----------|-----|-----------|-----|
|                   | South |     | North |     | West |     | Northwest |     | Southwest |     |
|                   | 04R   | 22L | 04R   | 22L | 27R  | 09R | 27R       | 09R | 27R       | 09R |
| <b>CDA</b>        | 13    | 28  | 21    | 18  | 14   | 14  | 15        | 12  | 16        | 10  |
| <b>Restricted</b> | 8     | 8   | 11    | 11  | 8    | 8   | 10        | 10  | 11        | 11  |

### 16.4.2 Operational Modeling

An estimate of the efficiency of CDA was obtained from a TAAM model that assumed all conflicting flows could be moved away from the CDA. Aircraft on CDA are assumed to be the last ones to be vectored for spacing. If possible, aircraft on all other approaches to the airport are

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<sup>16</sup> John-Paul Clarke, Liling Ren, James Brooks, Gaurav Nagle, and Evan McClain, *Analysis of Continuous Descent Arrivals for Newark and Philadelphia Airports*, Ga. Tech. Air Transportation Laboratory Report 2007-01, February 2007.

maneuvered first. Aircraft were spaced at the beginning of the CDA according to the results of a Monte Carlo simulation<sup>17</sup> that calculated the necessary time between successive arrivals on the CDA to make it 90 percent likely that the aircraft would have more than the minimum separation on final approach.

The approach paths for CDA aircraft included no maneuvering areas. When this is the case, TAAM absorbs delay either by speed control (which absorbs only a small amount of delay over these short distances) or by holding. Any need for holding on the CDA was removed by increased spacing over the other arrival fixes. Since spacing over the arrival fixes is increased, arrival throughput may be lower and delays may be higher. The magnitude of these efficiency losses gives a measure of the applicability of CDA during high-traffic periods.

## **16.5 Results**

### **16.5.1 Top of CDA: EWR**

Table 13 shows two very different possibilities for CDA at EWR. When the arrival fix is on the same side of the airport as the final approach, such as 04R from the south or 22L from the north, the CDA altitude at the fix is not too far from the restricted altitude.

Continuous descents are not generally possible for these flights because their preferred altitude at the fix is over 20,000 ft, which puts them at the same altitude as all but the fastest-climbing departures, traveling in the opposite direction. If the CDA begins at the specified arrival altitude, it must begin with a long level segment, which is approximately what will result from raising the downwind leg, as described in Section 10.

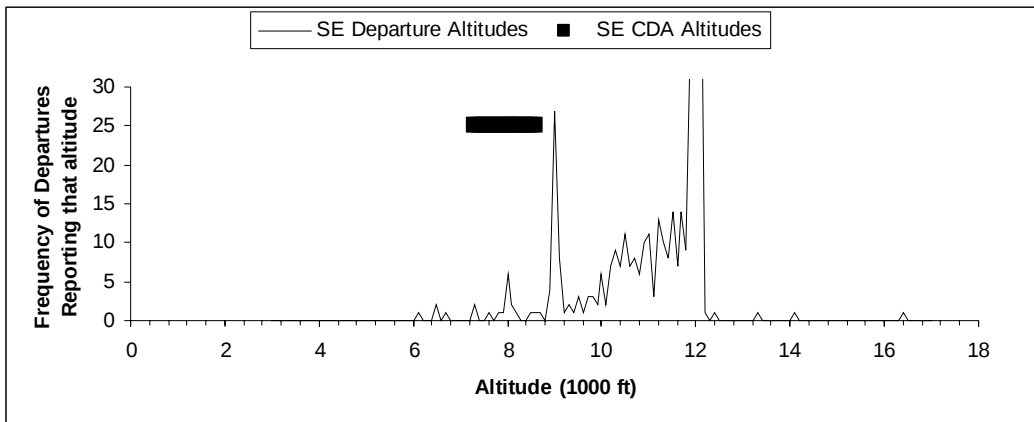
### **16.5.2 Top of CDA: PHL**

The feasibility of continuous-descent approaches in the presence of departures can be assessed by comparing estimates of the continuous-descent preferred altitudes for an with the observed altitudes of departures at each crossing point. The results are shown in Figures 41 through 43. In each figure, the departure altitudes are plotted in 100-foot bins. Arrival altitudes, which are much more consistent from flight to flight, are shown with black bars.

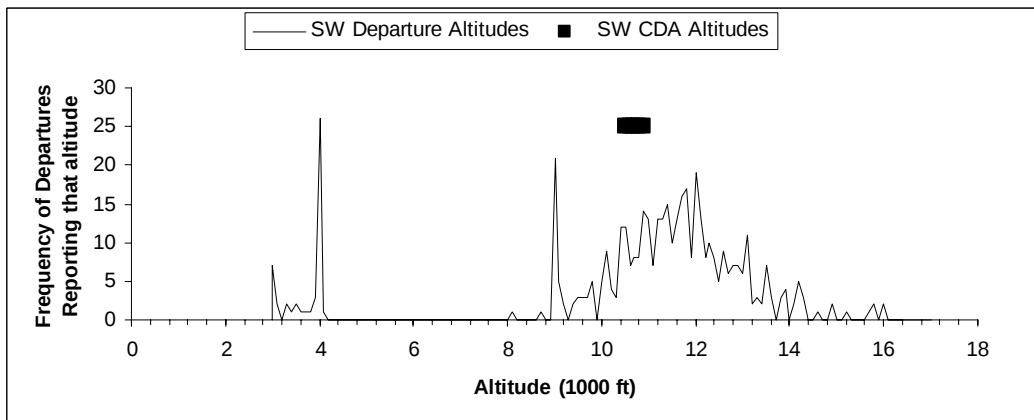
Southeast of the airport, Figure 41 shows the departures have had time to climb and the arrivals are nearing the final approach, so there is little chance of conflict between the CDA approach and any other traffic. Southwest of the airport, Figure 42 shows a wider range of departure altitudes, with preferred arrival altitudes near the middle of the range. Northwest of the airport, Figure 43 shows an unworkable situation. Not only are arrival altitudes in the middle of the altitude range, but there is a level flight segment for some departures that is in conflict with the CDA altitudes at 13,000 ft.

