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MITRE PRODUCT

NY/NJ/PHL Metropolitan Area Airspace Redesign

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McLean, Virginia

CAASD

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Abstract

In April 1998, the Federal Aviation Administration (FAA) initiated the first major redesign of the airspace supporting the New York and Philadelphia metropolitan areas. For each set of different operating assumptions, an alternative design was created by FAA airspace designers from the affected facilities. Since the beginning of this critical effort, The MITRE Corporation's Center for Advanced Aviation System Development (CAASD) has been part of the FAA's team, using state-of-the art analysis to facilitate design decisions and analyze the operational impacts of the proposed airspace alternatives. This report documents the analysis approach, design details and operational impacts of the five airspace alternatives for the New York/New Jersey/Philadelphia (NY/NJ/PHL) Metropolitan Area Airspace Redesign project. The Integrated Airspace with Integrated Control Complex alternative is recommended on the basis of the results derived from the series of simulations described in this report. This alternative assumes integrated routes and airspace and a single facility that combines the New York terminal and en route air traffic control functions, personnel, and facilities.

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

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Executive Summary

Keeping the design of the airspace around New York City and Philadelphia aligned with the demand on the aviation system has always been a priority of the Federal Aviation Administration (FAA). In April 1998, the FAA launched a multi-year effort to redesign this large and critical piece of airspace. This is the first major redesign of the airspace supporting the New York and Philadelphia metropolitan areas in over a decade. The project has been named the New York/New Jersey/Philadelphia (NY/NJ/PHL) Metropolitan Area Airspace Redesign. The purpose of this effort, broadly stated, is to maintain safety and increase the efficiency of air traffic operations in the area. This broad purpose was refined by the FAA's redesign team into a set of system improvements.

Since the beginning of this critical project, The MITRE Corporation's Center for Advanced Aviation System Development (CAASD) has been part of the FAA's team. The FAA requested that CAASD work with the FAA's redesign team to evaluate the operational impacts, specifically safety and efficiency, of five proposed airspace designs. The first alternative, the **Future No Action** Alternative, is required by the National Environmental Policy Act (NEPA) and is based on current airspace and routing. The second alternative, the **Modifications to Existing Airspace** Alternative, assumes minor modifications to today's airspace and routing. The third alternative, the **Ocean Routing** Alternative, is a proposal of the Office of the Governor of New Jersey, originally developed by the New Jersey Coalition Against Aircraft Noise, Inc. The fourth alternative, the **Integrated Airspace** Alternative, assumes integrated routes and airspace but without constructing a new proposed air traffic control facility. The fifth alternative, the **Integrated Airspace with Integrated Control Complex** Alternative, assumes integrated routes and airspace as well as construction of the proposed New York Integrated Control Complex (NYICC).

CAASD has conducted analyses to aid the design process, provided quantitative input on the choice of alternatives, and supported the preparation of the Environmental Impact Statement (EIS). The EIS describes the purpose and need for the airspace redesign and analyzes the potential environmental impacts. The results of the CAASD operational analysis are reported here and will be referenced in FAA's EIS.

NY/NJ/PHL Metropolitan Area Airspace Redesign Process

The NY/NJ/PHL Metropolitan Area Airspace Redesign is a cooperative effort among many FAA facilities. The redesign team for this project consists of participants from the New York Terminal Radar Approach Control (TRACON), the New York Air Route Traffic Control Center (ARTCC), the Philadelphia TRACON, the Washington ARTCC, and the Boston ARTCC. Additional input was also provided by neighboring ARTCCs in the Great Lakes Corridor. The FAA's redesign team began the process of redesigning the airspace by understanding the problems in the airspace and translating those issues into desirable features of new designs. The redesign team developed several options for airspace improvements, ranging from minor modifications to a fundamental redesign of the airspace. These concepts were coordinated and merged into alternative designs to be considered in the EIS, each defined by a set of airways, holding fixes, altitude restrictions, and terminal arrival and departure procedures. The redesign team gave their airspace design alternatives, along with one externally-developed alternative, to CAASD for modeling and simulation.

CAASD's simulation models started with airport models that were simple enough to be practical for combining into a single large simulation, while still being detailed enough to show the effect of an airspace change. CAASD provided quantitative feedback from the simulations to the redesign team. If these observations matched the design goals, they were confirmed by the redesign team; if they did not, the design was modified. When a complete simulation of an alternative was operationally validated by the redesign team, the simulated aircraft trajectories were passed to the environmental analysis consortium for assessment of noise impacts and other environmental factors. If the environmental analysis uncovered any remaining unworkable details of the airspace design, another cycle of feedback took place with the redesign team making modifications and CAASD adapting the simulation accordingly.

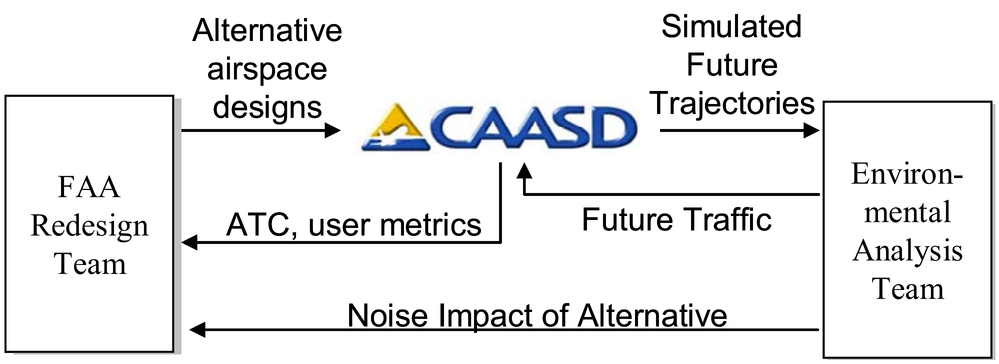

Figure ES-1. Role of CAASD in the Study Consortium

CAASD modeled and evaluated five airspace alternatives for the NY/NJ/PHL Metropolitan Area Airspace Redesign. All applicable traffic flows in the airspace were evaluated. The area's eight primary airports,[1] where airspace redesign will have an effect on runway operations, were modeled in detail from the runways up.

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1 The eight airports modeled were John F. Kennedy International (JFK), LaGuardia (LGA), Long Island MacArthur (ISP), Morristown Municipal (MMU), Newark Liberty International (EWR), Philadelphia International (PHL), Teterboro (TEB), and Westchester County (HPN).

Alternatives Overview

The first alternative, the **Future No Action** Alternative, is required by NEPA and is based on current airspace and routing. In this alternative the airspace operates as it has since 2002 with a few improvements that are independent of the larger scale airspace redesign concepts in the NY/NJ/PHL Metropolitan Area Airspace Redesign project.

The second alternative is the **Modifications to Existing Airspace** Alternative. This alternative assumes minor modifications to today's airspace and routing, improving operations as much as possible within the limitations of current air traffic control facility boundaries. Departure efficiency at many of the modeled airports is improved by addition of multiple departure headings. A parallel offset route is created to take some demand off the most congested westbound airway. Southern departures from New York are rearranged to alleviate an occasional congestion problem out of Philadelphia.

The **Ocean Routing** Alternative, the third alternative, is a proposal of the Office of the Governor of New Jersey, originally developed by the New Jersey Coalition Against Aircraft Noise, Inc. This alternative keeps Newark and LaGuardia departures over water until they have climbed high enough so that noise is not a problem west of the Hudson River. Making this change requires corresponding changes to JFK's operations as well.

The fourth alternative is the **Integrated Airspace** Alternative, which assumes integrated routes and airspace but without constructing a new proposed air traffic control facility. This form of integration can provide benefits to customers and controllers, even if control responsibility remains distributed among four facilities. This alternative has multiple departure headings and a parallel jet airway to the west, as in the Modifications alternative. It rearranges departure fixes on the west side of New York. JFK satellite departures to the south are given separate routes, and the routes are separated earlier. This alternative stands alone, but if the air traffic control facilities are to be integrated, it can serve as a transition state between current operations and full integration of both airspace and operations.

The fifth alternative is the **Integrated Airspace with Integrated Control Complex** Alternative, which assumes integrated routes and airspace as well as construction of the proposed NYICC. This alternative is a fundamental redesign of the airspace from New York to Philadelphia. NYICC would control a large area using terminal separation rules (up to FL230 in altitude in some places), with the higher altitude portion (up to FL350) operating with en route separation rules. The inefficiencies associated with transfer of control from one facility to another are minimized by the integration. Many new routes are available to New York departures. Arrivals are rearranged so that airspace constraints do not prevent use of dual approaches to Newark at times of heavy arrival demand.

Operational Impacts

Each of the five alternatives was operationally modeled using the *Total Airspace and Airport Modeller* (TAAM). TAAM is a fast-time simulation tool that can model ground, terminal, and en route airspace environments.[2] As part of the model development, MapInfo™ geographical information system software was used to facilitate arrival and departure route definition. The Radar Audio Playback Terminal Operations Recording (RAPTOR) tool was used to show the TAAM simulation output in the form of simulated flight tracks as part of the validation effort. Special purpose software was developed by CAASD to simulate ground delay for arrivals to the modeled airports, and to delay departures from the modeled airports to adjust for airway congestion downstream. The Sector Design and Analysis Tool (SDAT) was used to extract times of entry and exit of aircraft for airspace volumes, which facilitated the development of metrics other than delay.

CAASD applied these tools to the validated alternatives to generate the metrics shown in Table ES-1. The most advantageous value for each metric, across the alternatives, is boldfaced.

Modifications to Existing System Alternative shows benefits relative to the **Future No Action** Alternative from the fanning of departure headings. West departures from the New York metropolitan airports (JFK, LGA, EWR, HPN, ISP, TEB, and MMU) and Philadelphia have an additional jet route, similar to that in **Integrated Airspace** Alternative. This jet route is used for arrivals to the Indianapolis and Cleveland ARTCC internal airports. **Modifications to Existing System** Alternative reduces airspace delays by about one-third, compared to the current published procedures.

2 Detailed information on TAAM is presented on web site http://www.preston.net/products/TAAM.htm.

Table ES-1. Summary of Operational Impacts

System Improvements	Metric	Future No Action	Modifications to Existing Airspace	Ocean Routing	Integrated Airspace	Integrated Airspace with ICC
Reduce complexity	*Jet route delays + time below 18,000 ft (min)*	12	12	12	11	**10**
	Arrival Distance below 18,000 ft (nmi)	96	**95**	99	96	102
Reduce voice communications	*Max Inter-facility handoffs per hour*	525	525	521	529	**382**
Reduce delay	*traffic-weighted Arrival Delay 2011*	22.9	22.6	23.6	22.8	**19.9**
	traffic-weighted Departure Delay 2011	23.3	20.9	29.5	20.8	**19.2**
Balance controller workload	*Equity of west gate fix traffic counts*	0.37	0.37	0.37	0.34	**0.30**
Meet system demands & Improve user access to system	*End of day's last arrival push*	23:54	23:54	23:54	23:54	**23:00**
Expedite arrivals and departures	*Time below 18,000 ft (min)*	18.5	**18.2**	18.8	18.2	18.6
	Change in Route Length per flight (nmi)	0.0	0.0	4.5	**-1.2**	3.7
	Change in block time (minutes per flight)	0.0	- 0.9	3.9	-1.0	**-1.4**
Flexibility in routing	*Qualitative Assessment*	0	0	–	0	+
Maintain airport throughput	*Arrivals*	223	223	223	223	**238**
(total of maximum sustainable throughput)	*Departures*	238	239	221	240	**245**

In the **Oceanic Routing** Alternative, Newark departures are negatively impacted by longer distances (15 nmi) and extra block time (25 minutes) in comparison to the **Future No Action** Alternative. The **Ocean Routing** Alternative removes the delay on the west gate out of New York, since this gate is no longer available to Newark departures in the high capacity configuration. However, in its place is a new delay point to the south of NY. The result is a small reduction in airspace delay due to the ocean routing, but with a corresponding huge increase in airport departure delay. There is an additional complication in the en route airspace, as the proposed routing of Newark and Kennedy departures pass just north of the main departure fix out of Philadelphia. As Newark departures are pushed later in the day by the airspace capacity limits that traffic coincides 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. The **Oceanic Routing** Alternative does not meet the objectives of the airspace redesign. Based on these operational results, CAASD recommends that this alternative not be considered further.

The **Modifications to Existing System** and **Integrated Airspace** alternatives are very similar from the perspective of benefits to users of the airspace. The split of J80 into two airways is the critical change in each case. The primary difference is the interface between the New York TRACON and the split jet airway. In the **Modifications to Existing System** Alternative, as in the current system, the single fix ELIOT feeds several jet airways from two altitudes. The analysis in this report shows that a single fix with two altitudes is more efficient for users than splitting ELIOT into two fixes, each of which will feed an airway that is tightly constrained in the lateral dimension. If it is operationally feasible, the single fix with two altitudes would be a better transitional design to the **Integrated Airspace with Integrated Control Complex** Alternative, since the latter alternative has two altitudes on all the west gate fixes.

The **Integrated Airspace** Alternative has two major differences from the **Future No Action** Alternative. First, departures are fanned off the runways, reducing departure delay significantly. Second, a second departure fix is created out of New York to share ELIOT traffic, and a parallel airway to J80 handles arrivals to Indianapolis Center. These changes cut the J80 delay by 20 percent, reduce departure fix delay at the Modena VOR (MXE) by half, and eliminate ELIOT as a source of congestion. The net result is a reduction of airspace delay by about one-third.

One feature of the **Integrated Airspace** Alternative is the change to the Long Island MacArthur south departures. Though this change affects only about a dozen flights, the impact on airspace delay is substantial. South gate delays are reduced by almost a third, as downstream congestion over Norfolk, VA is reduced. In addition, flights benefit in terms of flying slightly shorter distances than in the **Future No Action** Alternative, with a small decrease in block time.

Overall, the metrics slightly favor the **Integrated Airspace with Integrated Control Complex** Alternative. The improvements in airspace delays are significant. The expanded west gate has no departure fixes with more than 30 minutes of delay per day. North gate departure delays are essentially eliminated. J80 and its offset partner are no more restrictive than other jet airways in the **Integrated Airspace with Integrated Control Complex** Alternative. The change to the south gate, which permits J79 traffic to be placed on the west side of J209 departures while still under New York departure control, balances the departure delay on the replacement fixes for WHITE and WAVEY. Moreover, while the majority of flights fly longer distances with the **Integrated Airspace with Integrated Control Complex** Alternative, users see a net benefit in terms of shorter block times in comparison to the other alternatives. Newark shows the greatest benefits from the **Integrated Airspace with Integrated Control Complex** Alternative, since the benefits associated with the use of dual arrival streams dominate the increased flying distance. Fanned departure headings also contribute significantly to delay reduction. The Integrated Control Complex also significantly decreases the voice communications associated with the number of inter-facility handoffs. With the integrating of the New York TRACON and New York Center, the peak number of inter-facility handoffs is as much as 30 percent lower per hour in the **Integrated Airspace with Integrated Control Complex** Alternative than in any of the multi-facility alternatives.

At the high demand levels forecast for 2011, the **Integrated Airspace with Integrated Control Complex** Alternative shows the best performance overall. However, it must be noted that the penalties caused by longer routes are a fixed cost that is proportional to the number of flights. The benefits due to improved airport operations increase faster than linearly as traffic increases. Therefore, there is a break-even point in traffic levels. If traffic is above that level, which is somewhere between the median and the 90^{th} percentile day in the 2011 forecast, the **Integrated Airspace with Integrated Control Complex** Alternative is a net benefit. If the forecast demand levels do not materialize, the **Integrated Airspace with Integrated Control Complex** Alternative may not reach the break-even point.

Recommendations

The delay metrics evaluated for the **Future No Action** Alternative show severe airport congestion that will be costly to users of the airspace. To meet the anticipated demand, changes must be made to the current system.

The simulations reported in this document show several changes that can ameliorate future conditions and bring the system closer to the stated needs:

- Airspace constraints that limit the use of available runways must be removed
- Departures should be permitted to fly dispersed headings as close to the runway as feasible

- Departure fixes should not have to serve more than one airway
- Multiple altitudes should be available at departure fixes
- Sequencing decisions for arrivals should be made as early as possible, and coordination between arrival streams should be seamless

Of the remaining alternatives, all have benefits. However, only one alternative incorporates enough of the changes listed above to be worth the effort and expense of implementing an airspace redesign of this magnitude. Therefore, the **Integrated Airspace with Integrated Control Complex** Alternative is the recommended choice.

Section 1

Background

The airspace that surrounds and supports the New York City, New Jersey, and Philadelphia metropolitan areas is complex on several levels. It is operationally complex, because the demand is high. It is organizationally complex, because the national airspace system has developed over time in such a way that this airspace is controlled by several facilities located in Virginia, Pennsylvania, New York, and Massachusetts, which are in two separate administrative regions. Heavy traffic in complex airspace leads to congestion, and congestion leads to delays. Delayed flights result in increased costs to customers and passengers. Increased costs in these busy metropolitan areas, including the largest economic center in the United States, have a potentially very large negative impact on the national economy.

Keeping the design of the airspace around New York City, New Jersey, and Philadelphia aligned with the demand on the aviation system has always been a priority of the Federal Aviation Administration (FAA). In April 1998, the FAA launched a multi-year effort to redesign this large and critical piece of airspace. As part of the National Airspace Redesign, (NAR) the project has been chartered as the New York/New Jersey/Philadelphia (NY/NJ/PHL) Metropolitan Area Airspace Redesign and is the first major redesign of the airspace supporting the New York and Philadelphia metropolitan areas in over a decade.[1]

Since the beginning of this critical project, The MITRE Corporation's Center for Advanced Aviation System Development (CAASD) has been part of the FAA's team. The FAA requested that CAASD work with the FAA's redesign team. As the airspace redesigners created (or forwarded) possible new plans from each set of operating assumptions, CAASD evaluated them for operational impacts, specifically safety and efficiency. CAASD has conducted analyses to aid the design process, provided quantitative input to the choice of alternatives, and supported the preparation of the Environmental Impact Statement (EIS). The EIS describes the purpose and need, affected environment, alternatives including the proposed action and the environmental consequences in accordance with the National Environmental Policy Act (NEPA). The results of the CAASD analysis are reported here and will be referenced in FAA's EIS.

1 The NY/NJ/PHL Metropolitan Area Airspace Redesign was preceded by many other redesigns, some implemented and some not, including the Metroplex Plan (1970), Northeast Airspace Procedures Study (1980), Regional Analysis of Metroplex Procedures (1981), East Coast Plan (1983), and Expanded East Coast Plan (1984-1987).

1.1 NY/NJ/PHL Metropolitan Area Airspace Redesign Process

The NY/NJ/PHL Metropolitan Area Airspace Redesign is a cooperative effort. The redesign team for this project consists of participants from the New York Terminal Radar Approach Control (TRACON), the New York Air Route Traffic Control Center (ARTCC), the Philadelphia TRACON, the Washington ARTCC, and the Boston ARTCC. Additional input was also provided by neighboring ARTCCs in the Great Lakes Corridor. The FAA's redesign team began the process of redesigning the airspace by understanding the problems in the airspace and translating those issues into desirable features of new designs. These concepts were coordinated and merged into alternative designs to be considered in the EIS, each defined by a set of airways, holding fixes, altitude restrictions, and terminal arrival and departure procedures. The airspace alternatives were communicated to CAASD by the redesign team.

CAASD developed simulation models of each alternative design. These simulation models started with airport models that were simple enough to be practical for combining into a single large simulation, while still being detailed enough to show the effect of an airspace change. CAASD provided quantitative feedback from the simulations to the redesign team. If these observations matched the design goals, they were confirmed by the redesign team; if they did not, the design was modified. When a complete simulation of an alternative was operationally validated by the redesign team, the simulated aircraft trajectories were passed to the environmental analysis consortium for assessment of noise impacts and other environmental factors. If the environmental analysis uncovered any remaining unworkable details of the airspace design, another cycle of feedback took place with the redesign team making modifications and CAASD adapting the simulation accordingly. As a result of the iterative process used in developing this study, the environmental and operational analyses are consistent.

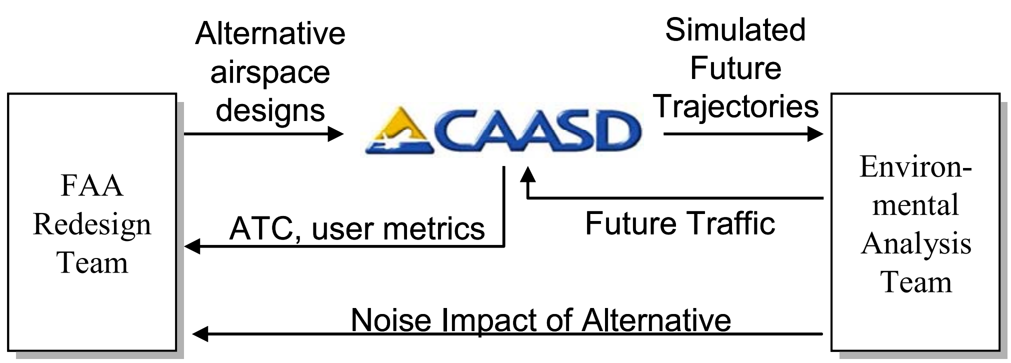

Figure 1-1. Role of CAASD in the Study Consortium

Section 2

Study Overview

This section provides an overview of the study purpose, airspace designs evaluated, tools used, and how the modeled designs were validated. Section 3 describes the overall modeling assumptions and input parameters. The modeled alternatives are discussed in Sections 4 through 8. The operational analysis results are presented in Section 9 and conclusions and recommendations in Section 10.

2.1 Purpose

The purpose of the NY/NJ/PHL airspace redesign, broadly stated, is to increase the safety and efficiency of air traffic operations in the area. This broad purpose was refined by the FAA's redesign team into a set of system improvements:

- Reduce complexity
- Reduce voice communications
- Reduce delay
- Balance controller workload
- Meet system demands and improve user access to system
- Expedite arrivals and departures
- Increase flexibility in routing
- Maintain airport throughput

A detailed description of these objectives, associated metrics and simulation modeling results for each alternative are discussed in Section 9.

2.2 Airspace Designs Evaluated

CAASD modeled and evaluated five alternative airspace designs for the NY/NJ/PHL Metropolitan Area Airspace Redesign. All applicable traffic flows in the airspace were evaluated; however specific detail was paid to the area's eight primary airports:[1]

1. **Future No Action** Alternative which is based on today's airspace and routing,
2. **Modifications to Existing Airspace** Alternative which assumes minor modifications to today's airspace and routing,
3. **Ocean Routing** Alternative which keeps departures over water until noise is not a problem,
4. **Integrated Airspace** Alternative which assumes integrated routes and airspace but without constructing a new proposed ATC facility, the New York Integrated Control Complex (NYICC), and
5. **Integrated Airspace with Integrated Control Complex** Alternative which assumes integrated routes and airspace and the NYICC.

An overview of these alternatives is provided in 2.2.1 through 2.2.5. Detailed information about the airspace and airports is in Section 4 through Section 8.

2.2.1 Future No Action Alternative

Under the Future No Action Alternative, the airspace operates as it did during 2002, with a few improvements included that are independent of the large scale airspace redesign proposals. These improvements are anticipated to be in place before the final New York redesign is completed.

Most important of these improvements is the split of the western departures from PHL into two streams. As of the base year (2000), all traffic was routed over the Modena VOR (MXE). A separate stream was established in 2003 for traffic headed to the inland south and southwest (Atlanta and Charlotte, for example) along jet airways J48 and J75. Now that this is in place, the capacity of the junction between PHL and the en route airspace to the west has been effectively doubled.

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[1] The eight airports modeled were John F. Kennedy International, LaGuardia, Long Island MacArthur, Morristown Municipal, Newark Liberty International, Philadelphia International, Teterboro, and Westchester County.

Other improvements involve replacing current standard terminal arrival routes and departure procedures with Flight Management System (FMS) and area navigation (RNAV) overlays. Replacements like these are currently happening across the country, with the aim of reducing navigation workload for pilots and controllers.

2.2.2 Modifications to Existing Airspace Alternative

This alternative assumes minor modifications to today's airspace and routing, improving operations as much as possible within the limitations of current air traffic control facility boundaries. This alternative builds on the Future No Action Alternative with two significant changes. WHITE departures are moved farther west. PHL has a new DITCH departure that is moved eastward and climbs under the new WHITE departure. EWR adds a WAVEY oceanic departure route in the low capacity configuration (using Runway 04L/29 for departures, Runway 04R/11 for arrivals). Southwest bound departures out of PHL are restructured to allow unrestricted climbs.

2.2.3 Ocean Routing Alternative

The Ocean Routing Alternative is a proposal of the Office of the Governor of New Jersey, originally developed by the New Jersey Coalition Against Aircraft Noise, Inc.

This alternative begins by sending EWR departures south and east over water, regardless of their final destination. The aircraft climb over the water until they are high enough to be inaudible from the land. West departures then turn south and west to join their jet airways. In effect, the current four west fixes are replaced by a single fix. To accommodate this new flow of traffic, the JFK arrivals that currently use that airspace (the ones headed north from ZDC) are moved several miles eastward. Arrivals to JFK from ZDC are also moved eastward to give the EWR departures space to climb unimpeded. JFK westbound departures go even farther south before turning west.

EWR North departures go east, and then turn north over Long Island, then west. This loop eastward permits them to climb out of the New York TRACON through the top of the TRACON airspace, then proceed westward at high altitude.

North and west departures from LGA head north, keeping east of the Hudson River, until their engine noise is no longer a problem, then turn westward. They will be under the north departures from EWR.

PHL traffic is not directly affected by the Ocean Routing Alternative. Any impacts on PHL will be secondary, because departures may have a more difficult time merging with the JFK departures to the west, which are now overhead of the MXE departure fix.

2.2.4 Integrated Airspace Alternative

In this alternative, NY metro departures to north and east, and oceanic departures as well as all PHL departures are the same as in the Future No Action Alternative. West departures from NY metro airports have an additional departure fix. Also a jet route parallel to J80 is available for NY metro and PHL departures for airports in the Indianapolis ARTCC (ZID) internal airports. JFK satellite departures to the south are given separate routes from JFK and the routes are separated earlier depending on the destination (over water on J209 or over land on J79).

2.2.5 Integrated Airspace with Integrated Control Complex Alternative

This alternative is a fundamental redesign of the airspace from New York to Philadelphia. It envisions a large area, up to FL230 in some places, using terminal separation rules,[2] with a higher altitude portion (up to FL350) operating like an ARTCC. The airspace will comprise most of the current New York TRACON and Center, several sectors from ZDC, and several sectors from ZBW. The current TRACON and en route Center will lose their separate identities, as they are merged into a single facility that has some features of each. PHL TRACON will continue to exist as a separate facility, also using terminal separation rules in its expanded airspace. Airspace over top of the integrated control complex will be controlled by other ARTCCs. Fanning of departures to reduce inter-departure spacing is a feature of the Integrated Alternative, just as for the Modifications to Existing Airspace Alternative.

2.3 Tools

The alternatives were operationally modeled using the *Total Airspace and Airport Modeler* (TAAM). TAAM is a fast-time simulation tool that can model ground, terminal, and en route airspace environments.[3] The simulation approach and detailed modeling input is provided in Section 3.

As part of the model development, MapInfo™ was used to facilitate arrival and departure route definition. The Radar Audio Playback Terminal Operations Recording (RAPTOR) tool was used to show the TAAM simulation output in the form of simulated flight tracks as part of the validation effort. Special purpose software was developed to simulate ground delay for arrivals to the modeled airports, and to delay departures from the modeled airports to adjust for airway congestion downstream. The Sector Design and Analysis Tool (SDAT)

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2 Terminal separation rules provide for 3 nmi lateral separation at altitude (versus 5 for en route) and for a 15 degree course divergence to discontinue altitude separation.

3 Detailed information on TAAM is presented on website http://www.preston.net/products/TAAM.htm.

was used to extract times of entry and exit of aircraft for airspace volumes, which facilitated the development of metrics other than delay.

Special purpose software was developed by CAASD to simulate ground delay for arrivals to the modeled airports, in cases where the forecast demand greatly exceeded airport capacity, and to delay departures for modeled airports to accommodate airway congestion downstream. The complete description on how these delays were calculated via this software is described in Appendix A.

2.4 Model Validation

Airport models were calibrated to the observed throughputs, derived from the Computerized Analysis of Terminal Records (CATER). No attempt was made to calibrate TAAM delays to current delay data because there is no standard data applicable to the high traffic levels forecast for 2006 and 2011.

To validate the airport and en route models, air traffic controllers on the redesign team who were familiar with the terminal and en route airspace of interest were asked to look at the traffic in the model for their area of expertise, either statistically or using TAAM or RAPTOR animations. Most validation was done in person, with corrections made interactively on the spot. In other cases, the suggested changes were made off-line and sent back to the design team for confirmation. MapInfo™ was often used to display the aircraft tracks, annotated with altitude, speed, and traffic volume information. This gave a two dimensional picture about the path an aircraft should be taking. This process was repeated numerous times throughout the analysis. Once traffic was flowing as the validation controllers expected, it was incorporated into the production simulation.

Section 3

Modeling Assumptions and Input Data

The redesign of the airspace between New York City and Philadelphia has the potential to affect a significant number of high altitude flights in the United States and a large part of Canada. A huge study area, however, would make the efficiency analysis so lengthy and unwieldy that the analysis results would not be available in a timely manner to the decision makers who need to approve the redesign. Therefore, the first task in the operational analysis was therefore to simplify the simulation domain of the study. Then, the other factors such as weather phase of flight, geography, aircraft routes of flight, terminal procedures, and runway usages were considered. Finally, forecast traffic was determined and airport throughput was validated.

3.1 Simulation Domain

Decisions about simulation scope and detail were made for both airspace and airports. Airspace is modeled with the aircraft routes, terminal procedures, and sectorization. Airports can be modeled as point sources without runway capacity, or with all runways, taxiways, and gates (gate-to-gate modeling).

Because the NY/NJ/PHL Metropolitan Area Airspace Redesign has the possibility of improving the flexibility of runway use at several airports and enhancing the departure procedures at others, airport modeling was necessary. However, complete gate-to-gate modeling of flights was not needed since the only change to ground operations in any of the alternatives occurs when EWR operates under dual arrival streams. The feasibility of this operation for the airport surface has been verified in a previous study as described in subsection 3.3. The runways were the only part of the airports simulated, which is sufficient to permit changes in approach and departure procedures to be modeled.

Detailed operational modeling was conducted for a subset of the airports included in the EIS. The airports JFK, LGA, ISP, MMU, EWR, PHL, TEB, and HPN were selected based on several criteria: significant impact on traffic on the airways under study; significant impact on airport operations from the proposed airspace designs; or sharing arrival or departure fixes.

En route and terminal operations were modeled for eight airports. Runways were modeled for these airports in order to capture the impact of changed low altitude arrival and departure procedures in the various alternatives. Wherever possible, gate and taxiway modeling was excluded from the simulation. This exclusion was acceptable at JFK, TEB, MMU, ISP and HPN because ground capacity is not a constraint on operations. At LGA, the ground operation is a steady state of alternating arrivals and departures, which can be simulated without a ground model. At PHL, ground modeling was necessary to obtain the correct dependence between the runways in east configuration.

3.2 Weather

Visual Meteorological Conditions (VMC) were the only conditions simulated at the modeled airports. When the airports are at their maximum capacity (i.e., VMC), the sustained demand on the airspace is highest. Constraints from airspace design are most obvious when there is high demand from the airports. In routine situations with lower airport capacity, traffic flow management programs are implemented to reduce the demand and airspace is less of a constraint.

Wind was not explicitly included in the modeling. Arrival and departure procedures were simulated so that wind was included implicitly, with ground tracks and altitude profiles matching recorded radar tracks.

Unpredictable reduced-capacity situations due to weather are critically important to users of the system. Robustness in the face of adverse conditions lead most lists of what users want from the air traffic management system. Performance of the system during convective weather events is expected to be greatly affected by airspace redesign, and several adverse weather scenarios will be studied in future work. The good weather simulation is the first step in that direction.

3.3 Geography

The most radical of the proposed changes to the system is in the Integrated Airspace with Integrated Control Complex alternative, which integrates the NY airspace and air traffic control operations in the current ZNY and TRACON into a single integrated control complex. In this alternative, New York, Washington (ZDC), and Boston (ZBW) ARTCCs will be affected as shown in Figure 3-1. Cleveland ARTCC (ZOB), as well, may have to make changes to its operation to accommodate some of the alternative design proposals. The airspace of the ZNY, ZDC and ZBW ARTCCs (Centers) was included in the modeling effort. Other Centers were assumed to be able to accommodate the changes with minimal operational impact. Traffic to airports other than the eight modeled explicitly was omitted, because this traffic is procedurally separated from New York City and Philadelphia traffic in today's system and all the proposed alternatives.

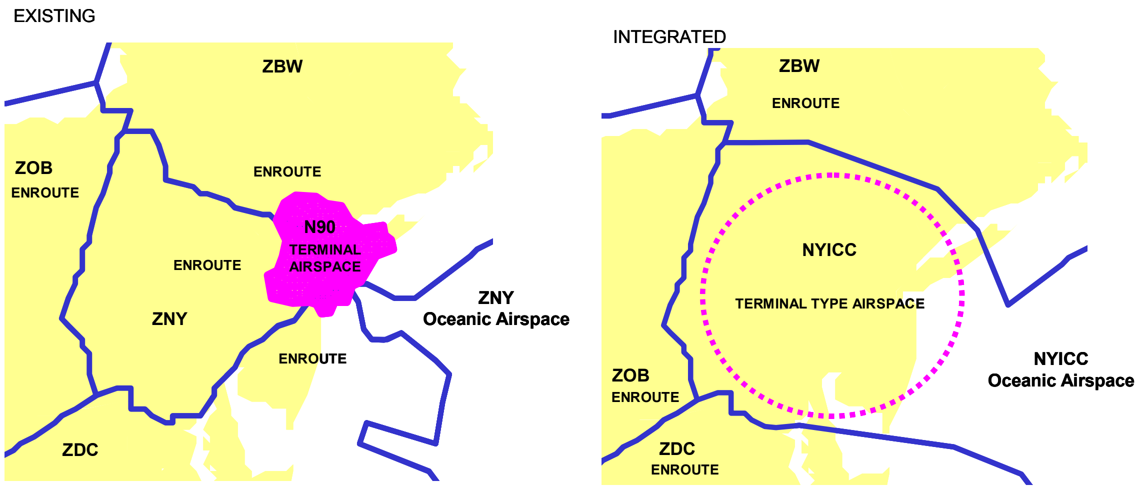

Figure 3-1. Existing and Integrated Airspace

3.4 Aircraft Routes

The Future No Action Alternative arrival and departure routes were derived from flight plan and flight track information from the Enhanced Traffic Management System (ETMS). New York Center's System Analysis Recording (SAR) data were used to derive general aviation (GA) routes.

Arrival and departure routes for the other alternatives were provided in both paper and electronic form by the redesign team.

All flights with the same origin and destination shared the same route in these simulations. Changes in route preference during the day due to changes in winds and congestion were omitted. Traffic to and from airports that are close together but far from the study area (for example, the three airports around San Francisco Bay) was frequently placed on different routes in order to reproduce the daily variation in route loading observed in flight plans from the ETMS.

Heuristics were developed to provide a method to assist in route design and route length comparisons among the different airspace design scenarios. With these heuristics, and through additional analysis of ETMS data, the Future No Action route and other alternative routes were compared and made consistent with each other to the point where the routes diverged based on the airspace design.

3.5 Wake Turbulence Separations

Standard wake turbulence separations have been derived from operational observations at a number of airports and account for the fact that separations in Visual Flight Rules (VFR) tend to be less than the Instrument Flight Rules (IFR) minima. Adjustments were made to the standard wake turbulence separations to match simulation results to conform to Automated Radar Terminal System (ARTS) data. ARTS provides track information on flights within a 60 mile radius of a terminal radar.

3.6 Altitude Restrictions

Altitude restrictions for the Future No Action, Modifications to Existing Airspace, and Integrated Airspace Alternatives were determined from 2002 Jeppesen approach plates and facility standard operating procedures. Altitude restrictions for the Integrated Airspace with Integrated Control Complex Alternative were provided by the redesign team.

3.7 Sector Configurations

It was assumed that sectorization of the airspace would be appropriate to permit all routes to be used at their design efficiency in good weather. Arrival sectors were assumed to cause no delay in excess of that needed for proper sequencing of aircraft. Departure sectors were assumed to have the ability to space aircraft appropriately for handoff to the next en route facility or terminal.

3.8 Terminal Arrival and Departure Procedures

The terminal arrival and departure procedures for the Future No Action Alternative were derived from ARTS data trajectories, 2002 Jeppesen approach plates, and controller input.

Arrival and departure procedures for the other alternatives were based on modifications to the current procedures as coordinated and validated by the redesign team.

3.9 Airport and Runway Configuration

Two sets of runway configurations were simulated for the operational analysis. The highest capacity configurations of runways at JFK, LGA, PHL, and EWR/TEB (considered as a single unit) were combined into a single scenario designed to put the maximum stress on the airspace. Another scenario of lower capacity configurations for these five airports was simulated to place different stresses on the arrival airspace and show dependence of the efficiency metrics on runway configuration. These two configurations were determined by the redesign team to span the range of interest. Over time, the low capacity configurations handle about 45 percent of the operations; high capacity configurations handle the rest. PHL also has a high capacity and low capacity configuration (West and East respectively), but the airport configuration in PHL is not dictated by the common configurations of the major NY airports. Therefore the configurations are labeled "East" and "West" instead. PHL operates to the west about 75% of the time; to the east about 25%.

The runway configurations for low and high capacity are shown in Table 3-1. The arrival runways are indicated by the letter "A" followed by a space and then by the runway name(s), and the departure runways are indicated by the letter "D" followed by a space and then by the runway name(s). Note that the table also shows the "All Fours" configuration, which was simulated to support the environmental modeling only and is not part of the operational analysis. Other configurations were omitted, since none of the hundreds of observed combinations accounts for more than a few percent of operations in a year.

The satellite airports, ISP, HPN and MMU, with their correspondingly lower traffic, do not place different demands on the airspace according to their configuration, so a single runway configuration was chosen for each.

Table 3-1. Runway Configurations

Airport	Low Capacity Configuration	High Capacity Configuration	All Fours
JFK	A 31R,31L D 31L,31R	A 13L,22L D 13R,13L	A 04R,04L D 04L,04R
LGA	A 31 / D 04	A 22 / D 13	A 04 / D 31
ISP	A 24 / D 24	A 24 / D 24	A 24 / D 24
MMU	A 23 / D 23	A 23 / D 23	A 23 / D 23
EWR	A 04R,11 D 04L,29	A 22L,11 D 22R,29	A 04R,11 D 04L,29
TEB	A 06 / D 01	A 19 / D 24	A 01 / D 06
HPN	A 34 / D 34	A 34 / D 34	A 34 / D 34
Airport	**East**		**West**
PHL	A 09R,35 D 09L (35)	A 09R,35 D 09L (35)	A 27R,35 D 27L (35)

Note that for the Integrated Airspace with Integrated Control Complex Alternative, EWR handles dual arrivals on Runway 04L/04R and Runway 22R/22L.

In addition to the runway usage depicted in Table 3-1, there are additional constraints applied to the runways based upon configuration and alternative. These constraints will be discussed in the following subsections.

3.9.1 John F. Kennedy International Runway Usage

Figure 3-2 is a graphical depiction of the runway configurations analyzed for JFK.

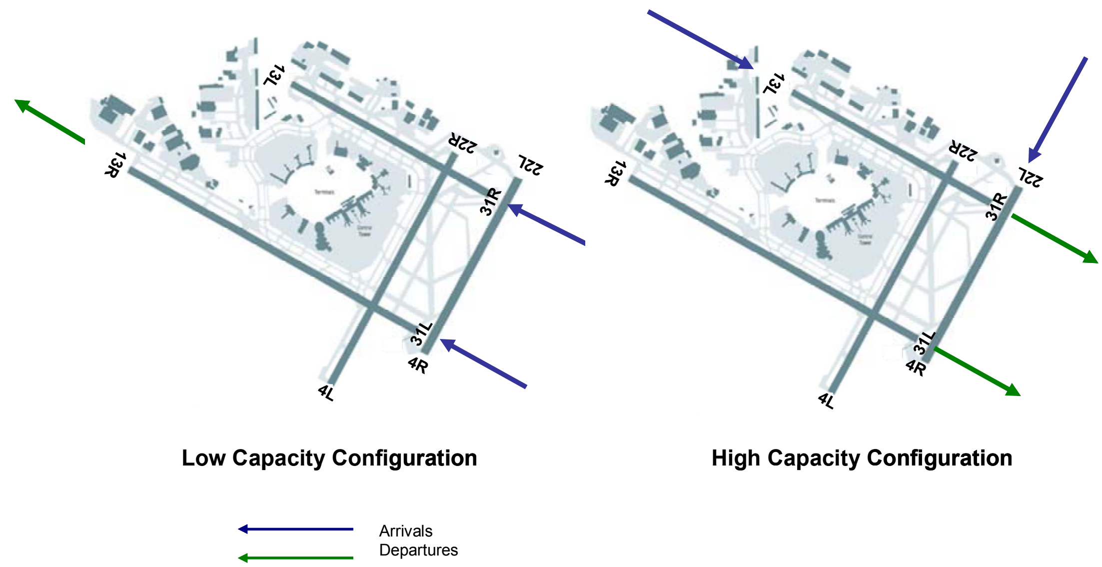

Figure 3-2. JFK Runway Usage

3.9.1.1 JFK Departure Runway Headings

Table 3-2 lists the headings used for departures from JFK. Note that, in the high capacity configuration case, jets and propeller-driven aircraft use different headings when departing from Runway 13R/L.

Table 3-2. JFK Departure Runway Headings (Degrees)

	Gate	JFK Runways 13s	31R	31L
Future No Action, Modifications to Existing Airspace and Integrated Airspace Alternatives	**new?**	no	no	no
	North	110j/90p	Not permitted	CRI
	East	110j/90p	Not permitted	CRI
	WATRS	155/170	Not permitted	CRI
	South	185	Bzy	Bzy
	West	Not permitted	Not permitted	Not permitted
Ocean Routing Alternative	**new?**	no	no	no
	North		Not permitted	
	East		Not permitted	
	WATRS		Not permitted	
	South			
	West	Not permitted	Not permitted	Not permitted
Integrated Airspace with Integrated Control Complex Alternative	**new?**	yes	yes	yes
	North	100j/85p	90	165
	East	100j/85p	90	165
	WATRS	130/150	Not permitted	185
	South	180	Bzy	Bzy
	West	115	Not permitted	Not permitted

A blank indicates no change from Future No Action Alternative

new? - ndicate whether the headings have changed from the Future No Action Alternative

j – indicates jet headings

p - indicates prop headings

Bzy – Breezy Point Climb (current procedure)

CRI – Carnarsie Climb (current procedure)

WATRS – West Atlantic Route System

3.9.1.2 Use of Runway 31L/R

In the low capacity configuration of the Future No Action Alternative, Runway 31L is the only runway used for departures while arrivals may land on both Runways 31L and 31R. The Modifications to Existing Airspace, Ocean Routing, and Integrated Airspace Alternatives operate the same way as in the Future No Action Alternative. In these four alternatives, in order to accommodate departures, jet arrivals may not land on 31L between the hours of 1100 – 1359 Greenwich Mean Time (GMT) and 2000 – 2300 GMT. Turboprops may land on Runway 31L 20% of the time and Runway 31R 80% of the time. All departing aircraft use Runway 31L. If an aircraft is approaching from the west or north and sequencing delay is less than 5 minutes and the aircraft is not a heavy jet, then Runway 31L is used. If an arrival aircraft is approaching from the east or south, then Runway 31R is used.

The Integrated Airspace with Integrated Control Complex Alternative operates a little differently. For example, this alternative allows Jet Blue departures (A320s) to use Runway 31R. Arrival aircraft approaching from the west or north may not land on Runway 31L. Turboprops that are not departing to the south may use Runway 31R. Most departures use Runway 31L. Arrival aircraft from the south use Runway 31L 10% of the time and Runway 31R 90% of the time.

3.9.1.3 Use of Runway 13L/R and 22L

In the high capacity configuration of the Future No Action Alternative, Runway 13R is used for departures and Runway 22L and 13L are used for arrivals. The Modifications to Existing Airspace, Ocean Routing, and Integrated Airspace Alternatives operate the same way as in the Future No Action Alternative. The departure waypoints are somewhat different from the Integrated Airspace with Integrated Control Complex but the same basic runway usage applies. Arrival aircraft from the south or west do not use Runway 22L; they instead use Runway 13L. Aircraft departing to the north that are not turboprops use Runway 13R. Aircraft arriving from the south use Runway 13L. International departures use Runway 13R.

3.9.2 LGA Runway Usage

The runway usage for LGA is shown in Table 3-1. In the low capacity configuration, arrivals use Runway 31 and departures use Runway 04. In the high capacity configuration, Runway 22 is used for arrivals while Runway 13 is used for departures. Figure 3-3 provides a graphical depiction of the runway configurations analyzed for LGA.

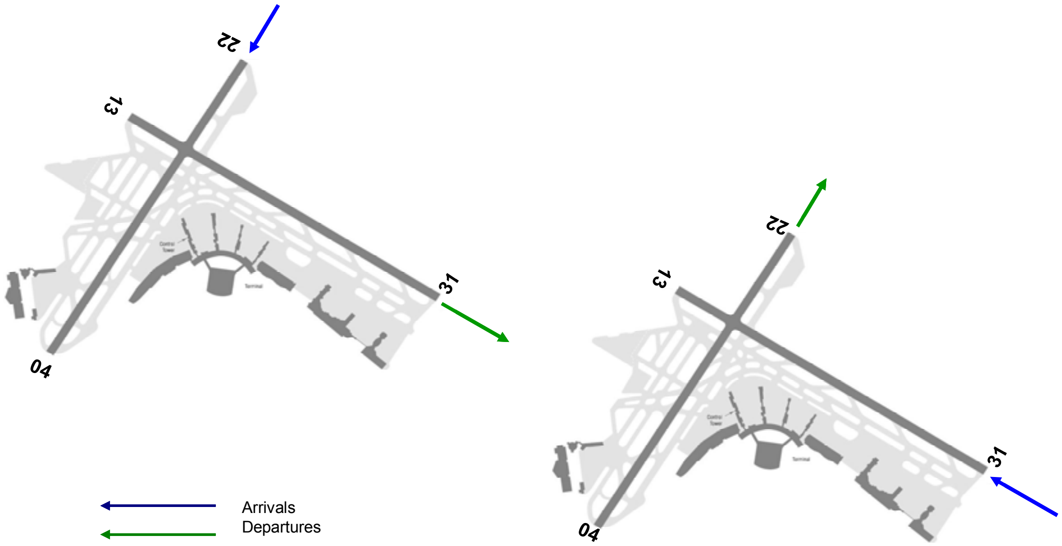

Figure 3-3. LGA Runway Usage

3.9.2.1 LaGuardia Departure Runway Headings

Table 3-3 shows the departure runway headings in degrees for LGA for each alternative.

Table 3-3. LGA Departure Runway Headings (Degrees)

		LGA Runways	
	Gate	**4**	**13**
Future No Action, and Ocean Routing Alternative	**North**	20	175
	East	40	175
	WATRS	60	175
	South	360	175
	West	360	175
Modifications to Existing Airspace and Integrated Airspace Alternatives	**North**	20	175
	East	40	175
	WATRS	60	175
	South	360	175
	West	360	175
Integrated Airspace with Integrated Control Complex Plan	**North**	20	175
	East	40	175
	WATRS	60	175
	South	350	175
	West	5	175

3.9.3 Long Island MacArthur Runway Usage

Runway usage at ISP is depicted in Figure 3-4. Both arrivals and departures use Runway 24. This configuration remains the same for both low and high capacity configurations and for all alternatives.

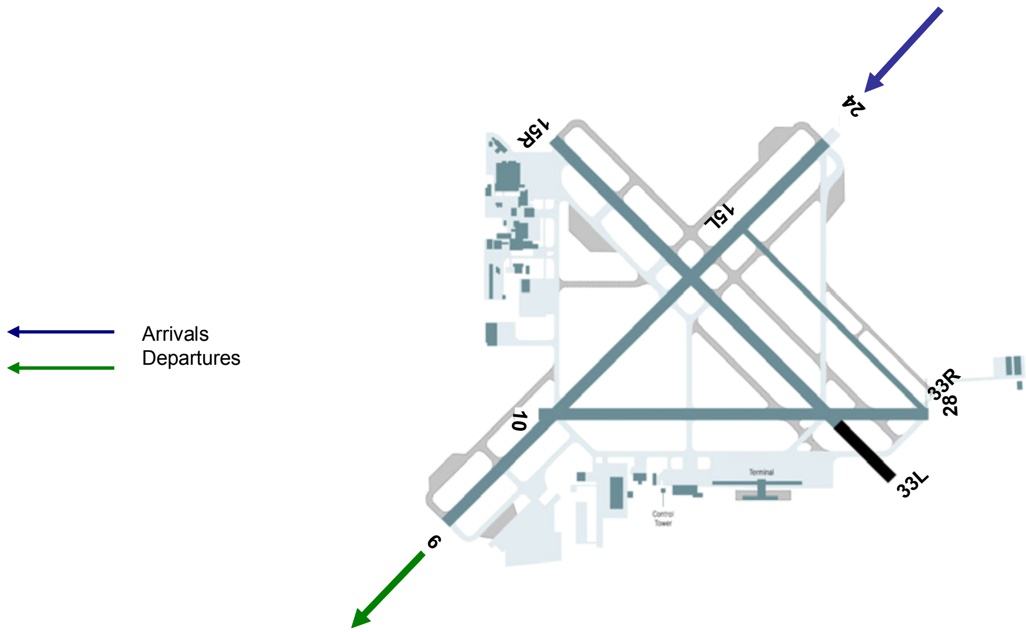

Figure 3-4. ISP Runway Usage

3.9.4 Newark Liberty International and Satellites Runway Usage

3.9.4.1 Newark Liberty International Runway Usage

Figure 3-5 shows EWR's runway usage for both the low capacity and high capacity configurations. In the simulations for the Future No Action, Modifications to Existing Airspace, Ocean Routing, and Integrated Airspace Alternatives; Runway 04R/22L and 04L/22R are the main arrival and departure runways, respectively. Arrival Runway 11 and departure Runway 29 are used as overflow runways during the peak arrival and departure hours, respectively, and are limited to light jets and propeller-driven aircraft. Runway 29 is used from 1000 – 1600 GMT; Runway 11 is available for use during the remaining hours. To more accurately represent their usage, Runway 11 was modeled with 15 miles in trail (MIT) at the runway; Runway 29 has 10 MIT at the runway. For the low capacity configuration, aircraft filing over one of the east-side departure fixes (GREKI, MERIT, BAYYS, and their equivalents in the other alternatives) do not use Runway 29, since that would cause them to cross the other departure streams at altitude. Low capacity arrivals from the south (Yardley [ARD], Robbinsville [RBV], and their equivalents in the other alternatives) do not use Runway 11 since that would cause them to cross the arrival stream for 04R. In the high capacity configuration, aircraft filing over the south-side departure fixes (DIXIE, WHITE, and their equivalents in the other alternatives) do not use Runway 29 because they would cross the Runway 22R departure paths.

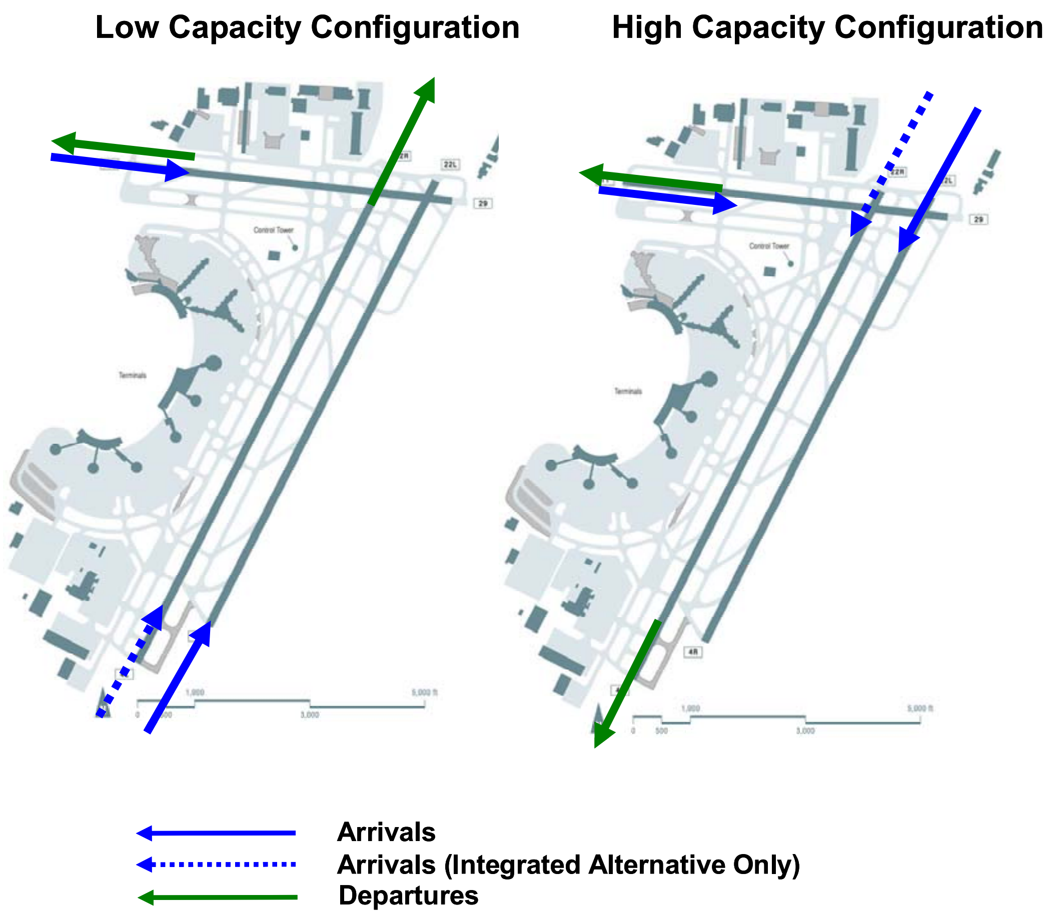

Figure 3-5. EWR Runway Usage

For the Integrated Airspace with Integrated Control Complex Alternative, the runways are used in a similar manner with the addition that the main departure Runway 04L/22R also supports limited arrivals when the main arrival runway is busy and the departure runway is underutilized (1615-1815 GMT and 2359-0915 GMT). To ensure that Runway 04L/22R is not over-utilized by TAAM, 04L/22R has 12 MIT at the runway for arrivals. Based on the wake turbulence criteria between the dual arrival runways, Runway 04L/22R is not used by wide body jets. The rules for Runways 29/11 apply as in the Future No Action Alternative except that for the low capacity configuration, Runway 11 is used by propeller-driven aircraft and piston aircraft only.

3.9.4.1.1 Newark Liberty International Departure Runway Headings

Table 3-4 shows the departure runway headings in degrees for EWR for each alternative.

Table 3-4. EWR Departure Runway Headings (Degrees)

		EWR Runways			
	Gate	**4s****	**11**	**22s**	**29**
Future No Action and Ocean Routing Alternatives	**new?**	no	no	no	no
	North	60-290		190	
	East	60-330		190	
	WATRS	Not permitted	Not permitted	Not permitted	Not permitted
	South	60-240		190	
	West	60-280		190	
Modifications to Existing System Integrated Airspace Alternative	**new?**	no	no	yes	no
	North	60-290		260*	300
	East	60-330		260*	300
	WATRS	Not permitted	Not permitted	Not permitted	Not permitted
	South	60-240		220	280
	West	60-280		240	240
Integrated Airspace with Integrated Control Complex Alternative	**new?**	no	no	yes	no
	North	60-290		260*	300
	East	60-330		260*	300
	WATRS	60-330	Not permitted	260*	Not permitted
	South	60-240		220	280
	West	60-280		240	240

A blank indicates no change from Future No Action Alternative

new? - Indicates whether the headings have changed from the Future No Action Alternative

* - a 240 degree heading is used when Runway 11 is open for arrivals

** - “60-.”: common initial heading, then divergence

WATRS – West Atlantic Route System

For the low capacity configuration, the departure headings are similar among the alternatives. In the Integrated Airspace with Integrated Control Complex Alternative, transatlantic traffic from EWR will be permitted access to oceanic fixes that are currently available only to JFK departures.

3.9.4.2 Teterboro Runway Usage

Figure 3-6 shows the runway usage for TEB airport. Runway usage is the same across alternatives. In the low capacity configuration, Runway 6 is used for arrivals and Runway 1 is used for departures. In the high capacity configuration, Runway 19 is used for arrivals and Runway 24 is used for departures.

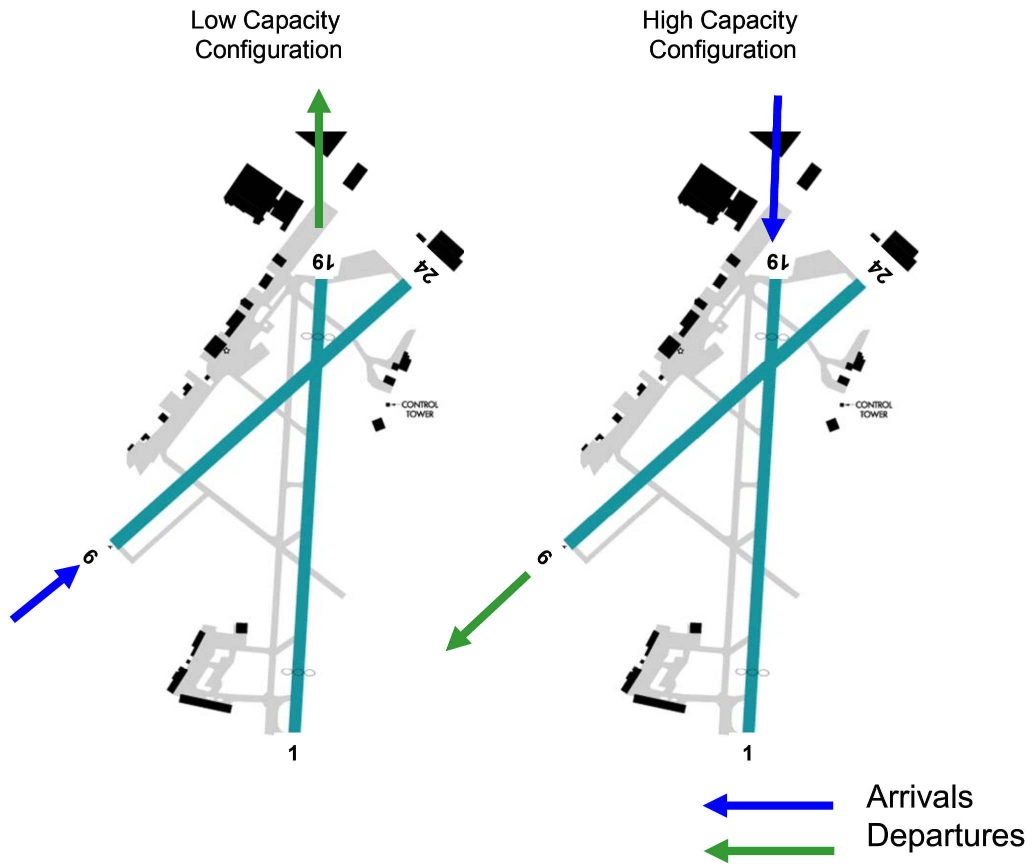

Figure 3-6. TEB Runway Usage

3.9.4.3 Morristown Municipal Runway Usage

Runway usage at MMU is the same for both the low and high capacity configurations as shown in Figure 3-7. Runway 23 is used for both arrivals and departures.

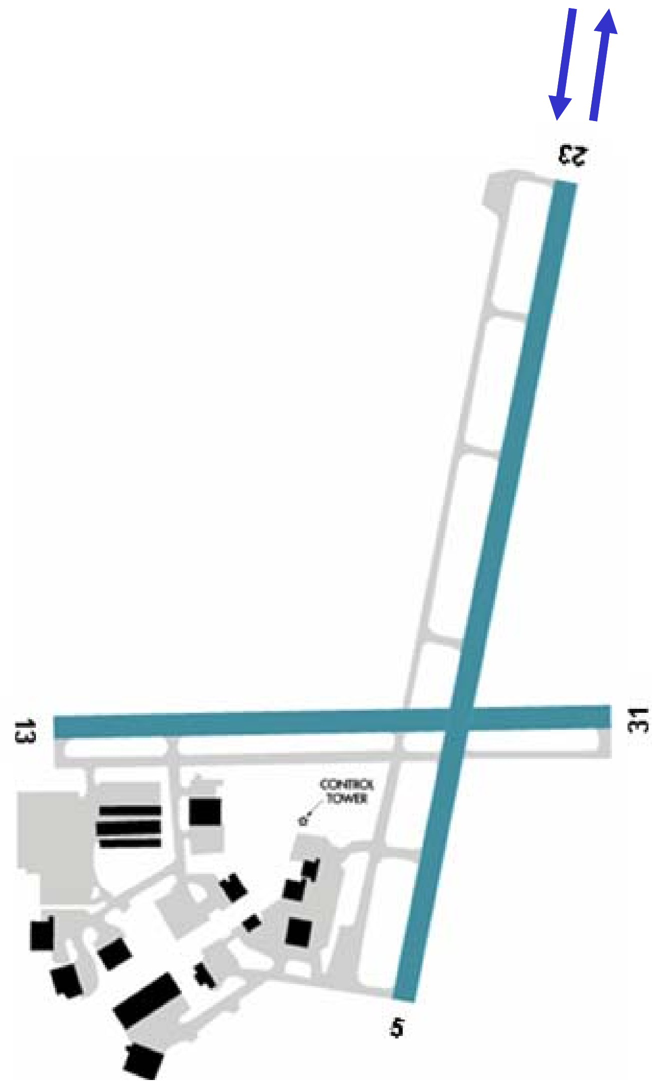

Figure 3-7. MMU Runway Usage

3.9.5 Philadelphia International Airport Runway Usage

PHL is currently involved in a master planning process that may change its runway layout completely in 2012. This is after the study years for this airspace redesign, so it is important to bear in mind the potential for a completely different operation in the PHL approach control. For the purposes of this study, a minimal change to PHL runways is assumed: a lengthened Runway 17/35 that permits expanded regional jet operations.

Figure 3-8 shows the runway usage for PHL. In all simulated alternatives, runway usage is the same. In the west configuration, Runway 27R is used for arrivals and Runway 27L is used for departures. In the east configuration, 09R is used for arrivals and Runway 09L is used for departures. Runway 35 is used for arrivals and departures in either configuration. Runway 35 is limited to propeller-driven aircraft, jets of regional-jet size or smaller and all general aviation traffic. Aircraft filing over one of the south-side departure fixes (DITCH, Woodstown [OOD], and their equivalents in the other alternatives) do not use Runway 35, since that would cause them to cross the other departure streams at altitude. In the east configuration, Tower En route Control (TEC)[1] aircraft to NY via RBV do not use Runway 35 for the same reason.

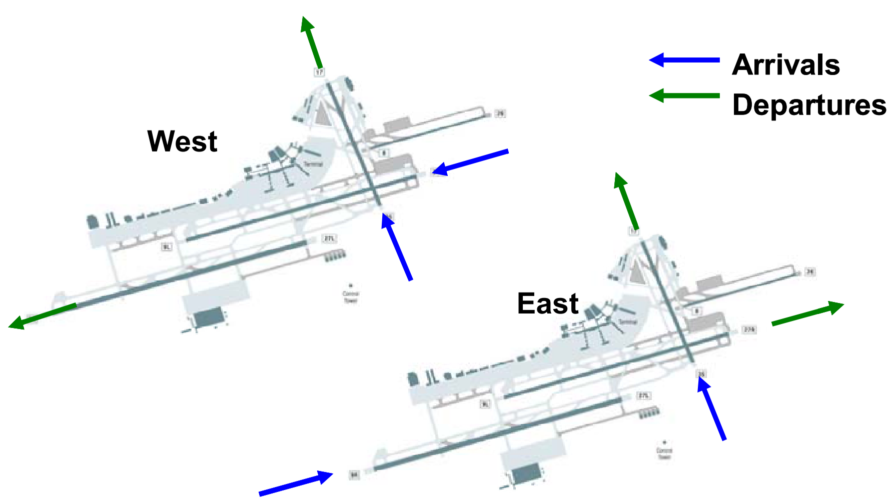

Figure 3-8. PHL Runway Usage

In the west configuration, departures on the main runway (27L) are not affected by operations on the transverse runway. The main arrival runway (27R) intersects the

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[1] As defined in the FAA Aeronautical Information Manual (AIM), TEC is an air traffic control (ATC) program to provide a service to aircraft proceeding to and from metropolitan areas. It links designated Approach Control Areas by a network of identified routes made up of the existing airway structure of the National Airspace System. Go to Para. 4-1-18 of http://www.faa.gov/ATpubs/AIM/ for more information on this topic.

transverse runway near the approach end. Arrivals to the main runway have priority over departures from the transverse runway; priority of arrivals to the two runways is determined by the approach control on a first-come, first-serve basis.

In the east configuration, arrivals to the main runway (09R) are independent of the other runways, but departures intersect the transverse runway near the airborne end. The east configuration is lower in capacity as a result. The interaction between traffic on the main runway with Runway 35 traffic is the same as in the westbound case, except that the contending traffic is a departure, so it is possible for the arrival to 35 to have priority.

No attempt was made to balance runway loading dynamically during the course of the simulation because it makes the delay metric highly sensitive to tiny changes in route length. In this case, the simulation does not permit the user to specify the (scheduled) arrival order in a way that is consistent across the alternatives. Therefore a small change in route could lead to large swings in delay among the alternatives that are not due to airspace changes, obscuring the effects to be measured.

3.9.6 Westchester County Runway Usage

For all alternatives, both arrivals and departures use Runway 34. Figure 3-9 provides a graphical depiction of the runway configuration analyzed for HPN.

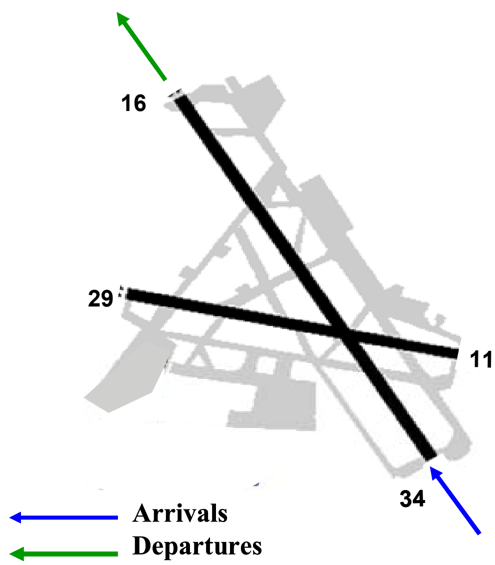

Figure 3-9. HPN Runway Usage

3.9.6.1 Westchester County Departure Runway Headings

Table 3-5 shows the departure runway headings for HPN for each alternative.

Table 3-5. HPN Departure Runway Headings (Degrees)

	Gate	4
Future No Action, and Ocean Routing Alternative	North	295
	East	295
	WATRS	None
	South	295
	West	295
Modifications to Existing Airspace and Integrated Airspace Alternatives	North	295
	East	295
	WATRS	None
	South	295
	West	295
Integrated Airspace with Integrated Control Complex Plan	North	295
	East	295
	WATRS	None
	South	295
	West	295

WATRS – West Atlantic Route System

3.10 Traffic Scenarios

Two levels of traffic demand were simulated for the operational analysis. Because the impact of good airspace design is not as measurable when the traffic demand is low, the 90th percentile day was simulated for the years 2006 and 2011. Annual-average days for those years were simulated to support environmental modeling, but operational metrics were not calculated at those traffic levels.

Traffic data for 2006 and 2011 was developed by Landrum and Brown and is based on the demand forecast as described in the *FAA New York Airspace Study: Forecast of Aviation Activity.*[2] The number of flights for each airport for the 90th percentile day for the years 2006 and 2011 is shown in Table 3-6.

2 This paper forecasts traffic based on expected regional airport trends, airline yield, new aircraft , and other factors such as the adaptation of air carriers in a new aviation economy.

Table 3-6. Arrival/Departure Traffic File Counts

Airport	2006 Arrivals	2006 Departures	2011 Arrivals	2011 Departures
JFK	624	616	684	671
LGA	646	668	646	668
ISP	87	88	100	103
MMU	55	57	61	65
EWR	782	793	813	821
PHL	889	875	968	954
TEB	393	401	448	452
HPN	119	121	126	129

3.10.1 Traffic Levels at LaGuardia (Forecast vs. Realistic)

The LGA 90^{th} percentile traffic files for 2006 and 2011, based on expected regional trends and other factors, contain levels of demand exceeding the capacity of the airport. These traffic files did not take into account the constraints on the airport based the actual runways in use. A simulation with such unreasonable demand will not produce meaningful results, as flights due to arrive at night continue to arrive well into the next morning. In order to produce a simulation with meaningful results, the traffic levels must be reduced to a size that is consistent with the airport's maximum theoretical capacity considering runway configuration and usage, but no airspace constraints.

In order to accomplish this, flights were removed from the latter part of the day's traffic. Single leg arrivals after 2000 GMT and single leg departures after 2100 GMT were deleted from each traffic file. All flights after 0300 GMT were removed from each traffic file. The original 90^{th} percentile traffic files each had 1,403 flights. Following the procedure described above, 89 flights were removed from the end of the day's demand to produce a manageable traffic file of 1,314 flights. This procedure produced traffic levels that still stressed the airport past the observed airport capacity, but it produced output metrics that have a reasonable interpretation.

Figures 3-10 and 3-11 illustrate the original traffic demand, deleted flights, and resulting modified demand for the 2006 and 2011 traffic files, respectively. Note that this reduction in traffic levels was only necessary for LGA.

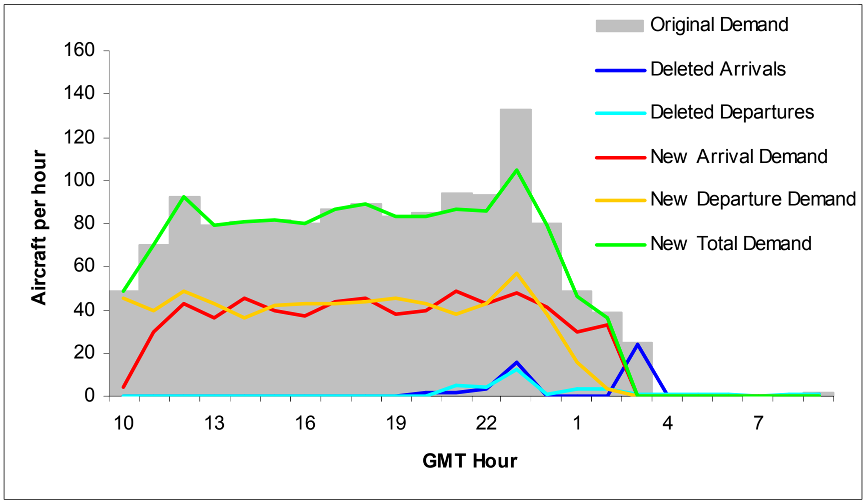

Figure 3-10. LGA 2006 Traffic Modifications

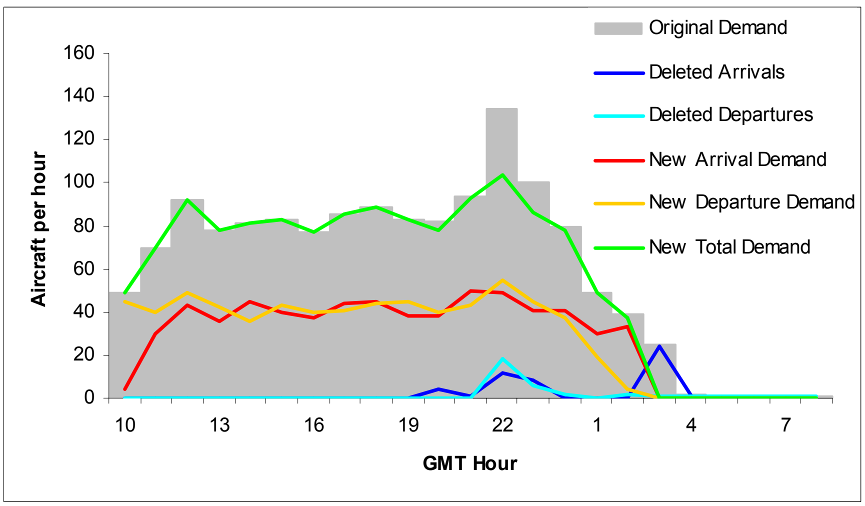

Figure 3-11. LGA 2011 Traffic Modifications

3.10.2 Approach to MIT Application for the Modeling of LaGuardia Traffic

Despite the reduced demand of the modified traffic file for LGA, the traffic levels remained high enough to require the use of MIT to control traffic flows into the NY TRACON. Due to airport specific requirements of LGA and the limitations of TAAM in modeling those requirements, the conventional method for the placement and use of MIT was ineffective. Consequently, the successful modeling of the traffic was achieved through an alternate approach.

In order to develop an appropriate application of the necessary MIT for the LGA traffic, it was decided that the separation should be built into the timing of the traffic file that was used as input to the TAAM model. In other words, the required separation was identified and each flight's departure time adjusted accordingly. The first step in this process was to determine the actual in-trail separation needed for each flow. Each traffic file for each scenario was simulated without the use of the sequencing option in TAAM. This, in effect, allowed the traffic to arrive unimpeded to the airport. From the output generated, the total number of flights crossing each arrival fix was noted, as well as the time at which each flight crossed its assigned fix (see Table 3-7.) From the total number of flights crossing each fix, the percentage of total traffic represented on each flow was determined (total number of flights crossing the arrival fix/total number of arrivals for the simulation). This percentage was then multiplied by the hourly target rate for the airport, yielding the number of arriving flights per hour that each flow should contribute. Once the breakdown of the hourly target arrival rate was obtained for each flow, the actual metering, in minutes of separation, to be applied was determined by dividing the hourly target arrival rate for each flow into 60 minutes. Any traffic flow that contributed only a small portion to the overall total was assigned a separation of 1.0 minute.

Table 3-7. Example Metering Calculations

Fix	# of Flights Crosing the Fix	% of Total Traffic	% of Target Arrival Rate	Min.Sep. (60/(% of Arrival Rate))
Fix 1	43	7%	2.33	1.0
Fix 2	138	21%	7.49	8.0
Fix 3	303	47%	16.44	3.6
Fix 4	161	25%	8.74	6.9

Table 3-8 shows the results of the above process: the in-trail separation applied to each configuration of each alternative. The Future No Action, Modifications to Existing Airspace, Ocean Routing and Integrated Airspace Alternatives share the same arrival routes and city-pair assignments. Consequently, the same in-trail separation values were applied in each respective configuration and traffic level. In the Integrated Airspace with Integrated Control Complex Alternative, the East and North flows were combined, as were the West and South flows, resulting in the need for only two time-based metering measurements for each configuration.

Table 3-8. LGA Time-Based Metering

	2006		2011		2011	
	Future No Action/Modifications to Existing Airspace/Integrated Airspace/Ocean Routing		Future No Action/Modifications to Existing Airspace/Integrated Airspace/Ocean Routing		Integrated Airspace with Integrated Control Complex	
Flow	**High Capacity**	**Low Capacity**	**High Capacity**	**Low Capacity**	**High Capacity**	**Low Capacity**
East	1.0	1.0	1.0	1.0		
West	6.7	7.8	6.8	8.0		
South	3.1	3.7	3.1	3.6	2.7	3.1
North	6.0	7.0	5.9	6.9	3.2	3.8

Once the appropriate metering for each flow had been identified, the departure time of each flight was adjusted accordingly by working backwards from the time each flight crossed its assigned arrival fix. The result was such that the flights on each arrival flow would then contain the correct separation in their flight plan.

3.10.3 Newark Liberty International MIT

EWR's traffic levels remained high enough to require the use of Minutes In Trail (MINIT) to control traffic flows into the NY TRACON as shown in Table 3-9 for both the low and high capacity configurations. The values were determined based on the percentage of aircraft arriving via each flow. A static setting for the whole simulation period was sufficient to regulate traffic while maintaining pressure on the airport and avoiding unnecessary delays.

Table 3-9. EWR MINIT

Flow	All Alternatives
West	3.6 min
South	3.2 min
North	5.5 min

3.11 Airport Throughput Validation

Over a volume the size of the NY/NJ/PHL study area, airspace is not always the most important constraint on operations. Airport and runway capacity are frequently the constraining resource. Therefore, the simulation must begin with validated airport models. From the output of these models, a target maximum throughput was extracted. The throughput target represents the best performance of the airport if airspace did not interfere with operations. This section describes the validation of the airport models in terms of throughput.[3]

Airports in this study fall into three types: capacity-constrained airports with CATER data available, capacity-constrained airports with CATER data not available, and airports that are not capacity-constrained.

For the biggest airports in New York City, throughput was validated against CATER collected by the Port Authority in 2000. The simulated days in 2006 and 2011 to be used in this study are artificial, but it was possible to find a day among the 366 in the CATER database that was in many respects similar to the annual-average traffic in 2006. The best matching traffic day was used to compile hourly traffic at JFK, LGA, and EWR. The models were tuned so that comparable performance was seen.

PHL is the entirety of the second type. CATER data is not available for PHL because the Philadelphia Department of Aviation uses different practices from the Port Authority's. At PHL, the throughput was validated against a ground simulation previously developed[4] at CAASD.

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3 Delay was not useful for validation, since delay is a convolution of dozens of factors, most of which will not obtain in the same way in 2011.

4 Canales, R., et al., July 2003, *Noise and Operational Analysis of Dual Modena Departures from Philadelphia International Airport*, The MITRE Corporation, McLean, VA.

The third type of airports are those that are not capacity-constrained. That is, forecast traffic is not sufficient to congest the runways at the airport for long periods. TEB is the largest of these airports, and is compared to CATER data. MMU, HPN, and ISP are also in this class; the predominance of VFR traffic makes it impossible to validate throughput at these airports against existing databases. Target throughputs for these airports were taken from currently declared arrival and departure acceptance rates.[5]

3.11.1 CATER Data for Capacity-Constrained Airports

Each of the following subsections contains two parts. In the first, the airport throughput as simulated for the median day in 2006 is compared to two days of recorded data from CATER. The chosen days are not the same for each airport; we have chosen two days for which (a) the airport was in the correct configuration all day and (b) the total operations count was close to the forecast traffic level.

In the second part, the forecast demand is compared to the simulated throughput. In those cases where the simulated throughput differs from the historical record, it is caused by large changes in the forecast demand. In these cases, the airport simulation is validated by ensuring that its response to the new demand patterns matches the historically-derived target throughput.

3.11.1.1 John F. Kennedy

Demand at JFK in 2000 was concentrated in the afternoon (around 2000 GMT) for arrivals, and early evening (around 2300 GMT) for departures. There is a peak of departures almost as intense in the morning. No single airline dominated the recorded data, so large variations in demand occurred from day to day. In the future, as Jet Blue is expected to expand its operation, demand will look more like the familiar pattern of repeated banks of arrivals followed by banks of departures. The simulated data show this pattern, where the historical data do not.

Some extreme peaks of performance are visible in the historical data. JFK frequently lands or departs more than its declared arrival rate, when particular coincidences of conditions occur. They can not be assumed in advance, and they do not last long. Where the CATER data showed traffic significantly in excess of the declared rates, the simulation was tuned to the declared rate, since 90th percentile demand in 2011 will require the airport to sustain its target capacity for several hours at a stretch.

Figures 3-12 through 3-15 show a comparison between the airport throughput as simulated for the median day in 2006 to two days of recorded data from CATER.

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5 Aviation System Performance Metrics Database, http://www.apo.data.faa.gov/faamatsall.HTM .

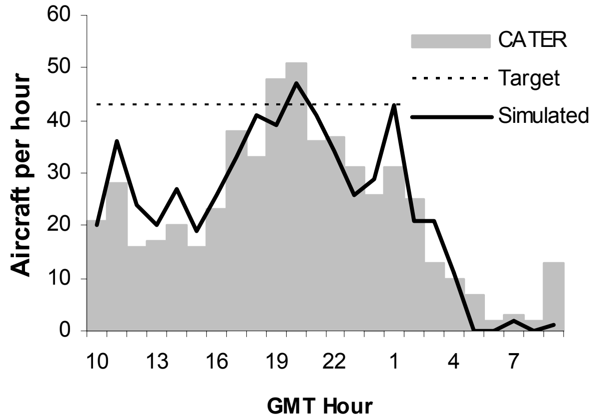

Figure 3-12. CATER vs. Simulated JFK Arrival Throughput, Low Configuration

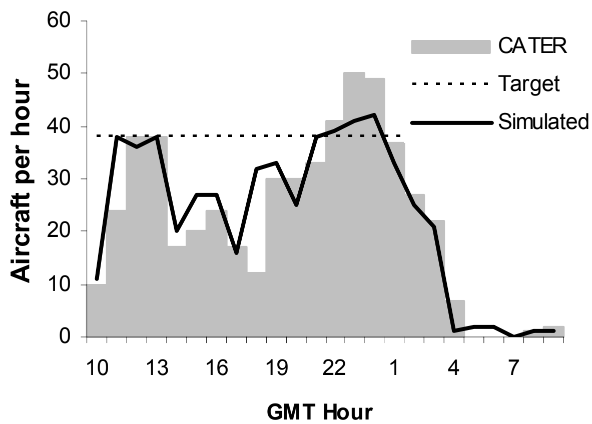

Figure 3-13. CATER vs. Simulated JFK Departure Throughput, Low Configuration

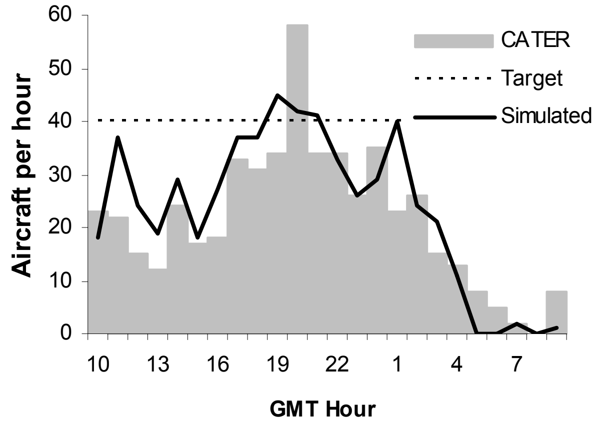

Figure 3-14. CATER vs. Simulated JFK Arrival Throughput, High Configuration

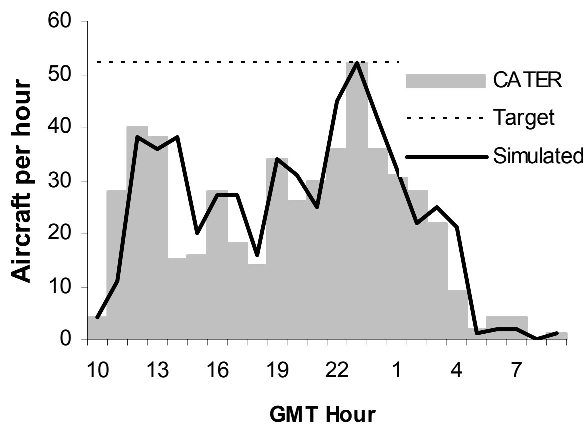

Figure 3-15. CATER vs. Simulated JFK Departure Throughput, High Configuration

Figures 3-16 and 3-18 show a comparison between the hourly arrival demand in the 2006 and 2011 traffic forecasts, the actual throughput observed in the TAAM model, and the target arrival throughput. Figures 3-17 and 3-19 shows a comparison between the hourly departure demand as provide in the 2006 and 2011 JFK traffic files, the actual throughput observed in the TAAM model, and the target departure throughput. Note that the terms “Low” and “High” at JFK refer to departure capacity. Arrival capacity is actually higher in Low configuration.

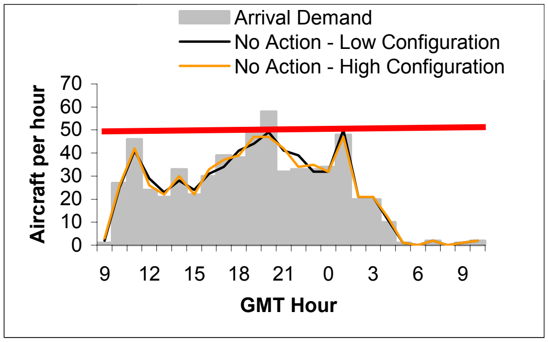

Figure 3-16. Future No Action 2006 Arrival JFK Throughput

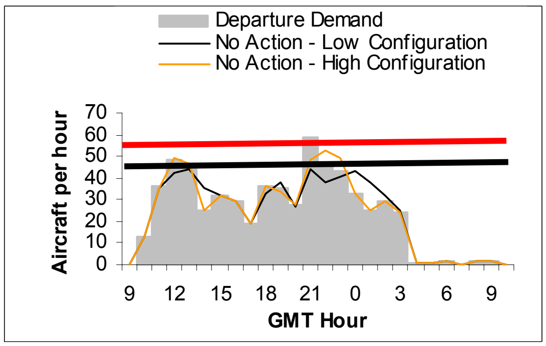

Figure 3-17. Future No Action 2006 Departure JFK Throughput

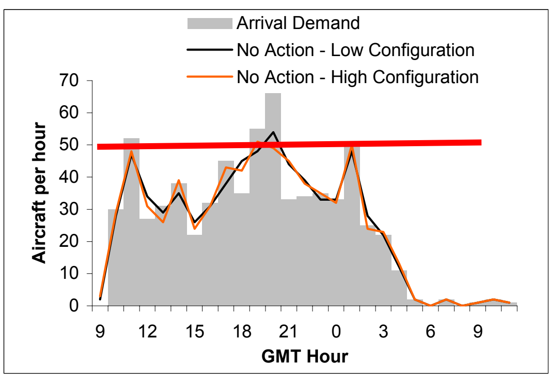

Figure 3-18. Future No Action 2011 Arrival JFK Throughput

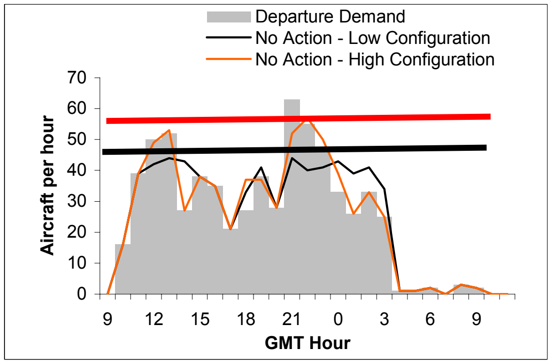

Figure 3-19. Future No Action 2011 Departure JFK Throughput

3.11.1.2 LaGuardia

Operations at LGA in 2000 changed dramatically from month to month. For the first part of the year, demand on the airport was regulated by the High Density Rule, as it had been since 1969. The High Density Rule was abolished by act of Congress in July, and demand immediately increased by 30%.[6]. Extraordinary delays resulted, so a form of slot-control by lottery was reinstated. The importance of those events for this work is that almost any desired level of demand on LGA can be found in the CATER data from 2000. Figures 3-20 through 3-23 show there is excellent agreement between simulated and observed traffic.

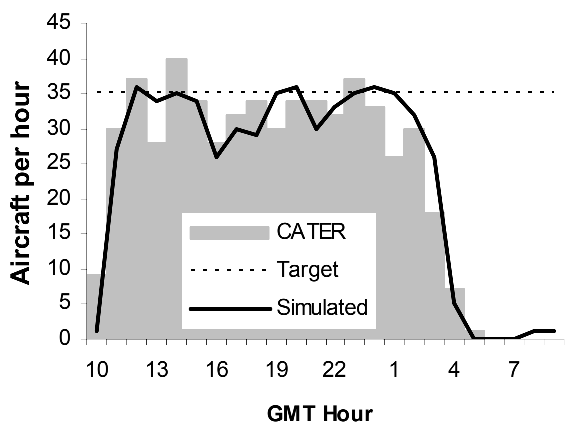

Figure 3-20. CATER vs. Simulated LGA Arrival Throughput, Low Configuration

6 J. Hoffman, *Demand Dependence of Throughput and Delay at New York LaGuardia Airport,* McLean, VA, The MITRE Corporation, April 2001

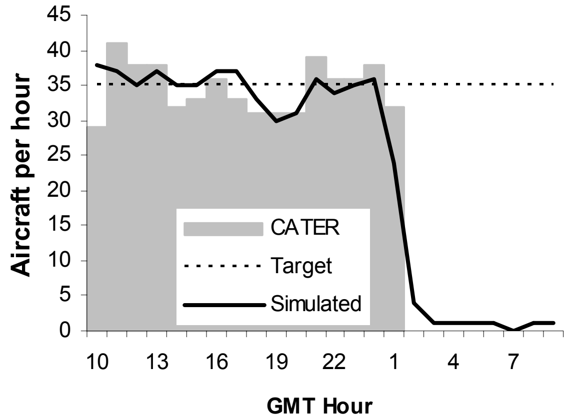

Figure 3-21. CATER vs. Simulated LGA Departure Throughput, Low Configuration

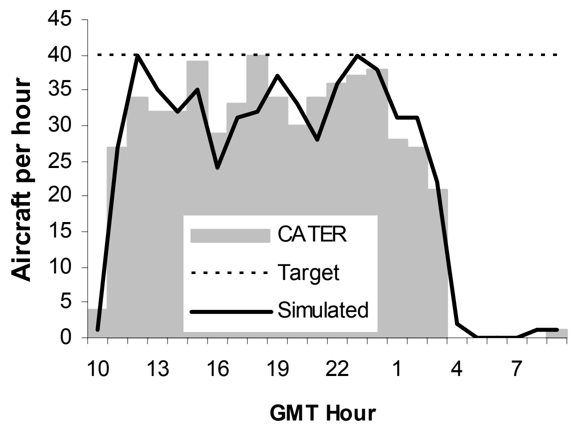

Figure 3-22. CATER vs. Simulated LGA Arrival Throughput, High Configuration

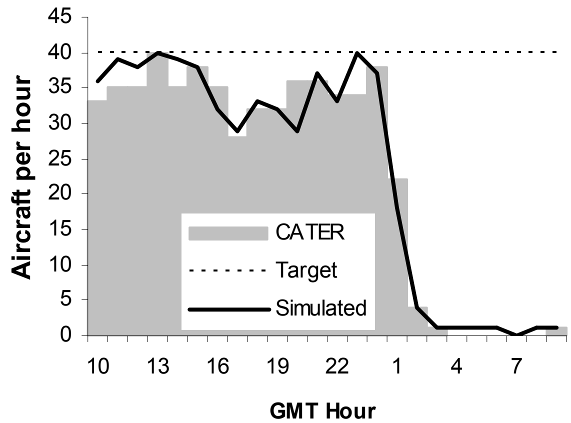

Figure 3-23. CATER vs. Simulated LGA Departure Throughput, High Configuration

Figures 3-24 through 3-27 show a comparison between the hourly total demand in the 2006 and 2011 traffic forecasts, the actual arrival/departure/total throughput observed in the TAAM model and the target throughput for each of the simulated traffic scenarios.

For most of the day, LGA operates with a "one-in-one-out" traffic flow. That is, between any two arrivals there is a departure and vice versa. This results in an equal number of arrivals and departures for any given hour of traffic, as well as preventing arrival or departure banks from forming. As LGA operates at full capacity throughout the day, the target throughput remains static at the level of runway capacity.

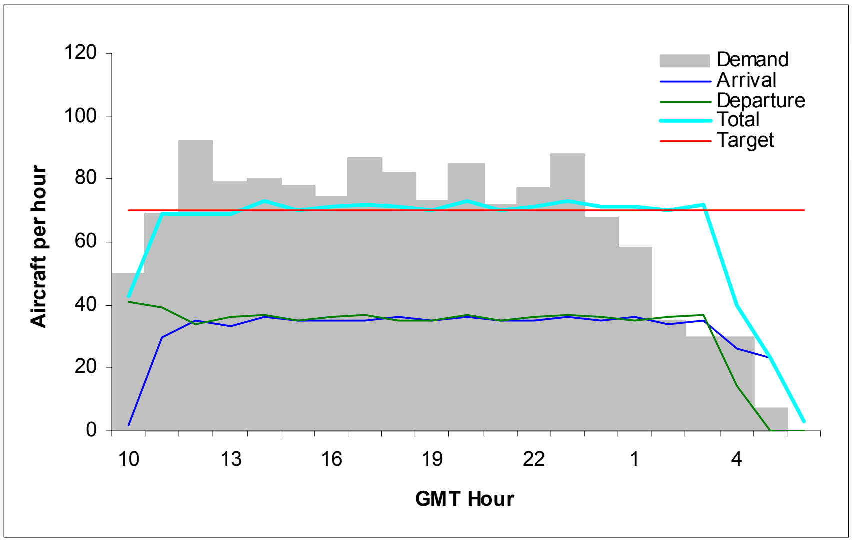

Figure 3-24. Future No Action 2006 LGA Low Capacity Configuration Throughput

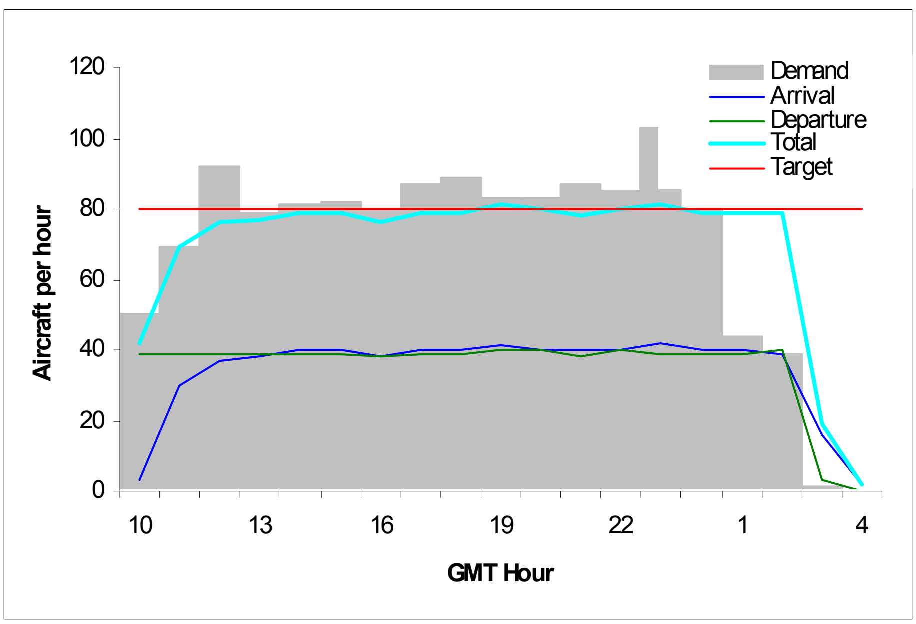

Figure 3-25. Future No Action 2006 LGA High Capacity Configuration Throughput

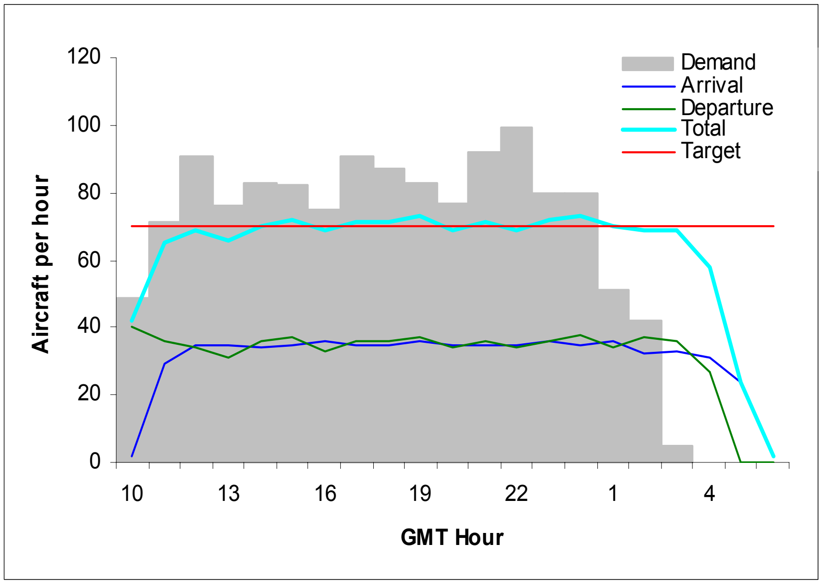

Figure 3-26. Future No Action 2011 LGA Low Capacity Configuration Throughput

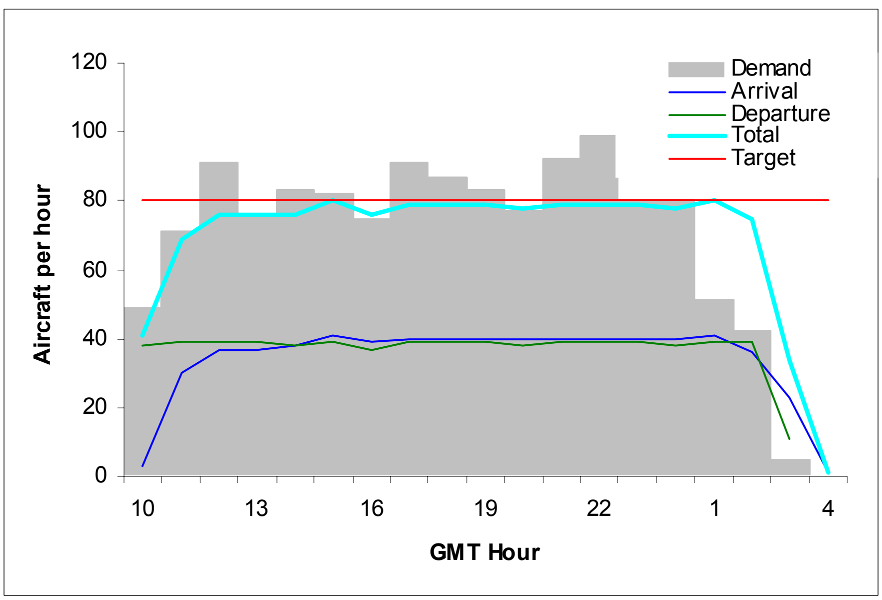

Figure 3-27. Future No Action 2011 LGA High Capacity Configuration Throughput

3.11.1.3 Newark Liberty International

Validation at EWR was done slightly differently. The overflow Runway 11/29 will be used differently from operations in 2000 (see Appendix B). Therefore, validation focused on the main runways only. Figures 3-28 through 3-31 compare single-runway throughputs, not full-airport throughputs.

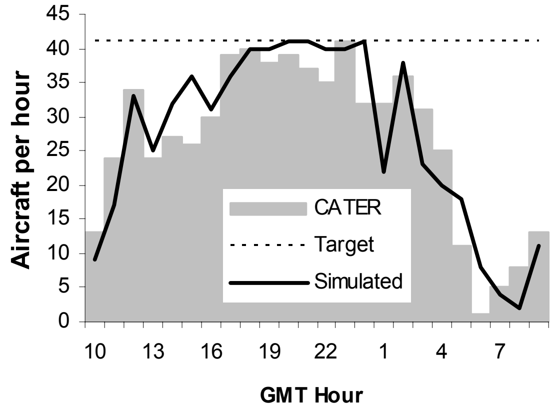

Figure 3-28. CATER vs. Simulated EWR 04R Arrival Throughput, Low Configuration

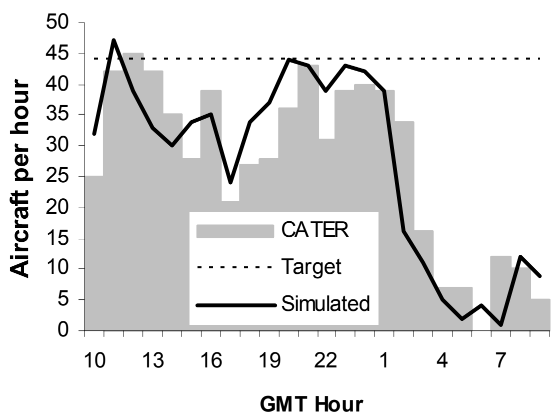

Figure 3-29. CATER vs. Simulated EWR 04L Departure Throughput, Low Configuration

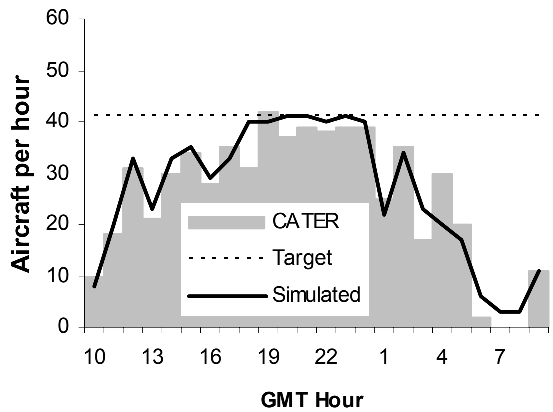

Figure 3-30. CATER vs. Simulated EWR 22L Arrival Throughput, Low Configuration

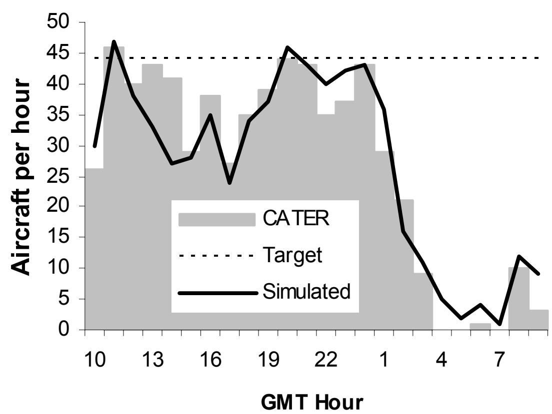

Figure 3-31. CATER vs. Simulated EWR 22R Departure Throughput, Low Configuration

Figures 3-32 and 3-34 show a comparison between the hourly arrival demand in the 2006 and 2011 traffic forecasts, the actual throughput observed in the TAAM model, and the target arrival throughput as obtained from CATER data for both the low capacity and high capacity configurations. Figures 3-33 and 3-35 show a comparison between the hourly departure demand in the 2006 and 2011 traffic forecasts, the actual throughput observed in the TAAM model, and the target departure throughput as obtained from CATER data for both the low capacity and high capacity configurations. The single-runway throughput targets are the lower plateau of the throughput targets in the figures; the higher plateau indicates use of the overflow runway in response to demand.

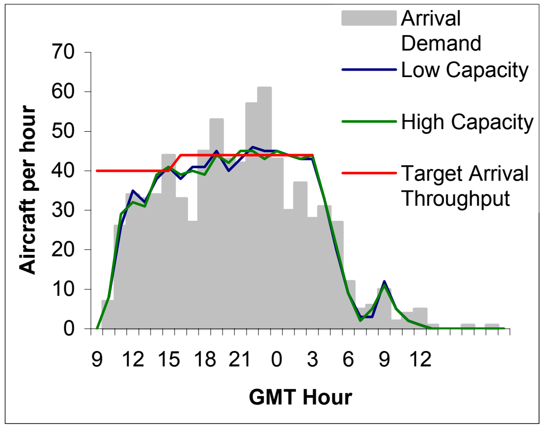

Figure 3-32. Future No Action 2006 Arrival EWR Throughput

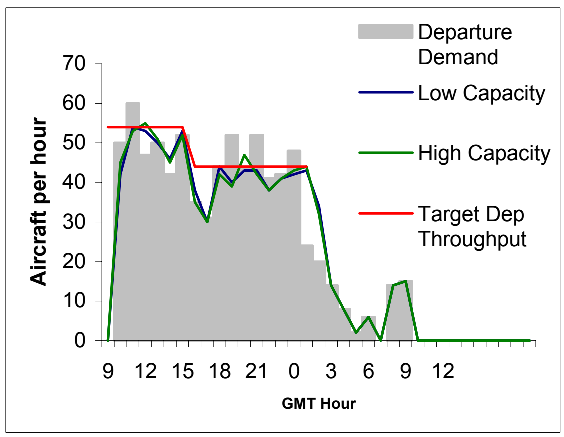

Figure 3-33. Future No Action 2006 Departure EWR Throughput

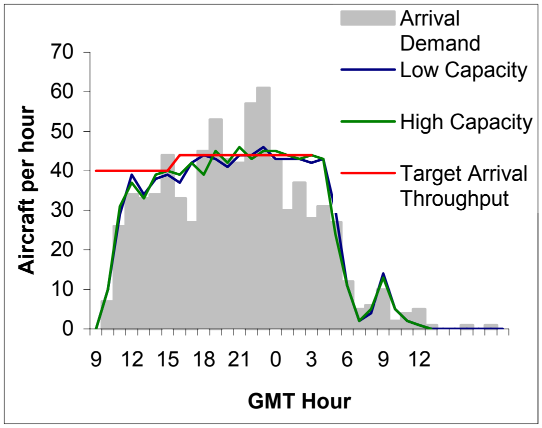

Figure 3-34. Future No Action 2011 Arrival EWR Throughput

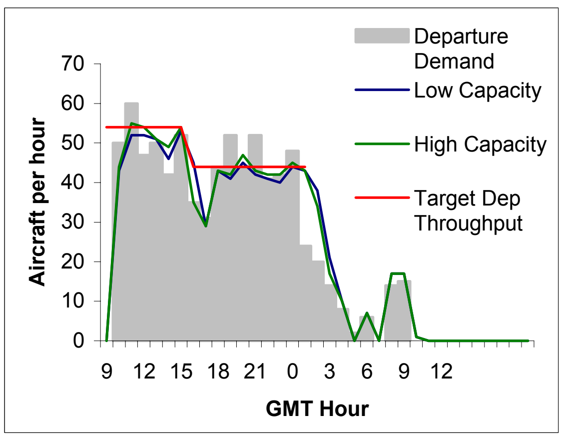

Figure 3-35. Future No Action 2011 Departure EWR Throughput

During the peak hours, the throughput closely aligns to the target throughput.