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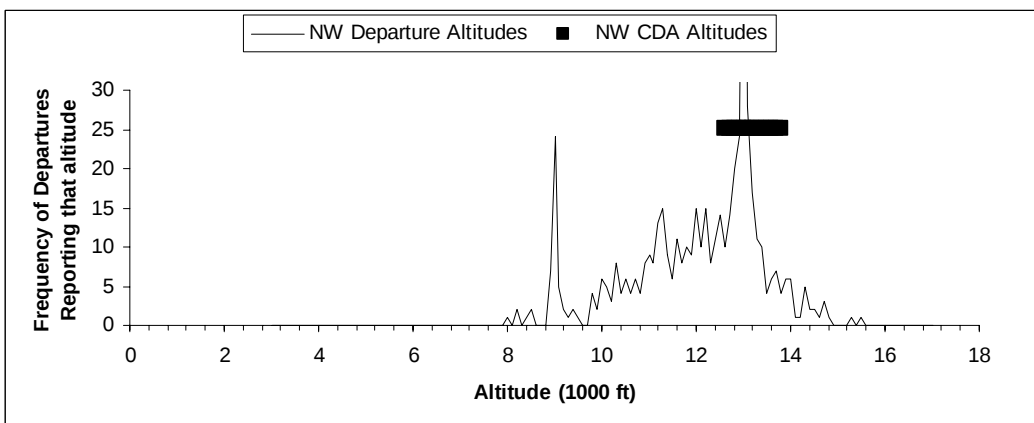
<sup>17</sup> *ibid.*



**Figure 41. Altitudes at the Southeastern Crossing Point**



**Figure 42. Altitudes at the Southwestern Crossing Point**



**Figure 43. Altitudes at the Northwestern Crossing Point**

### 16.5.3 Throughput and Delay

Throughput and delay metrics at PHL are very different in the two configurations studied. In east configuration, runway 09R is independent of all other operations, so a momentary slowdown due to maneuvering around a continuous-descent aircraft has only momentary impact. Throughput returns to normal within 15 minutes in all cases on the annual-average 2011 day. The delay increases due to CDA on the north and west sides are sensitive to the order in which CDA and conventional approaches appear in the arrival sequence. On average, the efficiency penalty is 88 minutes per day, or about 0.12 minutes per arrival.

In the west configuration at PHL, the situation primary departure runway, 27R, crosses runway 17/35 (Figure 44). To synchronize the various aircraft passing through the runway crossing point, in conventional operations, final vector controllers work closely with the tower, maneuvering both arriving aircraft and timing the clearance of the departing aircraft. In a CDA operation, final vector controllers do not maneuver the arrival to 27R. The loss of a maneuver option increases the delays on 27R, the same as to 09R, but also increases the delays of runway 35 arrivals that undergo larger maneuvers than they would in a conventional operation. Departures from 35, depending on the exact timing of the different operations, can be either delayed or expedited. Averaged over 15 different sets of aircraft departure times, arrival delay increases by 0.8 minutes per flight and departure delay is unpredictably affected ( $0.01 \pm 8$  minutes per flight).

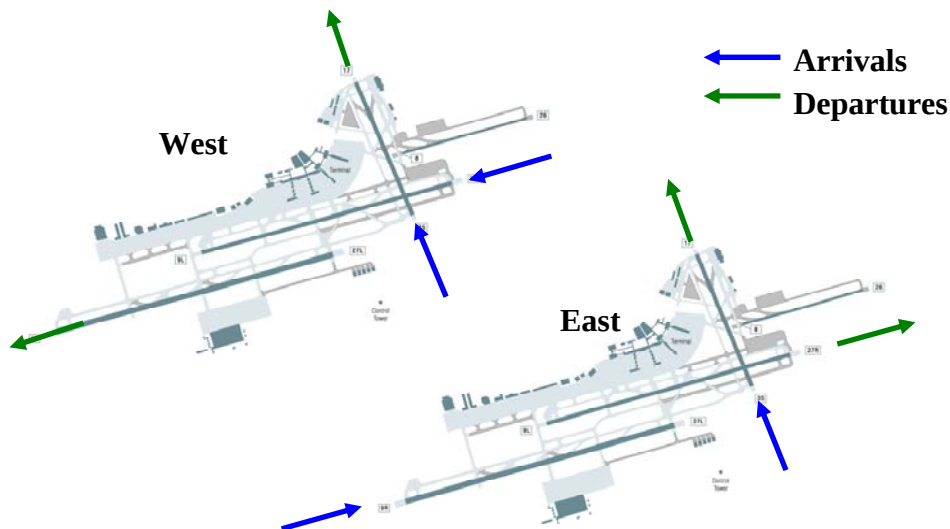
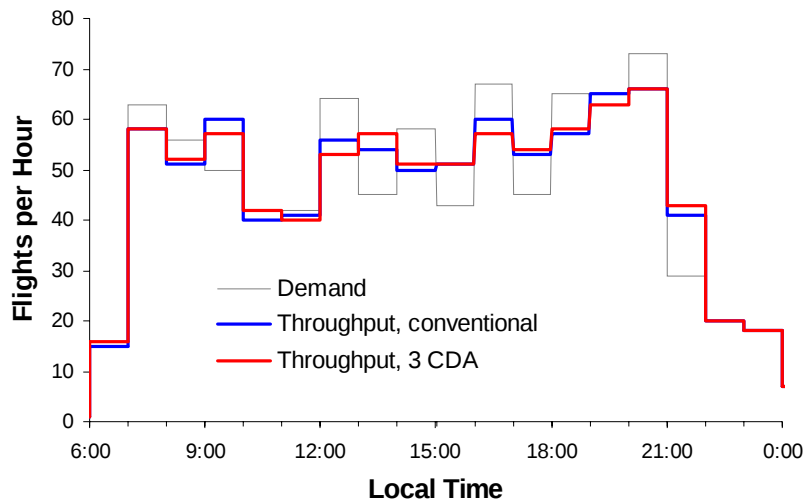