Runway 11/29 only changes its operations once during the day. Runway 29 is available for departures between the hours of 1000 to 1600 GMT and Runway 11 is available for arrivals for the remaining hours. Given these demand levels, total delay would increase significantly if Runway 29 was opened again for departures to meet the demand peaks in the 1900 and 2100 hours, so the overflow runway was used for arrivals instead.

Based on the Runway 11/29 operation, the target arrival throughput increases from 40 to 44 during the day and reflects the additional arrivals supported on Runway 11 in the afternoon. The target departure throughput decreases from 54 to 44 during the day and reflects the decreased departures as a result of closing Runway 29 in the afternoon.

3.11.2 Capacity-Constrained Airports Without CATER Data

3.11.2.1 Philadelphia International

Throughput at PHL was validated differently from throughput in NY, since CATER data are not available. Studies conducted in the past,[7] validated with the tower and with the principal carrier, gave target arrival throughputs for the main runway of 44 per hour in east configuration and 47 per hour in west configuration. An additional 13-15 arrivals on the (improved) transverse runway yield a total throughput of between 57 and 62 per hour. Six MIT are used for arrivals to the transverse runway, to avoid decreasing throughput on the parallels.

Figures 3-36 and 3-38 show the relation of simulated arrival throughput to demand and the desired throughput for 2006 and 2011. The demand contains very high peaks that the simulation correctly smoothes out to the desired throughput.

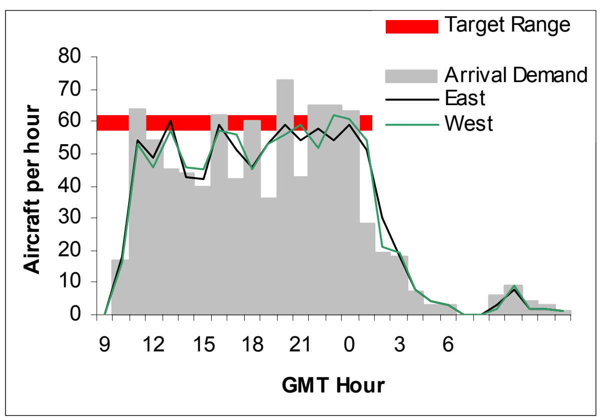

Figure 3-36. Future No Action 2006 Arrival PHL Throughput

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[7] Canales, R., et al., July 2003, *Noise and Operational Analysis of Dual Modena Departures from Philadelphia International,* The MITRE Corporation, McLean, VA.

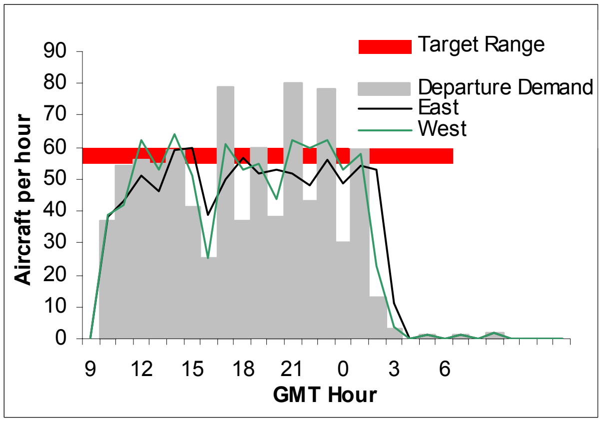


Figure 3-37. Future No Action 2006 Departure PHL Throughput

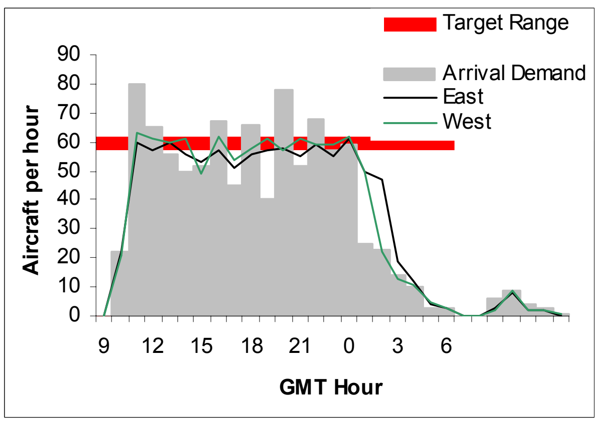


Figure 3-38. Future No Action 2011 Arrival PHL Throughput

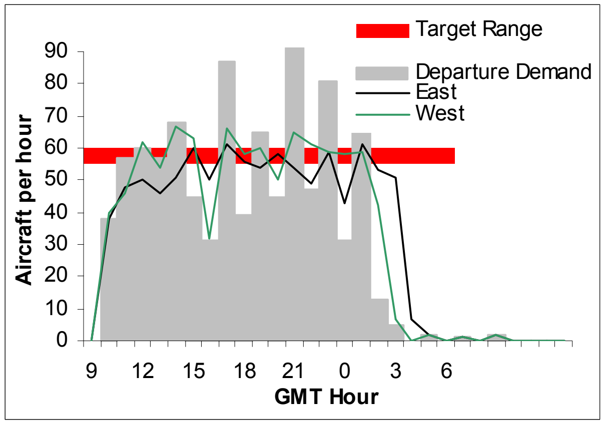


Figure 3-39. Future No Action 2011 Departure PHL Throughput

Figures 3-37 and Figure 3-39 show the relation of simulated departure throughput to demand and the desired throughput for 2006 and 2011. Departures from the main runway in east flow are set to be 40 per hour in east configuration, 45 in west configuration. Fifteen departures were permitted on the transverse runway, for a total of from 55 to 60 departures per hour.

3.11.3 Airports Not Constrained by Capacity

3.11.3.1 Long Island MacArthur

Figures 3-41 and 3-43 shows a comparison between the hourly departure demand in the 2006 and 2011 traffic forecasts, the actual throughput observed in the TAAM model, and the target arrival throughput. Figures 3-40 and 3-42 show a comparison between the hourly arrival demand as provided in the 2006 and 2011 ISP traffic file, the actual throughput observed in the TAAM model, and the target departure throughput. Note that the low and high capacity configurations are the same at ISP.

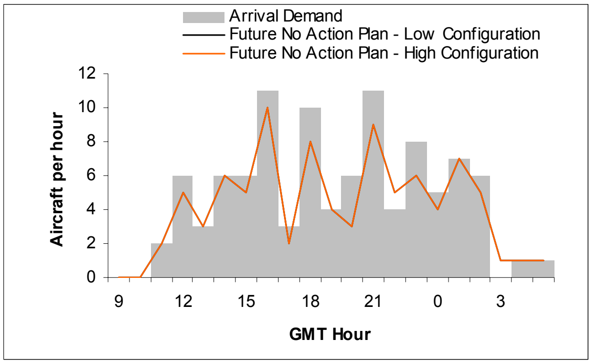


Figure 3-40. Future No Action 2006 Arrival ISP Throughput

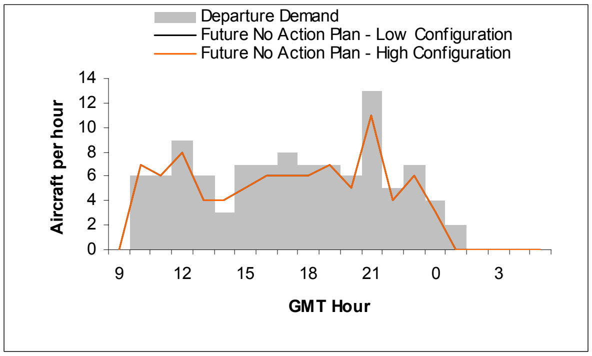


Figure 3-41. Future No Action 2006 Departure ISP Throughput

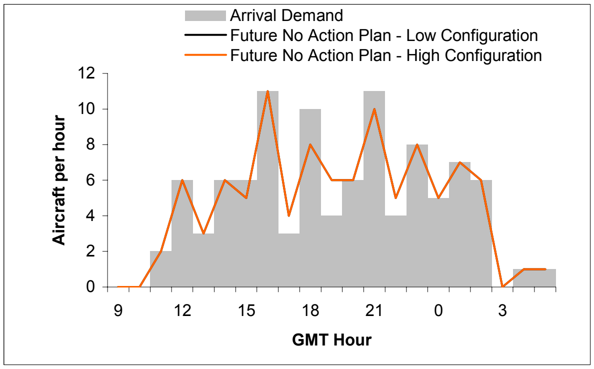


Figure 3-42. Future No Action 2011 Arrival ISP Throughput

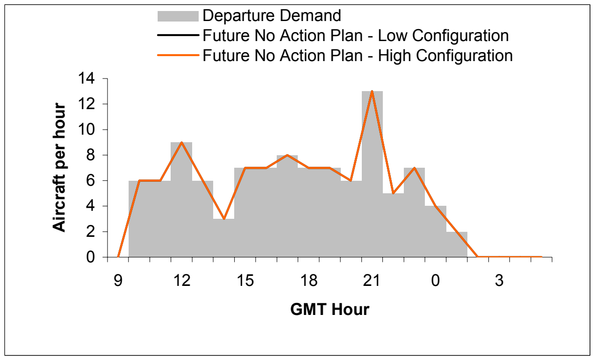


Figure 3-43. Future No Action 2011 Departure ISP Throughput

3.11.3.2 Newark Satellites (TEB and MMU)

Figures 3-44 and 3-46 show a comparison between the hourly arrival demand in the 2006 and 2011 TEB traffic forecast, the throughput observed in the TAAM model, and the target arrival throughput as obtained from CATER data. Figures 3-45 and 3-47 show a comparison between the hourly departure demand as provided in the 2006 and 2011 TEB traffic files, the throughput observed in the TAAM model, and the target departure throughput as obtained from CATER data. During the peak hours, the throughput closely aligns to the target throughput.

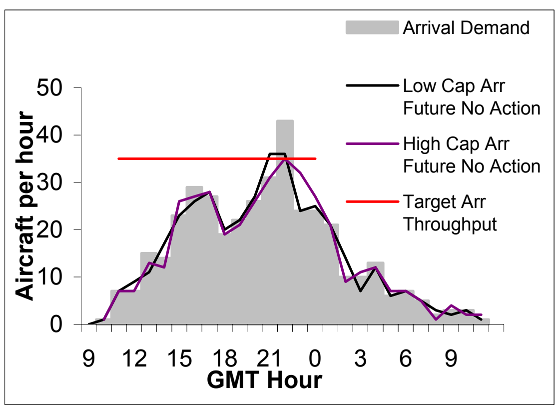


Figure 3-44. Future No Action 2006 Arrival TEB Throughput

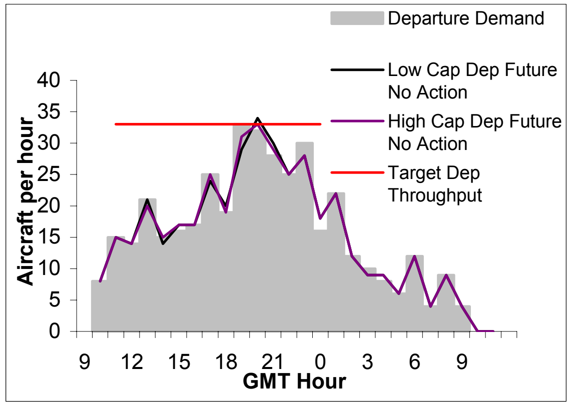


Figure 3-45. Future No Action 2006 Departure TEB Throughput

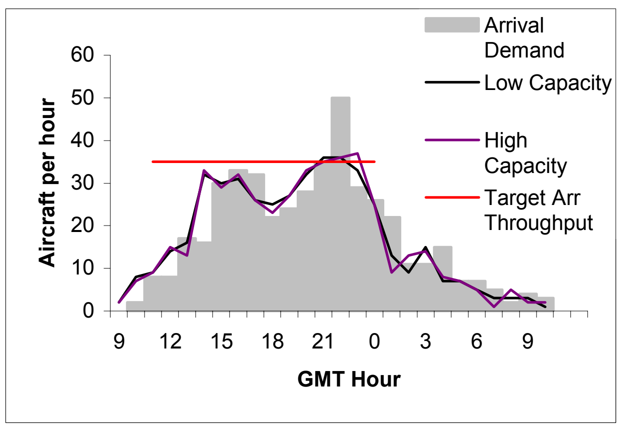


Figure 3-46. Future No Action 2011 Arrival ISP Throughput

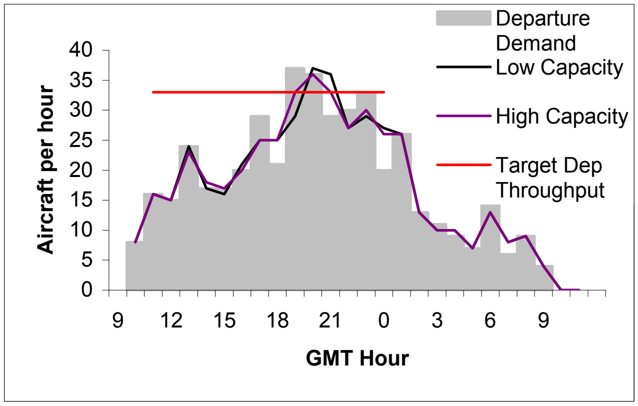


Figure 3-47. Future No Action 2011 Departure ISP Throughput

Figure 3-48 shows a comparison between the hourly arrival demand as provided in the 2006 MMU traffic file and the actual throughput observed in the TAAM model. Figure 3-49 shows a comparison between the hourly departure demand as provided in the 2006 MMU traffic file and the actual throughput observed in the TAAM model. Overall, the throughput closely aligns to the demand.

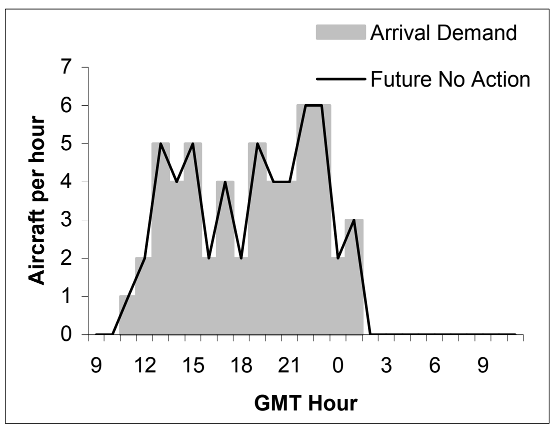


Figure 3-48. Future No Action 2006 Arrival MMU Throughput

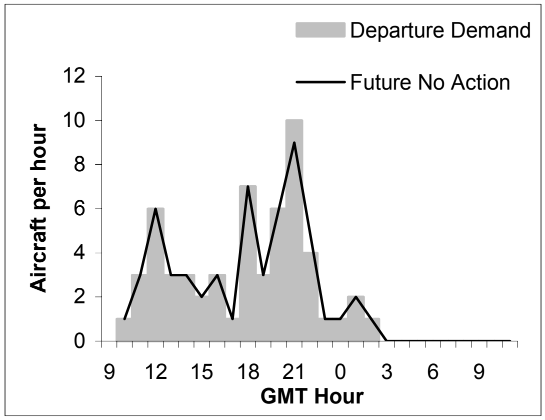


Figure 3-49. Future No Action 2006 Departure MMU Throughput

3.11.3.3 Westchester County

Figures 3-50 and 3-51 show a comparison between the hourly total demand in the 2006 and 2011 traffic forecast and the actual arrival/departure/total throughput observed in the TAAM model. The capacity of the airport was determined by calculating the number of flights a single runway could handle when operating with a mix of departure and arrival traffic. It is important to note the forecast traffic at HPN does not include flights operating under VFR. The IFR traffic levels never approach the calculated capacity of the single runway.

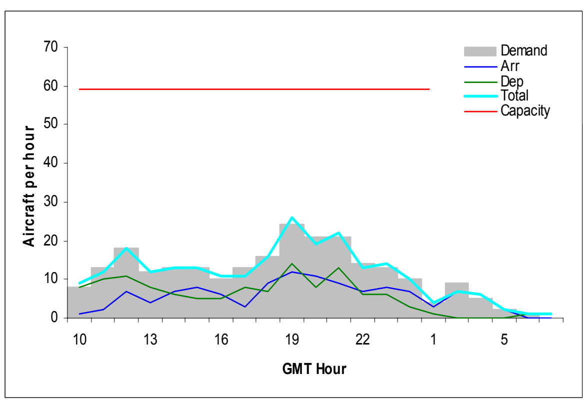


Figure 3-50. Future No Action 2006 Arrival HPN Throughput

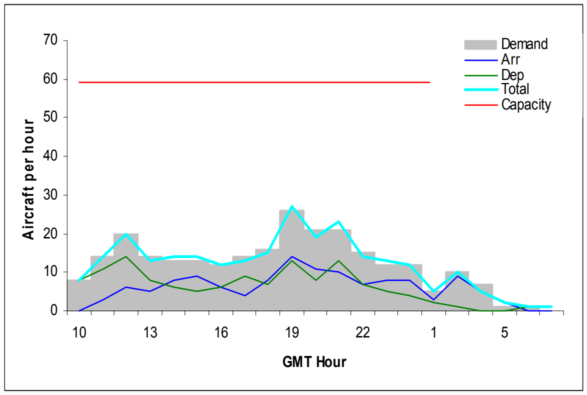


Figure 3-51. Future No Action 2006 Departure HPN Throughput

Section 4

Future No Action Alternative

4.1 Design Overview

Under the Future No Action Alternative, the airspace operates as it did during 2002, with a few improvements included that are independent of the large-scale airspace redesign proposals. These improvements are anticipated to be in place before the final NY redesign is completed.

Most important of these improvements is the split of the western departures from PHL into two streams. As of the base year (2000), all traffic was routed over the MXE. A separate stream was established in 2003 for traffic headed to the inland south and southwest (Atlanta and Charlotte, for example) along jet airways J48 and J75. Now that this is in place, the capacity of the junction between PHL and the en route airspace to the west has been effectively doubled.

Other improvements involve replacing current standard terminal arrival routes and departure procedures with FMS and RNAV overlays. Replacements like these are currently happening across the country, with the aim of reducing navigation workload for pilots and controllers.

Detailed operational TAAM modeling of this alternative was conducted for the highest-traffic subset of the airports (JFK, LGA, ISP, HPN, EWR, PHL, TEB and MMU) to be studied in the EIS. As part of the model development, the departure and arrival routes were derived from flight plan and flight track information from ETMS and validated with the redesign team. The terminal arrival and departure procedures were derived from ARTS data trajectories, 2002 Jeppesen approach plates, and controller input.

Based on the destination airport, the modeled departures typically use the same jet route and departure fix. The departure jet route and departure fix usage modeled in TAAM is described in Section 4.2. The specific en route and terminal arrival and departure profiles modeled in TAAM are described in Section 4.3.

4.2 Airspace

This section describes the modeled departure routes from the NY metro and PHL airports in the Future No Action Alternative. As described in Section 2.3.6, it is common that different departure fixes and jet routes are used for the same destination depending on time of the year, wind, weather, and congestion on specific jet routes. In this analysis, however, the departure fix and jet route that were observed to be most commonly taken are used with some adjustment to accommodate route variation.

Figure 4-1 illustrates NY metro and PHL departure routes. In the Future No Action Alternative, NY metro departures are grouped into five directions: North (via GAYEL, NEION, and COATE), west (via ELIOT, PARKE, LANNA, BIGGY, and RBV), south (via WHITE and WAVEY), east (via BAYYS, MERIT, and GREKI) and oceanic routes (SHIPP, HAPIE, and BETTE). Departure fixes used only by turboprop departures are not discussed in detail. South departures from NY metro airports have an option to use the off-shore radar route when there is a severe weather to avoid, but it was not included because the analysis assumed VMC. PHL departures are grouped into four directions by departure fix: Pottstown (PTW), Modena (MXE) and STOEN, Woodstown (OOD), and DITCH. Table 4-1 contains a list of the jet route and departure fix assignments based on the destination airport.

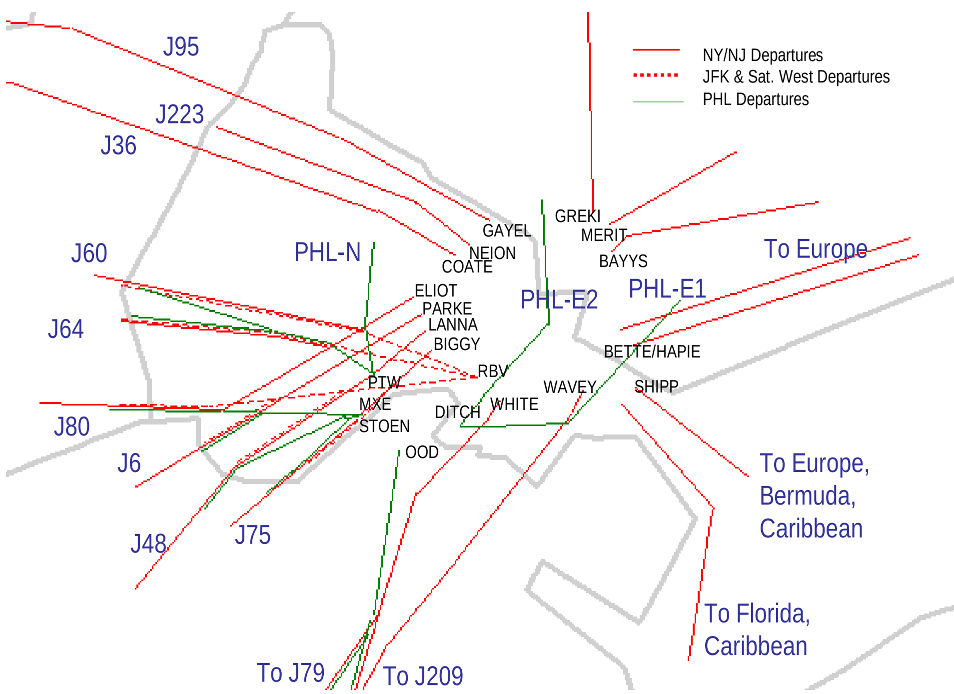


Figure 4-1. Future No Action Departure Routes

Table 4-1. NY Metro Departure Fix, Assigned Jet Route and Typical Destinations

	Dep Route	Dep Fix	Origin	Destination
North (*)	J95	GAYEL	NY Metro	Central Canada, Detroit Metro Wayne County (DTW), Los Angeles International (LAX), Minneapolis Saint Paul International (MSP), San Francisco International (SFO), Salt Lake City International (SLC), Northern Asia
	J223	NEION	NY Metro	Greater Buffalo International (BUF), Cleveland Hopkins International (CLE), DTW, Oakland County International (PTK), Greater Rochester International (ROC), Syracuse Hancock International (SYR)
	J36	COATE	NY Metro	Kent County International (GRR), General Mitchell International (MKE), ORD, Pittsburgh International (PIT), SFO, SL
	PHL-N	PTW	PHL	SYR, ROC, Elmira/Corning Regional (ELM), Tompkins County (ITH), Wilkes-Barre/Scranton International (AVP)
West (**)	J60	ELIOT/RBV	NY Metro	CLE, Denver International (DEN), McCarran International (LAS), Chicago-Midway (MDW), Eppley (OMA)
	J60	PTW	PHL	CLE, Denver International (DEN), McCarran International (LAS), Chicago-Midway (MDW), Eppley (OMA)
	J64	RBV/ELIOT PTW	NY Metro PHL	Findlay (FDY), Fort Wayne International (FWA)
	J80	ELIOT MXE	NY Metro PHL	Albuquerque International (ABQ), Port Columbus International (CMH) , James M. Cox Dayton International (DAY), Indianapolis International (IND), LAX, Kansas City International (MCI), PHL, PIT, San Diego International (SAN), Lambert-Saint Louis International (STL)
	J6	PARKE/RBV MXE	NY Metro PHL	DFW, Memphis International (MEM), San Antonio International (SAT), Tulsa International (TUL), Dallas Love (DAL), Cincinnati/Northern Kentucky International (CVG)
	J48	LANNA/RBV STOEN	NY Metro PHL	Hartsfield Atlanta International (ATL), Birmingham International (BHM), Houston Intercontinental (IAH), New Orleans International (MSY), Dekalb-Peachtree (PDK)

Table 4-1. NY Metro Departure Fix, Assigned Jet Route and Typical Destinations (concluded)

	Dep Route	Dep Fix	Origin	Destination
West (**)	J75	BIGGY/RBV STOEN	NY Metro PHL	Bush Field (AGS), Charlotte/Douglas International (CLT), Piedmont Triad International (GSO), Tampa International (TPA), Central Mexico
South (***)	J209	WHITE/WAVEY OOD	NY Metro PHL	Florida over water, Eastern Mexico, South America
	J79	WHITE/WAVEY OOD	NY Metro PHL	Florida over land, Jacksonville ARTCC (ZJX), Atlanta ARTCC (ZTL)
East	E-3	BAYYS	NY Metro	Theodore Francis Green State (PVD), Barnstable Municipal-Boardman/Polando Field (HYA), Nantucket (ACK)
	E-2	MERIT	NY Metro	Boston Logan International (BOS), Bangor International (BGR), Pease International Tradeport (PSM), North Atlantic
	E-1	GREKI	NY Metro	Ottawa/MacDonald-Cartier International (CYOW), Montreal International (CYUL), Burlington International (BTV), Manchester (MHT), Portland International (PWM)
	PHL-E1	DITCH	PHL	North Atlantic, BGR, Lebanon Municipal (LEB), PWM
	PHL-E2	DITCH	PHL	CYOW, CYUL, BOS, MHT, ALB (Albany), BTV
Oceanic (****)	E-6,E-7	SHIPP OOD	NY Metro PHL	Europe, Caribbean, South America
	E-4	BETTE	NY Metro	North Atlantic
	E-5	HAPIE	NY Metro	North Atlantic
		DITCH	PHL	North Atlantic

(*) NEION departures frequently merge with J95 in ZNY airspace.
(**) JFK and ISP departures are via RBV.
(***) JFK departures are via WAVEY. JFK satellite departures merge with JFK departures south of WAVEY. Other NY metro departures are via WHITE.
(****) HAPIE is used when the warning area is accessible.

Departure routes are described in detail below.

4.2.1 North Departures from NY Metro Airports

North departures from NY metro airports are served by three fixes: GAYEL, NEION, and COATE. GAYEL serves J95 and COATE serves J36. NEION serves J223 for flights destined to the airports in northwest ZNY and to DTW.

4.2.2 North Departures from PHL

Flights from PHL to ZNY internal destinations, the Great Lakes, and points north are routed via PTW to the destination.

4.2.3 West Departures from NY Metro Airports and PHL

Figure 4-2 illustrates in more detail the west departures in the Future No Action Alternative.

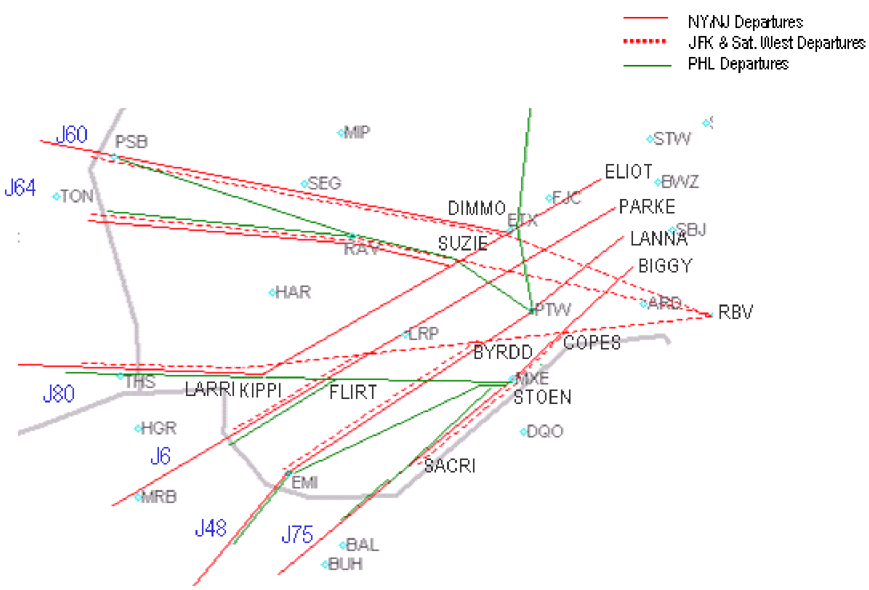


Figure 4-2. Future No Action West Departures

Five departure fixes serve NY metro departures to the west: RBV for JFK and ISP, and ELIOT, PARKE, LANNA, and BIGGY for other NY metro departures. ELIOT serves J60, J64, and J80. PHL west departures are via PTW (for J60 and J64), MXE (for J80 and J6), and STOEN (for J48 and J75). Description of departures for each west jet route follows:

- J60 departures from EWR, LGA, and their satellites take ELIOT and merge with departures from JFK, ISP, and their satellites (which travel via RBV) at ETX. PHL departures (which travel via PTW, SUZIE, and Ravine (RAV)) merge with NY metro departures at Philipsburg (PSB).
- J64 departures from JFK, ISP, and their satellites take RBV and merge with other NY metro departures, which come via ELIOT, at SUZIE. PHL departures travel via PTW and also merge with this traffic at SUZIE.
- J80 departures from JFK, ISP, and their satellites take RBV and merge with other NY metro departures, which come via ELIOT at LARRI. PHL departures take MXE and merge with NY metro departures at KIPPI.
- J6 departures from EWR, LGA and their satellites take PARKE, merge with departures from JFK, ISP, and their satellites (which come via RBV) at northeast of FLIRT. This traffic merges with PHL departures coming via MXE at FLIRT.
- J48 Departures from EWR, LGA and their satellites take LANNA, merge with departures from JFK, ISP, and their satellites (which come via RBV) at BYRDD, and merge with PHL departures via STOEN at EMI.
- J75 Departures from EWR, LGA and their satellites take BIGGY, merge with departures from JFK, ISP, and their satellites (which come via RBV) at COPES, and merge with PHL departures coming via STOEN at SACRI. NY metro departures to Reagan Washington National (DCA) and Baltimore Washington International (BWI) are among the J75 departures via BIGGY. They diverge from J75 at MXE.

4.2.4 South Departures from NY Metro Airports and PHL

Figure 4-3 provides a closer view of the south departures from NY metro airports and PHL.

South departures from all NY metro airports except for JFK and ISP take WHITE. At Salisbury (SBY), flights using the over the land route (J79) turn southwest and continue via KATZN, WEAVR, and ISO. Those using the over water route (J209) continue south via SAWED, ORF, and DIW. South departures from JFK and satellite take WAVEY to SAWED where they merge with other NY metro departures coming via WHITE and continue to ORF. At ORF, flights using the over water route continue on J209 and flights over land turns inland merging with other NY metro departures from WHITE at WEAVR.

PHL departures to the south merge with NY metro departures from WHITE at SBY. At SBY, flights using the over water route (J209) continue via SAWED, Norfolk (ORF), and Dixon (DIW). Flights using the over land route (J79) turns inland and continue via KATZN, WEAVR, and Kinston (ISO).

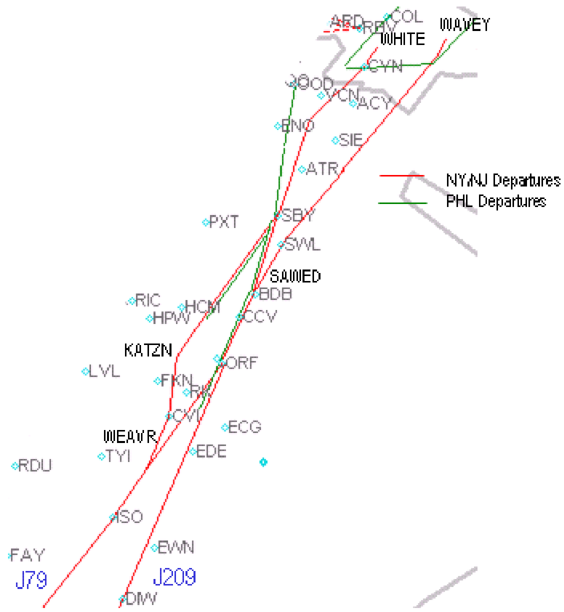


Figure 4-3. South Departures from NY Metro Airports and PHL

4.2.5 East Departures from NY Metro Airports and PHL

Three fixes serve NY metro departures to the east: GREKI, MERIT, and BAYYS. GREKI serves destination airports in northern ZBW. MERIT serves North Atlantic departures and northeastern New England. BAYYS mainly serves destination airports south of BOS.

DITCH serves PHL departures to ZBW and to the North Atlantic. PHL flights destined for central and northern ZBW (including CYOW, CYUL, BDL, BED, BOS, and MHT) and Northern Europe (including Heathrow (EGLL) and Schiphol (EHAM)) are routed from DITCH to the JFK navigational aid (NAVAID). PHL flights destined to other parts of Europe and eastern ZBW (including BGR, Tri-Cities Regional (BON), LEB, and New Haven (HVN)) are routed from DITCH to Coyle (CYN) and then to the east.

4.2.6 Oceanic Departures from NY Metro Airports

Three fixes are available for oceanic departures from NY metro airports: SHIPP, HAPIE, and BETTE:

- SHIPP is used for Caribbean and South American destinations.
- BETTE and HAPIE are used for Central and Southern European and African destinations.
- HAPIE is available only when the warning area is accessible.

PHL departures destined to North Atlantic Routes are routed to the east from DITCH, and are turned northeast at a point south of WAVEY.

4.3 Airports

The subsections below describe the en route arrival/departure profiles and the terminal arrival/departure profiles for the Future No Action Alternative for JFK, LGA, ISP, EWR, EWR satellites (TEB and MMU), PHL, and HPN. In each subsection, there is an overall description of en route arrival/departure profiles and an enhanced view of the modeled terminal arrival/departure procedures. In the supporting figures, altitudes below 18,000 feet are shown in hundreds of feet (e.g., 8000 is shown as 80), and altitudes above 18,000 feet are given in Flight Levels (FLs) (e.g., 19,000 feet is shown as FL190).

4.3.1 John F. Kennedy International

This subsection describes the JFK en route and terminal profiles as modeled in TAAM for the Future No Action Alternative.

4.3.1.1 John F. Kennedy En Route Arrival/Departure Profiles

JFK runs with four basic arrival routes into the airport as shown in Figure 4-4. Arrivals from the west fly over LENDY. Arrivals from the north and some from the west use IGN. European arrivals use ROBER. Arrivals from the south use CAMRN. ZIGGI is used as a turboprop arrival route from the south. The busiest arrival traffic flow goes over the LENDY fix. This fix is comprised of the westbound arrivals which then must be merged with the IGN arrivals.

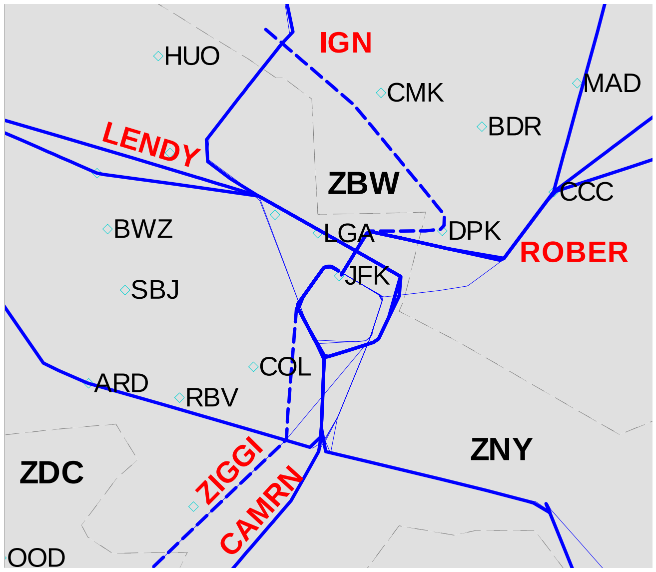


Figure 4-4. Future No Action JFK Arrivals

Figure 4-5 shows the regions that use each arrival fix at JFK. Arrivals from Europe come from the northeast corner via ROBER, arrivals from Canada and the Pacific Rim come from the north via IGN, arrivals from South America and the Caribbean come in via CAMRN, and arrivals from the west coast use LENDY.

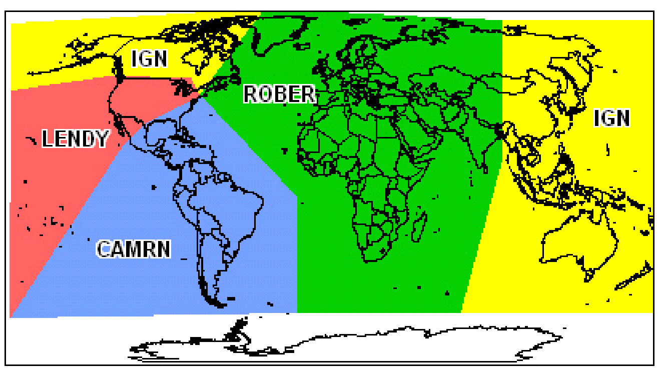


Figure 4-5. Origins of Traffic to Each JFK Arrival Fix

Due to the complexity of the airspace numerous altitude restrictions are imposed on the arrivals into JFK. The restrictions are shown in Figure 4-6. Altitudes are shown in hundreds of feet (e.g., 80 is 8,000 feet) and Flight Levels. JFK arrivals from the north and west stay high to make room for westbound departures from the surrounding airports which run underneath. This allows westbound departures from the surrounding airports to climb higher and get out of the way faster.

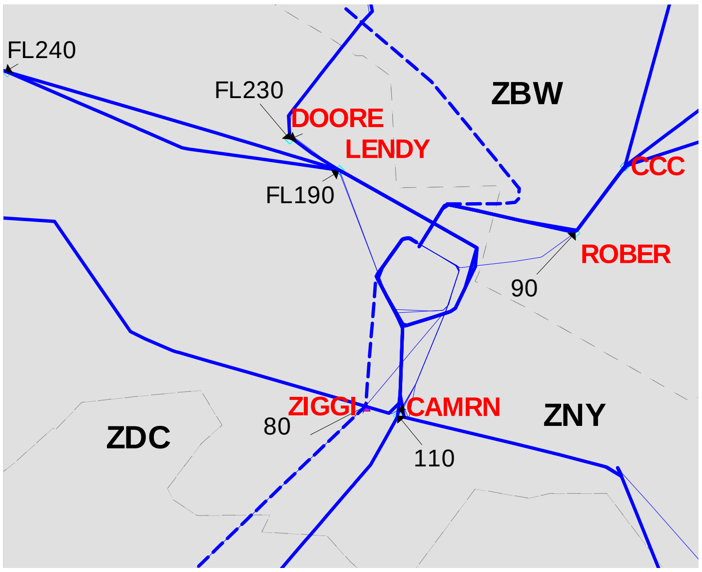


Figure 4-6. Future No Action JFK Arrivals Altitudes

The departure profiles and associated altitude gates for JFK are shown in Figure 4-7. In the low capacity configuration, the aircraft are not permitted to climb above 17,000 feet (shown as 170 in the figure) after reaching the departure gates. The high capacity configuration allows aircraft to climb to FL200 (or FL200 as shown in the figure) after reaching the departure gates. In both configurations, westbound departures out of JFK are almost exclusively served by the Robbinsville (RBV) departure fix.

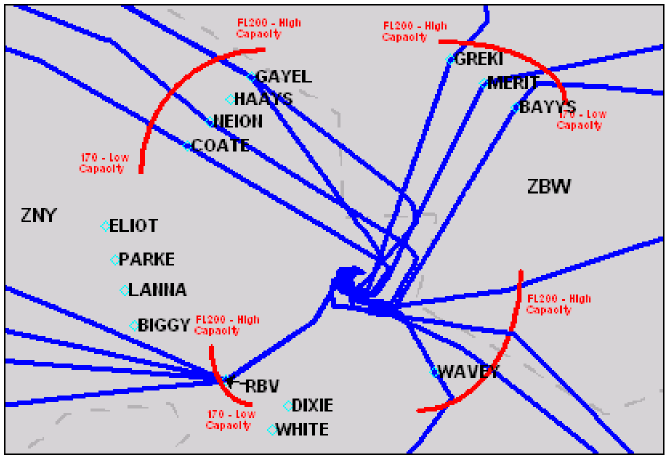


Figure 4-7. Future No Action JFK Departures

4.3.1.2 John F. Kennedy Terminal Arrival/Departure Profiles

Figure 4-8 presents a close-up view of the arrivals and departures for JFK in the low capacity configuration. In this configuration, flights depart and arrive on Runways 31L and 31R. In addition, the majority of the departures must loop around the airport before heading out to their departure fixes. This occurs to make room for LGA arrivals and departures. Figure 4-9 presents a close-up view of arrivals and departures for JFK in the high capacity configuration. In this configuration, the flights arrive on Runways 13L and 22L and depart on Runways 13R and 13L. The blue lines display the TAAM-based tracks for JFK arrivals, and the green lines display the TAAM-based tracks for the JFK departures.

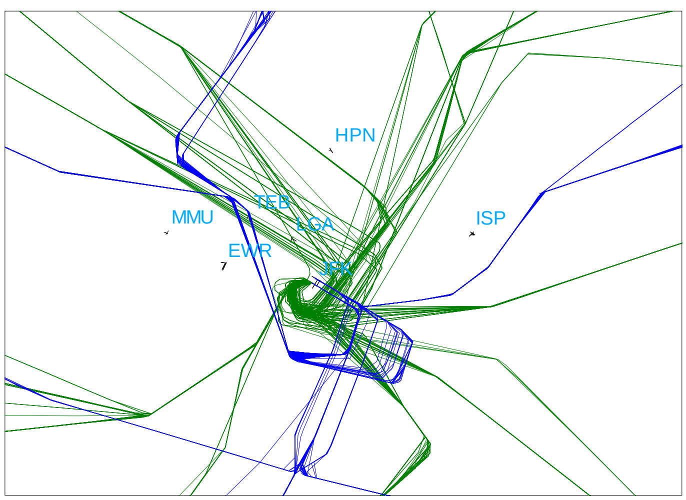


Figure 4-8. Future No Action Low Capacity Configuration JFK Terminal Profile

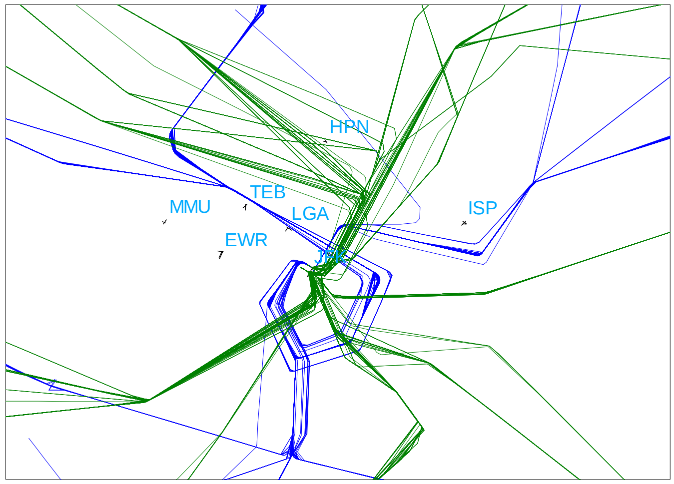


Figure 4-9. Future No Action High Capacity Configuration JFK Terminal Profile

4.3.2 LaGuardia

This subsection describes the LGA en route and terminal profiles as modeled in TAAM for the Future No Action Alternative.

4.3.2.1 LaGuardia En Route Arrival/Departure Profiles

EWR traffic uses the airspace to the west of LGA. JFK traffic uses the airspace to the east. LGA has available airspace on the north side, but from the south or west, all traffic is channeled into a narrow space in the middle between EWR and JFK. Aircraft from ZDC are routed over Robbinsville (RBV) while aircraft arriving from ZNY are routed over LIZZI. These two flows merge at NESOM. North of the airport, jets from ZBW arrive over VALRE and turbo-props from ZBW arrive over NOBBI. Low altitude traffic from ZBW is provided a separate arrival route over Bridgeport (BDR). The heaviest flow of traffic is over RBV.

The arrival routes in Figure 4-10 are the end of several stages of converging routes. Upstream Centers, particularly ZDC and ZOB, structure the traffic so the sectors closest to NY, with their limited airspace, can focus on sequencing. Each arrival route ends up with traffic from a region of the United States, like a watershed. Figure 4-11 shows the watersheds for the arrival routes to LGA. (Distance restrictions on LGA arrivals prevent traffic from points in the United States farther west than Denver.) The areas for VALRE and RBV extend outward beyond the borders of the map: arrivals from eastern Canada are routed to VALRE; arrivals from the Caribbean and Bahamas come in via RBV.

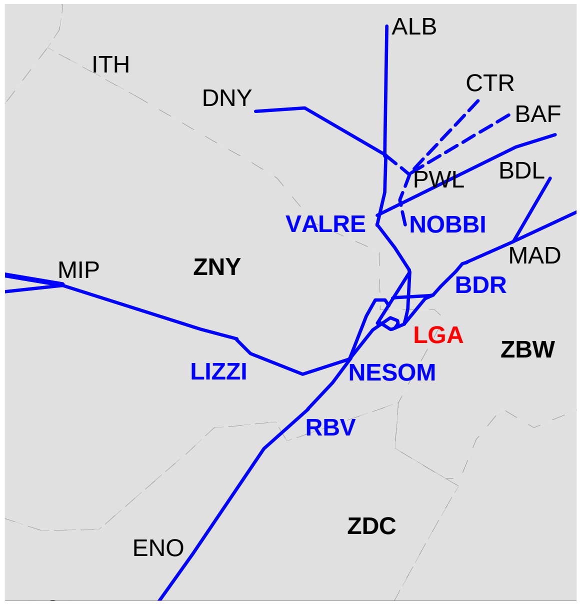


Figure 4-10. Future No Action LGA Arrivals

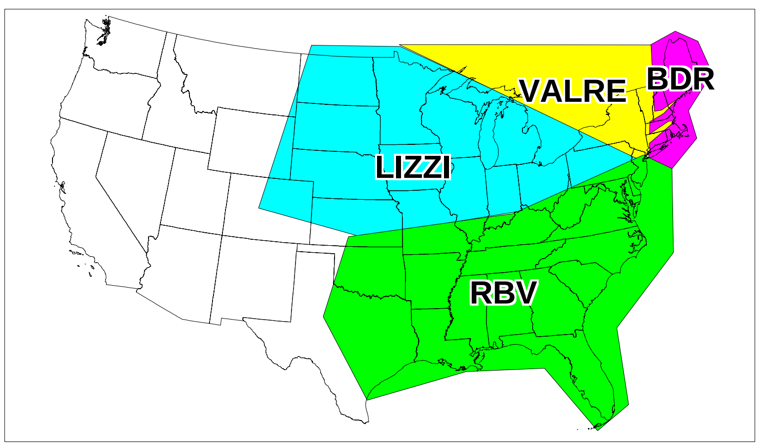


Figure 4-11. Origins of Traffic to Each LGA Arrival Fix

The airspace on the airways to LGA is made complex by the presence of crossing traffic to EWR and its satellites, by crossing traffic to JFK and ISP, by climbing traffic out of the Washington/Baltimore area, and by northbound traffic through ZBW. Complexity is managed here by numerous altitude restrictions, so traffic steps down in a predictable way. Crossing traffic passes over or under, according to its own altitude restrictions.

The major flows were modeled by explicit altitude requirements at many fixes. Low altitude flows were modeled by limiting the requested altitude in the flight plans. Figure 4-12 shows the most important altitude restrictions en route, expressed in hundreds of feet.

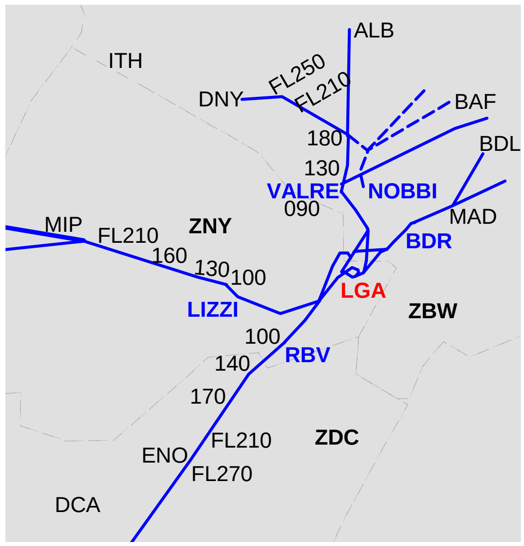


Figure 4-12. Future No Action LGA Arrival Altitudes

Figure 4-13 shows the NY metro airports share five departure gates and their corresponding fixes (a detailed discussion of these gates, their fixes, and assigned city pairs can be found in Section 4.2). The LGA departures to each of these gates must remain at or below 17,000 feet until they pass through the gate. Those flights routed to the ELIOT departure fix are an exception to this; they may climb to, but not exceed, FL200 before passing through the gate. Altitudes in the figure are shown in hundreds of feet.

TEC flights to HPN use BDR as a departure fix. Flights to TEB and MMU, also TEC, depart LGA over NYACK. These routes lie underneath the jet departure routes depicted on the map in Figure 4-13.

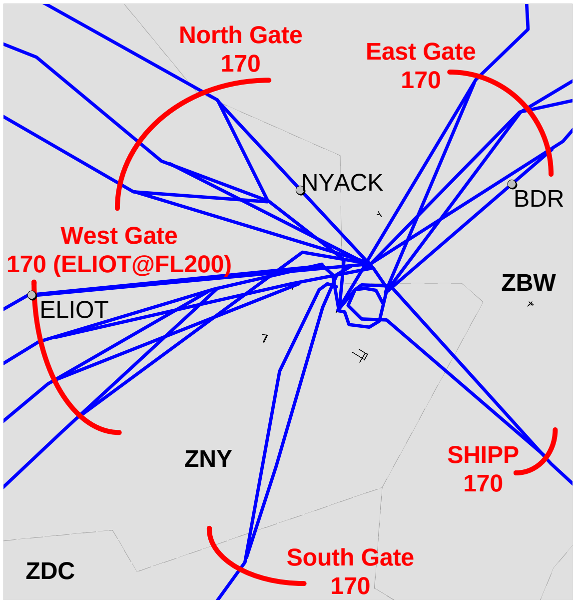


Figure 4-13. Future No Action LGA Departure Profile

4.3.2.2 LaGuardia Terminal Arrival/Departure Profiles

Figures 4-14 and 4-15 show a close-up view of the low altitude routings in the LGA terminal airspace. The arrivals are shown in blue, and the departures are shown in green. As discussed in Section 3.10, in the low capacity configuration, departures from Runway 4 are fanned into four headings. In the low capacity configuration, southern arrivals to Runway 31 cross over the LGA airport to vector to the northeast, where they are merged with the arrivals from the north. This allows arrival traffic to avoid the JFK arrivals to the south while remaining below the JFK departures traveling north. In the high capacity configuration the southern arrivals to Runway 22 follow the Hudson River north, staying east of the EWR airspace. Once north of LGA, they are merged with the arrivals from the north for final approach. All departures in the high capacity configuration at LGA follow the same climb out of the airport. Once they are approximately 15 miles northeast of LGA, they begin to vector to their respective departure gates.

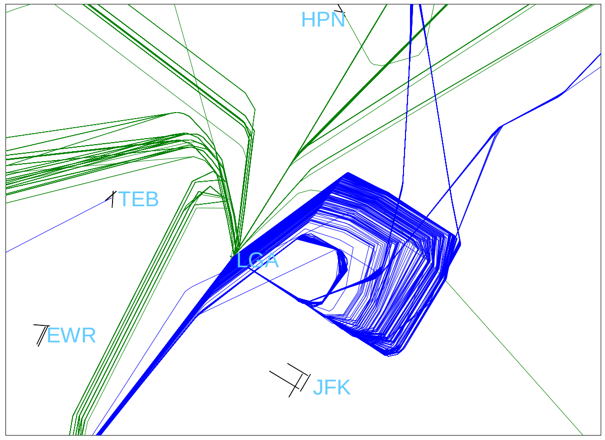


Figure 4-14. Future No Action Low Capacity Configuration LGA Terminal Profile

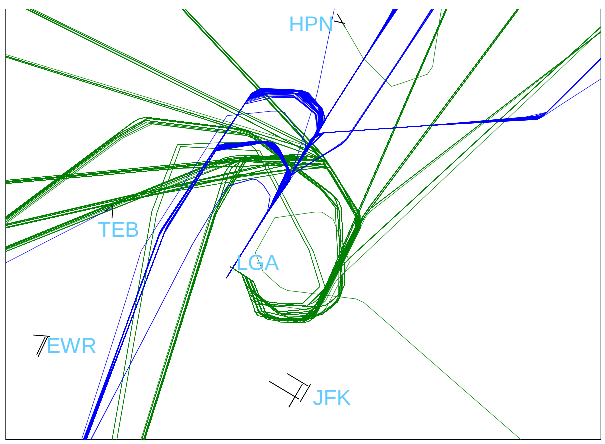


Figure 4-15. Future No Action High Capacity Configuration LGA Terminal Profile

4.3.3 Long Island MacArthur

This subsection describes the ISP en route and terminal profiles as modeled in TAAM for the Future No Action Alternative.

4.3.3.1 Long Island MacArthur En Route Arrival/Departure Profiles

Arrivals to ISP use either a northern or southern arrival route as shown in Figure 4-16. Arrivals from the NY metropolitan area and Midwest use the CCC fix, while arrivals from the Florida and Washington DC metropolitan area use the SARDI fix.

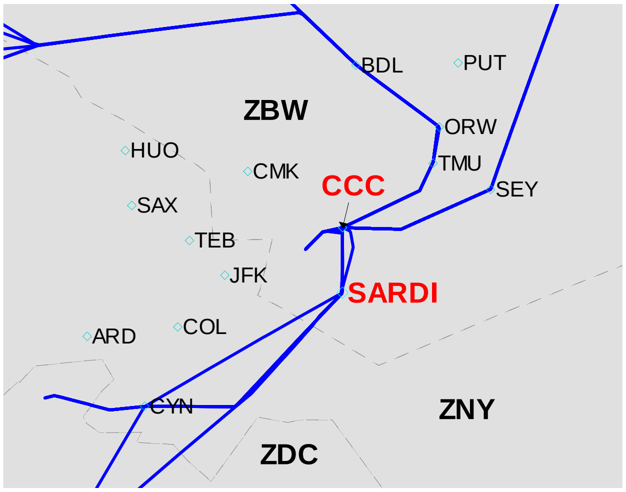


Figure 4-16. Future No Action ISP Arrivals

Figure 4-17 depicts the regions of origin for aircraft using the two ISP arrival fixes.

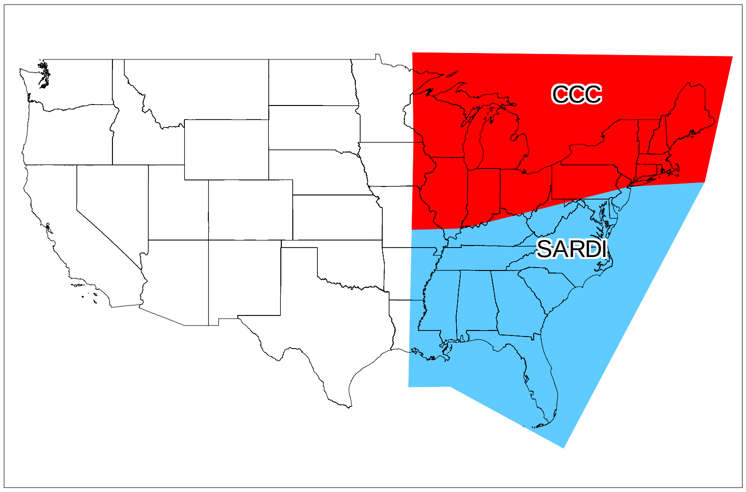


Figure 4-17. Origins of Traffic to Each ISP Arrival Fix

There are several altitude restrictions for arrivals into ISP as shown in Figure 4-18. ISP arrivals come in low to make room for oceanic departures. Altitudes in the figure are shown in hundreds of feet.

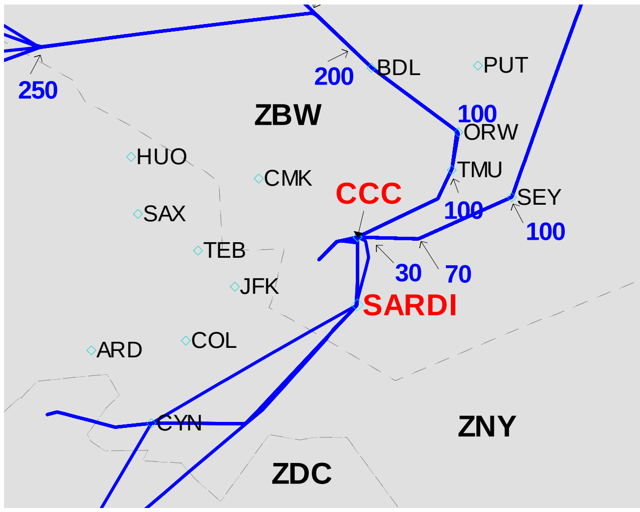


Figure 4-18. Future No Action ISP Arrival Altitudes

Figure 4-19 depicts the Future No Action Alternative departure streams with their corresponding departure gate altitudes for ISP. There is no change in configuration between the high and low capacity configurations.

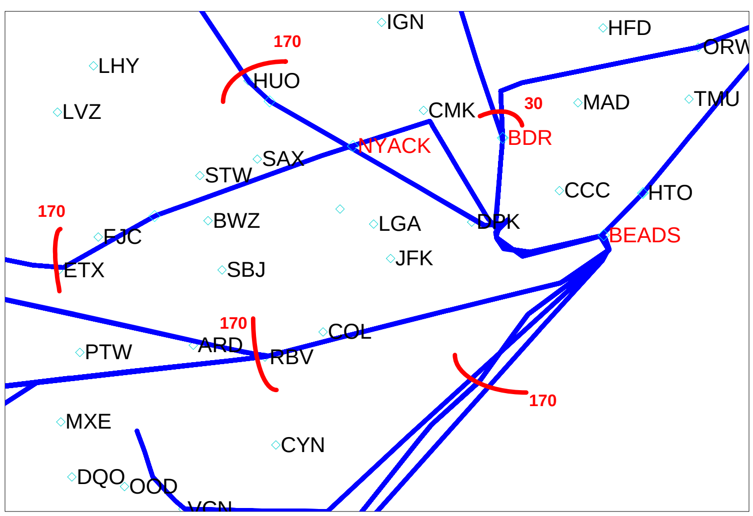


Figure 4-19. Future No Action ISP Departures

4.3.3.2 Long Island MacArthur En Route Terminal Arrival/Departure Profiles

Figure 4-20 provides a close-up view of the arrival and departures for ISP in the Future No Action Alternative. The blue lines display the TAAM based tracks for ISP arrivals. The green lines display the TAAM based tracks for ISP departures. The high and low capacity configurations are the same for ISP

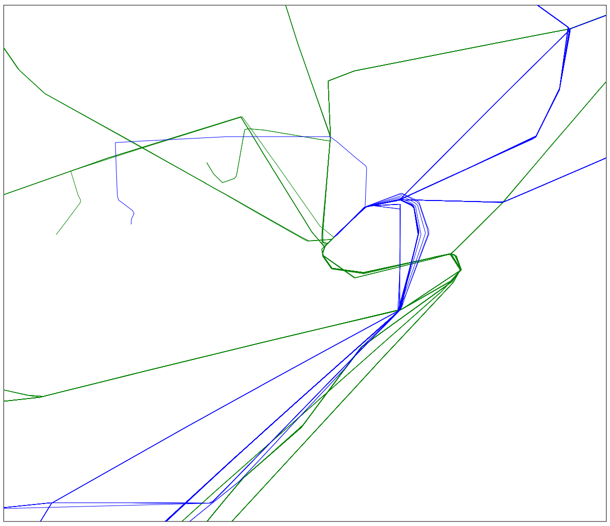


Figure 4-20. Future No Action ISP Terminal Profile

4.3.4 Newark Liberty International

This subsection describes the EWR en route and terminal profiles as modeled in TAAM for the Future No Action Alternative.

4.3.4.1 Newark En Route Arrivals/Departure Profiles

EWR jet arrivals are organized into three corner post flows as shown in Figure 4-21. Each center feeding the NY TRACON has its own corner post fix: ZDC routes aircraft over Yardley (ARD); ZNY routes aircraft over PENNS; and ZBW routes aircraft over SHAFF. The heaviest flow of traffic is over ARD.

Low altitude arrivals, whether jets or props, are usually segregated over a subsidiary fix. From ZDC, TEC arrivals from PHL approach control and McGuire AFB are routed over Robbinsville (RBV), beneath the arrival flow to LaGuardia. From ZNY, the low altitude route follows the same ground track to PENNS, beneath the jet flow. This route is also used by EWR satellite airports. From ZBW, fast low altitude traffic is merged with the jet flow, while slow traffic is brought in farther to the west over COATE.

The arrival routes in Figure 4-21 are the end of several stages of converging routes. Upstream Centers, particularly ZDC and ZOB, structure the traffic so the sectors closest to New York, with their limited airspace, can focus on sequencing. Each arrival route ends up with traffic from a region of the world, like a watershed. Figure 4-22 shows the watersheds for the arrival routes to EWR. Each area extends outward beyond the borders of the map: arrivals from Europe come from the northeast corner via SHAFF; arrivals from the Pacific Rim come from the north via SHAFF; arrivals from South America come in via ARD; and so on.

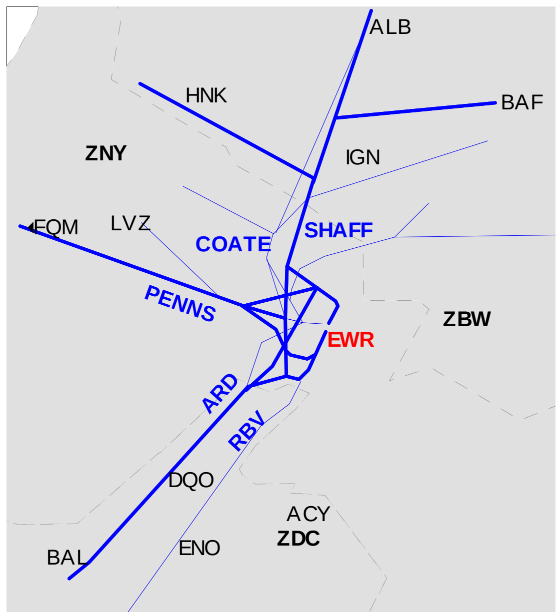


Figure 4-21. Future No Action EWR Future Arrivals

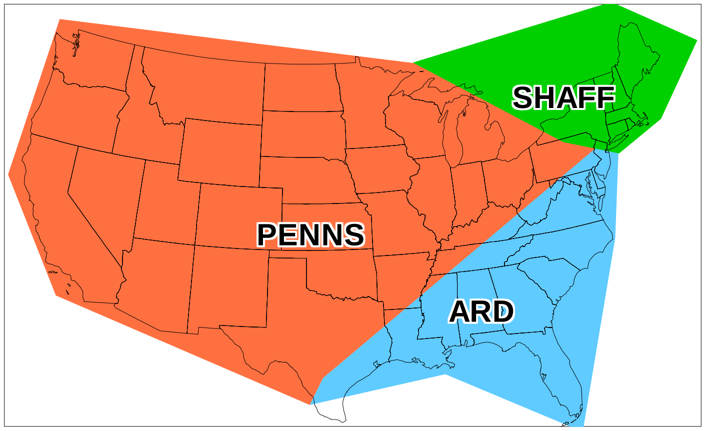


Figure 4-22. Origins of Traffic to Each EWR Arrival Fix

The airspace on the airways to EWR is made complex by the presence of crossing traffic to PHL and its satellites, by climbing traffic out of the Washington/Baltimore area, and by northbound traffic through ZBW. Complexity is managed here by numerous altitude restrictions, so traffic steps down in a predictable way. Crossing traffic passes over or under, according to its own altitude restrictions.

The major flows were modeled by explicit altitude requirements at many fixes. Low altitude flows were modeled by limiting the requested altitude in the flight plans. Figure 4-23 shows the most important altitude restrictions en route, expressed in hundreds of feet. An additional restriction is west of the map, requiring ZOB to hand off arrivals at FL370 or below.

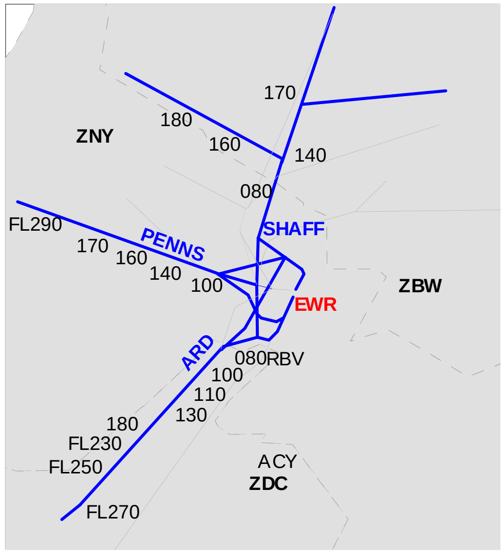


Figure 4-23. Future No Action EWR Arrival Altitudes

The EWR departure routes are illustrated in Figure 4-24. The jet departure routes for the north, south and east are described in detail in Section 4.2 as part of the airspace overview. In terms of the south departures, EWR departures to Florida use the WHITE departure fix, and oceanic departures take DIXIE to South America. EWR does not use the oceanic fixes SHIPP, BETTE and HAPIE. Prop departures are also shown in this figure. Props flying locally to Elmira or Plattsburgh take the HAAYS departure fix. Props flying to Albany, Hartford or Burlington take BREZY. EWR departures must stay below 17,000 feet until they reach the departure gate.

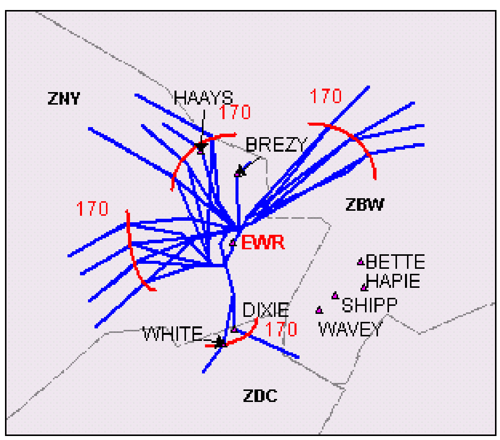


Figure 4-24. Future No Action EWR Departure Routes

4.3.4.2 Newark Liberty International Terminal Arrival/Departure Profiles

Figures 4-25 and 4-26 shows a close-up view of the low altitude routings for EWR. The blue lines display the TAAM-based tracks for EWR arrivals via Runway 04R/22L and 11, and the green lines display the TAAM-based tracks for the EWR departures for Runways 04L/22R and 29. EWR departures to the south are held below 6000 feet until Colts Neck (COL) to stay below the LGA arrivals.

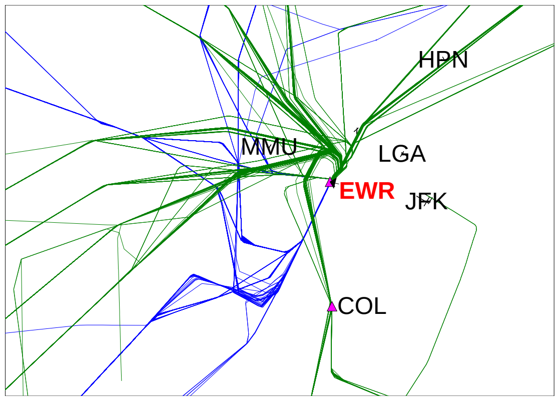


Figure 4-25. EWR Future No Action Low Capacity Terminal Profile

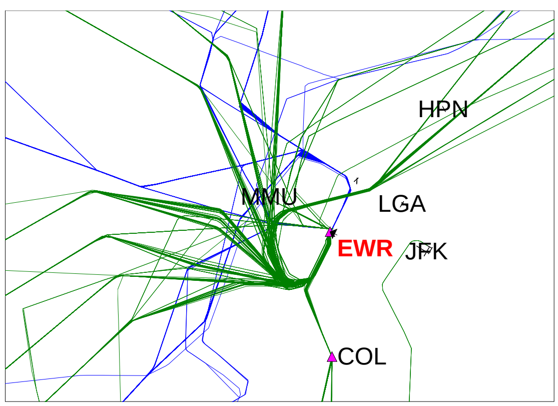


Figure 4-26. EWR Future No Action High Capacity Terminal Profile

4.3.5 Newark Liberty International Satellites (TEB and MMU)

This subsection describes the TEB and MMU en route and terminal profiles as modeled in TAAM for the Future No Action Alternative.

4.3.5.1 Teterboro and Morristown Municipal En Route Arrival/Departure Profiles

Figure 4-27 displays the TEB/MMU arrival routes. MMU routes that differ from TEB are shown in purple.

TEB and MMU jet arrivals are organized into three corner posts. Each center feeding the New York TRACON has its own corner post fix: ZDC routes aircraft over MAZIE for TEB, and over Broadway (BWZ) for MMU; ZNY routes aircraft over LVZ; and ZBW routes aircraft over COATE. The heaviest flow of traffic is from the south.

Low altitude arrivals, whether jets or props, are usually segregated over a subsidiary fix. From ZBW, low altitude flights from New England fly via BREZY.

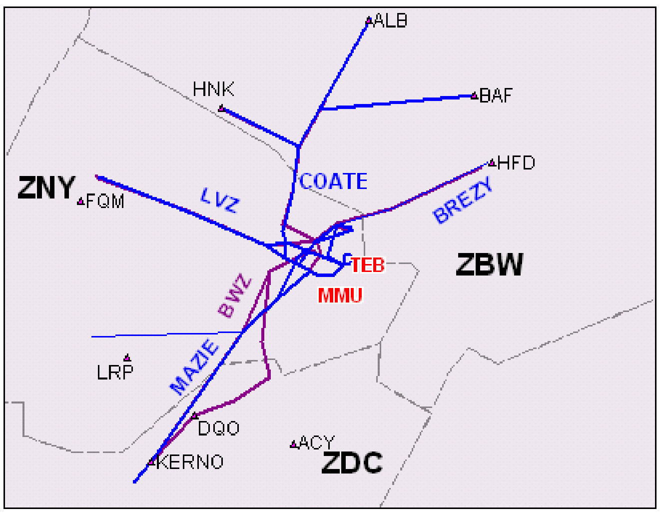


Figure 4-27. Future No Action TEB/MMU Arrivals

The arrival routes in Figure 4-27 comprise the end of several stages of converging routes. Upstream centers, particularly ZDC and ZOB, structure the traffic so the sectors closest to New York, with their limited airspace, can focus on sequencing. Each arrival route ends up with traffic from a region of the world, like a watershed. Figure 4-28 shows the watersheds for the arrival routes to TEB and MMU. Each area extends outward beyond the borders of the map. For example, arrivals from Canada come from the northeast corner via COATE.

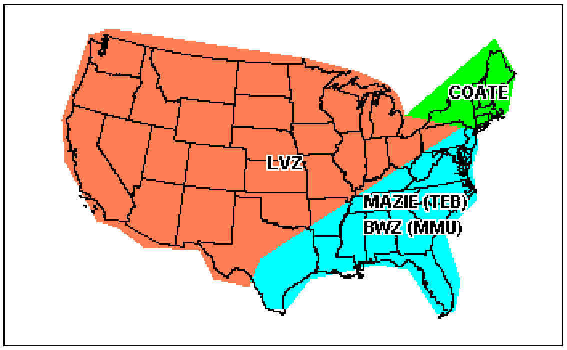


Figure 4-28. Origins of Traffic to Each TEB/MMU Arrival Fix

Similar to EWR, the airspace on the airways to TEB and MMU is made complex by the presence of crossing traffic to PHL and its satellites, by climbing traffic out of the Washington/Baltimore area, and by northbound traffic through ZBW. Complexity is managed here by numerous altitude restrictions, so traffic steps down in a predictable way.

The major flows were modeled by explicit altitude requirements at many fixes. Low altitude flows were modeled by limiting the requested altitude in the flight plans. Figure 4-29 shows the most important altitude restrictions en route, in hundreds of feet. An additional restriction is west of the map, requiring ZOB to hand off arrivals at FL370 or below.

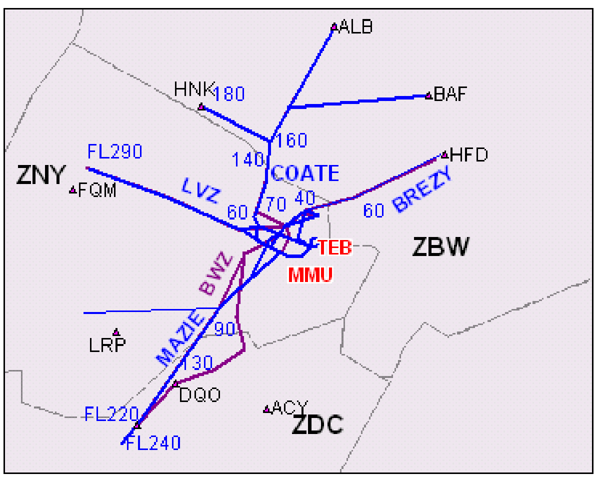


Figure 4-29. Future No Action TEB/MMU Arrival Altitude

Figure 4-30 shows the TEB and MMU Future No Action Alternative departure routes and associated gate altitudes for both the low capacity and high capacity configurations. The TEB departures are shown in blue, and the MMU departures are shown in purple. Similar to EWR, TEB/MMU departures to Florida use WHITE only and do not use WAVEY. Oceanic departures take DIXIE to South America and do not use the oceanic fixes SHIPP, BETTE and HAPIE. This figure also shows the prop routes for HAAYS and BREZY. Props flying locally to Buffalo, Syracuse or Utica use the HAAYS departure fix. Aircraft flying to the New England area take the BREZY departure fix. Aircraft must not climb above 17,000 feet until they reach the gate.

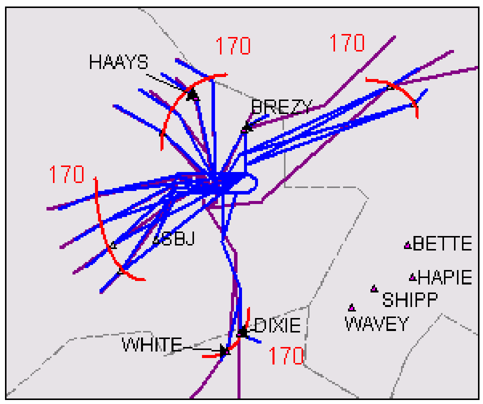


Figure 4-30. Future No Action TEB/MMU Departure Routes

4.3.5.2 Teterboro and Morristown Municipal Terminal Arrival/Departure Profiles

Figures 4-31 and 4-32 show a close-up view of the arrival and departure procedures for the TEB Future No Action low capacity and high capacity configurations. The blue lines display the TAAM-based tracks for TEB 06/19 arrivals, and the green lines display the TAAM-based tracks for TEB 01/24 departures. TEB arrivals are funneled to the west of the airport. In the high capacity configuration, the arrivals to Runway 19 cross over the airport to a tight teardrop approach. TEB departures to the south are held below 6000 feet until COL to stay below the LGA arrivals.

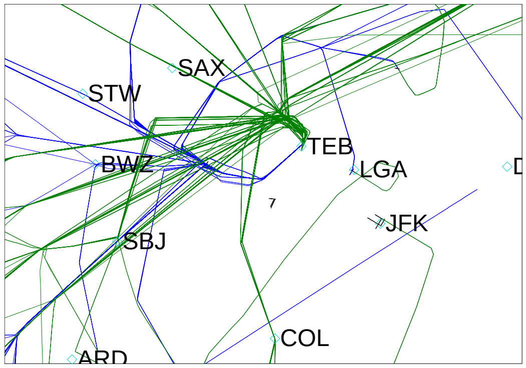


Figure 4-31. Future No Action TEB Low Capacity Terminal Profile

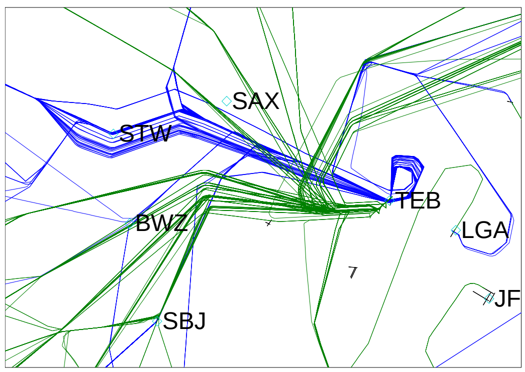


Figure 4-32. Future No Action TEB High Capacity Terminal Profile

In Figure 4-33, the blue lines display the tracks for MMU Runway 23 arrivals, and the green lines display the tracks for Runway 23 departures and the red line shows the localizer for EWR Runway 11. MMU departures must perform a tight left hand turn to travel to the west or north to maneuver around the EWR Runway 11 arrivals. MMU arrivals are merged north of the airport.

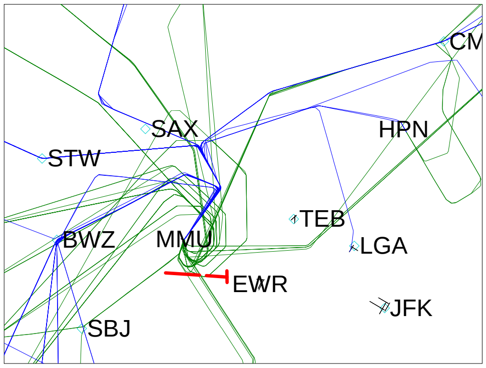


Figure 4-33. Future No Action MMU Terminal Profile

4.3.6 Philadelphia International

This subsection describes the PHL en route and terminal profiles as modeled in TAAM for the Future No Action Alternative.

4.3.6.1 Philadelphia En Route Arrival/Departure Profiles

Most arrivals to PHL use one of six arrival fixes. BUNTS, TERRI, SPUDS, and VCN are for long-haul flights. PTW and KERNO are for shorter flights originating in Pennsylvania, New York, and the Baltimore/Washington area. New York metro departures landing at PHL fly under TEC. Although they have departure and arrival fixes in their flight plans, they typically are vectored wherever the controllers think is most efficient for that particular flight. Figure 4-34 shows the assignment of arrival fixes to connecting airports in the contiguous United States. Flights from outside the depicted area use the fix corresponding to the point where they make landfall. For example, European and South American flights use VCN.

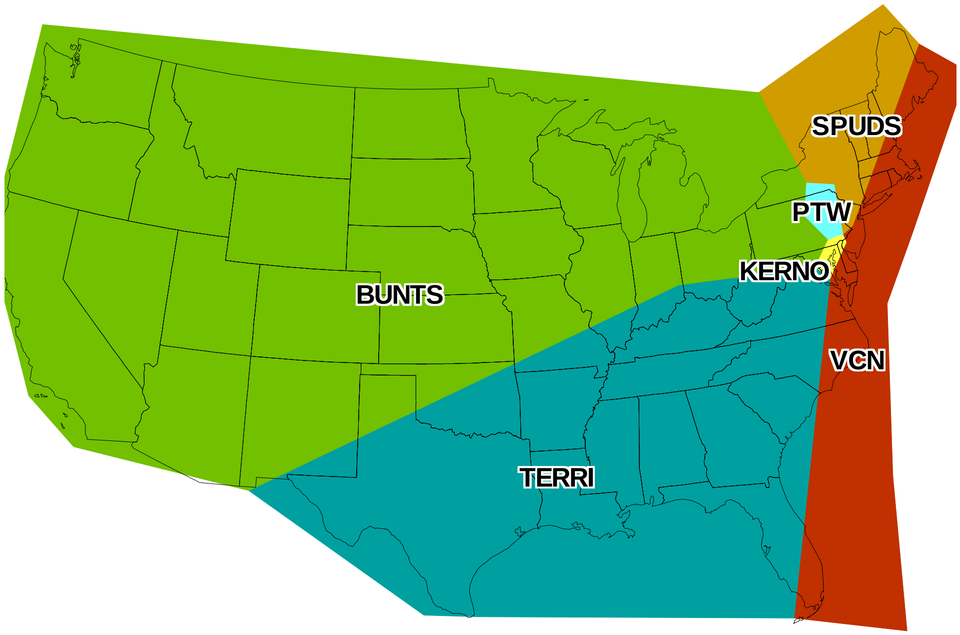


Figure 4-34. Origins of Traffic for Each PHL Arrival Fix

Figure 4-35 shows the arrival routes to PHL. Because of the position of the PHL approach control at the boundary of two centers, sandwiched between two large TRACON airspaces, the typical corner post operation is distorted. Flights from New England are routed either over water, to come in via VCN, or routed far west, to come in over SPUDS. Low altitude arrivals use PTW, which is also a departure fix.

Dotted lines show the arrival routes to Runway 35. When the main runways are being used in west configuration, aircraft approach 35 on the west downwind. In east configuration, the east downwind is used.

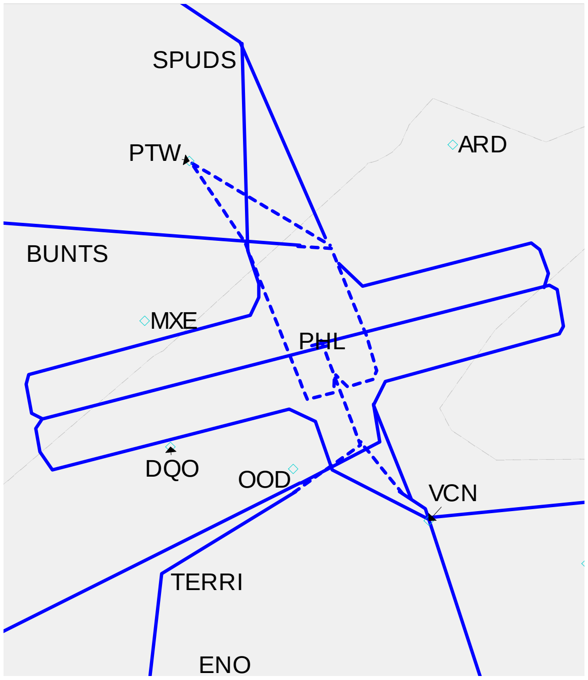


Figure 4-35. Future No Action PHL Arrivals

Arrivals to PHL are tightly constrained in altitude as well as in ground track. Figure 4-36 shows the step downs as arrivals approach the airport. The arrivals from over water via VCN are the least constrained. Arrivals from the north over SPUDS are forced down to 12,000 feet very early, to keep them beneath New York traffic. Altitudes in the figure are shown in hundreds of feet.

Arrivals to Runway 35 pass over the final approaches to the main runways, then turn on to the base leg at 3,000 feet. Arrivals to the main runways are 3-4,000 feet higher as they turn onto their downwind legs.

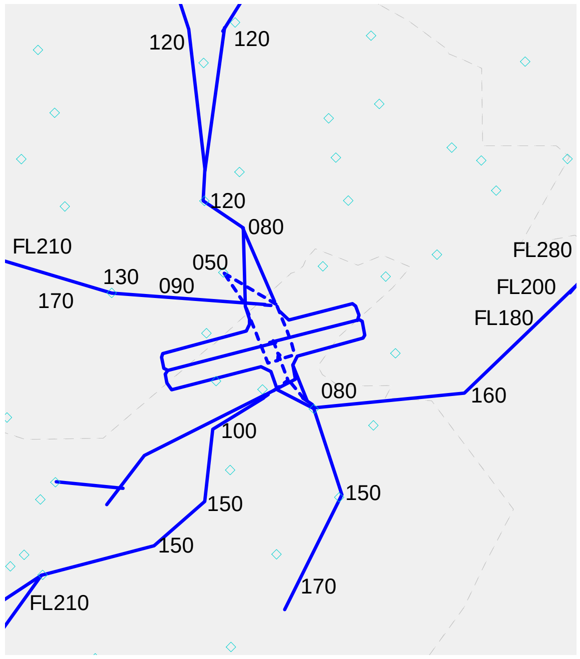


Figure 4-36. Future No Action PHL Arrival Altitudes

Figure 4-37 shows the departure routes and their associated altitudes. PHL departures do not use gates as do New York departures. Since one airport dominates the flow, a single fix is sufficient to feed the jet airways. The western departures include the dual flow in the direction of MXE. One flow is over MXE, the other is about 5 miles south.

Departures to the northeast of PHL, over RBV and west of Yardley (ARD), are not directed to jet airways. These routes are for Tower En route Control (TEC) aircraft bound for airports in the New York TRACON. There is a similar route over the DQO VOR, southwest of PHL, for TEC flights to Potomac Consolidated TRACON, but it lies under the line shown in the figure, and is not displayed separately.

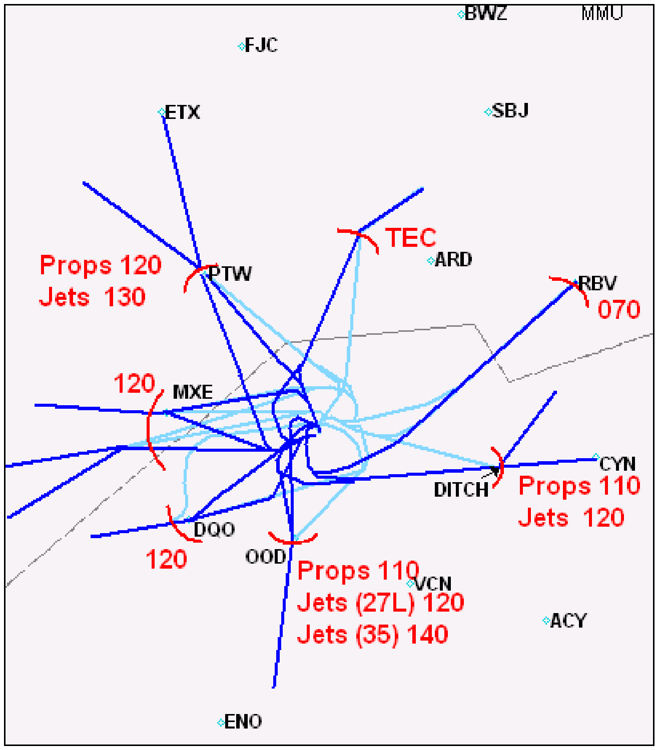


Figure 4-37. Future No Action PHL Departure Profile

4.3.6.2 Philadelphia Terminal Arrival/Departure Profiles

Figures 4-38 and 4-39 show a close-up view of low altitude routings in PHL terminal airspace. The arrivals are shown in blue, and the departures are shown in green. A classic "trombone" pattern is available for arrivals to PHL, since there are no major airports competing for its low altitude airspace. In west flow, there are no "short-side" arrivals, which simplify the operation. In east flow, all the arrivals would be from the short side, so a zigzag approach has been implemented to make vectoring possible. This is one reason why east flow is not the preferred configuration. (Restrictive runway dependencies are the others.)

Departures from the main runway and Runway 35 can be seen in these figures in green. Traffic from the two runways is blended into a single stream by PHL departure control before the aircraft reach the fix and are handed off to en route control.

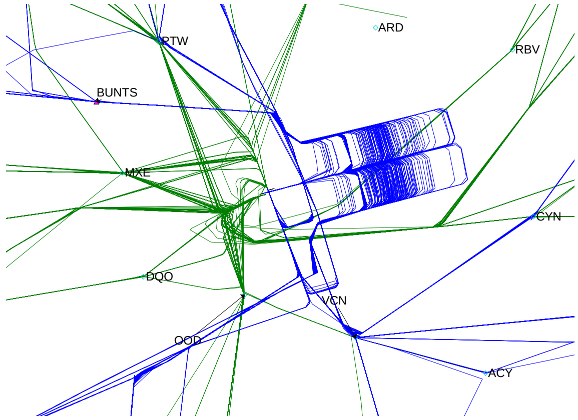


Figure 4-38. Future No Action West Flow PHL Terminal Profile

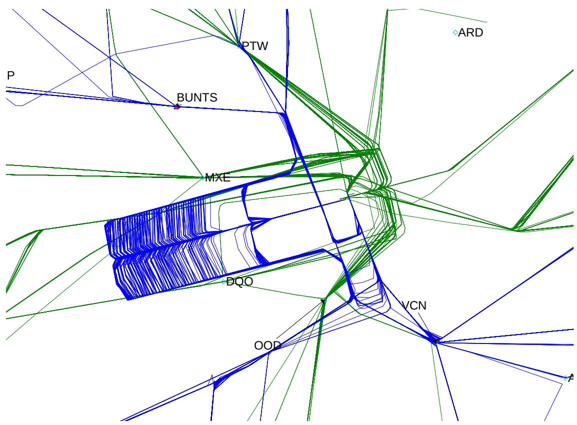


Figure 4-39. Future No Action East Flow PHL Terminal Profile

4.3.7 Westchester County

This subsection describes the HPN en route and terminal profiles as modeled in TAAM for the Future No Action Alternative.

4.3.7.1 Westchester County En Route Arrival/Departure Profiles

HPN is situated to the northeast of the other New York Metro airports. Dense traffic to and from these airports constrains the HPN arrivals to operate to the north and southeast as shown in Figure 4-40. Aircraft from ZDC arriving from the eastern coastal areas are routed over RICED while aircraft arriving from inland areas of the southeast are routed over BOUNO. These two streams merge at BDR, approaching HPN from the east. Jet arrivals from the west merge with arrivals from the north at Kingston (IGN) and approach HPN from the north over VALRE. Turbo props from these areas split off at IGN to utilize the NOBBI arrival route. Low altitude traffic from ZBW, as well as arrivals from PHL, are provided a separate arrival route over RYMES.

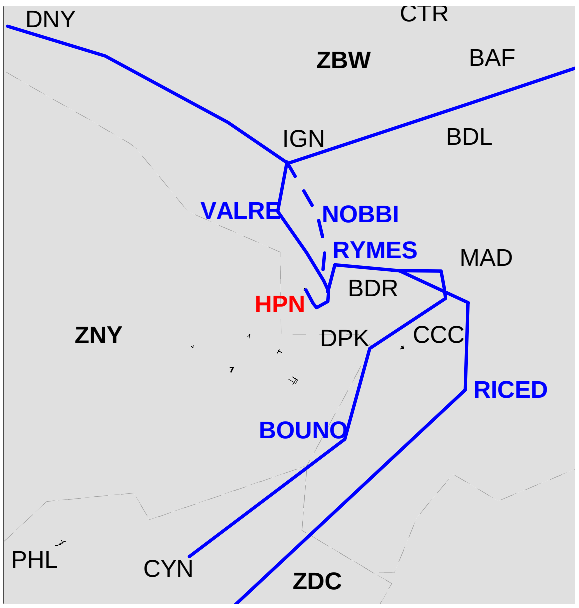


Figure 4-40. HPN Future No Action Arrivals

Arrivals to HPN are routed over one of six arrival fixes based on the geographical area of the country from which they originate as shown in Figure 4-41. The largest of these areas, covering most of the United States, requires arriving aircraft to be merged by ZOB and funneled over VALRE. The other major flow, arriving from the south, utilizes BOUNO. Short-haul flights, from the Washington DC area for example, are routed over RICED, while those from southern New England are routed over BDR. PHL and ISP flights, under TEC, arrive over RYMES. TEC arrivals from the north and west use CMK.

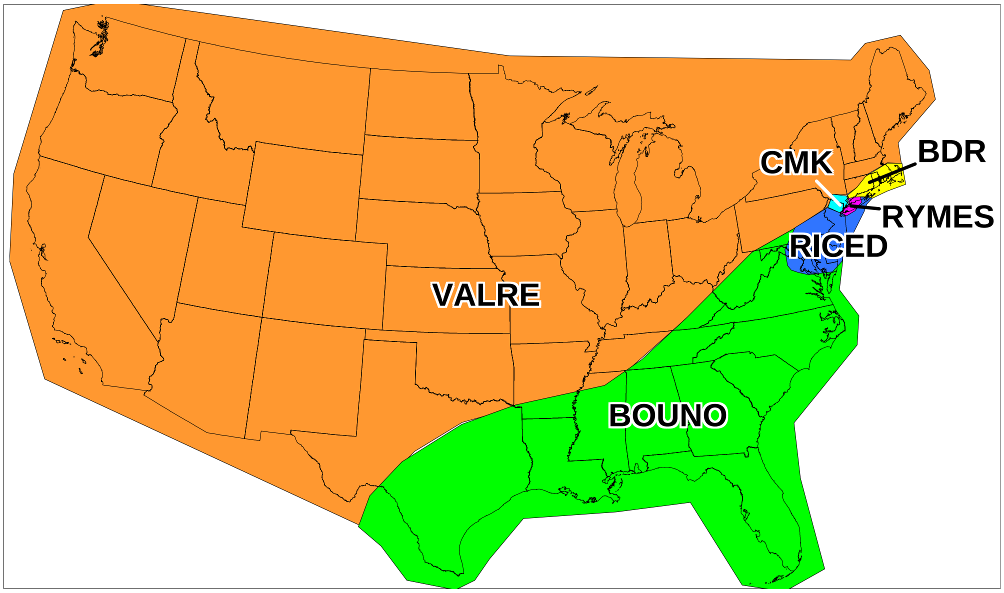


Figure 4-41. Origins of Traffic to Each HPN Arrival Fix

The indirect routing of the HPN arrival traffic insures that the flights are separated from much of the arrival and departure traffic to the busier airports. In the instances where crossing flows could not be avoided, altitude restrictions were employed to insure vertical separation as shown in Figure 4-42. Altitudes in the figure are shown in hundreds of feet.

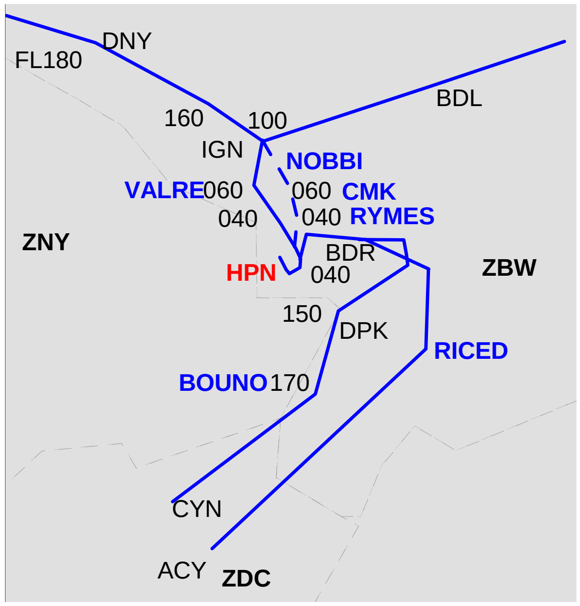


Figure 4-42. HPN Arrival Altitude Restrictions

The NY airports share five departure gates and their corresponding fixes (a detailed discussion of these gates, their fixes, and assigned city pairs can be found in Section 4.2). The four departure gates utilized by HPN are shown in Figure 4-43. The HPN departures to each of these gates must remain at or below 17,000 feet until they are under control of the Center.

TEC flights to TEB and MMU depart HPN over NYACK. Flights to PHL, also TEC, circle over the HPN airport and fly over JFK before proceeding through the south gate at DIXIE. These routes lie underneath the jet departure routes depicted on the map in Figure 4-43. Altitudes in the figure are shown in hundreds of feet.

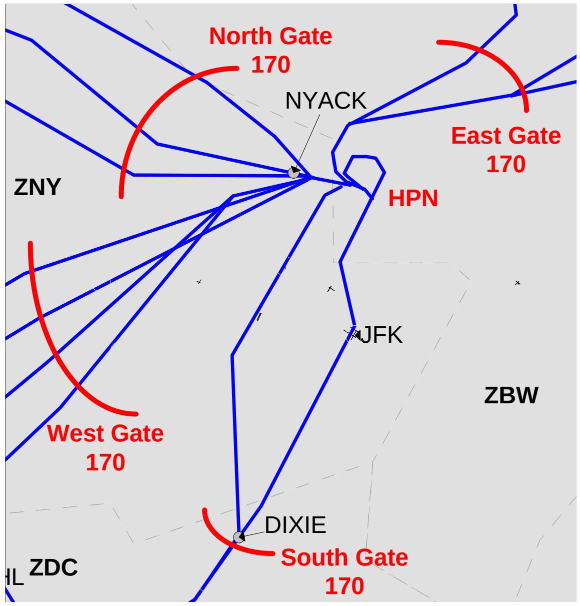


Figure 4-43. HPN Departure Profile

4.3.7.2 Westchester County Terminal Arrival/Departure Profiles

Departures out of HPN, shown in Figure 4-44 in green, share an initial heading of 295. At an altitude of 3,000 feet flights to the east, as well as those to the south, split off of the initial heading. Flights to PHL, which circle to pass over the airport while turning south, also split off at about 3,000 feet in altitude. Aircraft traveling through the north or west gates do not fan off of the initial heading until they are five miles from HPN. Arrivals to HPN, shown in blue, stay east of the departure flows. The two main flows into the terminal airspace are merged on the downwind leg, just before turning onto the crosswind leg.

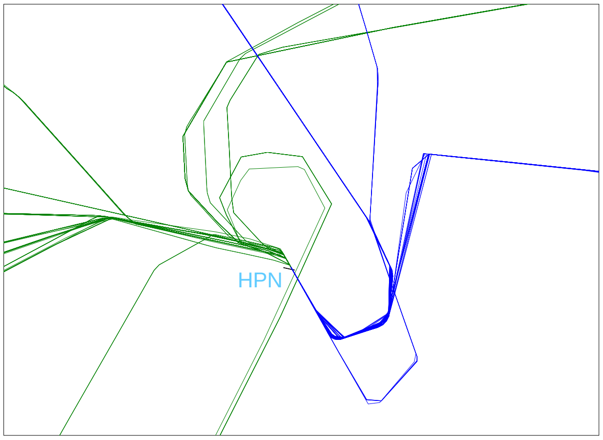


Figure 4-44. Future No Action HPN Terminal Profile

Section 5

Modifications to Existing Airspace Alternative

5.1 Design Overview

The Modifications to Existing Airspace Alternative is a variation of the Future No Action Alternative. In the Modifications to Existing Airspace Alternative, PHL has a new DITCH departure that is moved eastward and climbs under a new WHITE departure as shown in Figure 5-1. In Future No Action, PHL DITCH departures to the north turn northeast immediately after DITCH, climbing above JFK RBV departures, resulting in the PHL departures having to stay at a low altitude until they exit the NY TRACON. In the Modifications to Existing Airspace Alternative, PHL DITCH departures to the north stay on the eastbound course longer until after crossing the WHITE departure corridor. This ensures the PHL departures cross above the JFK RBV departures

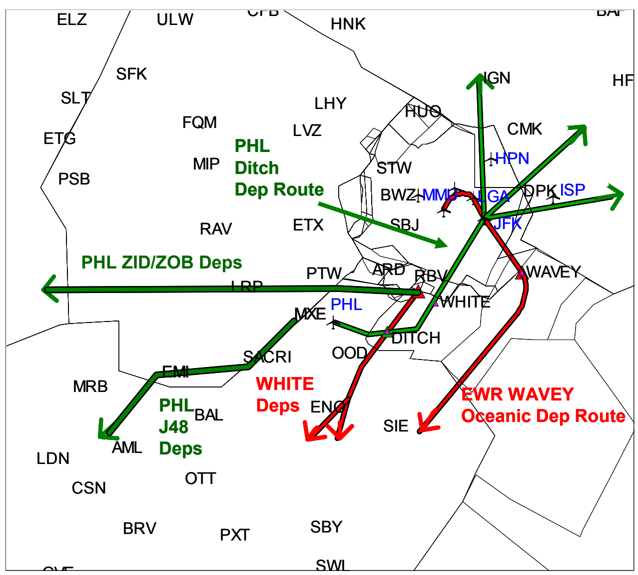


Figure 5-1. Modification to Existing Airspace Alternative Overview

In addition, southwest-bound departures out of PHL are also restructured to allow unrestricted climbs and west departures from NY metro airports and PHL have an additional jet route for destinations within ZID or ZOB airspace. Philadelphia departure profiles at low altitude are permitted departure headings according to departure fix; instead of solely by engine type as in the Future No Action Alternative.

As shown in the Figure 5-1, EWR adds a WAVEY oceanic departure route in the low capacity configuration (using Runway 04L/29 for departures, Runway 04R/11 for arrivals). EWR departures are fanned in the high capacity configuration.

The TAAM implementation of Modification to Existing Airspace Alternative is based on airspace and airport modifications to the validated Future No Action Alternative TAAM models. Detailed operational TAAM modeling of this alternative was conducted for the highest-traffic subset of the airports (JFK, LGA, ISP, HPN, EWR, PHL, TEB and MMU) to be studied in the Environmental Impact Statement. As part of the model development, the departure and arrival routes were provided by the redesign team. The terminal arrival and departure procedures were based on modifications to the current procedures as coordinated and validated by the redesign team.

Based on the destination airport, the modeled departures typically use the same jet route and departure fix. The departure route and departure fix usage modeled in TAAM is described in Section 5.2. The specific en route and terminal arrival and departure profiles modeled in TAAM are described in Section 5.3.

5.2 Airspace

In this alternative, NY metro departures to north, east and south, and oceanic departures are the same as Future No Action Alternative. West departures from NY metro airports and PHL have an additional jet route that is used for destination airports internal to ZID or ZOB. PHL STOEN departures to J48 are routed to J75 then at SACRI to EMI merging with J48. The NY metro departures to J60, J64, J6, J48, and J75 take the same route as in the Future No Action Alternative. PHL DITCH departures stays on the eastbound course longer than in the Future No Action Alternative before turning north. Figure 5-2 illustrates NY metro and PHL departure routes for the Modifications to Existing Airspace Alternative. The purple lines in Figure 5-2 highlight where the Modifications to Existing Airspace Alternative is different from the Future No Action Alternative.