Figure 44. Runway Configurations Simulated

When the flow from a single fix to 09R or 27R is replaced with a CDA at PHL, there is almost no effect on throughput. There is always an aircraft from another fix that can be maneuvered into the gaps, so when a slot is missed, within 15 minutes the airport throughput has returned to its conventional value. When all three fixes analyzed (Figure 46 below) are CDA, throughput can be adversely affected and delay changes are greater. Figure 45 shows the hourly throughput in each case. A shortfall of at least 3 arrivals can be seen in each peak arrival-demand hour. The airport throughput with three CDA does not recover until 30-60 minutes after the conventional-approach peak. Delay increases by 1.0 minute per arrival, and 0.2 minutes per departure.



**Figure 45. PHL Arrival Throughput (West Configuration)**

The overflow runway 11/29 at EWR presents a less complex situation for air traffic control than runway 17/35 at PHL because it crosses nearer the end of the main runway. Therefore the loss of maneuver capability for CDA aircraft has a smaller impact on efficiency at EWR than at PHL. In addition, there is only one fix from which CDA is possible, so the delay impacts at EWR are much smaller. What impact is seen, is due to the expanded spacing at the arrival fix necessary to protect two consecutive CDA aircraft from overtaking. The resulting delay increases are very small.

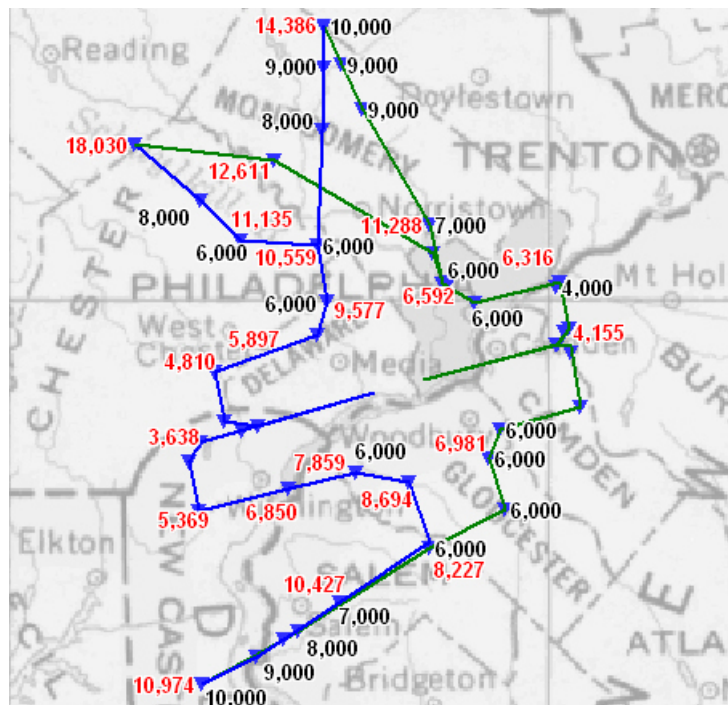
## 16.6 Conclusion

Continuous-descent approaches are one of the few things that can actually reduce aircraft noise. The other strategies for mitigating noise exposure presented in previous chapters of this document simply move the noise to another place. In some cases, there are fewer people living in the other place, so noise exposure is reduced, but if the length of the flight track is increased, the total amount of noise generated increases. Since continuous-descent approaches do not penalize any

other area, it is natural to attempt to implement them everywhere, and use conventional, stepped arrivals only if some safety or efficiency constraint requires them.

Unfortunately, safety and efficiency constraints are still common, even in an RNAV-based airspace design like the preferred alternative. The most important constraint is the need to avoid departures. The wheels-off time for a departing aircraft is notoriously unpredictable, so timing to avoid departures is not possible. When the arrival fix is on the opposite side of the airport from the final approach, CDA can only be used when there are no departures. Even at a hub-and-spoke airport like PHL, those times happen only at night. En route airspace above the arrival fixes to New York and Philadelphia is being used for other flows with unrelated schedules, so even at night a continuous-descent approach from the arrival fix is the only kind that can be universally applied. (Pilot's discretion descents from cruise altitude are possible on a case-by-case basis, but these are done today, so they do not count as a benefit of CDA.) Since en-route restrictions preclude continuous-descent arrivals, collinear traffic on jet airways does not cause additional complexity.

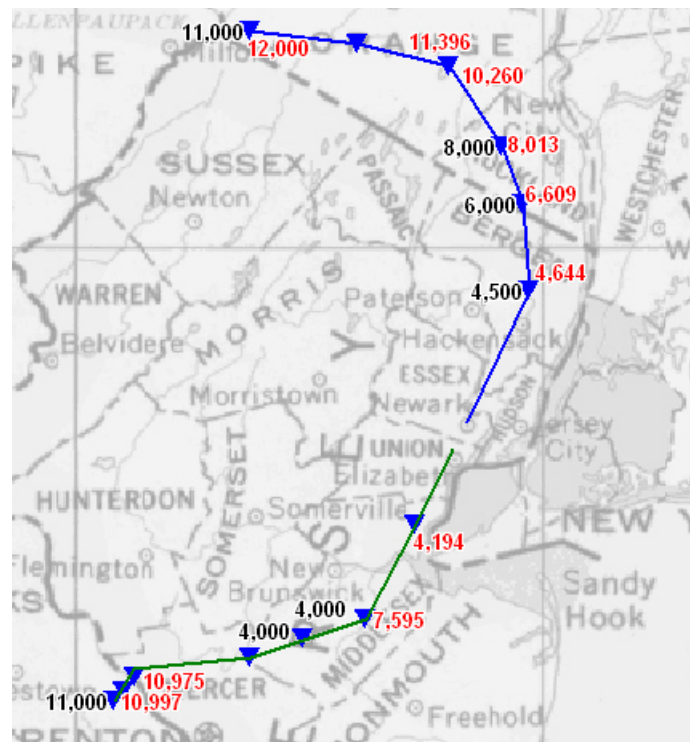
The approaches for which CDA are practical and effective for nighttime noise mitigation at PHL are shown in Figure 46. The altitudes of the CDA are shown in red; the altitudes of the conventional approaches they replace are shown in black.