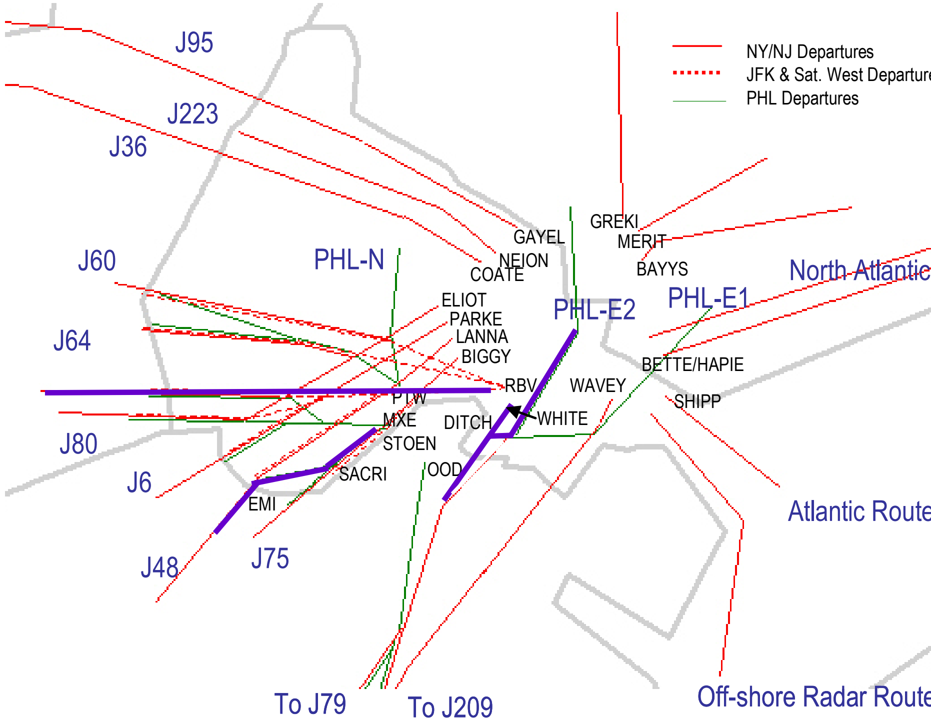


Figure 5-2. Modification to Existing Airspace Departures

5.2.1 West Departures

West departures from NY metro airports and PHL have an additional jet route for destination airports internal to ZID or ZOB as shown in Figure 5-3. J230 is realigned to go from RBV, LRP, then to APE (330 nmi west of LRP) creating the second westbound route into ZOB. The LRP to APE segment is used for flights landing within ZOB and/or ZID. JFK flights over AIR (240 nmi west of LRP) use the LRP267 radial to join J110. ELIOT departures merge onto J230 at the intersection of J80 and J230. PHL departures merge onto J230 approximately 20 nmi west of LRP.

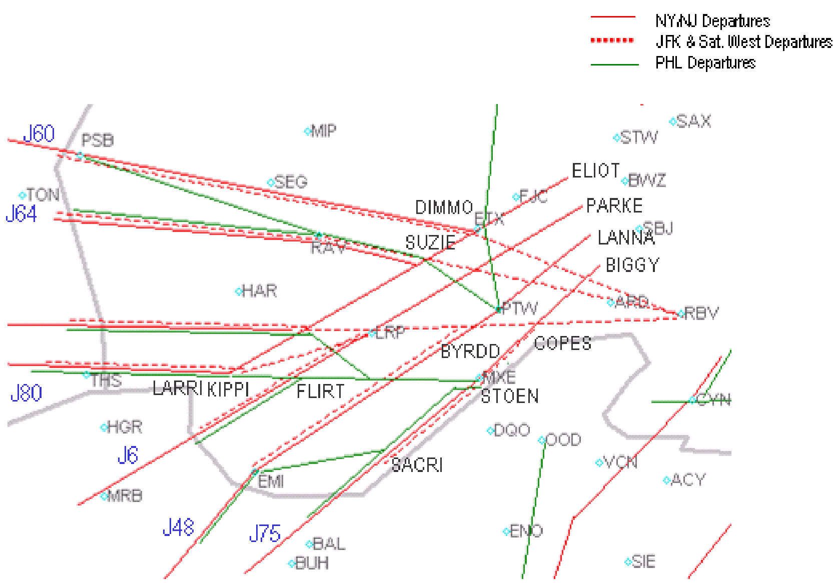


Figure 5-3. Modifications to Existing Airspace West Departure Routes

5.2.2 PHL STOEN Departures to J48

In the Future No Action Alternative, PHL STOEN departures to J48 proceed towards southwest on J110 and turn onto J48 merging with NY departures at EMI. In Modifications to Existing System Alternative, they are routed to J75 then turn west at SACRI, merging with J48 at EMI. This change allows PHL departures an unrestricted climb to FL230.

5.2.3 PHL DITCH Departures to North

PHL DITCH departures to the north in Future No Action turn northeast immediately after DITCH, climbing above JFK RBV departures.

5.3 Airports

The subsections below describe the en route arrival/departure profiles and the terminal arrival/departure profiles for the Modifications to Existing System Alternative for JFK, LGA, ISP, EWR, EWR satellites (TEB and MMU), PHL, and HPN. Where there are significant differences from the Future No Action Alternative, there are overall descriptions of en route arrival/departure profiles and enhanced views of the modeled terminal arrival/departure procedures. In the supporting figures, altitudes below 18,000 feet are shown in hundreds of feet (e.g., 8000 is shown as 80), and altitudes above 18,000 feet are given in Flight Levels (FLs) (e.g., 19,000 feet is shown as FL190).

5.3.1 John F. Kennedy International

JFK is generally unaffected in this alternative. Arrivals are exactly the same as in the Future No Action Alternative. There is a small change for the few aircraft from JFK that depart over WHITE. The WHITE fix was moved 10 nmi to the west. As discussed in Section 9, this change did not affect the results for JFK.

5.3.2 LaGuardia

LGA is generally unaffected in this alternative. Arrivals and departures are exactly the same as in the Future No Action Alternative. The departure headings for the low capacity remain the same as in the Future No Action Alternative. There is a small change for the few aircraft that depart over WHITE. The WHITE fix was moved 10 nmi to the west. As discussed in Section 9, this change did not affect the results for LGA.

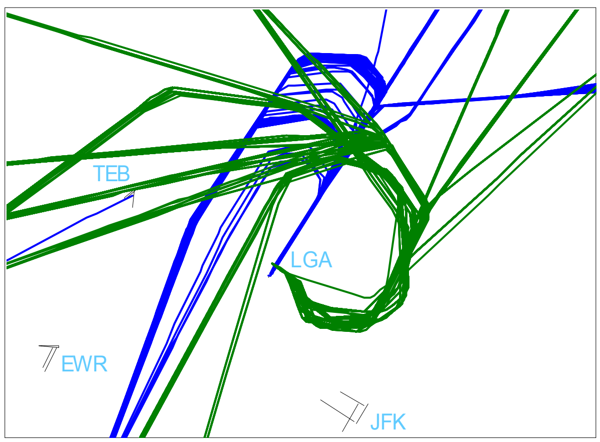


Figure 5-4. Modifications High Capacity LGA Terminal Profile

5.3.3 Long Island MacArthur

ISP is generally unaffected in this alternative. Arrivals are exactly the same as in the Future No Action Alternative. There is a small change for the few aircraft from ISP that depart over WHITE. The WHITE fix was moved 10 nmi to the west. As discussed in Section 9, this change did not affect the results for ISP.

5.3.4 Newark Liberty International

5.3.4.1 Newark Liberty International En Route Arrival/Departure Profiles

The EWR arrival routes in this alternative are the same as in the Future No Action Alternative. In terms of departure routes, there are two changes. WHITE departures are moved 10 miles west (new departure fix location MWHITE shown in 5-5) and EWR adds a WAVEY oceanic departure route in the low capacity configuration (using Runway 04L/29 for departures, Runway 04R/11 for arrivals). These changes are shown in Figure 5-5. Altitudes in the figure are shown in hundreds of feet.

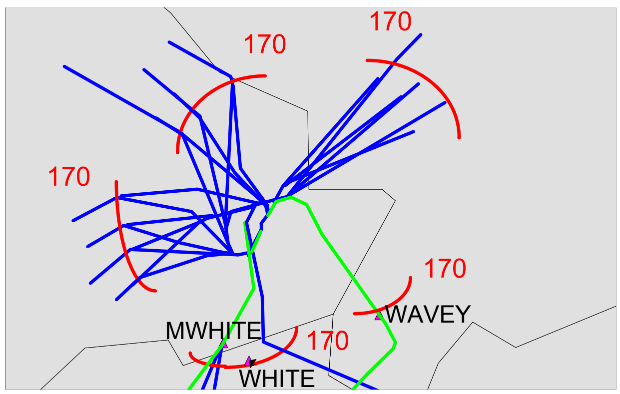


Figure 5-5. Modifications to Existing Airspace EWR Departure Routes

5.3.4.2 Newark Liberty International Terminal Arrival/Departure Profiles

Figures 5-6 and 5-7 compares the low-altitude routings for the Future No Action and Modifications to Existing Airspace Alternatives. The green lines display the TAAM-based tracks for the Modifications to Existing Airspace EWR departures and the blue lines show the Future No Action Alternative departures for Runways 04L/22R and 29. Terminal arrival routes are the same as in the Future No Action Alternative and are not shown in the figure. The new WAVEY departure for the low capacity configuration crosses JFK at or above 8000 feet to 17,000 feet at WAVEY to jet route J174 in the Modifications to Existing Airspace Alternative.

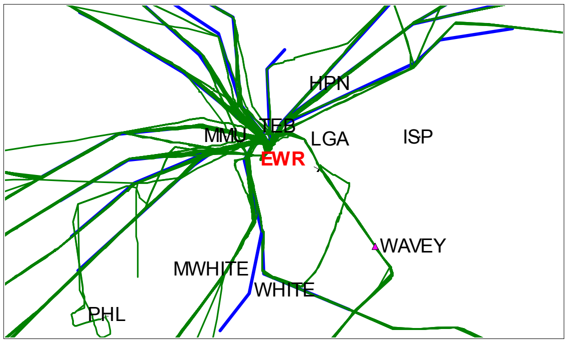


Figure 5-6. EWR Modifications to Existing Airspace Low Capacity Terminal Profile

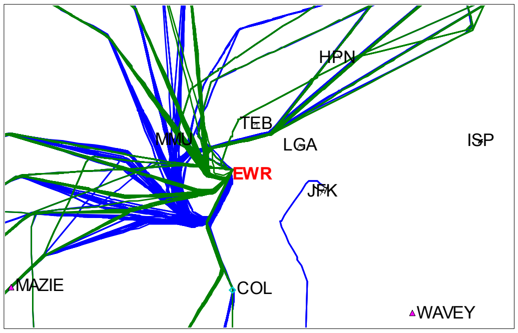


Figure 5-7. EWR Modifications to Existing Airspace High Capacity Terminal Profile

For the high capacity configuration for the Integrated Airspace Alternative, departures are "fanned" off Runway 22R as shown in Figure 5-7. Fanned departures take different headings off of the runway depending on their destination rather than being in-trail as in the Future No Action Alternative. This capability allows for an increased number of departures from the Future No Action Alternative. The headings used depend on whether Runway 11 is open for arrivals, so that Runway 11 arrivals do not interfere with Runway 22R departures. Table 5-1 shows the fanned headings used for Runway 22R.

Table 5-1. Runway 22R Departure Headings for Integrated Airspace Alternative

Departure Direction	Runway 11 Open for Arrivals	Runway 11 Closed
North	240 degrees	260 degrees
East	240 degrees	260 degrees
West	240 degrees	240 degrees
South	220 degrees	220 degrees

5.3.5 Newark Liberty International Satellites

TEB and MMU are generally unaffected in this alternative. Arrivals are exactly the same as in the Future No Action Alternative. There is a small change for the few aircraft from TEB and MMU that depart over WHITE. In this alternative, the WHITE fix was moved 10 nmi to the west. As discussed in Section 9, this change did not affect the results for TEB or MMU.

5.3.6 Philadelphia International

5.3.6.1 Philadelphia En Route Arrival/Departure Profiles

As described above in Section 5.2, there are two changes to PHL's profiles in this alternative.

First, the low-performing departures to the northeast are freed to climb unobstructed, since the DITCH departure path has been moved east, roughly to the CYN navigation aid. This is permitted by the change in New York departures from WHITE to MWHITE.

Second, J48 departures are kept in trail with J75 longer. They join J48 at EMI.

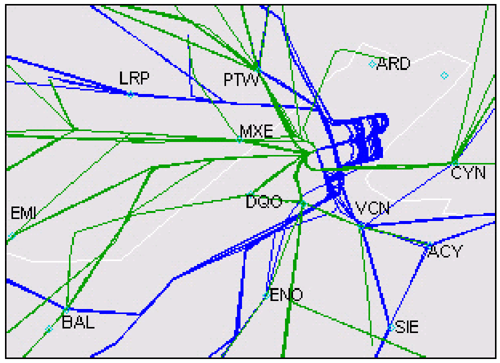


Figure 5-8. Modifications to Existing Airspace PHL Arrival/Departure Profile

5.3.6.2 Philadelphia Terminal Arrival/Departure Profiles

Philadelphia departure profiles at low altitude are permitted departure headings according to departure fix; instead of solely by engine type as in the Future No Action Alternative. Figure 5-8 shows simulated departure tracks for the high-capacity configuration (west) in green and for the low-capacity configuration (east) in black for the Future No Action and Modification to Existing Airspace Alternatives. PHL arrival profiles are not affected in this alternative.

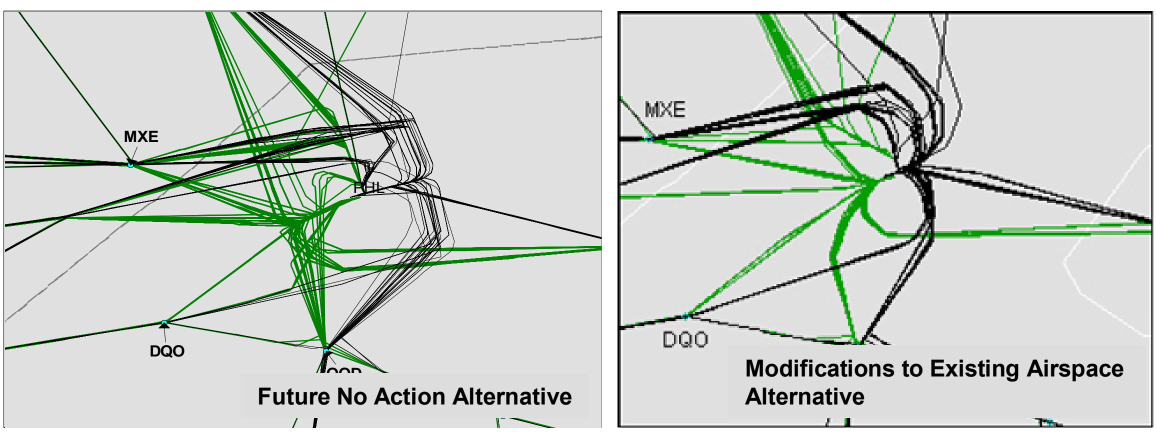


Figure 5-9. Future No Action and Modifications to Existing Airspace PHL Terminal Profiles

5.3.7 Westchester County

HPN is generally unaffected in this alternative. Arrivals are exactly the same as in the Future No Action Alternative. There is a small change for the few aircraft that depart over WHITE. The WHITE fix was moved 10 nmi to the west. As discussed in Section 9, this change did not affect the results for HPN

Section 6

Ocean Routing Alternative

6.1 Design Overview

The Ocean Routing Alternative is a proposal of the Office of the Governor of New Jersey, originally developed by the New Jersey Coalition Against Aircraft Noise, Inc.

As shown in Figure 6-1, this alternative begins by sending EWR departures south and east over water, regardless of their final destination. The aircraft climb over the water until they are high enough to be inaudible from the land. West departures then turn south and west to join their jet airways. In effect, the current four west fixes are replaced by a single fix. To accommodate this new flow of traffic, the JFK arrivals that currently use that airspace (the ones headed north from ZDC) are moved several miles eastward. Arrivals to JFK from ZDC are also moved eastward to give the EWR departures space to climb unimpeded. JFK westbound departures go even farther south before turning west.

EWR North departures go east, and then turn north over Long Island, then west. This loop eastward permits them to climb out of the New York TRACON through the top of the TRACON airspace, then proceed westward at high altitude.

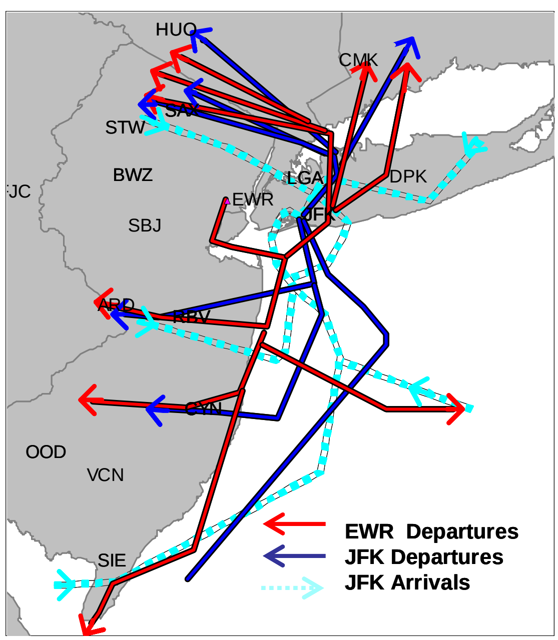


Figure 6-1. Ocean Routing Alternative Overview

North and west departures from LGA head north, keeping east of the Hudson River, until their engine noise is no longer a problem, then turn westward. They will be under the north departures from EWR.

PHL traffic is not directly affected by the Ocean Routing Alternative. Any impacts on PHL will be secondary, because departures may have a more difficult time merging with the JFK departures to the west, which are now overhead of the MXE departure fix.

The TAAM implementation of Ocean Routing Alternative is based on airspace and airport modifications to the validated Future No Action TAAM models.

Detailed operational TAAM modeling of this alternative was conducted for the highest-traffic subset of the airports (JFK, LGA, ISP, HPN, EWR, PHL, TEB and MMU) to be studied in the EIS. As part of the model development, the departure and arrival routes were provided by the redesign team. The terminal arrival and departure procedures were based on modifications to the current procedures as coordinated and validated by the redesign team.

Based on the destination airport, the modeled departures typically use the same jet route and departure fix. The departure route and departure fix usage modeled in TAAM is described in Section 6.2. The specific en route and terminal arrival and departure profiles modeled in TAAM is described in Section 6.3.

6.2 Airspace

In the Ocean Routing Alternative, all departure routes from LGA, ISP, HPN, PHL, TEB and MMU are the same as in the Future No Action Alternative as shown in Figure 6-2. West departures from EWR are routed to RBV or CYN rather than using west gate departure fixes (ELIOT, PARKE, LANNA, and BIGGY). Some west departures from JFK are also routed to CYN, rather than RBV used in the Future No Action Alternative. South departures from EWR are routed to SIE rather than to WHITE. These differences are highlighted in purple in Figure 6-2.

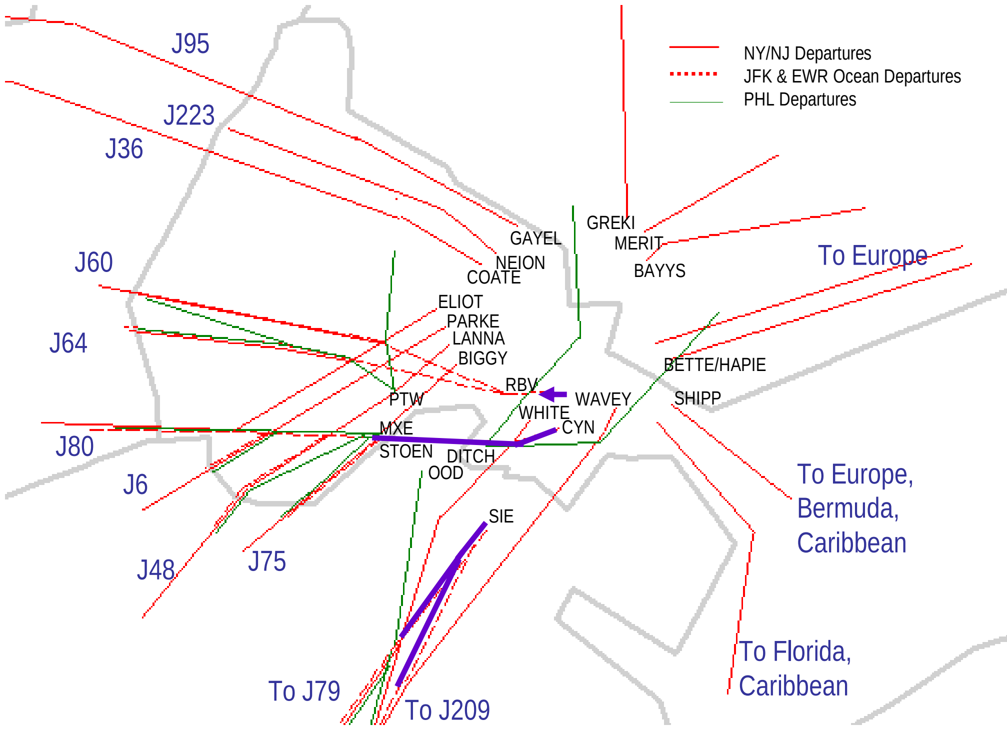


Figure 6-2. Ocean Routing Airspace

6.2.1 West Departures in Ocean Routing

Figure 6-3 shows departures from EWR and JFK to J60 and J64 are routed to RBV. Departures to J80 from JFK and EWR are routed to CYN and continue west on J110, and merge with PHL departures and other NY departures via ELIOT at KIPPI and LARRI. Departures to J6 are routed to CYN, continue west on J110 and turn southwest at FLIRT, merging with other NY metro departures from PARKE. Departures to J48 from JFK and EWR are routed to CYN, continue west on J110, where J48 departures turn south at PENSY merging with other NY metro departures from LANNA. Departures to J75 from JFK and EWR are routed to CYN, continue on J110, where J75 departures turn south at a few miles west of MXE, and merge with other NY metro departures from BIGGY at SACRI.J80 departures continue west, merging with PHL departures and other NY departures via ELIOT at KIPPI and LARRI.

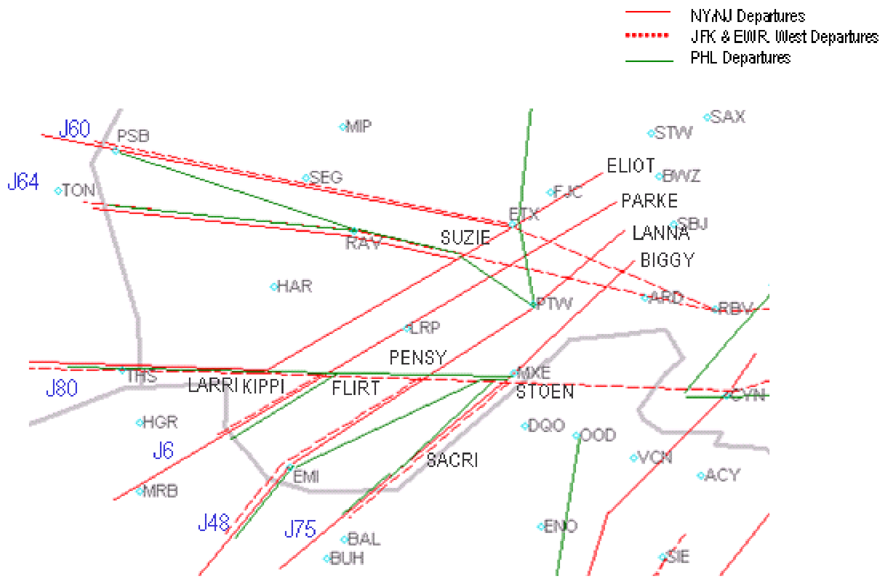


Figure 6-3. Ocean Routing West Departures

6.2.2 South Departures in Ocean Routing

Figure 6-4 shows south departures are the same as in the Future No Action Alternative except that EWR departures are routed over the ocean to Sea Isle (SIE). At SIE, EWR flights are separated based on whether the flights are destined to fly over land (J79) or over water (J209). EWR flights destined to fly over water via route (J209) are merged with JFK and ISP departures at Snow Hill (SWL). EWR flights destined to fly over land (J79) are merged with WHITE departures and PHL departures at SBY and continue via KATZN, WEAVR and ISO to jet route J29.

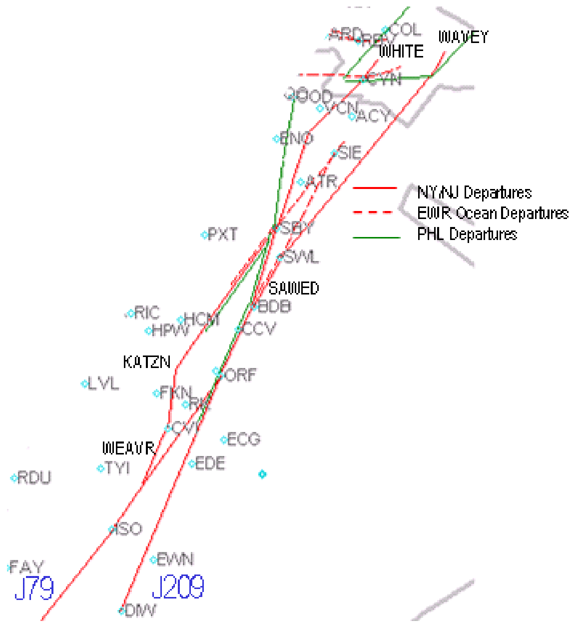


Figure 6-4. Ocean Routing South Departures

6.3 Airports

The subsections below describe the en route arrival/departure profiles and the terminal arrival/departure profiles for the Ocean Routing Alternative for JFK, LGA, ISP, EWR, EWR satellites (TEB and MMU), PHL, and HPN. In each subsection, there is an overall description of en route arrival/departure profiles and an enhanced view of the modeled terminal arrival/departure procedures. In the supporting figures, altitudes below 18,000 feet are shown in hundreds of feet (i.e., 8,000 is shown as 80), and altitudes above 18,000 feet are given in Flight Levels (FLs) (i.e. 19,000 feet is shown as FL190).

6.3.1 John F. Kennedy International

6.3.1.1 JFK En Route Arrival/Departure Profiles

Figure 6-5 shows the Ocean Routing arrival routes.

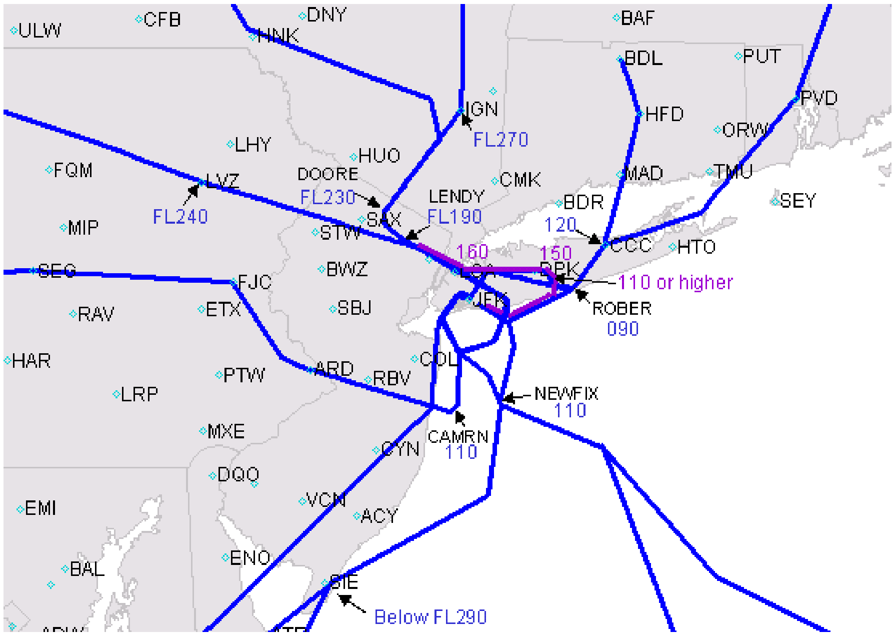


Figure 6-5. Ocean Routing JFK Arrival Profile

Arrivals to JFK are the same as in the Future No Action Alternative with the following exceptions.

- Jet arrivals from the south via CAMRN are routed out in the ocean from SIE (altitude is below FL290) to SIE radial 074 to intercept DPK radial 206, then to the fix (NEWFIX) at the intersection of DPK radial 206 and COL radial 131. Altitude at NEWFIX is 11,000 feet.
- In the JFK low configuration, Jet Arrivals from the northwest to 31L/R (LENDY and KINGSTON arrivals) pass LGA at 16,000 feet, continue to DPK (cross DPK at 15,000 feet.), start turning south staying at 11,000 feet or higher to intercept HTO radial 260, then descend to 4000 feet.

Figure 6-6 shows the Ocean Routing departure routes and associated gate altitudes.

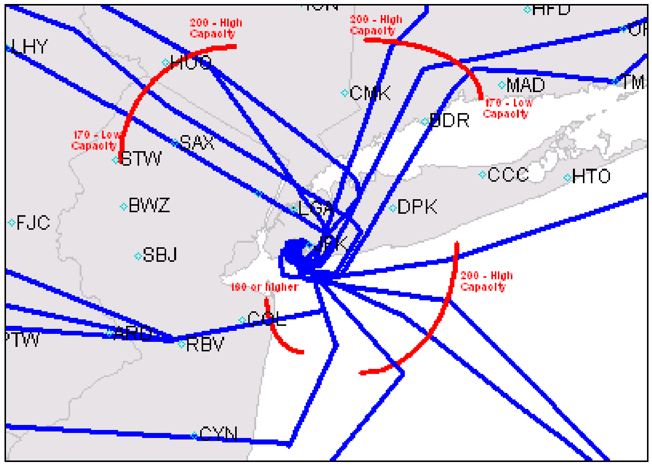


Figure 6-6. Ocean Routing JFK Departure Profile

Departures to north and east are the same as in the Future No Action Alternative. Departures to J60 and J64 fly via JFK 180 radial to intercept RBV 90 radial to RBV. Departures to J80, J6, J48, and J75 fly via JFK 180 radial to intercept DPK 217 radial and then intercept CYN 110 radial to CYN and continue on J110.

6.3.1.2 JFK Terminal Arrival/Departure Profiles

Figures 6-7 and 6-8 compare the arrival and departure procedures for the Future No Action and Ocean Routing Alternatives. The blue lines display the TAAM-based tracks for JFK arrivals, and the green lines display the TAAM-based tracks for the JFK departures. The change to northwest arrivals for the low configuration and change to southbound departures are shown in these figures.

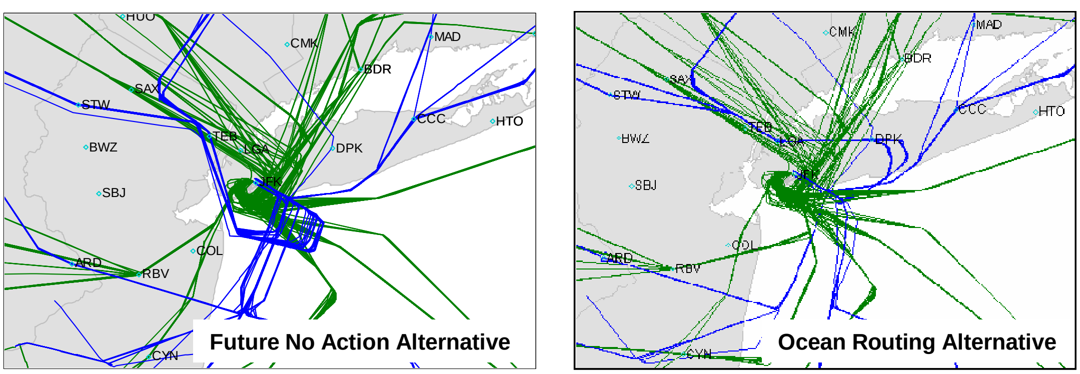


Figure 6-7. Future No Action and Ocean Routing JFK Low Capacity Terminal Profiles

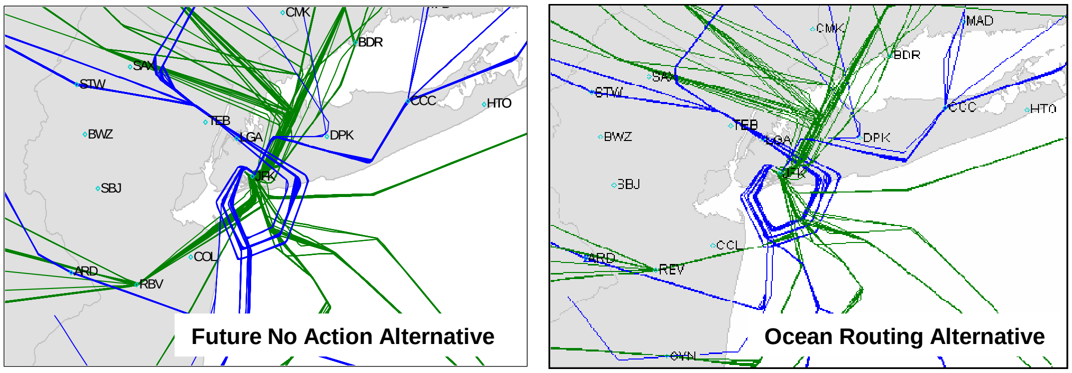


Figure 6-8. Future No Action and Ocean Routing JFK High Capacity Terminal Profiles

6.3.2 LaGuardia

6.3.2.1 LaGuardia En Route Arrival/Departure Profiles

In Ocean Routing, LGA arrivals are the same as in the Future No Action Alternative except for the altitude restriction for arrivals from south and west. Arrivals from south and west are at 9000 feet when they cross CRI radial 256 to allow the departures from EWR to climb to the altitude. Figure 6-9 shows the arrival routes and altitudes. Altitudes in the figure are shown in hundreds of feet and FLs.

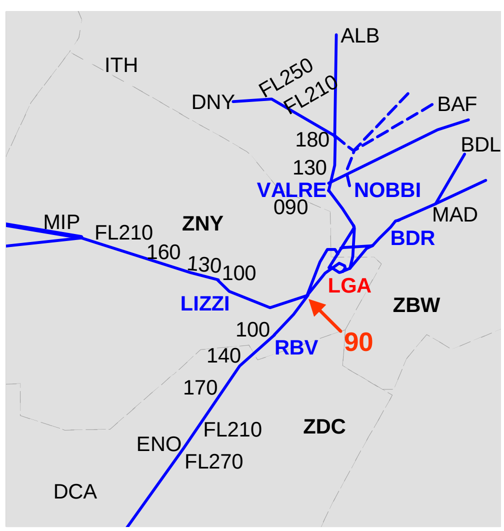


Figure 6-9. Ocean Routing LGA Arrival Profile

In Ocean Routing, LGA departures to north gates (GAYEL, NEION, and COATE) remain over the Hudson River for a longer period of time than in the Future No Action Alternative. LGA departures remain over or east of the Hudson River until intercepting the appropriate DPK radial where aircraft proceed westbound: GAYEL via DPK radial 319, NEION via DPK radial 311, and COATE via DPK radial 300.

Figure 6-10 shows the Ocean Routing departure routes and associated gate altitudes. Altitudes in the figure are shown in hundreds of feet.

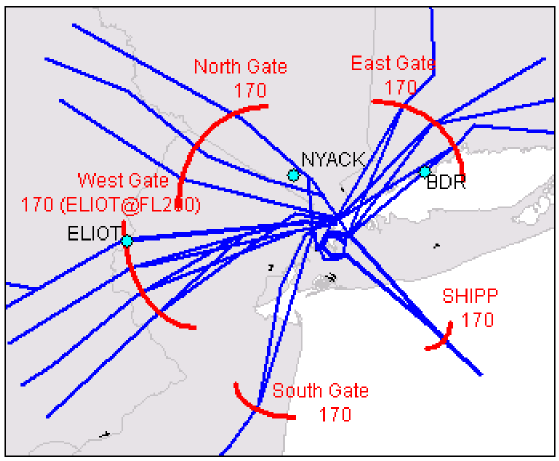


Figure 6-10. Ocean Routing LGA Departure Profile

6.3.2.2 LaGuardia Terminal Arrival/Departure Profiles

Figures 6-11 and 6-12 compare the arrival and departure procedures for the Future No Action and Ocean Routing Alternatives. The blue lines display the TAAM-based tracks for LGA arrivals, and the green lines display the TAAM-based tracks for the LGA departures.

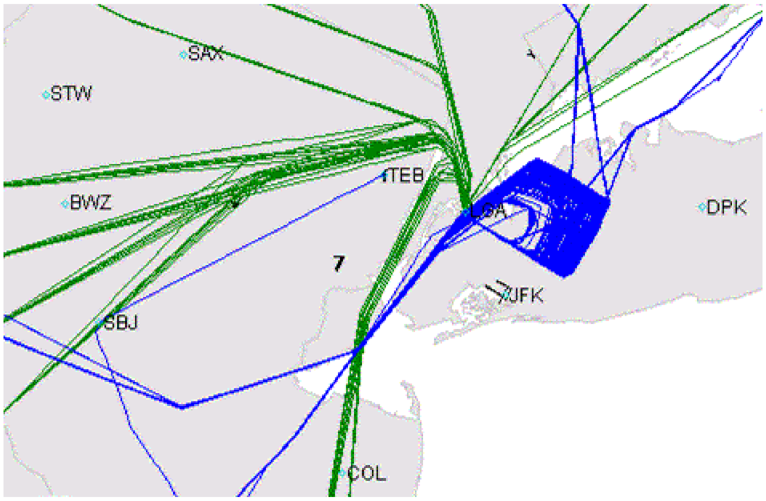


Figure 6-11. Ocean Routing LGA Low Capacity Terminal Profile

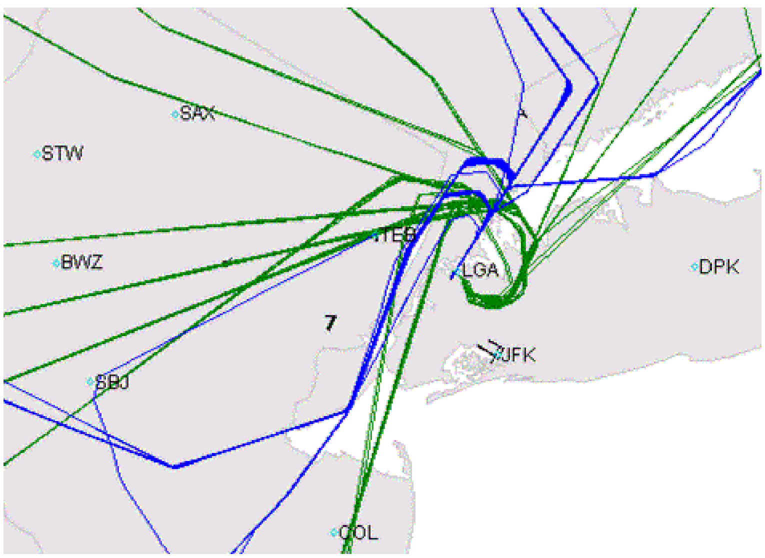


Figure 6-12. Ocean Routing LGA High Capacity Terminal Profile

6.3.3 Long Island MacArthur

There is no change in ISP in Oceanic Routing from the Future No Action Alternative

6.3.4 Newark Liberty International

6.3.4.1 Newark Liberty International En Route Arrival/Departure Profiles

In Ocean Routing, EWR arrivals are the same as in the Future No Action Alternative as discussed in Section 4.3.4.

Figure 6-13 shows the Ocean Routing departure routes and associated gate altitudes. Altitudes in the figure are shown in hundreds of feet and FLs.

Departures to north and east from Runway 04L are the same as in the Future No Action Alternative. Departures to the south and west from Runway 04L turn south, then east via SBJ114041 then via the JFK210 radial to intercept the RBV110 radial to RBV J64 (J60 departures) or intercept the CYN 090 radial to CYN and then to J110 (J80, J48, J48, J6, J75 departures), or intercept J121 and follow J121 to SIE (WHITE departures). South and west departures must be at or above 10,000 feet when crossing with LGA arrivals from RBV. J60 departures must be at FL230 when they turn inland, and other departures must be FL300 or above when they turn inland.

All departures from Runway 22R turn east via SBJ110041. South and west departures from Runway 22R are the same as 04L departures except that aircraft must be 6,000 feet or below when crossing with LGA arrivals from RBV. North and east departures turn toward DPK at SBJ110041. Once aircraft cross the south shore of ISP (aircraft must be at 16,000 feet or above), east departures vector left to the assigned fix, whereas north departures continue left until crossing the Hudson River, then turn to the assigned fix.

Departures from Runway 29 are the same as the in Future No Action Alternative.

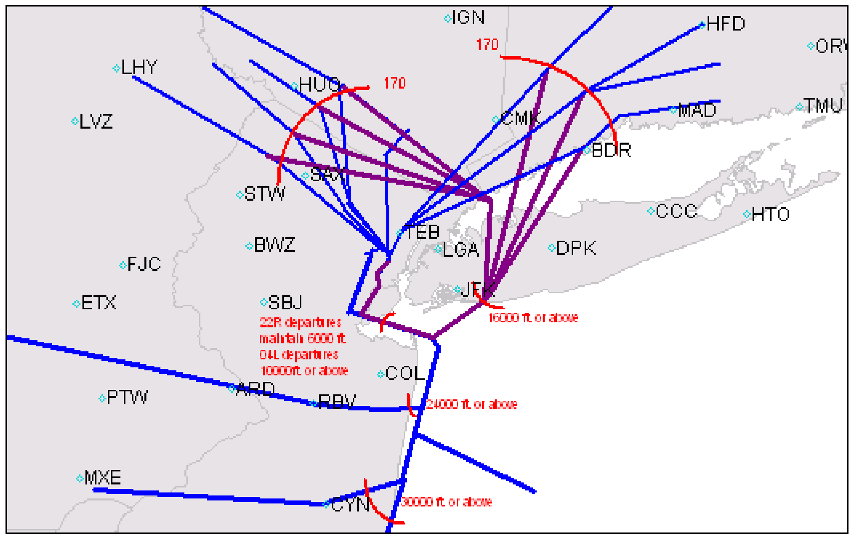


Figure 6-13. Ocean Routing EWR Departure Profile

6.3.4.2 Newark Liberty International Terminal Arrival/Departure Profiles

Figures 6-14 and 6-15 compare the arrival and departure procedures for the Future No Action and Ocean Routing Alternatives. The blue lines display the TAAM-based tracks for EWR arrivals, and the green lines display the TAAM-based tracks for the EWR departures. These figures show the impact to the west departures with this alternative.

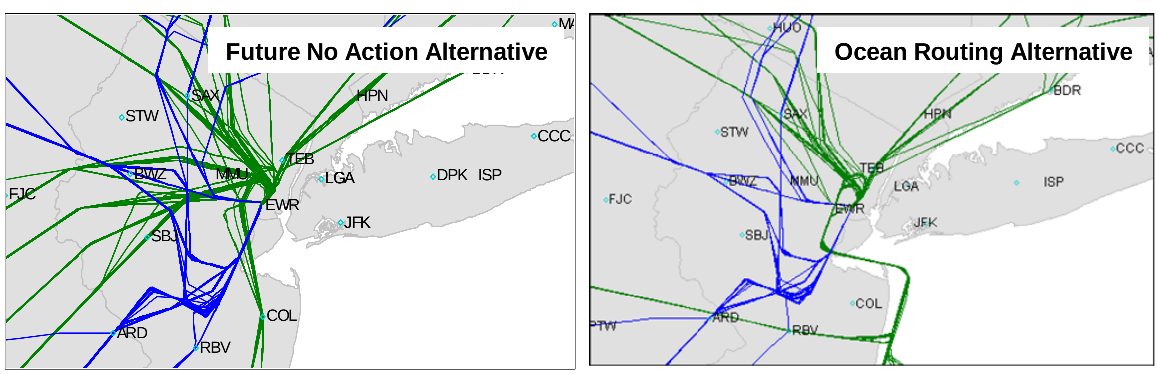


Figure 6-14. Future No Action and Ocean Routing EWR Low Capacity Terminal Profiles

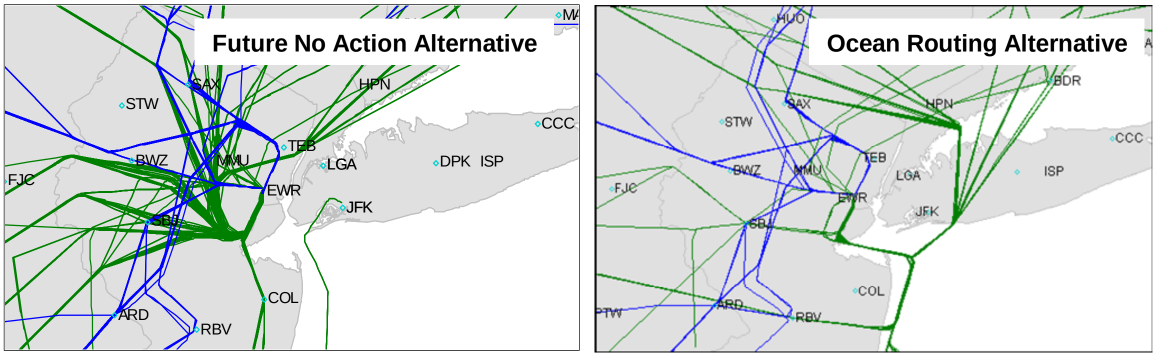


Figure 6-15. Future No Action and Ocean Routing EWR High Capacity Terminal Profiles

6.3.5 Teterboro and Morristown Municipal

There is no change to TEB and MMU operations for Ocean Routing from the Future No Action Alternative as discussed in Section 4.3.5.

6.3.6 Philadelphia International

There is no change to PHL operations for Ocean Routing from the Future No Action Alternative.

6.3.7 Westchester County

There is no change to HPN operations for Ocean Routing from the Future No Action Alternative.

Section 7

Integrated Airspace Alternative

7.1 Design Overview

In the Integrated Airspace Alternative, NY metro departures to north and east, and oceanic departures as well as all PHL departures are the same as in the Future No Action Alternative. West departures from NY metro airports have an additional departure fix. As shown in Figure 7-1, a jet route parallel to J80 is available for NY metro and PHL departures for Indianapolis ARTCC (ZID) internal airports. JFK satellite departures to the south are given separate routes from JFK and the routes are separated earlier depending on the destination (over water on J209 or over land on J79). In addition, there is a new prop route for EWR and its satellites, and ISP gains a new southern departure stream. Finally, HPN southern arrival route is modified and has a straighter approach to the airport.

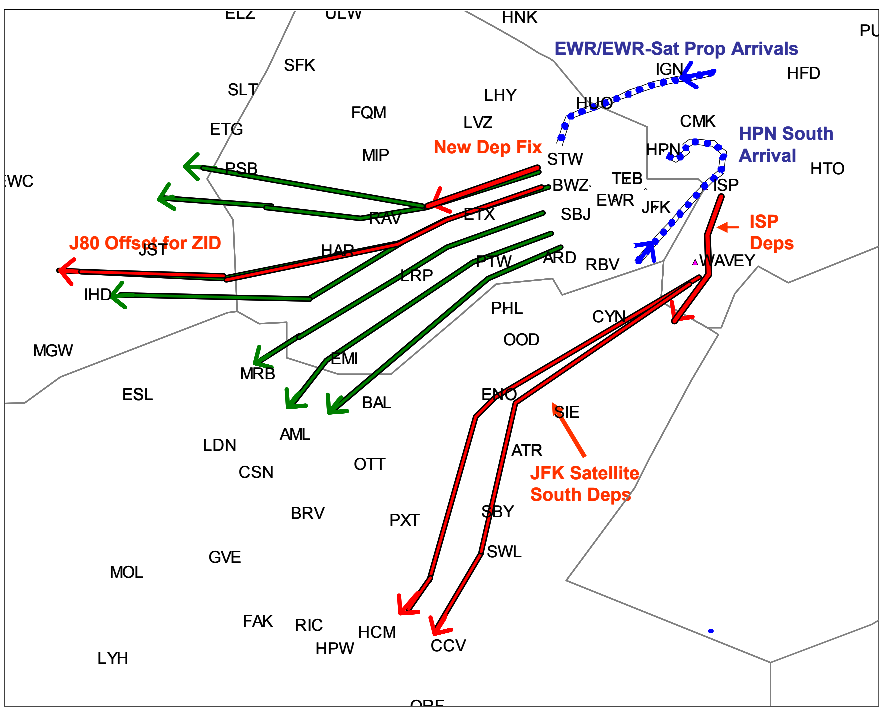


Figure 7-1. Integrated Airspace Alternative Overview

The TAAM implementation of the Integrated Airspace Alternative is based on airspace and airport modifications to the validated Future No Action Alternative TAAM models. Detailed operational TAAM modeling of this alternative was conducted for the highest-traffic subset of the airports (JFK, LGA, ISP, HPN, EWR, PHL, TEB and MMU) to be studied in the Environmental Impact Statement. As part of the model development, the departure and arrival routes were provided by the redesign team. The terminal arrival and departure procedures were based on modifications to the current procedures as coordinated and validated by the redesign team.

Based on the destination airport, the modeled departures typically use the same jet route and departure fix as in the Future No Action Alternative. The departure route and departure fix usage modeled in TAAM is described in Section 7.2. The specific en route and terminal arrival and departure profiles modeled in TAAM is described in Section 7.3.

7.2 Airspace

In this alternative, NY metro departures to the north and east, and oceanic departures as well as all PHL departures are the same as in the Future No Action Alternative as shown in Figure 7-2. The purple lines in the figure highlight the Integrated Airspace Alternative differences from the Future No Action Alternative. West departures from NY metro airports have an additional departure fix. Additionally, a jet route parallel to J80 is available in this alternative for NY metro and PHL departures for ZID internal airports. JFK satellite departures to the south are given separate routes from JFK departures and the routes are separated earlier depending on the destination (over water on J209 or over land on J79).

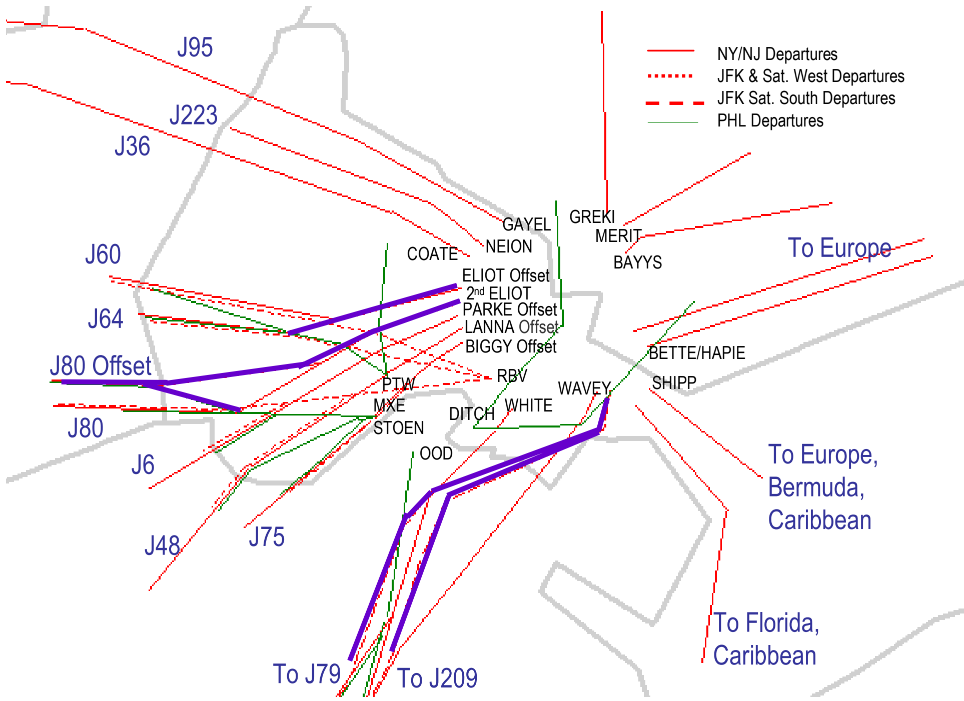


Figure 7-2. Integrated Airspace

7.2.1 West Departures

In this alternative as shown in Figure 7-3, NY metro departures to the west have one additional departure fix (2nd ELIOT). In order to accommodate this additional fix, the locations of the existing four west departure fixes (ELIOT, PARKE, LANNA, and BIGGY) are shifted slightly. These shifted fixes are shown in Figure 7-3 as ELIOT Offset, PARKE Offset, LANNA Offset and BIGGY Offset. The additional fix (2nd ELIOT) allows the ELIOT departures in the Future No Action Alternative to be split into two streams based on the jet route. ELIOT Offset is used for departures to J60 and J64, and 2nd ELIOT is used for departures to J80. Furthermore, ZID internal destinations (including CMH, DAY, ILN, IND, and LCK) from NY metro and PHL airports are assigned to a jet route offset of J80. The departures to J6, J48, J75, and the west departures from JFK and ISP take the same routes as in the Future No Action Alternative.

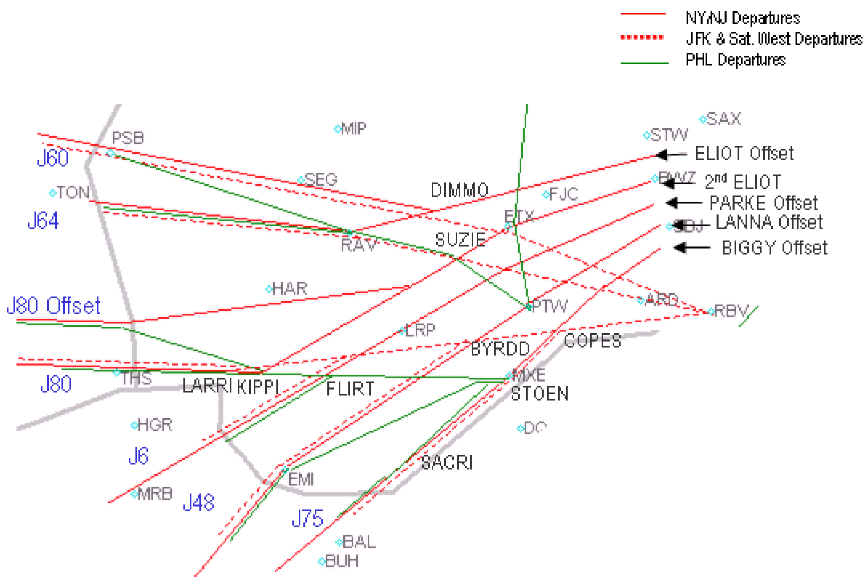


Figure 7-3. Integrated Airspace West Departures

7.2.2 South Departures

Figure 7-4 shows south departures are the same as in the Future No Action Alternative except for JFK satellite departures. In the Future No Action Alternative, JFK satellite departures merge with JFK departures south of WAVEY. In Integrated Airspace Alternative, they are routed south from PLUME and then to the southwest. North of ATR, flights destined to J209 turn south towards SAWED where they merge with JFK departures from WAVEY. Flights destined to J79 continue southwest and turns south when south of ENO and merge with other J79 bound flights at north of KATZN.

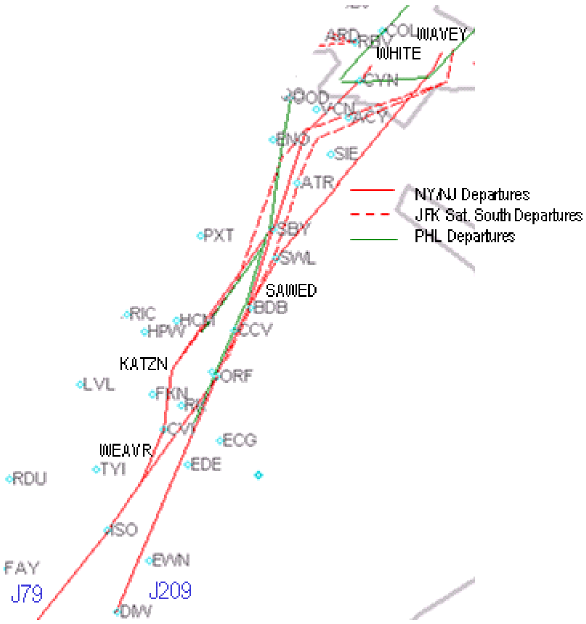


Figure 7-4. Integrated Airspace South Departures

7.3 Airports

The subsections below describe the en route arrival/departure profiles and the terminal arrival/departure profiles for the Integrated Airspace Alternative for JFK, LGA, ISP, EWR, EWR satellites (TEB and MMU), PHL, and HPN. In each subsection, there is an overall description of en route arrival/departure profiles and an enhanced view of the modeled terminal arrival/departure procedures. In the supporting figures, altitudes below 18,000 feet are shown in hundreds of feet (i.e., 8,000 is shown as 80), and altitudes above 18,000 feet are given in Flight Levels (FLs) (i.e., 19,000 feet is shown as FL190).

7.3.1 John F. Kennedy International

JFK is generally unaffected in this alternative. Arrivals and departures are exactly the same. There are some differences in route allocation but the arrival and departures entering the terminal area are not affected by these changes.

7.3.2 LaGuardia

7.3.2.1 LaGuardia En Route Arrival/Departure Profiles

Arrival traffic to LGA in the Integrated Airspace Alternative does not change from the Future No Action Alternative. The departure traffic changes only with respect to the west gate as shown in Figure 7-5. In the Integrated Airspace Alternative, the ELIOT fix is split into two fixes which feed J60 and J80. The PARKE, LANNA, and BIGGY fixes are shifted south to allow room for the ELIOT split. The Future No Action west gate departures are in light blue and Integrated Airspace Alternative departures are in dark blue. As in the Future No Action Alternative, departures to the west gate must not exceed 17,000 feet except for those flights routed over the two ELIOT fixes, which may climb as high as FL200 (FL200) before passing through the west gate. Altitudes in the figure are shown in hundreds of feet and FLs.

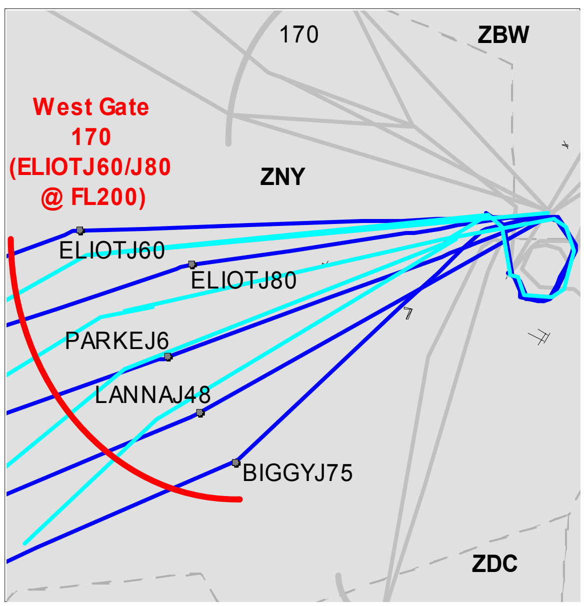


Figure 7-5. Comparison of LGA West Gate Departures (Future No Action vs. Integrated Airspace)

7.3.2.2 LaGuardia Terminal Arrival/Departure Profiles

Figures 7-6 and 7-7 compare the terminal arrival and departure profiles for the Future No Action and Integrated Airspace Alternatives. The arrivals are shown in blue, and the departures are shown in green. The arrival profiles have not changed from the Future No Action Alternative. The departure profiles reflect the changes in alignment of the southwest gate and the split of the ELIOT departure fix.

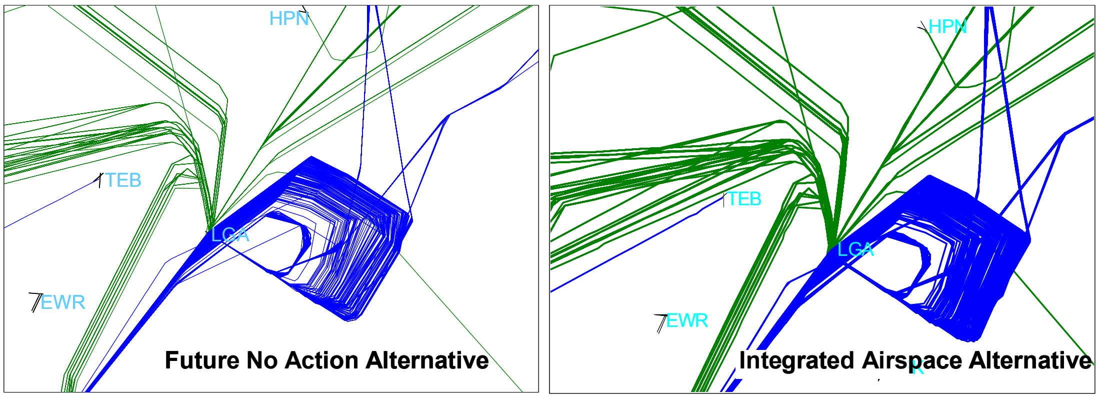


Figure 7-6. Future No Action and Integrated Airspace Low Capacity LGA Terminal Profiles

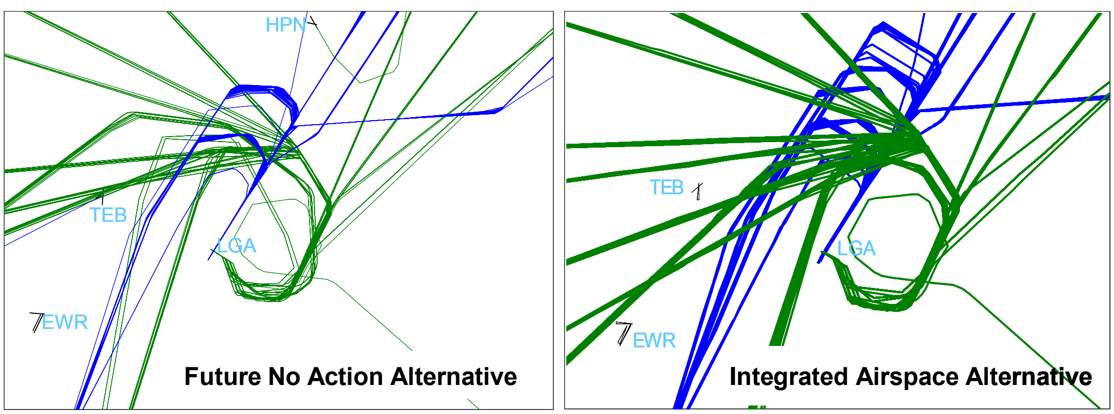


Figure 7-7. Future No Action and Integrated Airspace High Capacity LGA Terminal Profiles

7.3.3 Long Island MacArthur

7.3.3.1 Long Island MacArthur En Route Arrival/Departure Profiles

Arrivals are the same in the Future No Action and Integrated Airspace Alternatives. There is no change in arrival configuration between the high and low capacity configurations.

Figure 7-8 depicts the Integrated Airspace Alternative departure streams with their corresponding departure gate altitudes for ISP. There is no change in departure configuration between the high and low capacity configurations. The addition of one southern departure stream, marked dashed green line, is the only difference between the Future No Action Alternative departures and the Integrated Airspace Alternative departures. Altitudes in the figure are shown in hundreds of feet.

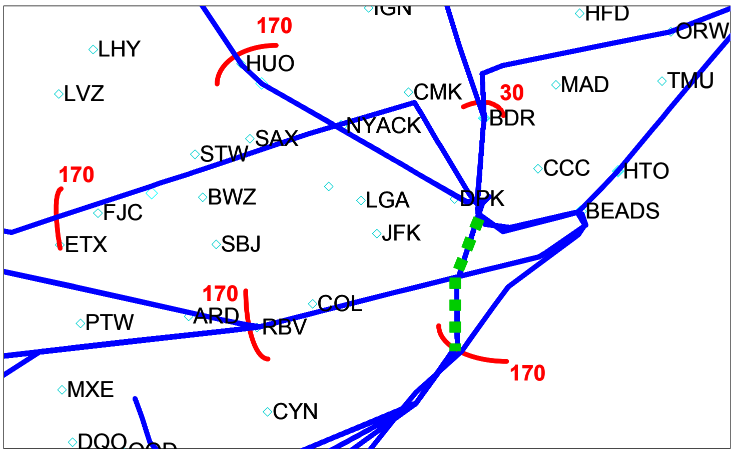


Figure 7-8. Integrated Airspace ISP Departure Profile

7.3.3.2 Long Island MacArthur Terminal Arrival/Departure Profiles

Figure 7-9 provides a comparison of the arrival and departures for ISP for the Future No Action and the Integrated Airspace Alternatives. The blue lines display the TAAM based tracks for ISP arrivals. The green lines display the TAAM based tracks for ISP departures. The high and low capacity configurations are the same for ISP. The addition of one southern departure stream for the Integrated Airspace Alternative is shown in the figure.

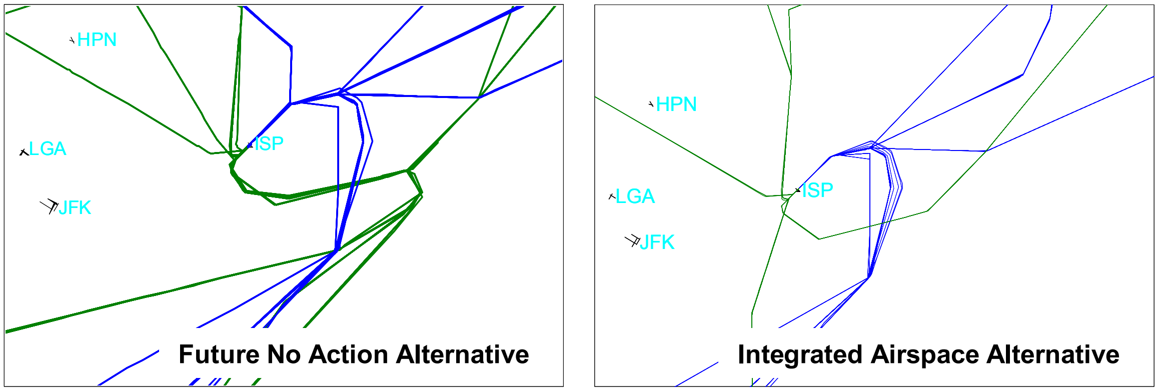


Figure 7-9. Future No Action and Integrated Airspace ISP Terminal Profiles

7.3.4 Newark Liberty International

7.3.4.1 Newark En Route Arrival/Departure Profiles

Figure 7-10 shows the overall Integrated Airspace Alternative en route EWR route structures and altitude profiles that were modeled in TAAM. The arrival fixes and arrival routes are the same as in the Future No Action Alternative except for a new EWR/EWR-satellite route for propeller-driven aircraft from the HFD NAVAID to south of HUO. This creates a more direct route to the airports along with allowing HPN arrivals and departures on ILS 16 an easier route in and out of the airport. Altitude restrictions are the same as in the Future No Action Alternative

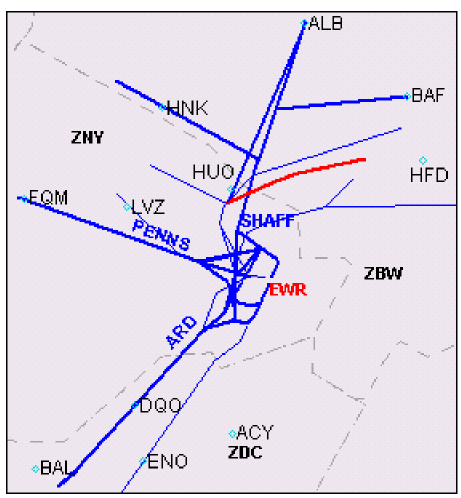


Figure 7-10. Integrated Airspace EWR Arrivals

Figure 7-11 shows the Integrated Airspace Alternative EWR departure routes and associated gate altitude. The north, south and east gates are unchanged from the Future No Action Alternative. There is slight realignment of the southwest gate to provide a new departure fix and airway from ELIOT to DIMMO, relieving congestion over present day ELIOT. This realignment and the departure route assignments are discussed Section 7.2. As in the Future No Action Alternative, aircraft must not climb above 17,000 feet until after they reach the gate. Altitudes in the figure are shown in hundreds of feet.

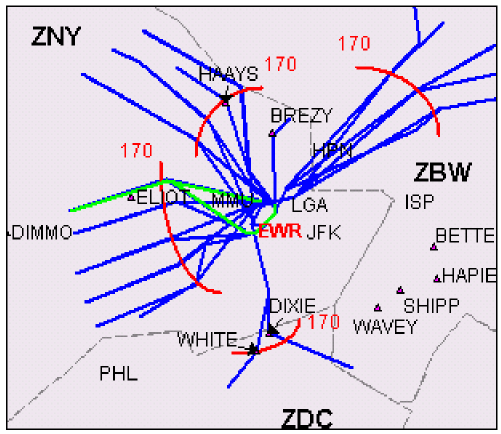


Figure 7-11. Integrated Airspace EWR Departures

7.3.4.2 Newark Terminal Arrival/Departure Profiles

Figures 7-12 and 7-13 compare the terminal arrival and departure profiles for the Future No Action and the Integrated Airspace Alternatives. The blue lines display the TAAM-based tracks for EWR arrivals via Runways 04R/22L and 11, and the green lines display the TAAM-based tracks for the EWR departures for Runways 04L/22R and 29. The arrival profiles have not changed from the Future No Action Alternative. The departure profile reflects the changes in alignment of the southwest gate.

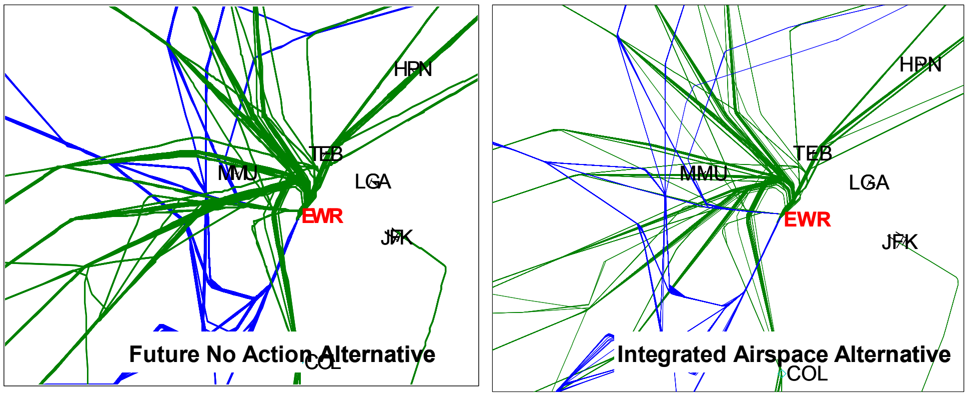


Figure 7-12. Future No Action and Integrated Airspace Low Capacity EWR Terminal Profiles

For the high capacity configuration, Runway 22R departures for Integrated Airspace Alternative are different from the Future No Action Alternative. In the Future No Action Alternative, all Runway 22R departures take a 190-degree heading when they reach 400 feet in altitude, then they take a 220-degree heading when they are 2.3 NM from the airport. Thus, for the Future No Action Alternative, all departures are in-trail initially. For the high capacity configuration, Runway 22R departures are fanned in the same way as in the Modifications to Existing Airspace Alternative. Table 5-1 in Section 5.3.4.2 provides the Runway 22R departure headings.

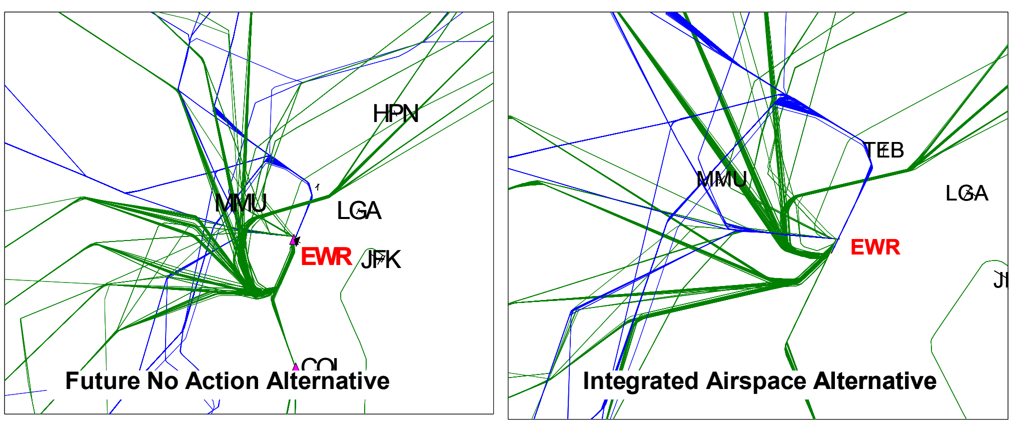


Figure 7-13. Future No Action and Integrated Airspace High Capacity EWR Terminal Profiles

7.3.5 Newark Liberty International Satellites (TEB and MMU)

7.3.5.1 Teterboro and Morristown Municipal En Route Arrival/Departure Profiles

Figure 7-14 shows the overall Integrated Airspace Alternative en route TEB and MMU arrival routes that were modeled in TAAM for both the low capacity and high capacity configurations. TEB is shown in blue. The MMU routes, where different from TEB, are shown in red.

The routes are the same as in the Future No Action Alternative except for a new EWR/EWR-satellite arrival route for propeller-driven aircraft from the east as shown in green in Figure 7-13. This route creates a more direct path to the airports. It also allows HPN arrivals and departures on ILS 16 an easier route in and out of the airport.

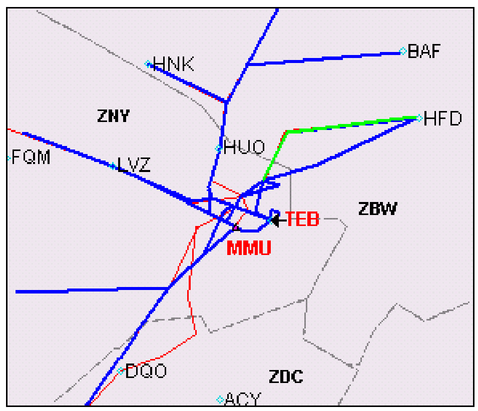


Figure 7-14. Integrated Airspace TEB/MMU Arrivals

Figure 7-15 shows the TEB and MMU Integrated Airspace departure routes and associated gate altitudes for both the low capacity and high capacity configurations. The north, south and east gates are unchanged from the Future No Action Alternative. There is slight realignment of the southwest gate to provide a new departure fix and airway from ELIOT to DIMMO, relieving congestion over present day ELIOT (shown in green). This realignment and departure route assignments are discussed Section 7.2. As in the Future No Action Alternative, aircraft must not climb above 17,000 feet until after they reach the gate. Altitudes in the figure are shown in hundreds of feet.

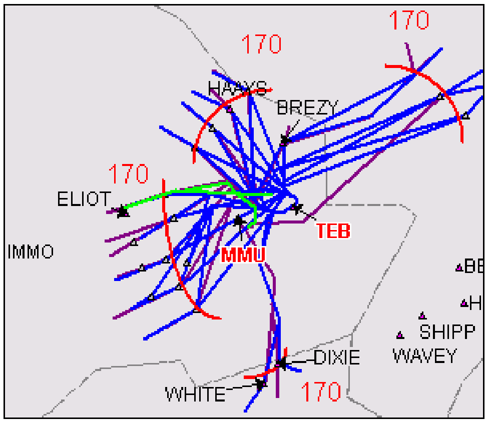


Figure 7-15. Integrated Airspace TEB/MMU Departures

7.3.5.2 Teterboro and Morristown Municipal Terminal Arrival/Departure Profiles

Figures 7-16 and 7-17 compares the modeled arrival and departure procedures for the Future No Action and Integrated Airspace Alternatives. The blue lines display the TAAM-based tracks for TEB 06/19 arrivals, and green lines display the TAAM-based tracks for TEB Runway 01/24 departures. Other than the new EWR/EWR-satellite arrival route for propeller-driven aircraft from the east, the arrival profiles have not changed from the Future No Action Alternative. The departure profile reflects the changes in alignment of the southwest gate and the additional departure fix to the west.

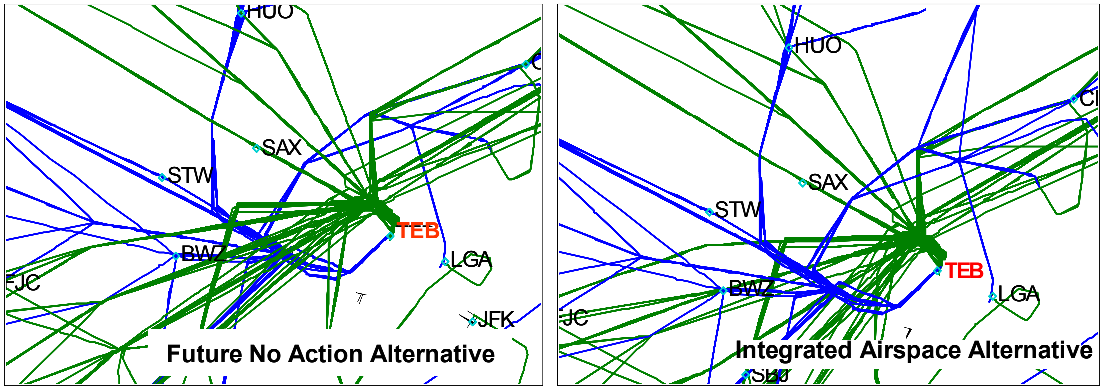


Figure 7-16. Future No Action and Integrated Airspace TEB Low Capacity Terminal Profiles

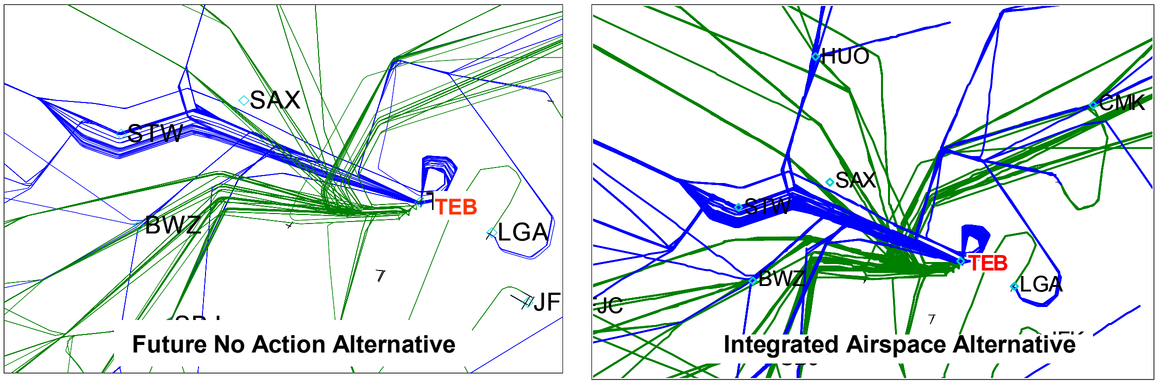


Figure 7-17. Future No Action and Integrated Airspace TEB High Capacity Terminal Profiles

Figures 7-18 compares the modeled arrival and departure procedures for the Future No Action and Integrated Airspace Alternatives. The blue lines display the TAAM-based tracks for MMU Runway 23 arrivals, and green lines display the TAAM-based tracks for MMU Runway 23 departures. Other than the new EWR/EWR-satellite arrival route for propeller-driven aircraft from the east, the arrival profiles are not changed from the Future No Action Alternative. The departure profile reflects the changes in alignment of the southwest gate and the additional departure fix to the west.

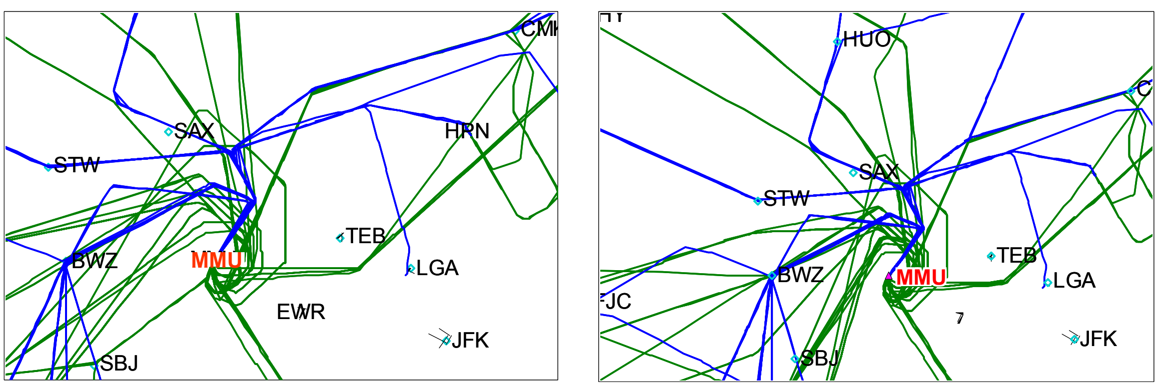


Figure 7-18. Integrated Airspace MMU Terminal Profile

7.3.6 Philadelphia International

PHL arrivals are generally unaffected in this alternative. PHL departures will be given headings off the runway according to their departure fix, exactly as in the Modifications to Existing Airspace Alternative (see Figure 5-8).

The splitting of J80/J110 into two airways will affect departure routing, but not until the aircraft are far from the airport.

7.3.7 Westchester County

7.3.7.1 Westchester County En Route Arrival/Departure Profiles

There is only one change to the HPN arrival traffic in the Integrated Airspace Alternative from the Future No Action Alternative. Arrivals from the south, previously routed over BOUNO, are routed over DPK. In this alternative, it is no longer necessary for the southern arrivals to avoid JFK airspace when the level of JFK traffic permits joint use. Figure 7-19 depicts this change to the southern arrivals. The previous route from the Future No Action Alternative is displayed in light blue, while the Integrated Airspace Alternative route is displayed in dark blue.

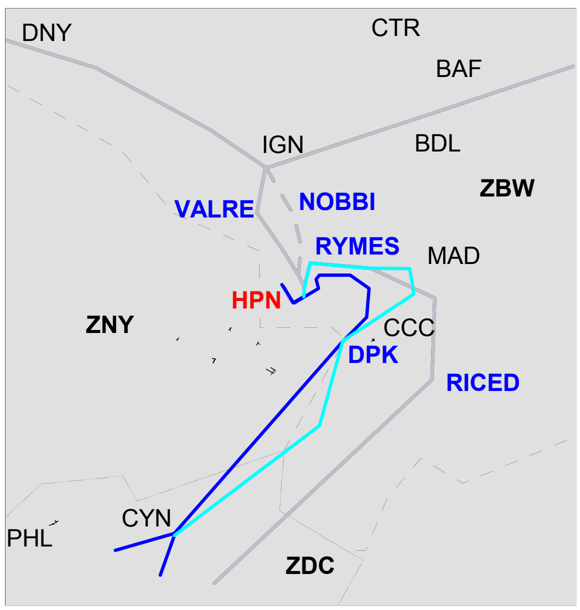


Figure 7-19. Comparison of HPN South Arrivals (Integrated Airspace vs. Future No Action)

The only change from the Future No Action Alternative to the Integrated Airspace Alternative is that the southern arrivals, those originating in the bright green area of Figure 7-20 are routed over DPK instead of BOUNO.

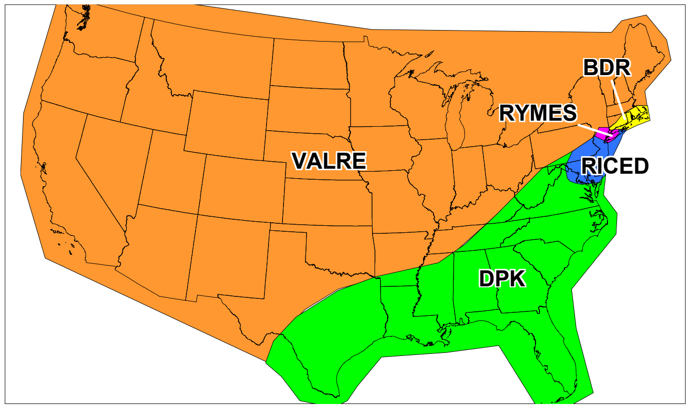


Figure 7-20. Origins of Traffic to Each HPN Arrival Fix

The indirect routing of the HPN arrival traffic insures that the flights are separated from much of the arrival and departure traffic to the busier airports. In the instances where crossing flows could not be avoided, altitude restrictions were employed to insure vertical separation. The altitudes modeled for the southern arrivals over DPK are shown in Figure 7-21. The dark blue line is the Integrated Airspace Alternative southern arrival track, and the light blue line is the Future No Action Alternative southern arrival track.

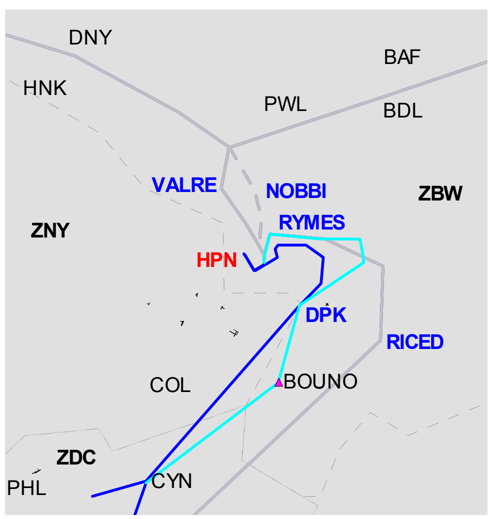


Figure 7-21. HPN Arrival Altitude Restrictions

The departure traffic in the Integrated Airspace Alternative changes from the Future No Action Alternative only with respect to the west gate as shown in Figure 7-22. In the Integrated Airspace Alternative, the ELIOT fix is split into two fixes which feed J60 and J80. The PARKE, LANNA, and BIGGY fixes are shifted south to allow room for the ELIOT split. Figure 7-22 depicts the Future No Action west gate departures in light blue and the Integrated Airspace departures in dark blue. As in the Future No Action Alternative, departures to the west gate must not exceed 17,000 feet. Altitudes in the figure are shown in hundreds of feet.

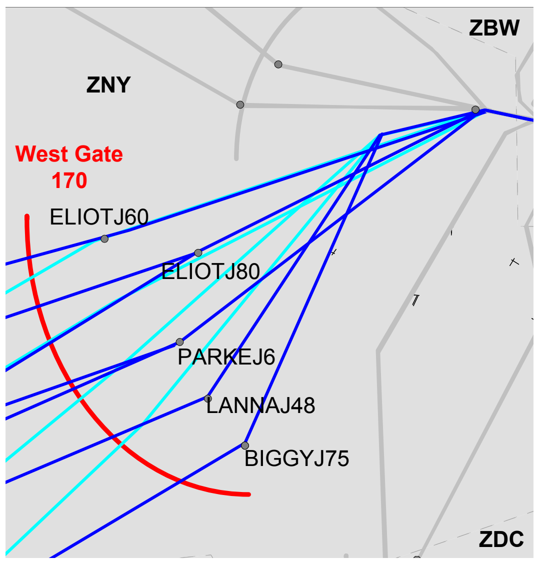


Figure 7-22. Comparison of HPN West Gate Departures (Future No Action vs. Integrated Airspace)

7.3.7.2 Terminal Arrival/Departure Profiles

Figure 7-23 compares the Future No Action Alternative and Integrated Airspace Alternative low-altitude routings in the HPN terminal airspace. The Integrated Airspace Alternative arrival profiles reflect the change in the southern arrival route using DPK, and the flight path from the east before turning onto the downwind is farther south. The Integrated Airspace departure profiles reflect the changes in alignment of the southwest gate and the split of the ELIOT departure fix.

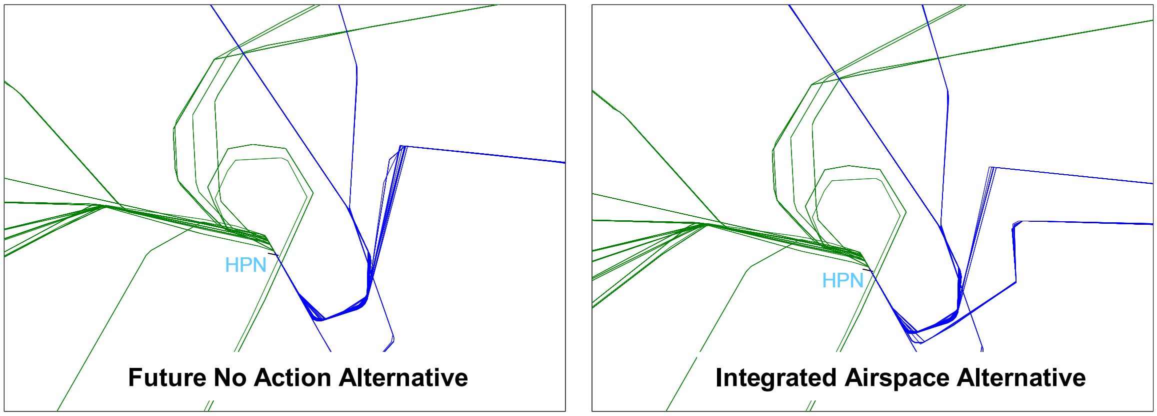


Figure 7-23. Future No Action and Integrated Airspace Alternative HPN Terminal Profiles

Section 8

Integrated Airspace with Integrated Control Complex Alternative

The TAAM implementation of the Integrated Airspace with Integrated Control Complex Alternative is based on airspace and airport modifications to the validated Future No Action Alternative TAAM models. Detailed operational TAAM modeling of this alternative was conducted for the highest-traffic subset of the airports (JFK, LGA, ISP, HPN, EWR, PHL, TEB and MMU) to be studied in the Environmental Impact Statement. As part of the model development, the departure and arrival routes were provided by the redesign team. The terminal arrival and departure procedures were based on modifications to the current procedures as coordinated and validated by the redesign team. A design overview is provided in Section 8.1. Based on the destination airport, the modeled departures typically use the same jet route and departure fix. The departure route and departure fix usage modeled in TAAM is described in Section 8.2. The specific en route and terminal arrival and departure profiles modeled in TAAM is described in Section 8.3.

8.1 Design Overview

This alternative is a fundamental redesign of the airspace from New York to Philadelphia. As shown in Figure 8-1, it envisions a large area, up to FL230 in some places, using terminal separation rules, with a higher-altitude portion (up to FL350) operating like an Air Route Traffic Control Center. The airspace will comprise most of the current New York TRACON and Center, several sectors from ZDC, and several sectors from ZBW. The current New York TRACON and en route Center will lose their separate identities, as they are merged into a single facility that has some features of each. The Philadelphia TRACON will continue to exist as a separate facility, also using terminal separation rules in its expanded airspace. Airspace over the top of the integrated control complex will be controlled by other ARTCCs.

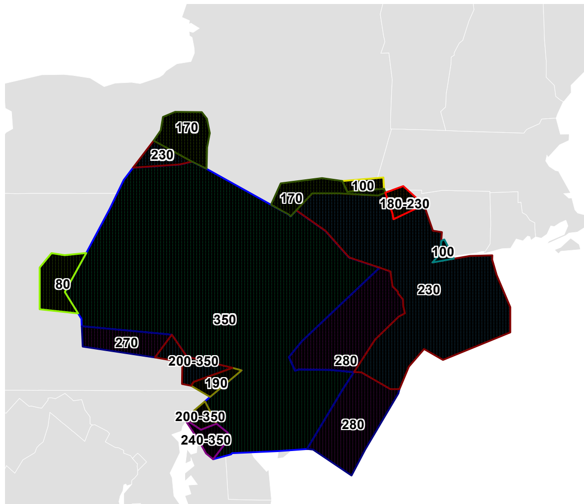


Figure 8-1. Integrated Airspace with Integrated Control Complex Airspace

Fanning of departures to reduce inter-departure spacing is a feature of this alternative, just as for the "Modifications to Existing Airspace" Alternative.

The Integrated Airspace with Integrated Control Complex Alternative will see significant improvements in routing, coordination among controllers, delay absorption strategies (especially holding) on arrivals, and use of departure fixes. Other facilities will also see benefits as constraints on their operation caused by congestion in NY are relieved. These improvements are discussed in the following subsections.

8.1.1 Routing

The Integrated Airspace with the Integrated Control Complex, because it is no longer constrained by existing facility boundaries, has more fixes than the current operation. As shown in Figure 8-2, there are three north departure fixes (as today, but some of the current traffic is sent out the expanded west gate), three east departure fixes (up from two), six west departure fixes (up from four), and two south departure fixes (up from one). The west gate fixes that serve more than one jet airway are split. In addition, transatlantic traffic from EWR is permitted access to oceanic fixes that are currently available only to JFK departures.

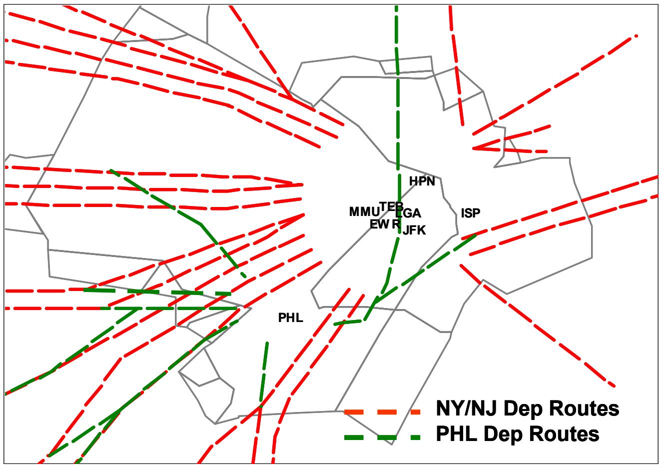


Figure 8-2. Integrated Airspace with Integrated Control Complex Departure Routes

JFK arrivals from the Pacific Rim via Canada are no longer routed over top of New York City (currently via IGN (Kingston)). Rather, they come in from the east as shown in Figure 8-3. As a result, the LENDY position is no longer merging two arrival streams. This means JFK and ISP can send traffic to the West gate, which permits RBV's current load to be split among six fixes.

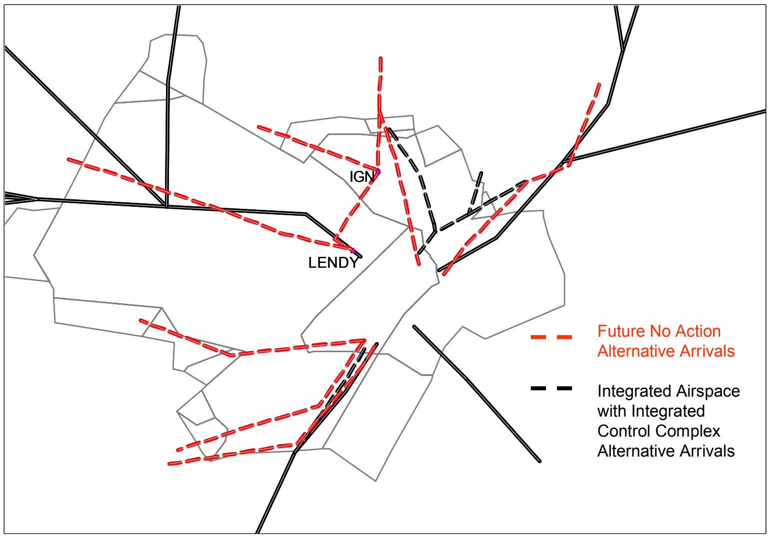


Figure 8-3. Integrated Airspace with Integrated Control Complex JFK Arrival Routes

8.1.2 Coordination Among Controllers

In the current airspace, changing a flight's departure fix frequently involves a three-way teleconference among the TRACON, the Center of the original departure, and the Center of the proposed reroute. Especially when convective weather is causing the reroute, time is critical for the departure. The Integrated Control Complex, which puts all the involved controllers in a common location, will permit face-to-face coordination, which makes it much faster to approve the reroute.

Arrivals to New York City airports are currently segregated in that each airport has its own arrival airspace. As a result, when traffic is light at one airport, that airspace is unused. If another airport is busy, its arrival controllers cannot take advantage of the unused airspace to solve their own congestion problems. The Integrated Airspace with Integrated Control Complex Alternative will permit the creation of integrated areas of specialization handling arrivals over the last 100-200 miles of their flights, where coordination among the various sectors can be more readily accomplished.

8.1.3 Delay Absorption Techniques

With several facilities controlling arrivals to New York City, there are severe limits on the ways that sequencing delay can be absorbed. The first to be tried is speed reduction and vectoring in the approach control airspace. When this is insufficient, the en route Centers begin to slow aircraft. The last resort is holding in the Center. There is no place to hold in the NY TRACON. These techniques are different, and small differences in how and when each is brought to bear can have large impacts on the efficiency of the operation. (At some point, of course, traffic flow management comes into the picture, which adds yet another layer of complexity.)

With the Integrated Airspace with Integrated Control Complex Alternative, controllers can make **smooth transitions between delay absorption techniques**. There are no gaps at handoff, during which neither controller can alter the aircraft's path. Perhaps most important is that, when it is necessary, **holding takes place under terminal separation rules**. Holding using terminal rules is so much more efficient than holding en route that it almost qualifies as an additional technique. For example, an aircraft holding in en route airspace must hold for a multiple of four minutes (one lap around the pattern), even if only one minute is needed. In terminal airspace, by contrast, aircraft may be taken out of the holding pattern at any time and in any order.

Arrivals from ZNY to EWR and LGA currently come in directly from the west, over the PENNS and LIZZI fixes, respectively. Under this alternative, the arrivals will be split into a north-side stream and a south-side stream as shown in Figure 8-4. These two **arrival streams will be sequenced with other arrival streams farther from the airport**. The current arrivals from ZDC will be merged with the south half; current arrivals from ZBW will be merged with the north half, after which the track to the airport should see much less vectoring of aircraft. The distance flown at low altitudes as the aircraft approach the airport should be shorter. The aircraft should remain higher for longer, which is more fuel-efficient.

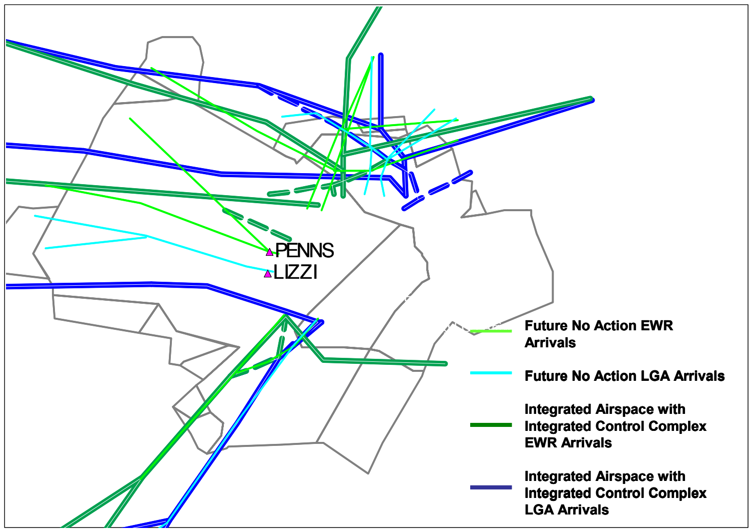


Figure 8-4. Integrated Airspace With Integrated Control Complex JFK and EWR Arrival Routes

8.1.4 Use of Departure Fixes

In today's airspace, where the TRACON has to hand off to the Center, a departure fix is typically used by a single aircraft at a time. That is, when two aircraft going to the same route are separated in altitude the requirements of safety have been met, but some separation in trail is also necessary or the traffic would overload the first en route sector. With terminal separation rules in force on both sides of the departure fix, as is planned in the Integrated Airspace with Integrated Control Complex Alternative, there will usually be no need to put lower-altitude flights in trail with higher-altitude flights. For example, out the west gate, departures from LGA and JFK have flown about 15 miles farther since takeoff than EWR departures. They will therefore be higher in altitude. If the airspace can handle two separate layers of departures, it reduces the frequency with which high traffic at one airport causes delays at another. The Integrated Airspace with Integrated Control Complex Alternative will accept two layers of traffic out most fixes: one at FL220, the other above FL230. The aircraft should remain higher for longer, which is more fuel-efficient.

8.1.5 Benefits in Other Facilities

Currently, south departures from LGA and EWR (and their satellites) use the WHITE fix. JFK departures use the WAVEY fix. These fixes are widely separated, and there are arrival streams between them. Under the Integrated Airspace with Integrated Control Complex

Alternative, the two South fixes are close together as shown in Figure 8-5. Therefore, traffic can be assigned to a fix on the basis of its jet airway, not its departure airport. Under the current airspace design, ZDC gets flights from EWR to Miami on the west side of flights from JFK to Orlando, though these flights would be more efficiently handled if they were on the east side. ZDC must work a switch near Norfolk, VA, which leads to well-known workload problems. The Integrated Airspace with Integrated Control Complex Alternative permits this switch to be done just after takeoff, where separation requirements are smaller.

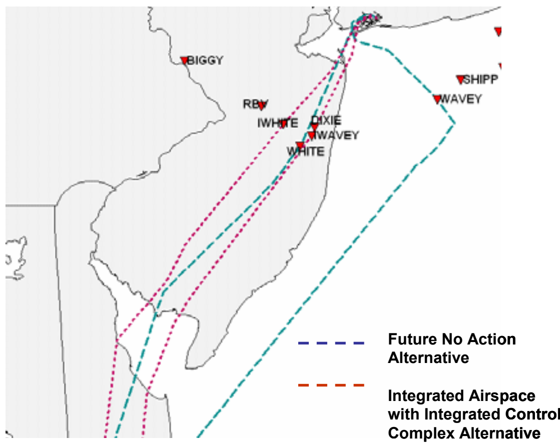


Figure 8-5. White and Wavey Departures

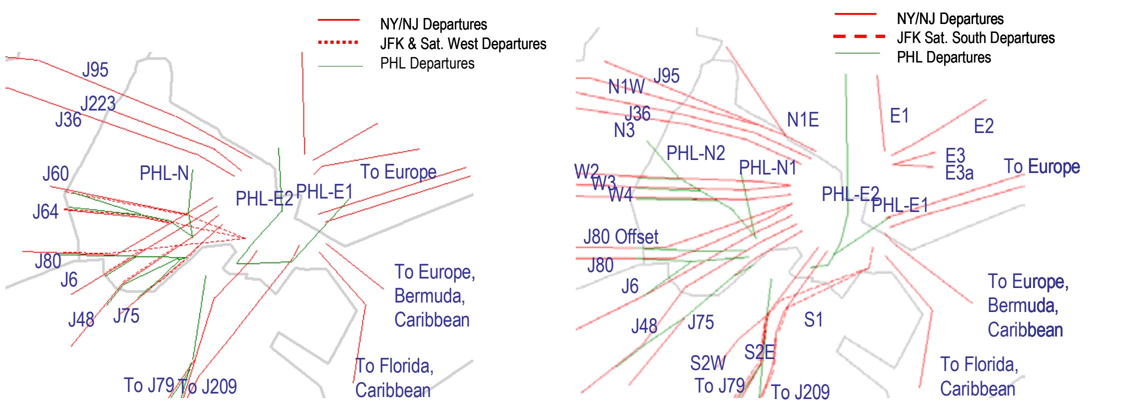
Flights from New York City to Washington Dulles currently use the same route as flights from Europe to Dulles. Since there is only room for one route to Dulles at those altitudes, the two flows must be put in trail. This is not good for the transatlantic flights, which are near the end of their range, and may not have much fuel available for holding. It is not good for New York departures, which may experience extra delays. Under the Integrated Airspace with Integrated Control Complex Alternative, the ZNY/ZDC border is less constraining of departure fixes, so an additional route can be made, separating the two flows.

The merge point of flows from the northeast and northwest is moved out and raised higher. Sequencing to the airport is done earlier, when the aircraft are at higher altitudes. Therefore, less maneuvering is necessary at low altitudes. When holding is necessary, it is done at more fuel-efficient altitudes.

8.2 Airspace

In the Integrated Airspace with Integrated Control Complex Alternative, north, west, and south NY metro departure fixes are relocated to accommodate rearranged west arrival routes as shown in Figure 8-6. The number of NY metropolitan departure fixes to west is increased to six. JFK and its satellites are given direct access to the west gate. The number of west jet routes is increased to eight. In this alternative, two south departure fixes are relocated closer to each other than they would be in the Future No Action Alternative, enabling the earlier segregation of route based on the destination. EWR and its satellite departures are given an access to oceanic departure fixes.

PHL departure routes to north west are the same as in the Future No Action Alternative except for slightly relocated turn points. PHL east departures fly more directly to the northeast and PHL southwest departures are segregated into three streams (J80 offset, J80 and J6, and J48 and J75) earlier.



Future No Action Alternative **Integrated Airspace with Integrated Control Complex Alternative**

Figure 8-6. Future No Action and Integrated Airspace with Integrated Control Complex Departure Routes

Table 8-1 contains the mapping among departure route, origin, and destination.