**Figure 46. Practical CDA for Noise Mitigation at PHL**

The PHL simulation showed that efficiency can be adversely affected, if more than one fix has a CDA approach. This section has shown the results of a hypothetical application of CDA in high-traffic times. The costs in throughput and delay are large for an airspace change. It should be noted that this analysis was of the best possible conditions for CDA. No unexpected events were included in the simulation. When uncertainty is taken into account, either the costs of losing maneuver capability are much greater. More likely, aircraft will be instructed to abandon the CDA procedure by air traffic control.

The crossing traffic constraints on EWR are so restrictive that the CDA that are practical have little effect on efficiency. Figure 47 shows the usable CDA, with the continuous-descent and conventional altitudes shown in red and black, respectively.



**Figure 47. Practical CDA for Noise Mitigation at EWR**

## 17 Interpreting Average Delay

### 17.1 Background

Several comments on the Draft EIS received from the public object to the Preferred Alternative on the grounds that the changes in aircraft routing will cause changes to noise exposure while saving airspace users only a few minutes per flight of delay. To those who study transportation systems at large scales, a few minutes per flight is an important change in operations. The use of the word “only” in this context indicates a need for explanation of system-scale performance metrics in terms of their impact on individual parts of the system, which will be more widely understood.

The benefits of airspace design look very different from the benefits of an airport expansion, to pick one common source of aviation-related environmental impact statements. An airport expansion adds capacity to the system, so benefits are typically quoted in terms of increased traffic and increased economic activity. Under the assumption of static traffic input, runway projects can show tens of minutes per flight of delay reduction. An airspace redesign, by contrast, does not usually add capacity<sup>18</sup>, so static traffic inputs are a valid assumption, and average-delay benefits of individual minutes are typical.

### 17.2 Benefits of Large-Scale Improvements to Aviation

The New York/New Jersey/Philadelphia area, as is obvious from its name, is composed of several parts. An FAA official charged with making decisions about this airspace needs a common denominator for all measures of performance, not just a metric for one part. It is insufficient to know, for example, how a change will affect Philadelphia when another competing change will affect New Jersey, and the better must be chosen. To identify which change is most efficient for the whole system, the whole system must be included in the efficiency measures. A consequence of this is that efficiency measures, which typically are averages, include many unaffected flights. This is not the case for local changes, such as an airport improvement.

Small changes to large numbers of flights are common in analyses of the air traffic control system. The same magnitude of benefits is found in studies of technological advances such as: decision support tools, which help air traffic controllers resolve conflicts; satellite-based direct routing, which reduces the longer flight paths needed for routing via ground-based navigation aids; and traffic flow management enhancements, which organize traffic more efficiently through excess-demand events. One example of the last category, called the Final Approach Spacing Tool, was reported<sup>19</sup> to have “huge” benefits for the aviation system, referring to an arrival improvement of two minutes per flight.

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<sup>18</sup> Except when the airspace is redesigned in conjunction with the opening of a new runway or airport.

<sup>19</sup> National Aeronautics and Space Administration, “Flight Software to Yield Huge Savings”, *Aerospace Technology Innovation* 6 No. 6, <http://ipp.nasa.gov/innovation/Innovation66/flight.htm>

This wide variety of improvements to the air traffic control system share a feature with airspace redesigns. Though the average delay changes are not high, the large number of flights involved small changes in the average important. There are over 7,000 flights using the New York/New Jersey/Philadelphia airspace in the forecast for the 90<sup>th</sup> percentile day of 2011.

The largest-scale studies of this sort are nationwide benefits analyses used in macroeconomic analysis. FAA management uses tools like the NAS Strategy Simulator, which deals in small changes per flight nationwide, to estimate<sup>20</sup> changes in capital improvement fund receipts. Another very large-scale example is the nationwide study conducted<sup>21</sup> by Logistics Management Institute in 1999. They found that air traffic congestion nationwide could cost 46 billion dollars to the nation's economy because of increased travel time. The nationwide change in travel time that was anticipated for 2010, converted to its equivalent in terms of the metrics used for this study, is approximately 3 minutes per flight. This includes costs to airlines, loss of service to people who wish to travel, and over 200,000 lost jobs in aviation and other industries. Forecasts of nationwide traffic in 2011 indicate that the New York/New Jersey/Philadelphia airspace will handle 15-20% of all the air traffic in the nation, so this airspace redesign is concerned with removing inefficiencies that could yield benefits of 7 to 9 billion dollars to airlines, passengers, and businesses in 2011. This is a crude estimate; congestion on the east coast is worse than average in the United States, so benefits to aviation in this area will likely be worth *more* than average as well.

Airlines are equally aware of the importance of a few minutes per flight. Airline scheduling practices are affected by small changes in time. A 1994 study showed<sup>22</sup> that an increase of 1% in the ratio of block time (gate-to-gate) to airborne time cost the largest airlines 150 million dollars per year. That 1% increase, in these metrics, is equivalent to 69 seconds.