Table 8-1. Integrated Airspace with Integrated Control Complex Departure Routes

	Route	Origin	Typical Destinations
North	N1E	NY metro	SYR, PANC and Asia, DTW Satellites, MSP, CYYZ and Pacific NW, FNT
	N1C	NY metro	ROC, BUF, MSN, SLC, SFO, SJC
	N1W	NY metro	DTW
	N2	NY metro	SLC, SJC, SFO, MKE, FAR, MSN, GRB, OAK
	N3	NY metro	ORD and ORD North Satellites
	PHL-N1	PHL	SYR, BGM, ELM, AVP
	PHL-N2	PHL	CYYZ, ROC, BUF
West	W2	NY metro	ZOB Internals, ORD South Satellites
		PHL	Pacific NW, MKE, MSP, CLE and Satellites
	W3	NY metro	Current J60, DEN
		PHL	ORD
	W4	NY metro	Current J64 and J80, West Coast
		PHL	Current J64, West Coast, DTW
	J80 Offset	NY metro, PHL	ZID internal airports except CVG
	J80	PHL	Current J110
	J6	NY metro, PHL	Current J6 and CVG
	J48	NY metro, PHL	Current J48
	J75	NY metro, PHL	Current J75
South	S1	NY metro, PHL	Florida over water, Caribbean and South America
	S2E	NY metro, PHL	ZTL, ZJX and Florida over land
	S2W	NY metro	ZDC internal airports south of PCT
East	E3	NY metro	BOS
	E3A	NY metro	PVD and Cape Cod Area
	E2	NY metro	Eastern ZBW
	E1	NY metro	Northern ZBW
	PHL-E1	PHL	North Atlantic, LEB, PWM, ORH, BGR
	PHL-E2	PHL	CYUL, CYOW, ALB, BTV, MHT
Oceanic	BETTE/HAPIE	NY metro	North Atlantic
	SHIPP	NY metro	Caribbean, South America

8.2.1 North Departures from NY Metro Airports

In this alternative, three north gates serve five main departure routes. Destinations served by J95 in the Future No Action Alternative are divided into N1E and N1C. N1C also serves destinations served by J36 in the Future No Action Alternative (FNT, AZO, AMN, OAK. SLC, MKE). Departures to DTW are given an independent route (N1W). ORD and its northern satellites are given N3 as an independent route. N2 serves those departures that currently compete with ORD traffic on J36 (which is preserved in the Future No Action Alternative).

8.2.2 North Departures from PHL

North departures from PHL take PTW. Flights destined to eastern up state NY (including BGM, ELM, AVP, and SYR) are routed directly north from PTW. Flights destined to CYYZ, ROC, and BUF fly northwest from PTW with west departures to W2, W3, and W4, and continue northwest after all the west departures turn west.

8.2.3 West Departures from NY Metro Airports

In the Integrated Airspace with Integrated Control Complex Alternative, six departure fixes serve current west departures as shown in Figure 8-7. The northern most departure fix serves two departure routes: W2 and W3. NY metro departures, including those to destinations in ZOB as well as ORD south satellites such as MDW and DPA, (currently assigned to J36, J60, and J64), are assigned to W2. PHL departures to the Pacific and northwest (SEA, SLC, PTK, MDW, MKE, MSP, CLE and its satellites) merge with W2 about 25 NM northeast of MIP. NY metro departures to destinations currently served by J60, such as DSM, OMA, SUX, and DEN are assigned to W3 in this alternative. W3 is also used by PHL departures to ORD.

The second west departure serves W4. W4 is for NY metro and PHL departures to the destinations currently served by J64 and J80 (such as LAX, LGB, OAK, ONT, PHX, SAN, SNA, VNY) and also PHL departures to DTW. Destinations in ZID that are currently served by J80 are given a separate departure route that is parallel to and north of J80. J80 is used for PHL departures to destinations currently served by J80 such as DEN, LAS, LAX, PHL, PIT, SFP, STL, and TUL. J48, J75, and J6 serve the same destination as Future No Action Alternative. J6 departures also include flights to CVG.

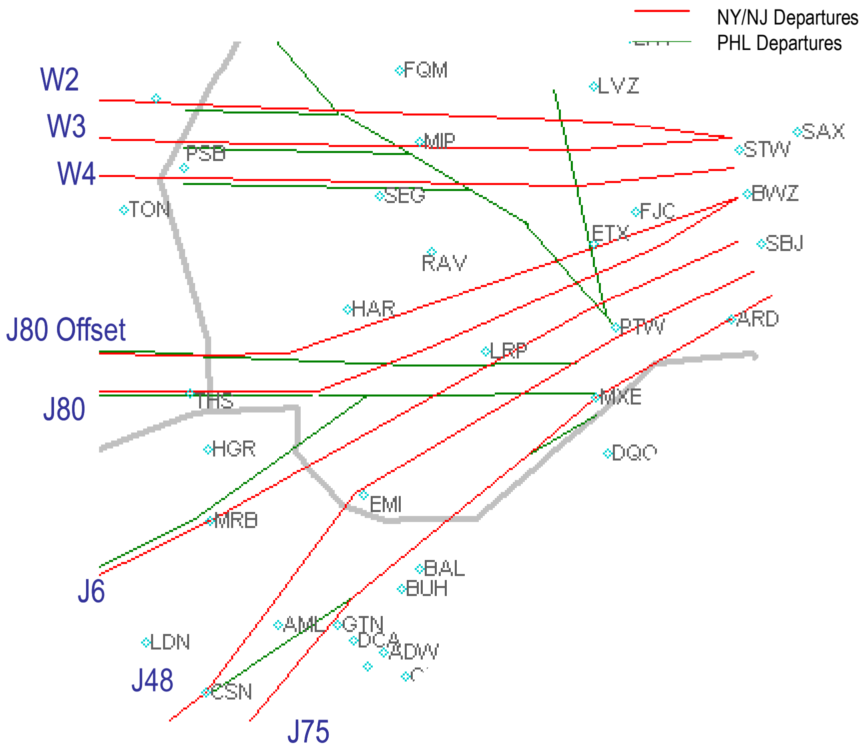


Figure 8-7. Integrated Airspace with Integrated Control Complex West Departures

8.2.4 West Departures from PHL

West PHL departures segregated into three streams. The northernmost departure fix serves the J80 offset route; the middle departure fix serves J80 and J6 departures, and the southern most departure fix serves J48 and J75 departures.

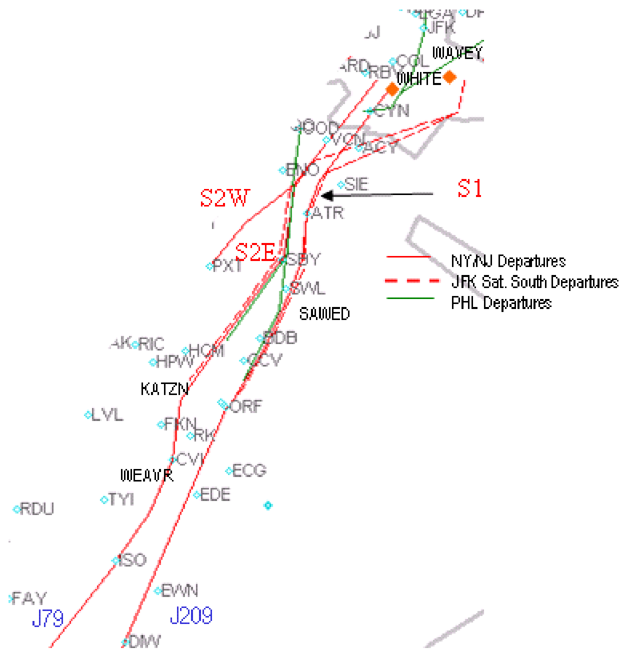


Figure 8-8. Integrated Airspace with Integrated Control Complex South Departures

8.2.4 East Departures from NY Metro Airports

EWR has an access to BETTE/HAPIE. BOS departures are routed to BAYYS rather than MERIT as in Future No Action Alternative.

8.2.5 East Departures from PHL

East departures from PHL take the same departure fix, DITCH, as in the Future No Action Alternative. The route splits to the north (departures to CYUL, CYOW, ALB, BTV, MHT, and BOS) and to east (departures to North Atlantic Route and eastern ZBW including BGR, ORH, LEB, and PWM) at northeast of CYN.

8.3 Airports

The subsections below describe the en route arrival/departure profiles and the terminal arrival/departure profiles for the Integrated Airspace with Integrated Control Complex Alternative for JFK, LGA, ISP, EWR, EWR satellites (TEB and MMU), PHL, and HPN. In each subsection, there is an overall description of en route arrival/departure profiles and an enhanced view of the modeled terminal arrival/departure procedures. In the supporting figures, altitudes below 18,000 feet are shown in hundreds of feet (i.e., 8,000 is shown as

80), and altitudes above 18,000 feet are given in Flight Levels (FLs) (i.e. 19,000 feet is shown as FL190).

8.3.1 John F. Kennedy International

8.3.1.1 John F. Kennedy En Route Arrival/Departure Profiles

Figure 8-9 shows the JFK arrival routes for the Integrated Airspace with Integrated Control Complex Alternative. In the Integrated Airspace with Integrated Control Complex, the IGN and LENDY merge is removed and traffic arriving from Canada and the Pacific Rim arrive from the east.

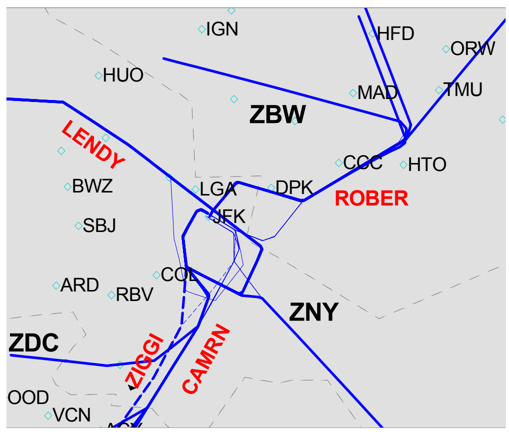


Figure 8-9. Integrated Airspace with Integrated Control Complex JFK Arrivals

Figure 8-10 depicts the arrival fixes used from different regions to arrive at JFK in the Integrated Airspace with Integrated Control Complex Alternative. Arrivals from Europe come from the northeast corner via ROBER; arrivals from South America and the Caribbean come in via CAMRN; and arrivals from the west use LENDY.

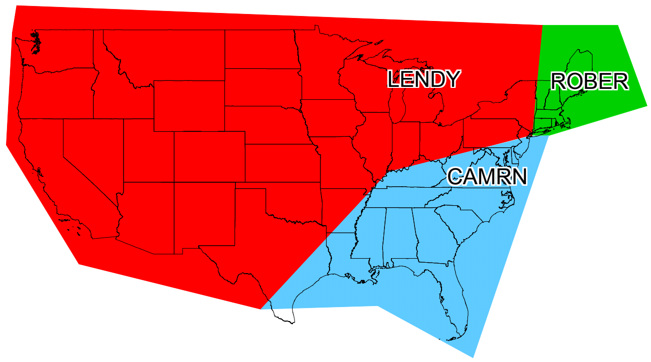


Figure 8-10. Origins of Traffic to Each JFK Arrival Fix

Figure 8-11 shows the altitude restrictions in the Integrated Airspace with Integrated Control Complex Alternative for en route JFK arrivals for both the high and low capacity configurations. Note that in this alternative all of the arrival altitudes for JFK are higher in comparison to the Future No Action Alternative. Altitudes in the figure are shown in hundreds of feet.

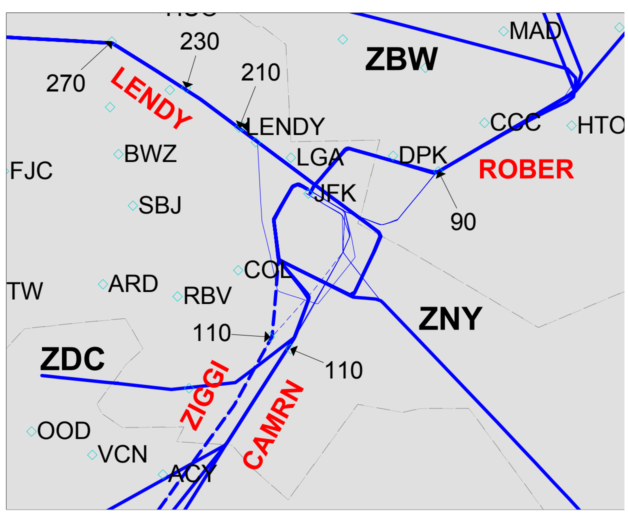


Figure 8-11. Integrated Airspace with Integrated Control Complex JFK Arrivals

Figure 8-12 shows the Integrated Airspace with Integrated Control Complex Alternative en route JFK departure routes and departure gate altitude profiles for both configurations that were implemented in TAAM. Traffic going westbound from JFK now has access to additional westbound departure fixes that were not available in the Future No Action, Modifications to Existing Airspace, or the Integrated Airspace Alternatives. Altitudes in the figure are shown in hundreds of feet and FLs.

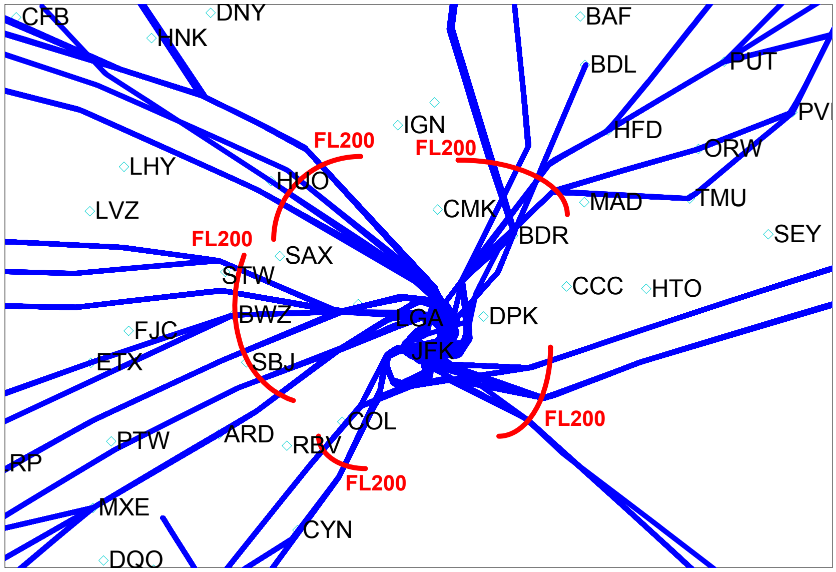


Figure 8-12. Integrated Airspace with Integrated Control Complex JFK Departures

8.3.1.2 John F. Kennedy Terminal Arrival/Departure Profiles

Figures 8-13 and 8-14 compare the modeled Future No Action Alternative and Integrated Airspace with Integrated Control Complex Alternative tracks for the low and high capacity configurations at JFK. The blue lines display the TAAM based tracks for JFK arrivals. The green lines display the TAAM based tracks for JFK departures. Note the additional westbound departures in the Integrated Airspace with Integrated Control Complex Alternative in comparison to the Future No Action Alternative.

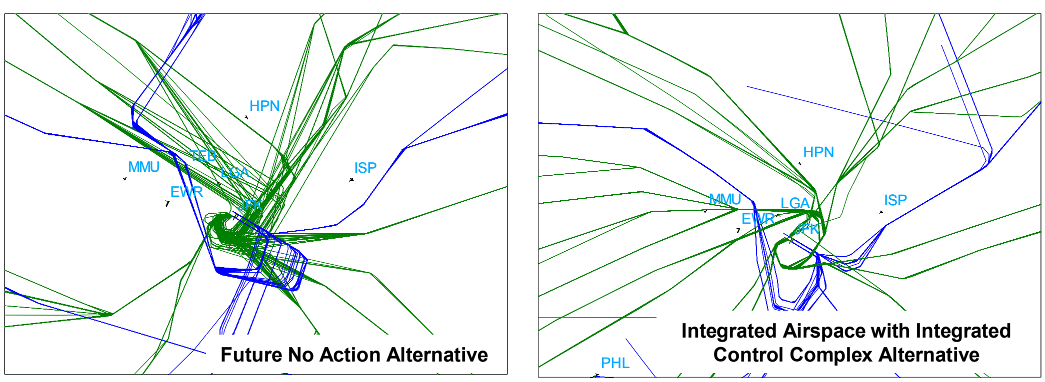


Figure 8-13. Future No Action and Integrated Airspace with Integrated Control Complex Low Capacity Configuration JFK Terminal Profiles

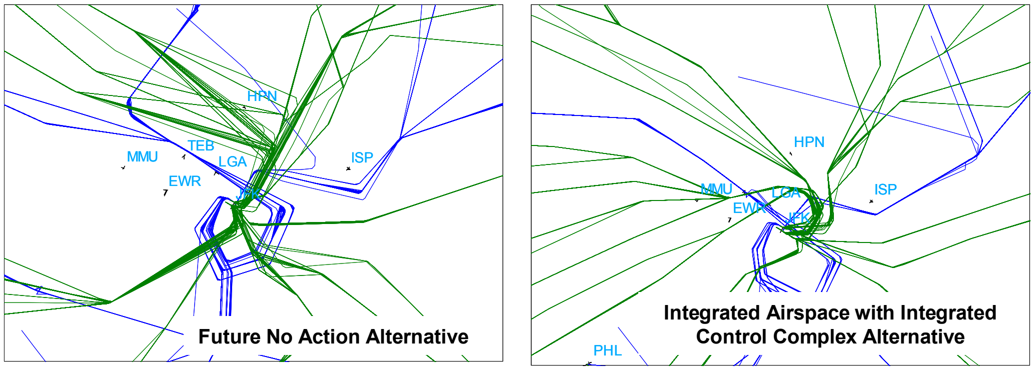


Figure 8-14. Future No Action and Integrated Airspace with Integrated Control Complex High Capacity Configuration JFK Terminal Profiles

8.3.2 LaGuardia

8.3.2.1 LaGuardia En Route Arrival/Departure Profiles

In the Integrated Airspace with Integrated Control Complex Alternative, the western arrivals to LaGuardia, merging over MIP in the Future No Action Alternative, have been split into two separate arrival streams. Figure 8-15 shows a comparison of the Integrated Airspace with Integrated Control Complex Alternative (shown in dark blue) and the Future No Action Alternative (shown in light blue) arrivals. The northern stream merges with the northern arrivals at VALRE. The southern stream, which is pushed farther south than the Future No Action Alternative route, arrives over ETX, merging at RBV with the southern arrivals. This is done in order to make room for the additional departure streams while maintaining the separation of the arrival and departure flows. Arrivals over DNY are pushed north and east of the Future No Action flow to allow room for the EWR arrivals. Northern arrival flows, those over DNY and ALB merge farther from the airport, at ATHOS instead of TRESA, and are moved east of the Future No Action flow. This allows more room for the HPN departures to climb, looping over the HPN field, as well as for the LGA departures to climb.

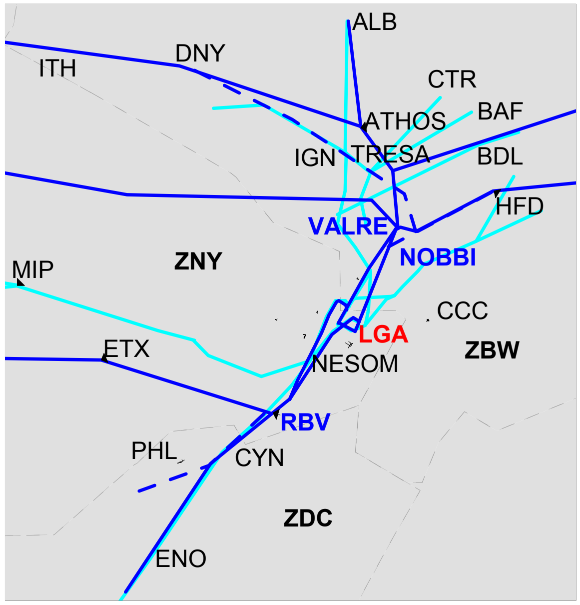


Figure 8-15. Comparison of LGA Arrivals (Integrated Airspace with Integrated Control Complex vs. Future No Action)

The ZDC and ZNY arrival routes in Figure 8-16 are the end of several stages of converging routes. Upstream Centers, particularly ZDC and ZOB, structure the traffic so the sectors closest to New York, with their limited airspace, can focus on sequencing. Each arrival route ends up with traffic from a region of the U.S., like a watershed. Figure 8-16 shows the watersheds for the arrival routes to LGA. (Distance restrictions on LaGuardia arrivals prevent traffic from points in the U.S. farther west than Denver.) The areas for VALRE and RBV extend outward beyond the borders of the map: arrivals from eastern Canada are routed to VALRE; arrivals from the Caribbean and Bahamas come in via RBV.

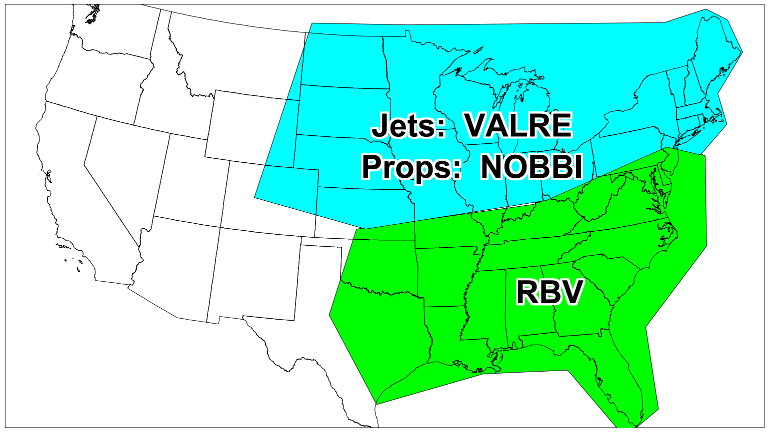


Figure 8-16. Origins of Traffic to Each LGA Arrival Fix

The altitude profiles for this alternative, displayed in Figure 8-17 are little changed from the Future No Action Alternative. Despite the additional arrival routes and the shifting of the present routes, the same relative altitude restrictions are still necessary to maintain proper separation with other New York and Philadelphia traffic. Altitudes in the figure are shown in hundreds of feet and Flight Levels.

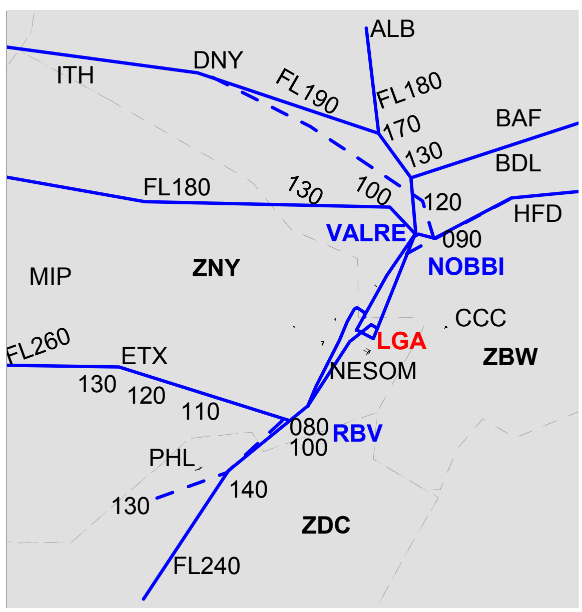


Figure 8-17. LGA Arrival Altitude Restrictions

Figure 8-18 shows the Integrated Airspace with Integrated Control Complex LGA departure routes and associated gate altitude. In this figure, the Integrated Airspace with Integrated Control Complex Alternative tracks are shown in dark blue, Future No Action Alternative are shown in light blue, and unchanged routes are depicted in dark grey.

In this alternative, departures to the east climb to FL220 (versus 17,000 in the Future No Action Alternative), and departures to the north, west and south climb to FL230. Despite using the west gate, flights from LGA to IAD are restricted to FL220, while those to DCA and BWI are restricted to FL200. Altitudes in the figure are shown in hundreds of feet.

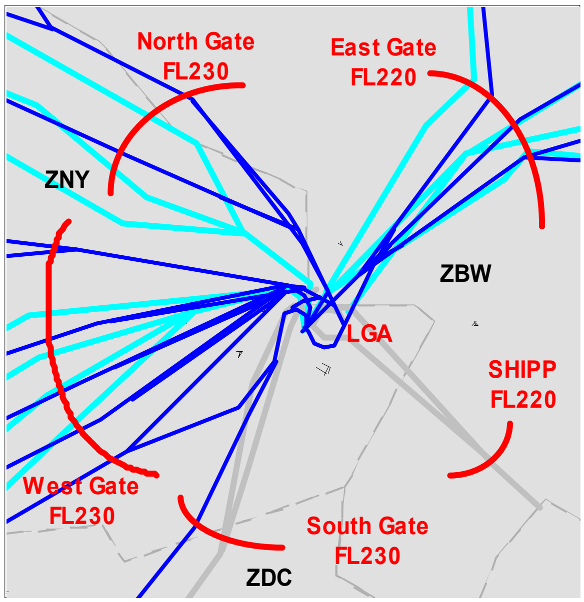


Figure 8-18. LGA Departure Profile Comparison (Integrated Airspace with Integrated Control Complex vs. Future No Action)

The Integrated Airspace with Integrated Control Complex Alternative, because it is no longer constrained by facility boundaries, also has more fixes than the current operation. In this alternative, there are three north departure fixes (as today, but some of the current traffic is sent out the expanded west gate), three east departure fixes (up from two), six west departure fixes (up from four), and two south departure fixes (up from one). The west gate fixes that serve more than one jet airway are split. Departures to the east are shifted south of their Future No Action placement in order to allow room for the LGA arrival streams. Northern departures are shifted farther north of the Future No Action routing to allow more space for EWR traffic.

8.3.2.2 LaGuardia Terminal Arrival/Departure Profiles

Figures 8-19 and 8-20 compare the low-altitude routings in the LaGuardia terminal airspace for the Future No Action and Integrated Airspace with Integrated Control Complex Alternatives. The blue lines display the TAAM based tracks for LGA arrivals and the green lines display the TAAM based tracks for LGA departures.

As discussed in Section 3.10.2, in the Integrated Airspace with Integrated Control Complex Alternative low capacity configuration, departures off of Runway 4 are fanned into four headings. Moreover, southern arrivals to Runway 31 cross over the LGA airport to vector to the northeast, where they are merged with the arrivals from the north. This allows arrival traffic to avoid the JFK arrivals to the south while remaining below the JFK departures traveling north.

In the Integrated Airspace with Integrated Control Complex high capacity configuration the southern arrivals to Runway 22 follow the Hudson River north, staying east of the EWR airspace. Once north of LGA, they are merged with the arrivals from the north for final approach. All departures in the high capacity configuration at LGA follow the same climb out of the airport. Once they are approximately 15 miles northeast of LGA, they begin to vector to their respective departure gates.

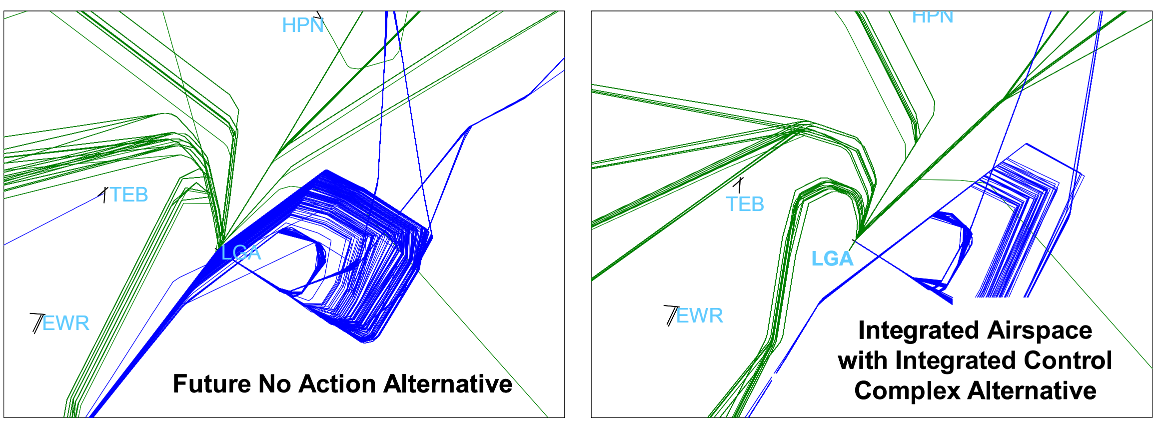


Figure 8-19. Future No Action and Integrated Airspace with Integrated Control Complex Alternative Low Capacity LGA Terminal Profiles

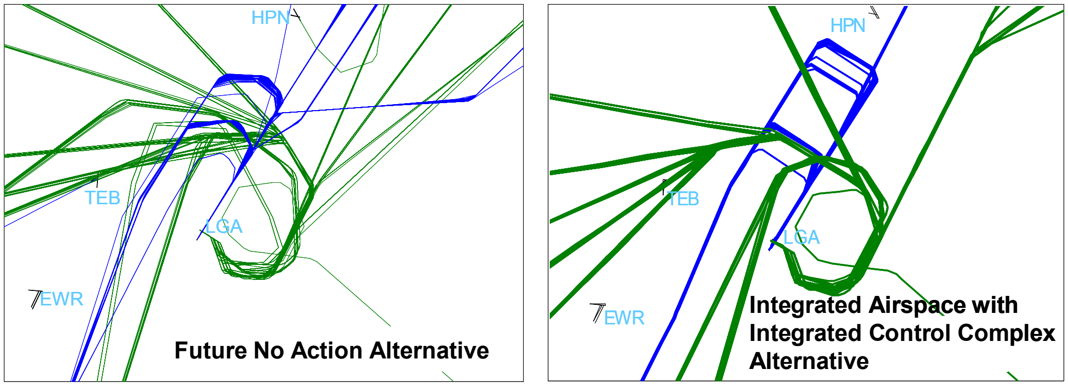


Figure 8-20. Future No Action and Integrated Airspace with Integrated Control Complex Alternative High Capacity LGA Terminal Profiles

8.3.3 Long Island MacArthur

8.3.3.1 Long Island MacArthur En Route Arrival/Departure Profiles

Figure 8-21 depicts the Integrated Airspace with Integrated Control Complex Alternative arrival streams with their corresponding altitudes for ISP. ISP arrivals are the same as in the Future No Action Alternative except that in the Integrated Airspace with Integrated Control Complex Alternative the arrivals are allowed to cross over LENDY. There is no change in configuration between the high and low capacity configurations. Altitudes in the figure are shown in hundreds of feet.

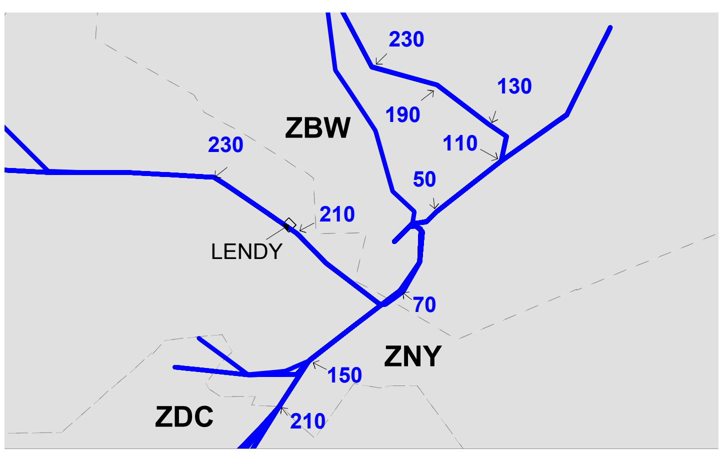


Figure 8-21. Integrated Airspace with Integrated Control Complex ISP Arrival Profile

Figure 8-22 depicts the Integrated Airspace with Integrated Control Complex Alternative departure streams with their corresponding departure gate altitudes for ISP. There is no change in configuration between the high and low capacity configurations. The departures in this alternative have a single southern departure stream versus multiple southern departure streams as in the Future No Action Alternative. Altitudes in the figure are shown in hundreds of feet.

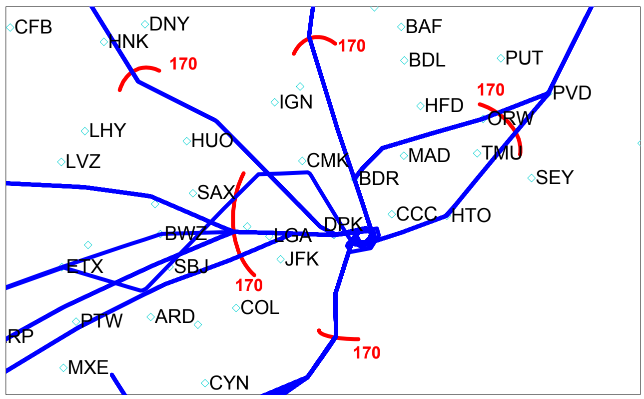


Figure 8-22. Integrated Airspace with Integrated Control Complex ISP Departure Profile

8.3.3.2 Long Island MacArthur Terminal Arrival/Departure Profiles

Figure 8-23 provides a comparison of the arrival and departures for ISP for the Future No Action and the Integrated Airspace with Integrated Control Complex Alternatives. The blue lines display the TAAM based tracks for ISP arrivals. The green lines display the TAAM based tracks for ISP departures. The high and low capacity configurations are the same for ISP.

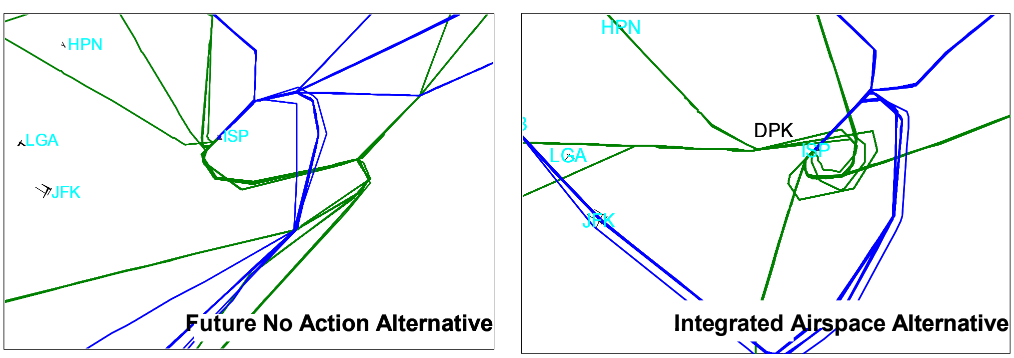


Figure 8-23. Future No Action and Integrated Airspace with Integrated Control Complex ISP Terminal Profiles

8.3.4 Newark Liberty International

8.3.4.1 En Route Arrival/Departure Profiles

Arrivals from ZNY to EWR currently come in directly from the west over PENNS. Under this alternative, the arrivals are split into a north-side stream and a south-side stream. These two arrival streams are sequenced with other arrival streams farther from the airport. The current arrivals from ZDC are merged with the south half; current arrivals from ZBW are merged with the north half.

The ZDC and ZNY and ZBW arrival routes are shown in Figure 8-24. The routes are the end of several stages of converging routes. Each arrival route ends up with traffic from a region of the world, like a watershed. Figure 8-25 shows the watersheds for the arrival routes to EWR. Each area extends outward beyond the borders of the map; for example, arrivals from Europe and eastern Canada arrive via IEAN1.

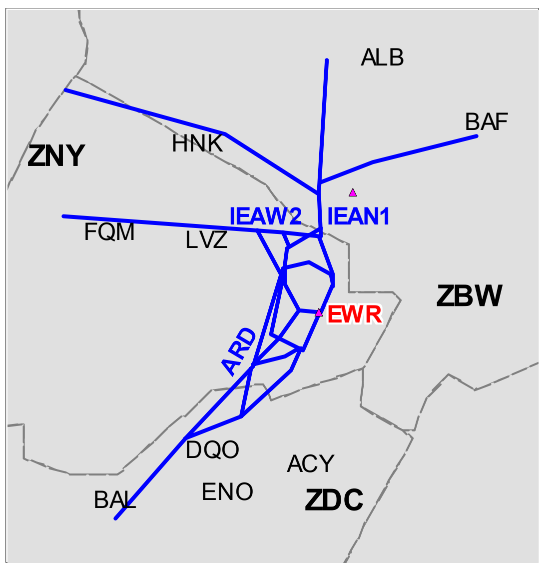


Figure 8-24. EWR Integrated Airspace with Integrated Control Complex Arrivals

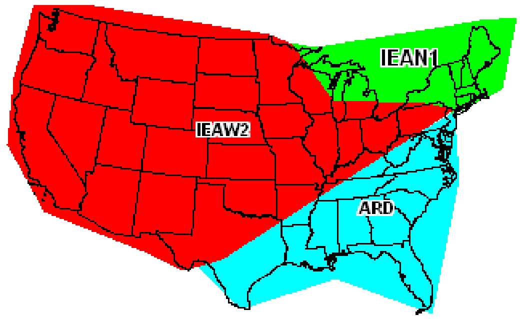


Figure 8-25. Origins of Traffic to Each EWR Arrival Fix

The major flows were modeled by explicit altitude requirements at many fixes. Low-altitude flows were modeled by limiting the requested altitude in the flight plans. Figure 8-26 shows the most important altitude restrictions en route, expressed in hundreds of feet and FLs. An additional restriction is west of the map, requiring ZOB to hand off arrivals at FL370 or below. The Integrated Airspace with Integrated Control Complex Alternative allows arrivals to fly at a higher altitude for a longer time than the Future No Action Alternative.

The Integrated Airspace with Integrated Control Complex Alternative, because it is no longer constrained by facility boundaries also has more departure fixes than the current operation. There are three north departure fixes (as today, but some of the current traffic is sent out the expanded west gate), three east departure fixes (up from two), six west departure fixes (up from four), and two south departure fixes. The west gate fixes that serve more than one jet airway are split. In addition, transatlantic traffic from EWR will be permitted access to oceanic fixes that are currently available only to JFK departures.

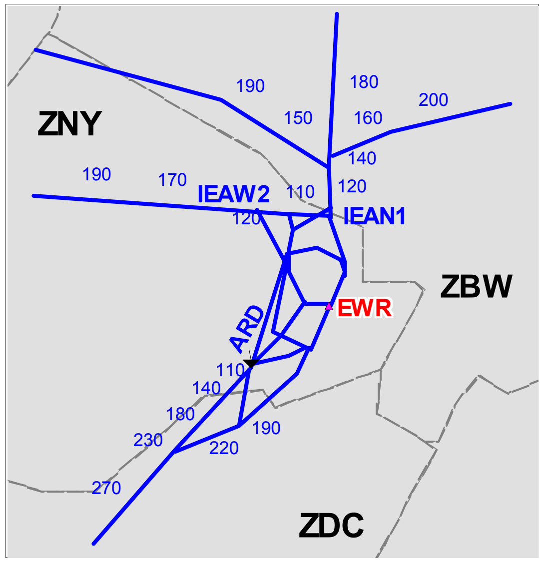


Figure 8-26. Integrated Airspace with Integrated Control Complex EWR Altitude Restrictions

Figure 8-27 shows the Integrated Airspace with Integrated Control Complex Alternative EWR departure routes and associated gate altitude. In this alternative, departures to the west and south climb to FL220 (versus 17,000 feet in the Future No Action Alternative), and east departures climb to 8000 feet before turning and climbing unrestricted. Jet departures to DCA climb to FL200 while propeller-driven aircraft climb to 16,000 feet.

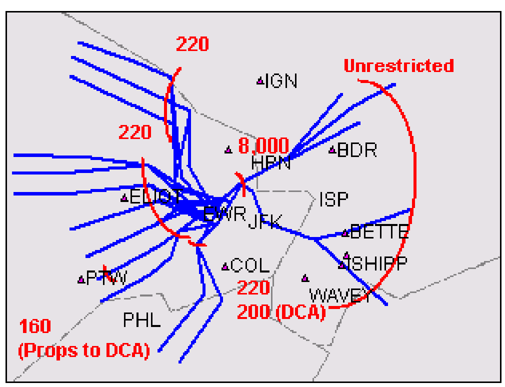


Figure 8-27. Integrated Airspace with Integrated Control Complex EWR Departure Profile

8.3.4.2 Newark Liberty International Terminal Arrival/Departure Profiles

Figures 8-28 and 8-29 compare the arrival and departure procedures for the Future No Action and Integrated Airspace with Integrated Control Complex Alternatives. The blue lines display the TAAM-based tracks for EWR arrivals, and the green lines display the TAAM-based tracks for the EWR departures.

In terms of Integrated Airspace with Integrated Control Complex Alternative, additional vectoring area to the south of EWR is provided for low capacity arrivals, and the use of dual arrival Runways 04R/04L is allowed. Runway 04L departures have been modified to accommodate the additional departure and oceanic fixes and can fly at a higher altitude than the Future No Action Alternative at the gate.

For the high capacity configuration, Runway 22R departures are fanned in the same way as in the Modifications to Existing Airspace Alternative. Table 5-1 in Section 5.3.4.2 provides the headings used for this alternative.

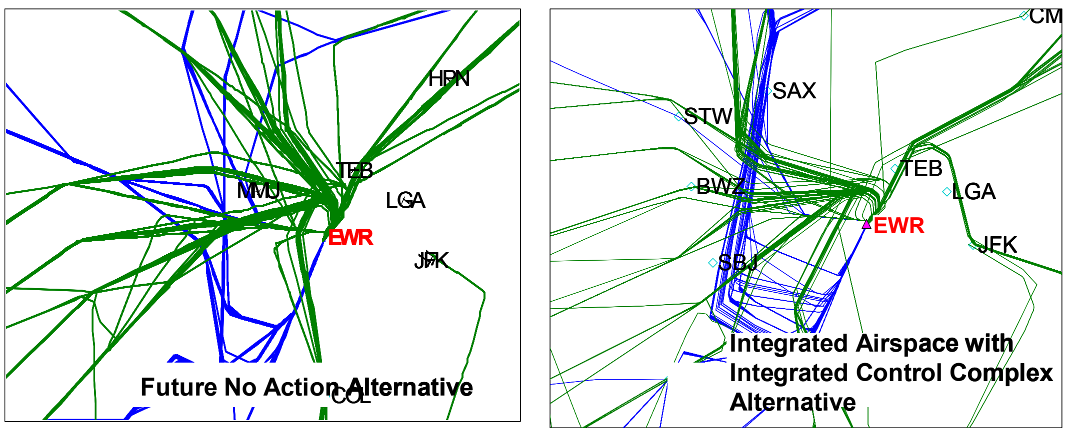


Figure 8-28. Future No Action and Integrated Airspace with Integrated Control Complex EWR Low Capacity Terminal Profiles

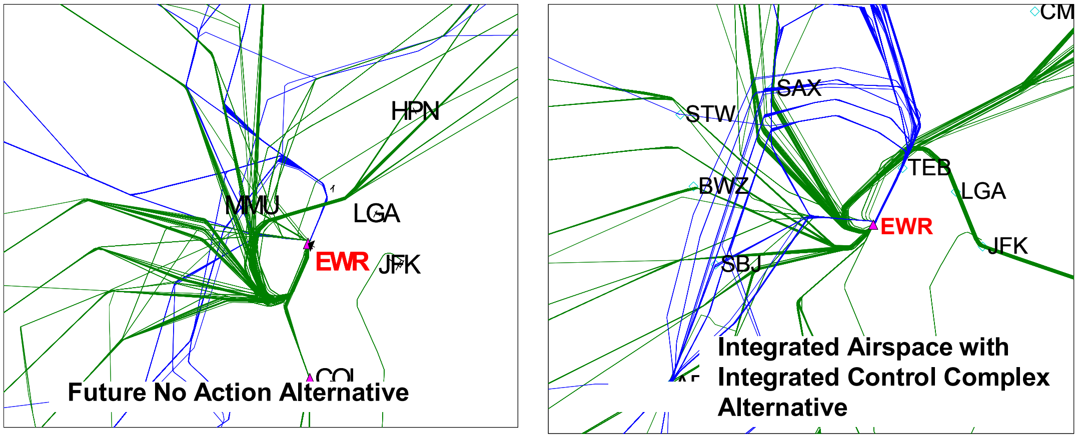


Figure 8-29. Future No Action and Integrated Airspace with Integrated Control Complex EWR High Capacity Terminal Profiles

8.3.5 Newark Liberty International Satellites (TEB and MMU)

8.3.5.1 Teterboro and Morristown Municipal En Route Arrival/Departure Profiles

Figure 8-30 displays the TEB/MMU arrival routes. MMU routes that differ from TEB are shown in purple.

Similar to EWR, TEB and MMU jet arrivals are organized into three corner posts. Each Center feeding the New York TRACON has its own corner post fix: ZDC routes aircraft over BWZ; ZNY routes aircraft over BWZ; and ZBW routes aircraft over IJTN1. The heaviest flow of traffic is from the south.

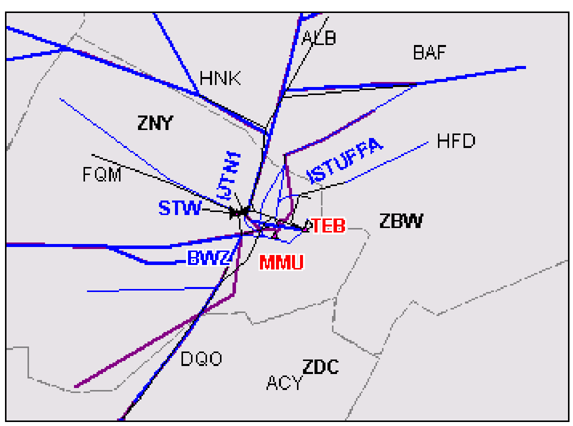


Figure 8-30. Integrated Airspace with Integrated Control Complex TEB/MMU Arrivals

Low-altitude arrivals, whether jets or props, are segregated over a subsidiary fix. From ZBW, low altitude flights from New England fly via ISTUFFA. From ZNY low altitude flights from NY fly via STW. TEB arrival routes in the Integrated Airspace with Integrated Control Complex Alternative are realigned from the Future No Action Alternative to allow for segregation of EWR and satellite arrivals. This realignment reduces the complexity of mixing different airports' arrivals within the same airspace.

Each arrival route ends up with traffic from a region of the world, like a watershed. Figure 8-31 shows the watersheds for the arrival routes to TEB and MMU. Each area extends outward beyond the borders of the map. For example, arrivals from Canada come from the northeast corner via IJTN1.

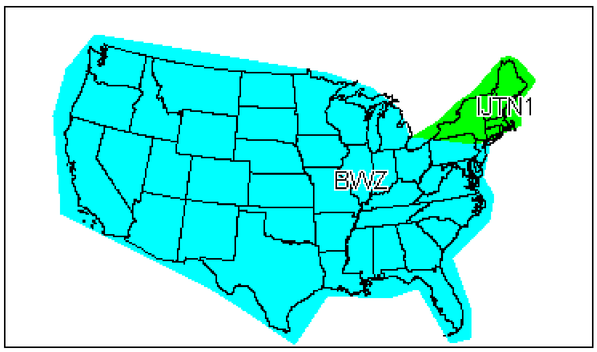


Figure 8-31. Origins of Traffic to Each TEB/MMU Arrival Fix

Similar to the approach in Future No Action, the major flows were modeled by explicit altitude requirements at many fixes. Low-altitude flows were modeled by limiting the requested altitude in the flight plans. Figure 8-32 shows the most important altitude restrictions en route, expressed in hundreds of feet. TEB routes are shown in blue; MMU routes, where different, are shown in purple. An additional restriction is west of the map, requiring ZOB to hand off arrivals at FL370 or below. The Integrated Airspace with Integrated Control Complex Alternative allows arrivals to fly at a higher altitude for a longer time than Future No Action Alternative.

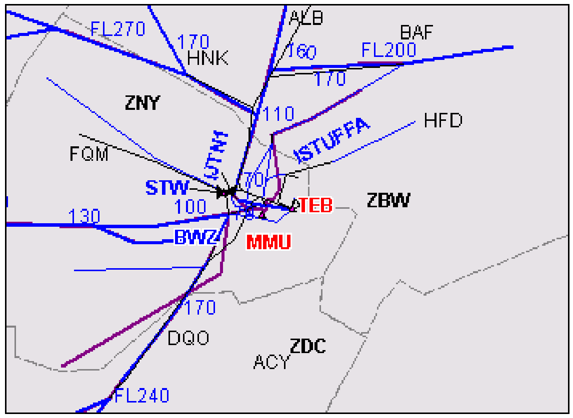


Figure 8-32. Integrated Airspace with Integrated Control Complex TEB/MMU Arrival Altitude Restrictions

Figure 8-33 shows the TEB Integrated Airspace with Integrated Control Complex departure routes and associated gate altitudes for both the low capacity and high capacity configurations for TEB and MMU. The blue lines in the figure are TEB; the purple lines are MMU. In this alternative, there are two additional departure fixes to the west. Departures to the north and west climb to FL220 (versus 17,000 in Future No Action). East departures climb to 8,000 feet before turning and climbing unrestricted. Jet departures to DCA climb to FL200 while propeller-driven aircraft climb to 16,000 feet.

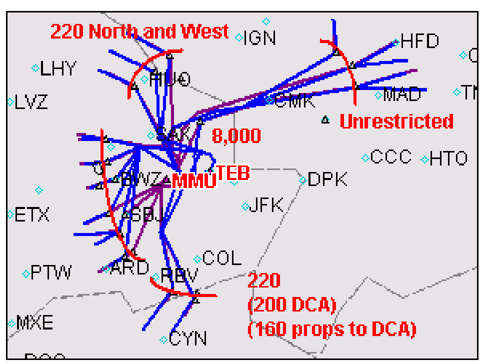


Figure 8-33. Integrated Airspace with Integrated Control Complex TEB Departure Profile

8.3.5.2 Teterboro and Morristown Municipal Terminal Arrival/Departure Profiles

Figures 8-34 and 8-35 compare the arrival and departure procedures for the TEB Future No Action and Integrated Airspace with Integrated Control Complex Alternatives. The blue lines display the TAAM-based tracks for TEB arrivals, and the green lines display the TAAM-based tracks for the TEB departures. The arrival profile reflects the realignment of routes from the Future No Action Alternative. The departure profile reflects the changes in alignment of the departure gates and the two additional departure fixes to the west. TEB west departures in this alternative fly to a single gate before heading west or southwest. TEB arrivals from the south are shifted slightly more west to BWZ.

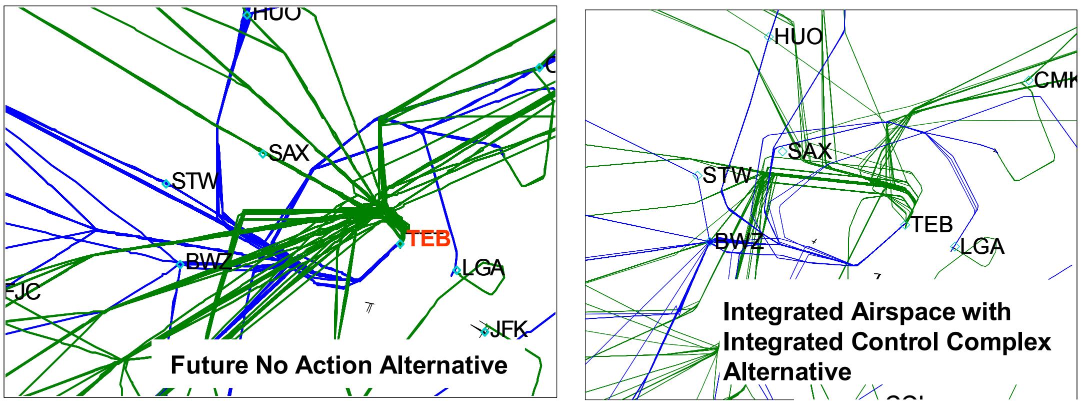


Figure 8-34. Future No Action and Integrated Airspace with Integrated Control Complex Low Capacity TEB Terminal Profiles

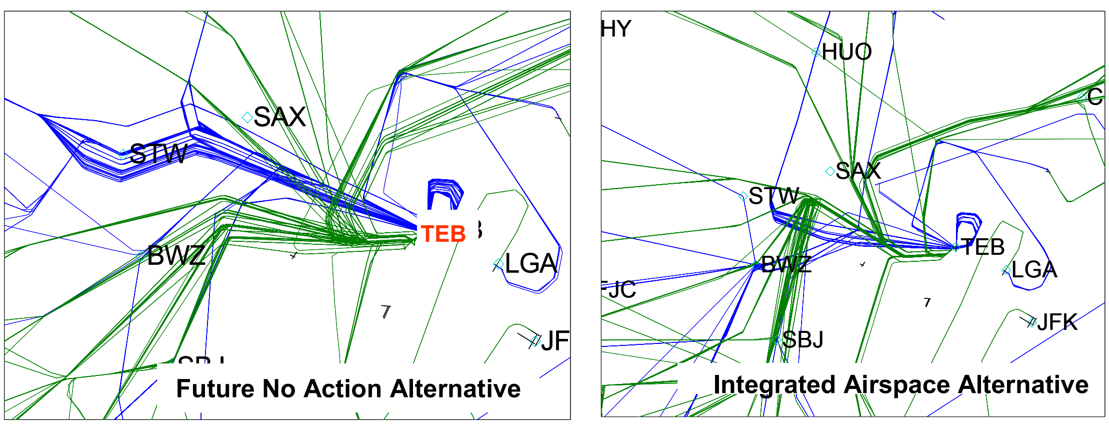


Figure 8-35. Future No Action and Integrated Airspace with Integrated Control Complex High Capacity TEB Terminal Profiles

Figures 8-36 compares the arrival and departure procedures for MMU for the Future No Action and Integrated Airspace with Integrated Control Complex Alternatives. The blue lines display the TAAM-based tracks for TEB arrivals, and the green lines display the TAAM-based tracks for the TEB departures.