### 17.3 Delays on Affected Flows

To get a better idea of the operating conditions described by a two-to-three minute increase in average delay, several examples from Newark Liberty International Airport are helpful. As reported in Appendix C of the Draft EIS, EWR departure delays in the Integrated Airspace Alternative with ICC, on the 90<sup>th</sup> percentile day of 2011, are five minutes per flight less than in the Future No Action Alternative. This performance improvement is primarily due to dispersal

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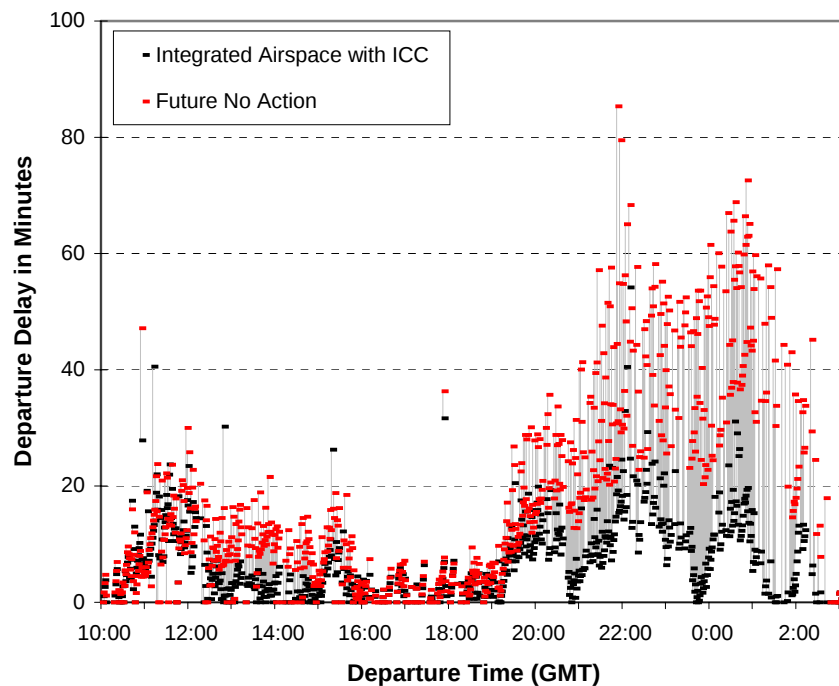
<sup>20</sup> Federal Aviation Administration, *Annual Performance Report 2004*, [http://www.faa.gov/library/reports/media/APR\\_year1.pdf](http://www.faa.gov/library/reports/media/APR_year1.pdf)

<sup>21</sup> Kostiuk, P., E Gaier, and D. Long, "The Economic Impacts of Air Traffic Congestion", *Air Traffic Control Quarterly* 7 pp.123-145, 1999.

<sup>22</sup> Quoted in Peterson, G. and J.Strahler, "Airline Scheduling" in *The Handbook of Airline Economics*, Darryl Jenkins, ed., Aviation Week Group, 1995.

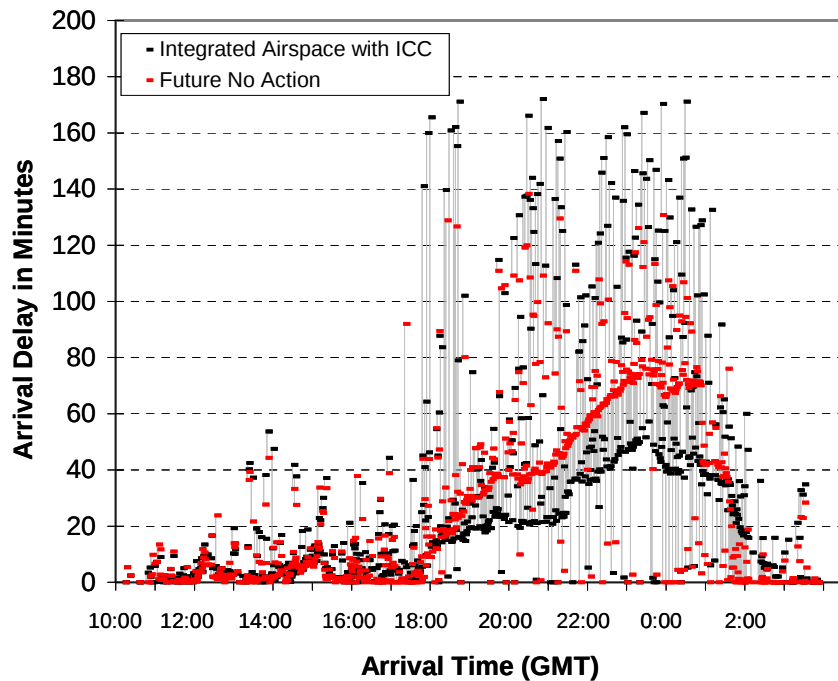
headings in the higher-capacity, southwest configuration and arrivals to both parallel runways during the evening arrival rush in both southwest and northeast configurations.

Figure 48 shows what that means to individual departing flights in the southwest runway configuration. Each flight is plotted as a horizontal dash at its Future No Action delay, another at its delay in the preferred alternative, and a vertical line connecting them. The difference in the average delay can be seen here as delays of 10 to 15 minutes more during the morning departure rush, a return to normal in the midday hours when departure demand is lower, and then a huge accumulation of delay in the afternoon and evening hours when arrivals and departures compete for runways. The majority of departures in the evening are 20-40 minutes later in the Future No Action simulation. The worst delay, over 80 minutes in the Future No Action simulation, is improved by more than half in the Preferred Alternative.



**Figure 48. Newark Departure Delays in the Preferred and Future No Action Alternatives**

The impact on arrivals is similar, but the effect is embedded in a more-complex situation. Figure 49 shows the same sort of chart for arrivals at EWR. Although the extremely-delayed flights still face extreme delays, most of the flights from the afternoon to the evening see 20-30 minute improvements in their arrival delay. When we consider that airlines at EWR typically plan for 45-60 minutes of time at the gate to get the aircraft loaded for its next flight, it is easy to see how 20-30 minutes of extra delay quickly become costly to everyone.



**Figure 49. Arrival Delays at EWR in the Preferred and Future No Action Alternatives**

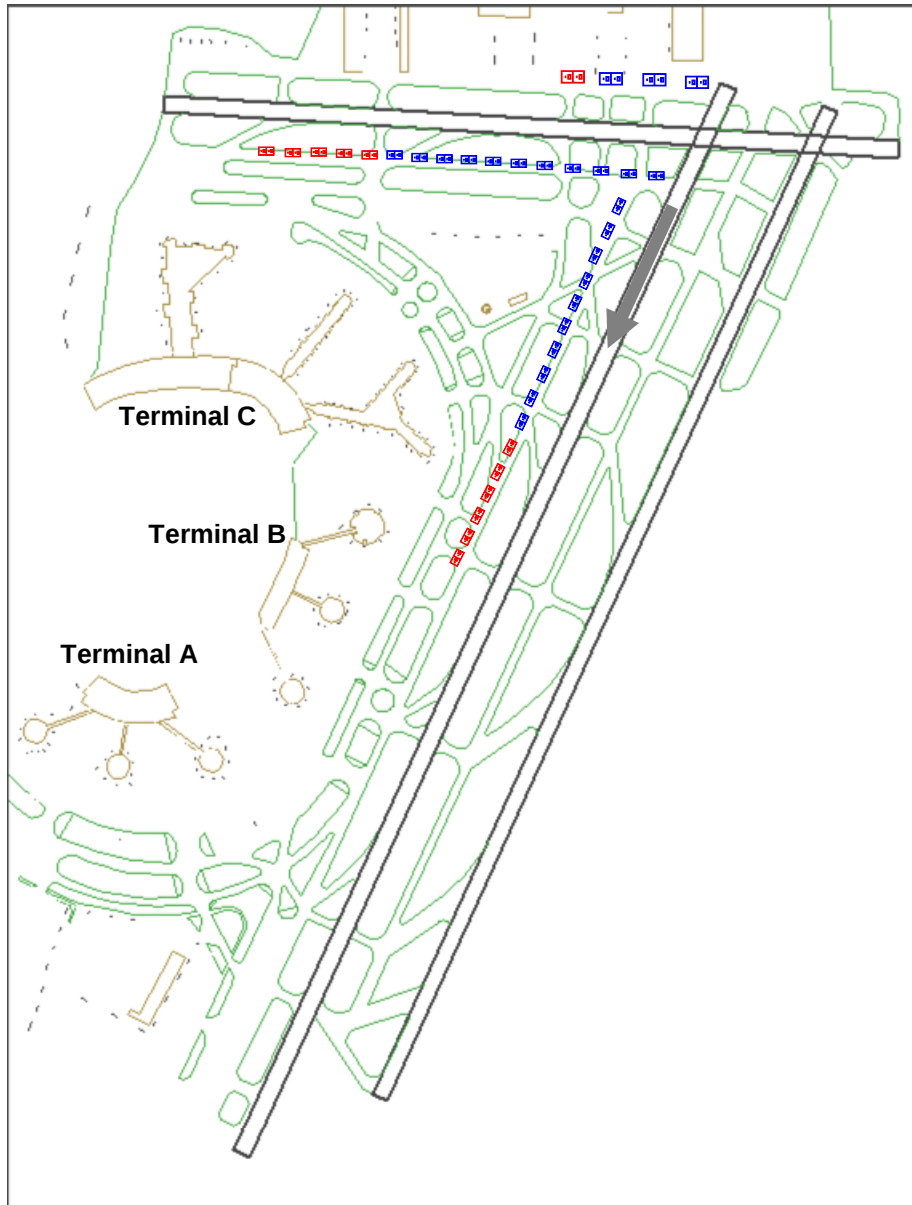
At airports where airspace is unavoidably congested, delay improvements resemble the average numbers in an intuitive way, though they are somewhat smaller. It is the large efficiency improvements at EWR that have the most influence on the departure benefit metric; the large differences in Figures 48 and 49 are moderated by the traffic at less-affected airports

## 17.4 Ground Congestion

Everyone who has traveled on an aircraft at a major airport has experienced delays in the departure queue. Pilots frequently announce the position of their aircraft in the queue so that the cabin crew and the passengers know how much time they have until the actual takeoff roll begins. As was shown in Section 7, the delay changes in the preferred alternative cause a reduction in the maximum length of the queue for departure at EWR. This is a separate measure of performance that depends on the same processes as the departure delay, so it may provide a more intuitive visualization of the meaning of departure delay.

EWR occupies a small area on the ground, for an airport that handles the large aircraft used in overseas travel. Departure queue management is critical, if arrivals are not to be obstructed from reaching their gates. Figure 50 shows the maximum length of the queue of aircraft waiting to depart runway 22R in the southwest configuration. The departure direction for all aircraft in the figure is shown with the large arrow. The longest queue in the Preferred Alternative consists of the

blue aircraft. The longest queue in the Future No Action Alternative consists of the red and blue aircraft combined. The impact of a five-minute-average delay reduction is obvious for departures. Its impact on arrivals can also be inferred by imagining an arriving aircraft near the bottom of the figure that would like to get to Terminal C.



**Figure 50. Maximum Departure Queues at EWR**

## **17.5 Conclusion**

Airspace redesigns affect large numbers of aircraft. Any particular features of the redesign will affect some flights positively, some negatively, and some not at all. For a decision-maker to assess the relative merit of several possible redesigns, benefits analyses must all be referred to a common denominator. One consequence of a large common denominator is that airspace redesign benefits, expressed as minutes or miles per flight, are numbers on the order of five miles or one minute. These numbers appear small, but a change of two or three minutes per flight, over a large set of aircraft, can have enormous economic consequences for the aviation industry and the flying public.

## 18 Mitigation of the Preferred Alternative

In response to public comments received on the Draft EIS, mitigation strategies intended to alleviate noise impacts within the project study area were evaluated for potential noise benefits as well as operational impact. As a result of these analyses, several design modifications were identified that could reduce noise without significant adverse operational impacts. A discussion of the operational changes to the Preferred Alternative due to the application of the selected mitigation strategies follows. *Note: Operations not addressed here will remain as described in section 2.5 of the DEIS.*

### 18.1 LaGuardia Airport: Runway 31 Departures

In today's airspace the departures off of LaGuardia's (LGA) runway 31 have two headings available for use. The traffic destined for routes to the south and to the west share one of the headings. Flights destined to the routes in the north and east share the second heading. The air traffic control rules for separating aircraft require two successive flights traveling the same heading to have more separation off the runway than two flights on diverging headings. The additional separation required between the large numbers of flights traveling the same heading results in increased departure delays and inefficient operation.

The Preferred Alternative provides for an additional heading for the departures off LGA's runway 31. This third heading allows for the division of the south and west departures into two separate streams. In addition to the third heading, all three headings were shifted to the east to allow the departures to the south and west room to gain altitude before turning to cross Newark's expanded arrival flow (to allow a longer final approach to EWR's runways in support of the dual arrival stream). While these changes resulted in reduced departure delay at LGA and increased the operational efficiency, they also resulted in increased noise impacts to Rikers Island.

Reducing the number of headings or shifting them to avoid the island are not possible without adverse operational impacts which would jeopardize the Purpose and Need of the project. Mitigation of the noise impact is possible, however, by using the third heading only during periods of low arrival demand and high departure demand. Given the forecast demand patterns at LGA, such a departure bank exists in the first hour of the day. Use of three headings during this period and then two headings at other times preserves much of the operational benefit while minimizing noise impacts to Rikers Island.

### 18.2 LaGuardia Airport: Runway 22 Arrivals

There are two approaches available for use when landing LGA's runway 22. The first approach uses the Instrument Landing System (ILS). The ILS approach is advantageous for the pilot in that it aligns the arriving flight precisely with the runway. This approach is required when visibility is poor as well as in various scenarios outlined in the Standard Operating Procedures (SOP) for safety reasons. The second approach is the Localizer Directional Aid (LDA) approach. The LDA approach is typically used in conditions of good visibility and when safety factors permit. It

provides an off-set approach to the runway which results in the arriving flights remaining over the Long Island Sound for much of their approach.

Due to the precise nature of the ILS approach, all flights using this approach are focused into a narrow band, aligned with the runway. Consequently, each arriving flight will fly the same ground path, and the resulting noise will be tightly concentrated on the communities directly under the flight path. Through the public comments on the Draft EIS, these communities asked for an increase in the use of the LDA approach to mitigate the noise impacts of the ILS use.

Use of the LDA by LGA arrivals is constrained by a number of factors. One of these factors is the dependency on the arriving flights to John F. Kennedy International Airport (JFK). According to the Standard Operating Procedures (SOP) for the New York TRACON, when JFK is landing the ILS to runways 22L/R, and LGA is landing runway 22, then LGA arrivals are required to use the ILS approach. These two flows are parallel and separated by less than 9 nautical miles, leaving little room for the LGA departures off runway 13 to maneuver between them. It is possible that increased use of the LDA could be facilitated through controller and pilot training, alleviating some of the noise exposure in the communities under the ground track of the ILS. This mitigation strategy would have little or no impact on LGA's operational efficiency.

### **18.3 Newark International Airport: Runway 22L Departures**

In the Future No Action Alternative, Newark International Airport (EWR) departures off runway 22L are allowed only a single heading, the 190-heading. Successive flights on the same heading require additional separation off the runway than if the flights were on diverging headings. This required pair-wise separation results in high departure delays and inefficient airport operations. Certainly, a single heading would not be sufficient to address the projected increase in demand in the years to come.

The Preferred Alternative increases the number of available departure headings from one to three, at approximately 220, 240, and 260 degrees. This reduces the in-trail separation required when two successive flights may be placed on these diverging headings. Use of three headings spreads the traffic over a larger geographical area, resulting in decreased noise exposure to the southeast, but increased noise exposure to areas southwest of the airport.

Throughout the public comment period for the Draft EIS, mitigation strategies were proposed for reducing the noise impacts to the areas southwest of EWR. Based on analysis of these proposals, the best combination of operational efficiency and mitigated noise exposure calls for the use of additional headings only during hours of peak demand. Specifically, when demand is at its lowest, only the 190 heading would be used. As demand increased and a second heading is needed, the 190 heading would be replaced by the 220 and 240 headings. As the 260 heading would impact the greatest residential population, its use is reserved for only the highest demand periods. This approach reduces the noise impacts while retaining most of the operational benefit. To further alleviate noise impacts, area navigation (RNAV) departure procedures, which permit the adjustment of departure procedures to overlie non-residential areas, may be developed. For

example, the 220 heading could be adjusted to follow the New Jersey Turnpike, while the 240 heading could follow an industrial corridor or along a railroad.

To further reduce noise impacts during the hours most people are sleeping, the nighttime departures from EWR's runway 22L are all consolidated to a single heading of 190 degrees, and directed to the east, out over the ocean, where they gain altitude before turning back over land to join their respective departure routes. This procedure is in the spirit of ocean routing, but with some inefficiencies of the Ocean Routing alternative removed (such as the requirement for large in-trail separation to maintain the safety of right angle turns to the north and south and the long north and south legs before turning back over New Jersey). The restriction to night hours obviates the need for these legs, since conflicting traffic does not occur late at night. The modified plan allows flights to gain altitude over the ocean and then fan out, immediately turning back to join their respective routes. This reduces the in-trail separation needed as well as reducing the total distance flights must travel before joining their routes, while providing some of the noise relief intended by the original design of the Ocean Routing Alternative.

#### **18.4 Newark International Airport: Arrivals**

In today's airspace, EWR arrivals from the south and north, enter the New York TRACON at their respective fixes at 8,000 feet. These flights then experience a long downwind of approximately 50 miles before turning East to continue the descent to the runway. The altitude of flights on the downwind is constrained to 6,000 feet due, in part, to the low ceiling of the approach airspace. Departing flights from EWR, TEB, and MMU that cross the path of the EWR arrivals, must climb above them. The altitude constraint of 6,000 feet for the downwind ensures EWR arrivals are separated from the departures above them.

In the Preferred Alternative, the downwind for arrivals from the south to EWR's runway 22R and the downwind for arrivals from the north to EWR's runway 04L were shifted to the west. This was done to make room for EWR's fanned departures to the west, which are allowed unrestricted climb to their respective departure fixes to achieve departure efficiencies. The result of this move was a change in which communities experience noise impacts from the arrivals.

The Preferred Alternative restricts the downwind of the arrivals to 6,000 feet for the duration of the downwind, a distance of over 50 nautical miles. An approach to alleviate the noise impacts of this lateral move of the downwind consists of raising the vertical profile by 2,000 feet for the duration of the downwind leg. An evaluation of this strategy showed that minimal impact to the airspace design, and no impact to the efficiency of the EWR arrivals, the altitude of the flights on the downwind may be raised from 6,000 feet to 8,000 feet, alleviating some of the noise impacts to the affected communities. However, in order to affect this change, flights that currently use V249 at an altitude of 8,000 feet would need to be lowered to the altitude of 6,000 feet. This results in 300-400 EWR arrivals being raised to the altitude of 8,000 feet while approximately 20 flights a day are lowered to 6,000 feet resulting in a net noise benefit. However, this noise relief comes at the cost of additional complexity for controllers working arrivals to EWR runway 11.

## **18.5 Newark International Airport: Continuous-Descent Approaches**

Continuous-descent approach procedures should be developed for night-time use to the main service runways at EWR from the arrival fixes on the same side of the airport as the final approach segment. The continuous-descent phase should begin at the arrival fix, since higher altitudes will not reliably be free of conflicting traffic, even at night. These CDA should be the primary approach to the airport at night; CDA from other directions and higher altitudes should be available for use as conditions permit.

## **18.6 Philadelphia International Airport: Departures**

In the Preferred Alternative, departures from PHL's runway 27L have six headings available to them. Likewise, available departure headings from runway 09L are increased to seven. The additional departure headings increase operational efficiency and provide for a considerable reduction in the departure delay that is currently experienced at PHL. However, these additional departure headings result in noise impacts to the surrounding communities.

One approach for alleviating noise impacts involves reducing the number of departure headings. Another approach prescribes the use of additional headings only during periods of increased demand. A third strategy involves directing departure flows over non-residential areas whenever possible. Adopting a combination of these approaches results in achieving a balance between minimizing noise impacts and retaining much of the operational efficiency. This combined approach involves selecting three headings from each runway for regular use with a fourth heading available during periods of peak demand. As at Newark Liberty International Airport, RNAV departure procedures would be adjusted to overlie non-residential areas whenever a major road, industrial corridor, waterway, or the like, would allow. There is, however, a trade off in efficiency for this combined approach. The tower chief must periodically evaluate the departure situation and revise the headings in use. This increases the operational complexity.

In an effort to further reduce noise impacts during the hours most people are sleeping, the nighttime departures off runway 27L would be combined into a single flow over the river for their initial climb. As these flights gain sufficient altitude, they would turn to join their respective departure routes.

## **18.7 Philadelphia International Airport: Arrivals**

In today's traffic, arrivals to PHL's runway 09R often use the ILS approach, resulting in noise impacts to the underlying communities. Many of the communities underlying the ILS approach have requested that the flights be required to approach over the river. Currently, a visual approach along the river exists, however, since use of runways 09R/L is often the result of inclement weather, the visual approach along the river is not often used. When conditions do allow for the use of the visual approach along the river, the operational efficiency of the airport suffers. The timing of visual approaches is notoriously unpredictable, making it difficult for the approach controller to effectively merge and space aircraft on the final. Increased use of the river approach may be facilitated in the Preferred Alternative by the application of an Area Navigation (RNAV)

procedure. This would allow flights to safely use the river approach to 09R in less than optimal weather conditions. It would also provide a standard procedure for the controller resulting in more predictable behavior of the arriving flights.

### **18.8 Philadelphia International Airport: Continuous-Descent Approaches**

Continuous-descent approach procedures should be developed for night-time use to the main service runways at PHL from the northwest and southwest arrival fixes. The continuous-descent phase should begin at the arrival fix, since higher altitudes will not reliably be free of conflicting traffic, even at night. These CDA should be the primary approach to runway 09R at night. CDA to runway 27R should be used when runway demand conditions make it efficient to do so. CDA from other directions and higher altitudes should be available for use as conditions permit.

### **18.9 Mitigation of the Preferred Alternative- Summary**

The Preferred Alternative includes operational changes that result in noise impacts to residents of communities throughout the study area. Mitigation strategies have been analyzed and several selected that alleviate the noise impacts without a substantial loss in operational efficiency. These strategies include:

- Reducing the number of departure headings,
- Using additional departure headings only during periods of increased demand
- Raising arrival altitudes,
- Routing flights over non-residential areas such as industrial corridors and waterways,
- Applying Continuous Descent Approach procedures to nighttime arrivals,
- Developing RNAV procedures, and
- Training controllers and pilots to choose non-noise-sensitive options whenever appropriate.