The Integrated Airspace with Integrated Control Complex arrival profile reflects the realignment of routes from the Future No Action Alternative. The associated departure profile reflects the changes in alignment of the departure gates and the two additional departure fixes to the west. MMU arrivals are merged to the west of the airport in the Integrated Airspace with Integrated Control Complex Alternative and to the north of the airport in the Future No Action Alternative.

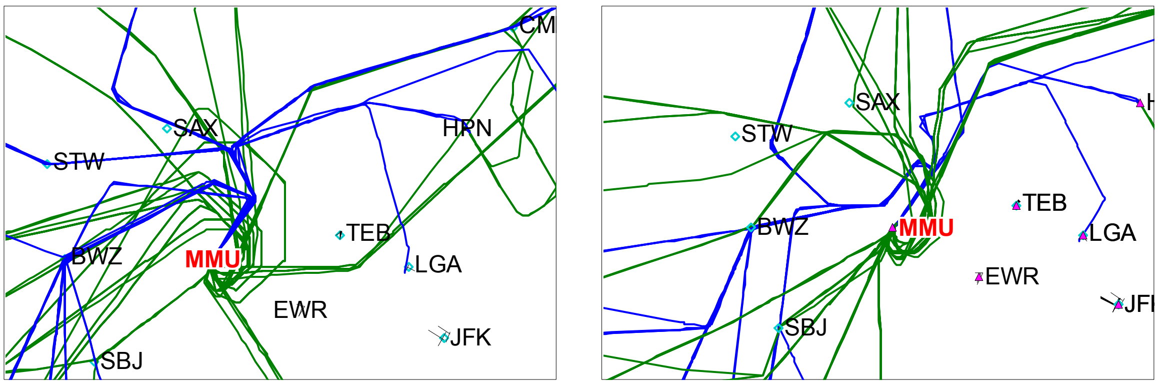


Figure 8-36. Integrated Airspace with Integrated Control Complex MMU Terminal Profile

8.3.6 Philadelphia International

8.3.6.1 Philadelphia En Route Arrival/Departure Profiles

Under the Integrated Airspace with Integrated Control Complex Alternative, there are two major changes to PHL operations. On the arrival side, there is the addition of an arrival route from Cleveland Center that passes over Williamsport (FQM). This route takes traffic from the Great Lakes off the overworked BUNTS arrival fix (now relocated to BUKKS) and brings it underneath the New York western departure flows to the vicinity of Pottstown. Connecting airports are reassigned to arrival fixes as shown in Figure 8-37. Existing fixes have been prefixed with an "I" to indicate that they have been slightly moved from their current positions, so the new arrival fix is called "ISPUDS". VOR navigation aids that serve as fixes are prefixed with "IA" to indicate that the approach to the VOR is different from the Future No Action Alternative. On the departure side, there are three departure fixes available – the current MXE fix has been split to match the split in J80 westbound (see Section 8.2).

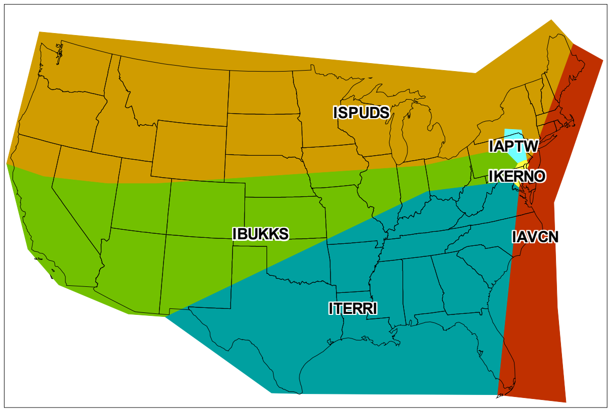


Figure 8-37. Origins of Traffic to Each PHL Arrival Fix

Figure 8-38 shows the arrival and departure routings for PHL near the airport. The new arrival route is shown passing near SPUDS. The relocation of the BUNTS flow to BUKKS is also visible. Other paths do not change significantly.

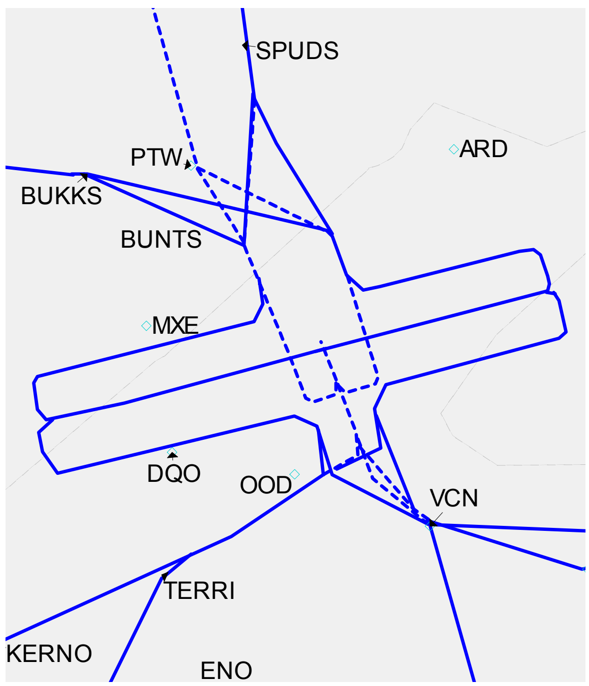


Figure 8-38. Integrated Airspace with Integrated Control Complex PHL Arrivals

Arrival altitudes are unchanged on the existing routes. Figure 8-39 shows the altitudes on the new arrival route for comparison. Altitudes in the figure are shown in hundreds of feet and Flight Levels.

Departures in this alternative are similar to the Integrated Airspace Alternative, except for the western flow as shown in Figure 8-40. The two main departure fixes are three in this alternative, one to each side and one close to the MXE. The route over MXE is split to match the traffic on J80 and J80 offset. The current MXE route is still available for propeller-driven aircraft and aircraft without RNAV equipage. It is rarely used in the simulation of 2011 traffic. Altitudes in the figure are shown in hundreds of feet.

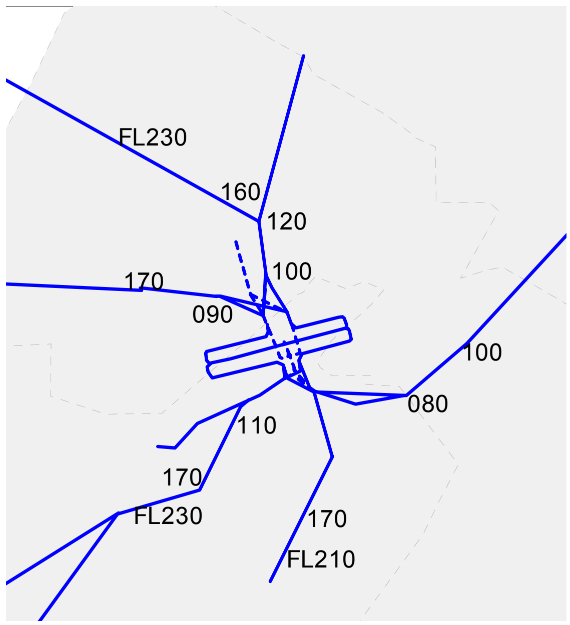


Figure 8-39. Integrated Airspace with Integrated Control Complex PHL Arrival Profile

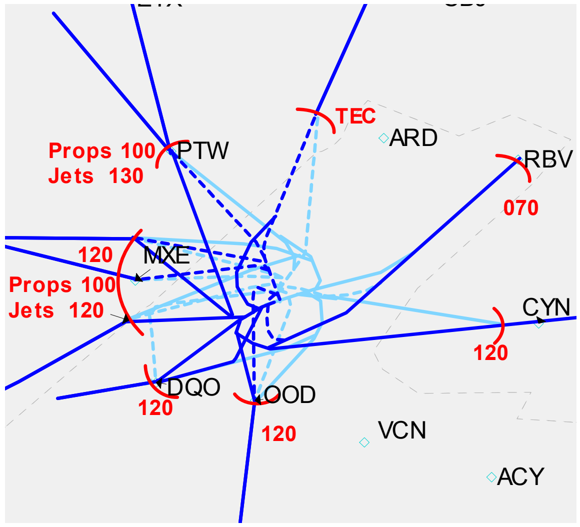


Figure 8-40. Integrated Airspace with Integrated Control Complex PHL Departure Profile

8.3.6.2 Philadelphia Terminal Arrival/Departure Profiles

Close-up views (Figures 8-41 and 8-42) of the low-altitude traffic at PHL for the Future No Action and Integrated Airspace with Integrated Control Complex Alternatives show that the arrival and departure fixes have been moved to accommodate changes in New York flows. The three westbound departure fixes look the same as in the Integrated Airspace alternative because the third westbound route overlies the non-RNAV routing over MXE.

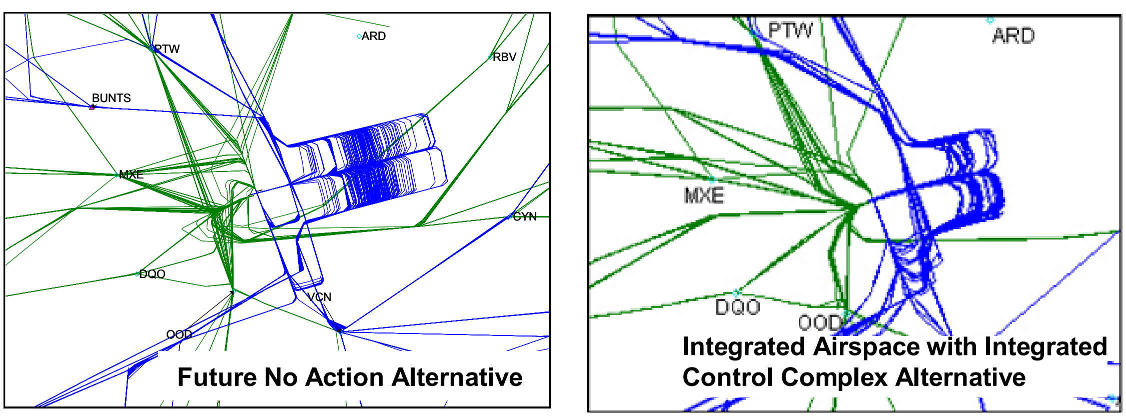


Figure 8-41. Future No Action and Integrated Airspace with Integrated Control Complex West Flow PHL Terminal Profiles

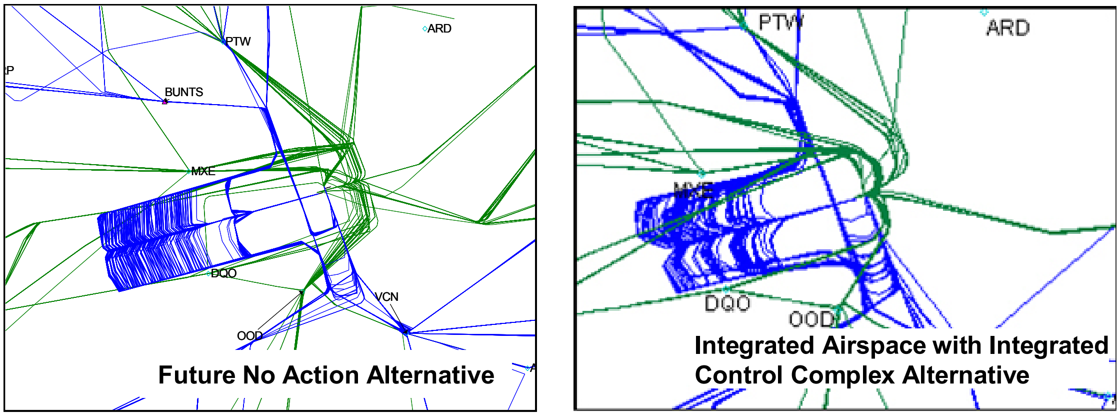


Figure 8-42. Future No Action and Integrated Airspace with Integrated Control Complex East Flow PHL Terminal Profiles

8.3.7 Westchester County

8.3.7.1 Westchester County En Route Arrival/Departure Profiles

In the Integrated Airspace with Integrated Control Complex Alternative, the HPN arrival flows from the north and east no longer merge over IGN, but rather remain separate until just before turning onto the crosswind leg. Once south of IGN, both flows are shifted east of their Future No Action placement. This provides more room for the departures to climb as they loop over the field. The southern arrivals, which utilize two flows in the Future No Action Alternative, are consolidated into a single flow, crossing through the ISP airspace. A comparison of the Future No Action Alternative (shown in light blue) and Integrated Airspace with Integrated Control Complex Alternative (shown in dark blue) HPN arrivals is shown in Figure 8-43.

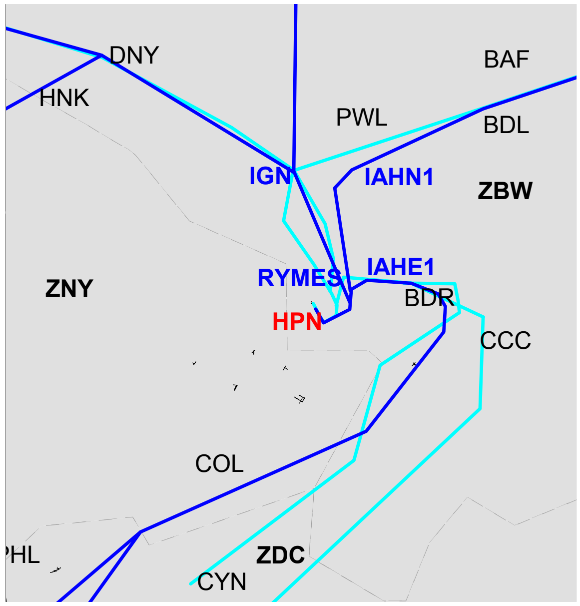


Figure 8-43. Comparison of HPN Arrivals (Integrated Airspace with Integrated Control Complex vs. Future No Action)

Arrivals to HPN are routed over one of four arrival fixes based on the geographical area of the country from which they originate as shown in Figure 8-44. The largest of these areas, covering most of the United States, requires arriving aircraft to be merged by ZOB and funneled over IGN. The other major flow, arriving from the south, utilizes IAHE1. Flights originating from Boston are routed over IAHN1 while the TEC flights from the New York area use the RYMES arrival fix.

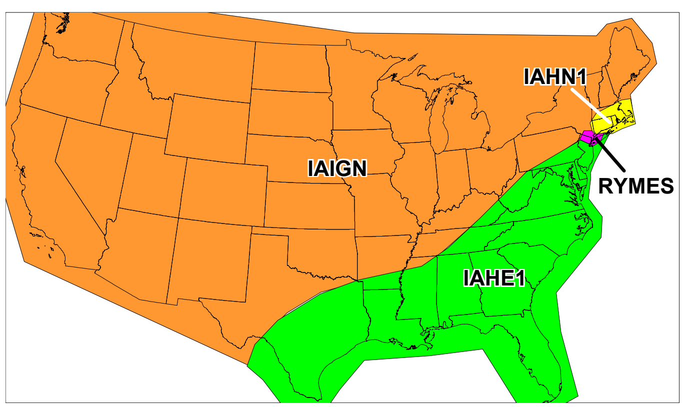


Figure 8-44. Origins of Traffic to Each HPN Arrival Fix

The indirect routing of the HPN arrival traffic insures that the flights are separated from much of the arrival and departure traffic to the busier airports. In the instances where crossing flows could not be avoided, altitude restrictions were employed to insure vertical separation. The restrictions in the Integrated Airspace with Integrated Control Complex Alternative allow the HPN arrival traffic to remain at higher altitudes longer than those of the Future No Action Alternative. The HPN arrival altitudes are shown in Figure 8-45. Altitudes in the figure are shown in hundreds of feet and Flight Levels.

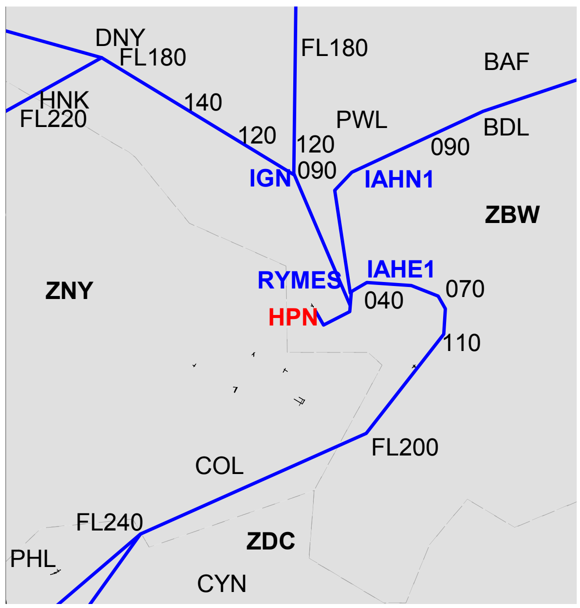


Figure 8-45. HPN Arrival Altitude Restrictions

In the Integrated Airspace with Integrated Control Complex Alternative, a number of changes from Future No Action are implemented. Figure 8-46 shows a comparison of the Integrated Airspace with Integrated Control Complex departures (in dark blue) and the Future No Action departures (in light blue). First, the eastern departures are shifted southeast of their Future No Action placement, increasing the available airspace for the HPN and LGA arrival streams. Second, northern and western departure flows both travel farther north before turning to their respective fixes, allowing them to avoid the TEB airspace. Third, the number of western departure fixes is increased. Finally, all southern departure streams now loop over the airport before heading south. This allows them to gain considerable altitude before crossing over the LGA traffic and EWR airspace.

In the Integrated Airspace with Integrated Control Complex Alternative, departures to the east climb to FL220 (versus 17,000 feet in Future No Action), and departures to the north, west and south climb to FL230. Flights from HPN to IAD, which use the west gate, are restricted to FL220, while those to DCA and BWI are restricted to FL200. Altitudes in the figure are shown in hundreds of feet and FLs.

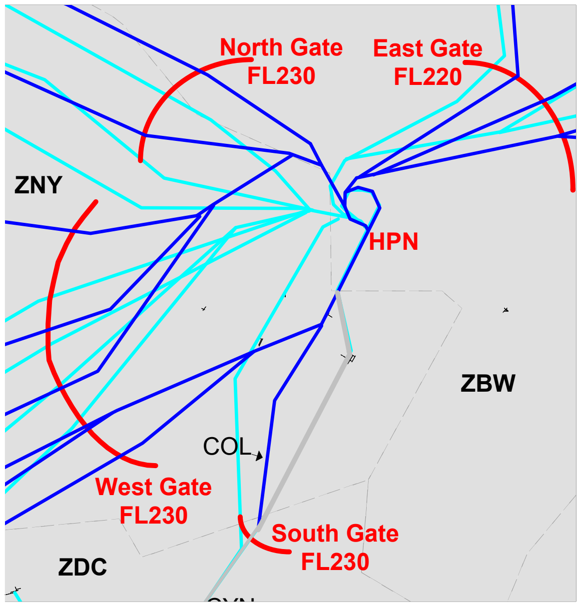


Figure 8-46. Comparison of HPN Departures (Future No Action versus Integrated Airspace with Integrated Control Complex)

8.3.7.2 Westchester County Terminal Arrival/Departure Profiles

Figure 8-47 compares the terminal profiles for the Future No Action and Integrated with Integrated Control Complex Alternatives. The Integrated Airspace with Integrated Control Complex Alternative provides for the arrivals, depicted in blue, to fly at higher altitudes for a longer time than the Future No Action Alternative. There is also an increase in the amount of space available for vectoring. The arrival profile depicts the split of the northern arrivals into two flows as well as the consolidation of the southern arrivals into a single flow. The departure profile, depicted in green, reflects the change to an initial northern climb for the north and west departures, as well as the looped climb of the southern flows.

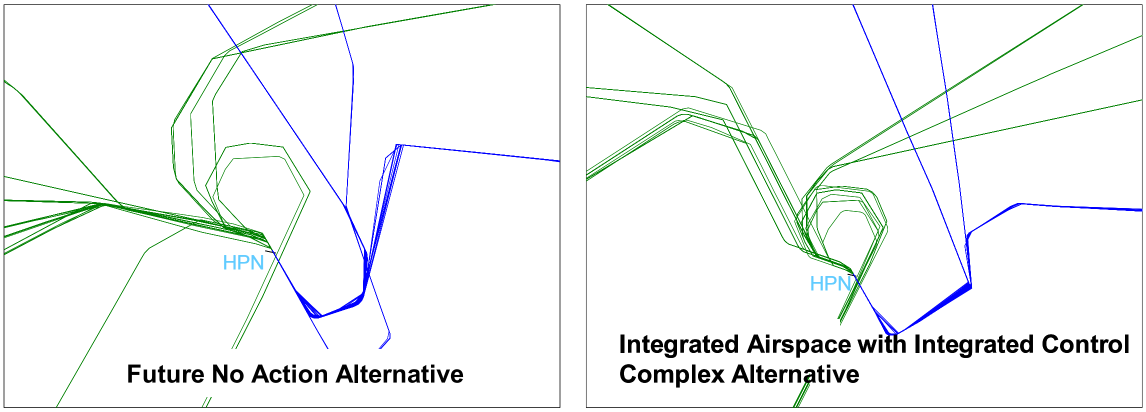


Figure 8-47. Future No Action and Integrated Airspace with Integrated Control Complex HPN Terminal Profiles

Section 9

Operational Analysis Results

The purpose of the NY/NJ/PHL airspace redesign, broadly stated, is to maintain the safety and increase efficiency of air traffic operations in the area. This broad purpose was refined by the FAA's redesign team into a set of tangible system improvements to the system that they wished to accomplish with their designs. These system improvements form the left-hand column of Table 9-1, and are expanded in Section 9.1. CAASD defined quantitative metrics for each of the system improvements. These metrics are described in the right-hand column of Table 9-1. Detailed definitions for each will be given in Sections 9.2 through 9.10, where the results are presented. Delay definitions are also provided in the Glossary.

The relationship between metrics and system improvements is not one-to-one. For one example, the Reduce Complexity system improvement is quantified by a combination of simulation metrics. For another, the time below 18,000 feet simulation output is used for both the Reduce Complexity and Expedite Arrivals and Departures system improvements.

To generate a single metric for each alternative, a weighted average is constructed from the low-capacity and high-capacity configurations:

- EWR, JFK, LGA, and TEB: 45% of delay in low capacity configuration + 55% of delay in high capacity configuration,
- PHL: 25% of delay in East Configuration + 75% of delay in West Configuration, and
- HPN, ISP, and MMU: 100% of delay in the single modeled configuration

Although there are hundreds of runway combinations that might be in use at any time in the New York Metro area, as far as airspace is concerned they fall into two broad categories. Northeast-type configurations handle about 45% of the operations; southwest-type configurations handle the rest. PHL operates to the west about 75% of the time; to the east about 25%.

Table 9-1. Metrics

System Improvements	Metric
Reduce Complexity	Airspace delays + time below 18,000 feet
	Arrival distance below 18,000 feet
Reduce Voice Communications	Max inter-facility handoffs per hour
Reduce Delay	Arrival delay
	Departure delay
Balance Controller Workload	Equity of fix traffic counts
Meet System Demands and Improve User Access to System	End of day's last arrival push
Expedite Arrivals and Departures	Time below 18,000 feet
	Ground track length and block time
Flexibility in Routing	Qualitative Assessment
Maintain Airport Throughput	Total maximum sustainable arrival throughput
	Total maximum sustainable departure throughput

The demand that drives the operational analysis is a forecast of air traffic in 2006 and 2011 extrapolated from observed operations in 2000. Appendix B describes a comparative analysis of the forecast fleet with the fleet observed in 2004, the changes necessary to correct the forecast, and the results obtained from changing the input fleet mix to the operational simulations.

9.1 Mapping Simulation Output to Improvement Metrics

9.1.1 Reduce Complexity

Complexity of an air traffic control operation is not well defined, despite years of attempts to generate a numerical measure in the field.[1] In this work, it is not critical to measure complexity directly, but rather to identify it through its impact on users of the airspace. To a first approximation, complexity is the result of merging aircraft from several flows into one. When the number of aircraft to be merged exceeds some hypothetical

1 See for example, Mogford, R. H., et al., *The Complexity Construct in Air Traffic Control: A Review and Synthesis of the Literature*, Report No. DOT/FAA/CT-TN95/22, July 1995.

threshold, traffic flow managers step in to the process and separate aircraft by more than the minimum separation, resulting in delays that are measurable in a simulation. Even when an aircraft is not delayed, it may be directed onto a longer path than optimum conditions would dictate. For this reason, time and distance are included separately in the calculation of complexity's impact.

We calculate complexity impact separately for departures and arrivals. Departures merge when flights from several New York airports are bound for the same departure fix, and at en route merge points where Philadelphia traffic contends with New York traffic for the same jet airway. Arrivals merge as jet airways converge onto Standard Terminal Arrival Routes (STARs), and as the flows from each arrival fix converge to final approach.

Overflights are excluded from the calculation because, to the greatest extent possible, they are procedurally separated from New York Metro/Philadelphia arrivals and departures.

Airspace delay results were generated via the CAASD developed en route airspace delay analyzer tool as described in Appendix A. Time and distance below 18,000 feet altitude was computed from the simulated trajectories generated by TAAM.

9.1.2 Reduce Voice Communications

Calculating the absolute number of voice communications involved in any particular airspace design would be a formidable task. Fortunately, only the reduction in voice communications needs to be calculated. Any voice communications that will be constant across all alternatives do not need to be calculated here. For most communications, the timing of the communication changes, but the number does not. These include:

- Voice communications for altitude changes as arrivals are stepped down
- Altitude clearances as departures transition to jet airways
- Frequency changes
- Vectors

The communication loads that will change are those due to handoffs of aircraft across facility boundaries and those due to vectors and altitude changes caused by traffic congestion. The latter are generally related to delay, so they will not be calculated separately under this rubric. The former are related to the number of aircraft crossing a facility boundary in each hour, which will be computed for this system improvement. The maximum hourly count over the simulated period will be the metric. Crossings are calculated by first importing simulated trajectories from TAAM into the SDAT. Crossings of Center boundaries and the NYICC boundary and exits from the New York TRACON are then generated from SDAT reports. PHL approach control will remain as an independent facility in all alternatives, so its handoffs remain constant.

9.1.3 Reduce Delay

Delay is an output of the simulation tools used in this analysis. It is calculated from the difference between the flight-planned time and the actual time of an arrival or departure operation. For the airports that are facing extremely-high forecast demand, LGA and PHL, the traffic was flow-managed outside of TAAM.[2] The delay caused at the flow-management step was added back in to the delay output after simulation.

9.1.4 Balance Controller Workload

In a high-demand environment like the airspace between New York City and Philadelphia, controller workload is unlikely to be reduced by any change in the system. If it were, new demand would quickly appear to bring the workload back to its previous level. The best that can be accomplished is to balance the workload among the available airspace resources.

The changes in controller workload balance will primarily come from changes to New York Metro departures. The distribution of traffic over departure fixes and departure routes is the major difference among the alternatives. For this metric, the difference between the share of New York Metro traffic allocated to each fix in a gate will be measured with a metric that is zero when all fixes have the same traffic and one when one fix has all the traffic.[3] This metric will be calculated gate-by-gate, since it would be counterproductive to balance workload by sending, say, westbound traffic out the northbound gate. (It may be desirable in adverse weather conditions, but this is not modeled here.)

Little additional balancing will be possible for NY arrivals, since the two major flows into New York will be under the control of the same facility in all alternatives. The addition of the smallest flow in the Integrated Airspace with Integrated Control Complex Alternative will not change the workload balance.

Philadelphia's airspace is so tightly constrained by other facilities (New York and Potomac TRACONs) that improving the workload balance via airspace design is unlikely. PHL will see little change in any alternative.

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[2] TAAM would solve excessive-delay situations through the use of holding at low altitudes. But low altitude holding would adversely affect another of our metrics: the time below 18,000 feet. Therefore, the excessive part of the delay was applied to simulation inputs through external flow management.

[3] The metric is called the "Gini Index" by economists. See, for example, Kuan Xu, *How has the Literature on Gini's Index Evolved in the Past 80 Years?* Halifax Nova Scotia, Dalhousie University, April 2003, and references therein.

This metric is calculated for each gate on an hourly basis, for busy hours only. The upper-bound value for each configuration is weighted by configuration to generate a single value.

9.1.5 Meet System Demands and Improve User Access to System

As the efficiency of the airspace improves, user access to the airports in the region should improve. Ideally, user access would be defined as a number of aircraft per day, computed via a feedback process in which traffic that can not be accommodated by the system drops out of the demand files. Unfortunately, changing traffic in this manner would make it impossible to compare delay and throughput metrics among plans (as well as introducing assumptions about user priorities that would complicate the design process).

Instead, as is usual in ATM simulations, this analysis maintained the demand as the fixed, independent quantity. The simulated airport keeps running to meet the demand, even if that requires operations very late into the night. The metric for user access in this case is the time at which the last arrival push of the evening finally is completed. (In New York, the last scheduled operations of the day are typically arrivals.)

9.1.6 Expedite Arrivals and Departures

Three things can get in the way of expeditious arrivals and departures at a large terminal like the ones in New York and Philadelphia. First, there are delays in the airspace due to volume. Second, there is excess routing distance due to procedural separation of flows. Third, altitude restrictions can keep aircraft at low altitudes where speeds are limited. In the (current) terminal area, these three effects are combined by calculating the time spent below 18,000 feet. Any decrease in the time, regardless of which of the causes has been ameliorated, is an equivalent benefit to users.

En route, the structure of airways has an impact on traffic. When aircraft are routed off the direct path to their destinations, this represents a cost to users that offsets the benefits of reduced delay. In low-traffic situations, weekends and midnight operations for example, the delay may not be there to reduce, but the route length remains. Ground track distance and end-to-end flying time are used to show the impact of en route structure.

9.1.7 Flexibility in Routing

The definition of “flexibility” used here is the ability of the system to accommodate changing demands from its users. Flexibility permits users to optimize their own operations according to their own criteria with the minimum constraint from air traffic management. In an all-VFR study like this one, flexibility in routing is a qualitative concept, since by definition changes in user demand are caused by factors outside the ATM system, which makes them unpredictable.

Factors that contribute to flexibility are:

- The number of runways available
- The number of arrival and departure fixes available
- The number of arrival and departure routes available
- The absence of equipment restrictions on routes

In adverse weather conditions, flexibility becomes a measurable quantity, since the need to maintain their schedule becomes the overriding concern of the users of the air traffic management system. Examining flexibility during adverse weather conditions will not be addressed in this report, but is a topic for future work.

9.1.8 Maintain Airport Throughput

Airports are frequently observed to handle more arrivals and departures than their declared capacity would permit, for a short time. TAAM simulations show the same effect. For this metric, the sustained throughput was used. Sustained throughput must continue for at least two consecutive hours.

9.2 Results by Metric

The results for each metric in Table 9-1 are presented in the following subsections.

9.2.1 Airspace Delays

Airspace delays were calculated to determine the jet route delays and departure fix delays. Because the arrival airspace delay is too small to separate from airport capacity constraints, only the departure airspace delay was calculated.

9.2.1.1 Departure Jet Route Delay

The departure jet route delays were calculated by first placing the departures to the same jet airway in trail. If jet route delays greater than four minutes are required, then the restriction is passed to the departure fix. If the departure fix delays are greater than six minutes, then the restriction is passed to the runway. The complete description of how these departure jet route delays were calculated at the fixes and jet airways is provided in Appendix A.

The total departure jet route delays and at departure fix delays for each alternative are shown in Table 9-2 based on 2011 traffic. The "average" column in this table is the departure airspace delay, divided by the number of flights using the departure fix or jet route. Ocean routing shows a small decrease in jet route delay because jet airways are less congested, as a result of the limits on EWR departures

The Modifications and Integrated Airspace alternatives remove about one third of the departure fix delay because of the split of J80. The difference between the two is that Integrated Airspace splits ELIOT into two fixes, where Modifications keeps a single fix with two altitudes (same as Future No Action). The single fix with two altitudes is more flexible, and causes less delay at the departure fix, but the net result is virtually the same, after the merge with JFK and PHL departures is taken into account.

When the facilities are integrated as well, two thirds of the Future No Action Alternative delay has been ameliorated because of the improvement of the south gate, and the split of the single JFK RBV departure stream into many westgate fixes.

Table 9-2. 2011 Departure Airspace Delay (Minutes)

	Departure Fix Delay	Departure Jet Route Delay	Total	Average (min/flt)
Future No Action	1530	1133	2663	0.76
Modifications to Existing Airspace	852	1045	1897	0.54
Ocean Routing	1276	1017	2293	0.70
Integrated Airspace	942	963	1905	0.56
Integrated Airspace with Integrated Control Complex	402	548	950	0.27

9.2.1.2 Departure Fix Delay

The total minutes of departure fix delay are shown in Figure 9-1. Delays at fixes accumulating less than 30 minutes per day are omitted for clarity. These delays are due to airspace alone; for airport departure delay, consult the appropriate airport in Section 8.2.5. The traffic used is the 2011 90th percentile day.

In the Future No Action Alternative, large amounts of congestion (as indicated by large departure fix delays) are visible: on the west gate from New York City; on the MXE departure fix out of PHL; and at WHITE, and downstream at the Norfolk VOR (ORF).

The Ocean Routing Alternative removes much of the delay on the west gate out of New York, since this gate is no longer available to Newark EWR departures in high-capacity configuration. In its place is a new delay point at Coyle (CYN). The result is a small reduction in airspace delay due to the ocean routing, but purchased at a huge cost in airport departure delay.

The Integrated Airspace Alternative has two major differences from the Future No Action Alternative. They are the opening of a second departure fix out of New York to share ELIOT traffic, and a parallel airway to J80 that will handle arrivals to Indianapolis Center. These changes cut the J80 delay by 20% (606 to 470 minutes), reduces departure fix delay at MXE by half (578 to 223 minutes) and eliminates ELIOT as a source of congestion. One minor feature of this alternative is the change to ISP south departures (shown in dashed lines). Though this change affects only about a dozen flights, the impact on airspace delay is significant. Airspace delays on the south gate are reduced by 20% (from 143 to 117 minutes).

The improvements of the Integrated Airspace with Integrated Control Complex Alternative on airspace delays are immediately visible all around the New York/Philadelphia area. The expanded west gate has no departure fixes with more than 30 minutes of delay per day. Airspace delays on the north gate are essentially eliminated. J80 and its offset partner are no more restrictive than other jet airways in this alternative. The change to the south gate, which permits J79 traffic (Florida over land) to be placed on the west side of J209 (Florida over water) while still under New York departure control, balances the departure delay on the replacement fixes for WHITE and WAVEY.

The total delay shown at each fix in Figure 9-1 shows that the modeled airports can congest J80 and J209/J174 (where the traffic from WHITE bound for J209 merge with the traffic from WAVEY). This congestion can create pass back restrictions that can cause a loss of 1-3 departures per hour from the high capacity airport configuration in the 2011 timeframe. The impact of these pass back restrictions on departure throughput is shown in Figure 9-2 and 9-3. EWR has a peak loss of 6 departures at 0:00 GMT, and LGA has a peak deficit of 3 departures per hour at 19:00 GMT due to pass back restrictions. With the Integrated Airspace with Integrated Control Complex Alternative, these restrictions are no longer needed.

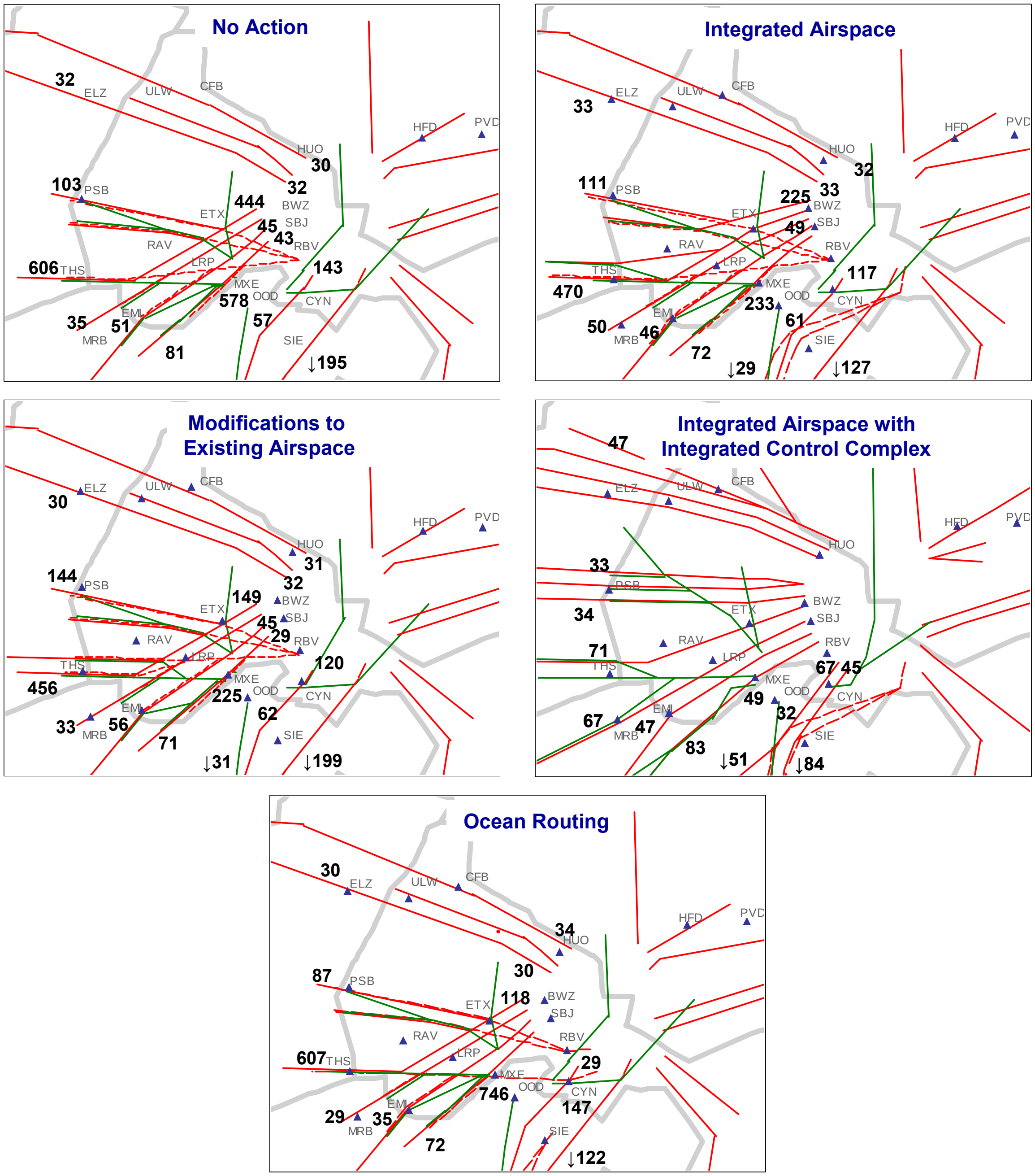

Figure 9-1. 2011 Departure Delay: Airspace Alone

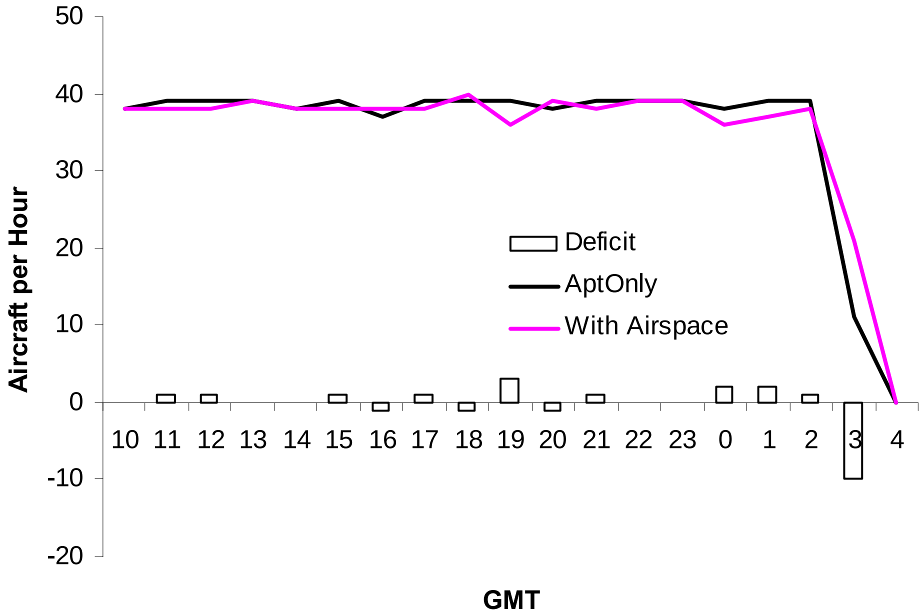

Figure 9-2. LGA Departure Throughput with Airspace Delays

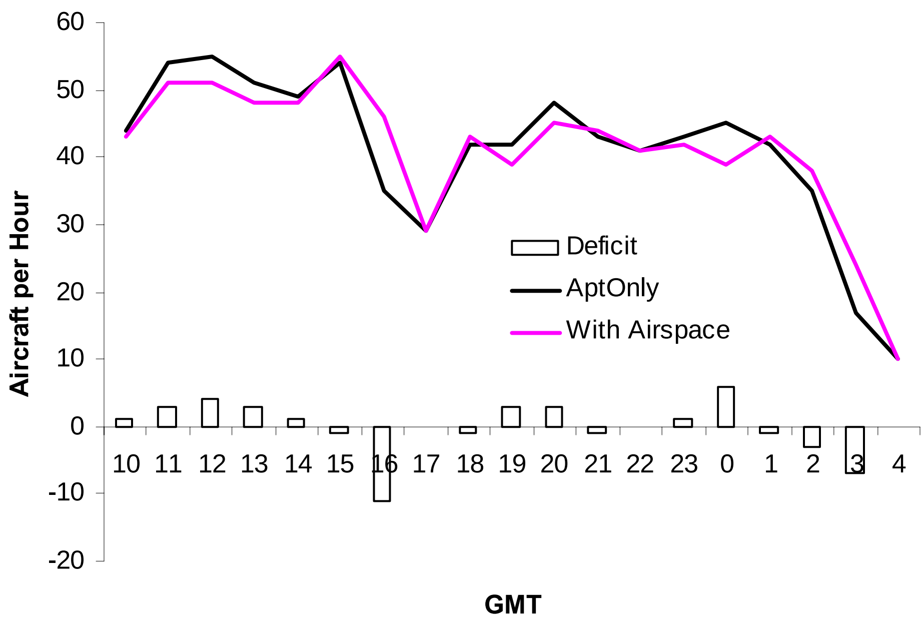

Figure 9-3. EWR Departure Throughput with Airspace Delays

9.2.2 Time Below 18,000 feet

Tables 9-3 through 9-8 show the simulated times and distances flown between the runway and 18,000 feet. For each metric, there are two tables provided. The first table displays the simulation results and the second table displays the differences from Future No Action for each alternative, weighted by frequency of occurrence of each configuration. In the difference tables, negative numbers in the table show that the metric decreased (generally good), positive numbers show that the metric increased, which is generally bad. Blank entries indicate no change from Future No Action Alternative. Numbers in **bold** are calculated for the 2011 traffic level.

9.2.2.1 Time to Climb

The "Time to Climb" to 18,000 feet metric includes ground track and altitude restriction effects. Small improvements are seen in most alternatives. The Ocean Routing Alternative causes a large penalty on JFK departures, which is due to the loss of the turboprop routes near RBV. This penalty is less important in 2011, as turboprops disappear from the fleet. The Integrated Airspace Alternative shows a small improvement due to the increased number of departure fixes. The Integrated Airspace with Integrated Control Complex Alternative shows a larger one, due to expanded use of piggyback altitudes at the fixes.

Table 9-3 shows the time to climb results for the alternatives for both high and low capacity configurations for both 2006 and 2011 traffic. Each airport has two rows per alternative. The first row provides the time to climb for the high capacity configuration for 2006 (abbreviated as Hi06) and the high capacity configuration for 2011 (abbreviated as Hi11). The second row provides the time to climb for the low capacity configuration for 2006 (abbreviated as Lo06) and the low capacity configuration for 2011 (abbreviated as Lo11). The numbers in bold are the times to climb for the 2011 traffic level

Table 9-3. Time to Climb to 18,000 Feet (Minutes)

Hi06/**Hi11** Lo06/**Lo11**	**Future No Action**	**Modifications to Existing Airspace**	**Ocean Routing**	**Integrated Airspace**	**Integrated Airspace with ICC**
EWR	12/**12**	11/**11**	14/**14**	11/**11**	**9**
	12/**11**	11/**11**	9/**10**	11/**11**	**9**
JFK	10/**9**	11/**11**	19/**12**	10/**9**	**10**
	12/**12**	13/**13**	12/**11**	12/**12**	**10**
LGA	13/**13**	14/**14**	13/**13**	12/**12**	**10**
	12/**12**	13/**13**	12/**12**	11/**11**	**10**
PHL	10/**10**	10/**10**	10/**10**	10/**10**	**11**
	11/**11**	10/**11**	11/**11**	11/**10**	**11**
TEB	12/**12**	12/**12**	12/**12**	12/**12**	**10**
	12/**11**	12/**11**	12/**11**	11/**11**	**9**

Table 9-4 shows the weighted effect on the time to climb for the alternatives in comparison to the Future No Action for 2006 and 2011 traffic. Negative numbers in Table 9-4 indicate that the time to climb was less than Future No Action, positive numbers indicate the time to climb was greater than Future No Action Alternative. Blank entries indicate no change from Future No Action Alternative. Numbers in bold are the time to climb difference for the 2011 traffic level.

Table 9-4. Effect on Time to Climb, Weighted (Minutes)

2006/**2011**	**Modifications to Existing Airspace**	**Ocean Routing**	**Integrated Airspace**	**Integrated Airspace with ICC**
EWR	-1/**-1**		-1/**-1**	**-1**
JFK	1/**1**	5/**1**		**-1**
LGA	1/**1**		-1/**-1**	**-1**
PHL				**1**
TEB			-1/**-1**	**-2**

9.2.2.2 Time to Descend

The “Time to Descend” metric includes time spent vectoring and holding (below 18,000 feet) for runways. Tables 9-5 and 9-6 show the results. Ocean routing harms JFK because of the competition for airspace between its arrivals and EWR departures. The Integrated Airspace Alternative shows a small improvement in this metric, which is a secondary effect of the improved efficiency of the airport. In the Integrated Airspace with Integrated Control Complex Alternative, the time increases because low altitude holding is possible near the airport. (Low altitude holding is one of the factors that contribute to reduced arrival delay.) This effect is most pronounced at LGA, the airport that showed the biggest improvement in arrival delay due to the integration of the facilities.

In Table 9-5, each airport has two rows. The first row provides the time to descend for the high capacity configuration for 2006 (abbreviated as Hi06) and the high capacity configuration for 2011 (abbreviated as Hi11). The second row provides the time to descend for the low capacity configuration for 2006 (abbreviated as Lo06) and the low capacity configuration for 2011 (abbreviated as Lo11). The numbers in bold are the times to climb for the 2011 traffic level.

Table 9-6 shows the weighted effect on the time to descend for the alternatives in comparison to the Future No Action for 2006 and 2011 traffic. Negative numbers in Table 9-6 indicate that the time to descend was less than for the Future No Action Alternative, positive numbers indicate the time to descend was greater than for Future No Action Alternative. Blank entries indicate no change from Future No Action Alternative. The numbers in bold are the time to climb difference for the 2011 traffic level.

Table 9-5. Time to Descend (Minutes)

Hi06/**Hi11** Lo06/**Lo11**	**Future No Action**	**Modifications to Existing Airspace**	**Ocean Routing**	**Integrated Airspace**	**Integrated Airspace with ICC**
EWR	26/**27**	26/**27**	26/**27**	26/**27**	**27**
	28/**29**	28/**29**	28/**29**	27/**28**	**28**
JFK	16/**16**	15/**15**	17/**17**	16/**16**	**17**
	14/**14**	14/**13**	18/**17**	14/**14**	**16**
LGA	31/**27**	30/**28**	31/**27**	30/**28**	**33**
	30/**29**	31/**29**	30/**29**	30/**29**	**33**
PHL	27/**26**	25/**25**	27/**26**	27/**26**	**26**
	24/**31**	24/**23**	24/**31**	24/**31**	**32**
TEB	31/**34**	31/**34**	31/**34**	31/**34**	**33**
	25/**29**	25/**29**	25/**29**	25/**29**	**32**

Table 9-6. Effect on Time to Descend, Weighted (Minutes)

2006/**2011**	**Modifications to Existing Airspace**	**Ocean Routing**	**Integrated Airspace**	**Integrated Airspace with ICC**
EWR			0/**-1**	**0**
JFK	-1/**-1**	2/**2**		**2**
LGA			-1/**1**	**5**
PHL	-1/**-4**			**1**
TEB				**1**

9.2.3 Distance Below 18,000 feet

9.2.3.1 Descent Distance

Tables 9-7 and 9-8 show the distance flown below 18,000 feet (in nautical miles) on arrival. The distance flown below 18,000 feet on arrivals includes vectoring distance, but not flying in holding stacks. As in the case of descent time, the Ocean Routing Alternative adversely affects JFK arrivals, but other airports are not significantly affected. The Integrated Airspace Alternative has almost no effect on this metric. The Integrated Airspace with Integrated Control Complex Alternative shows an increase in this metric, except at EWR. This reflects the increased role of vectoring at low altitudes, since high-altitude holding is no longer so important for sequencing aircraft. Note also that the increased distances are much longer than the increased descent times would imply. This is a sign that aircraft are flying faster after descending through 18,000 feet. This is due to raised altitudes at the arrival fixes.

In Table 9-7, each airport has two rows. The first row provides descent distance for the high capacity configuration for 2006 (abbreviated as Hi06) and the high capacity configuration for 2011 (abbreviated as Hi11). The second row provides the descent distance for the low capacity configuration for 2006 (abbreviated as Lo06) and the low capacity configuration for 2011 (abbreviated as Lo11). The numbers in bold are the descent distances for the 2011 traffic level.

Table 9-8 shows the weighted effect on the descent distance for the alternatives in comparison to the Future No Action for 2006 and 2011 traffic. Negative numbers in Table 9-8 indicate that the descent distance was less than for the Future No Action Alternative, positive numbers indicate the descent distance was greater than for Future No Action Alternative. Blank entries indicate no change from Future No Action Alternative. The numbers in bold are the descent distance difference for the 2011 traffic level.

Table 9-7. Descent Distances (nmi)

Hi06/**Hi11** Lo06/**Lo11**	**Future No Action**	**Modifications to Existing Airspace**	**Ocean Routing**	**Integrated Airspace**	**Integrated Airspace with ICC**
EWR	106/**106**	106/**106**	106/**106**	106/**106**	**91**
	102/**102**	102/**102**	102/**118**	102/**102**	**99**
JFK	58/**59**	55/**56**	58/**58**	58/**59**	**73**
	52/**52**	48/**49**	63/**67**	52/**52**	**63**
LGA	114/**109**	110/**111**	114/**109**	114/**108**	**114**
	114/**115**	115/**117**	114/**115**	114/**115**	**123**
PHL	94/**102**	102/**102**	94/**102**	95/**102**	**109**
	101/**100**	101/**100**	101/**100**	101/**100**	**110**
TEB	107/**108**	108/**108**	107/**108**	107/**108**	**127**
	108/**109**	94/**95**	108/**109**	108/**109**	**134**

Table 9-8. Effect on Descent Distance (nmi),Weighted

2006/**2011**	**Modifications to Existing Airspace**	**Ocean Routing**	**Integrated Airspace**	**Integrated Airspace with ICC**
EWR		0/**7**		**-10**
JFK	-4/**0**	5/**6**		**13**
LGA	-2/**0**		0/**-1**	**7**
PHL	4/**0**			**9**
TEB	-6/**0**			**22**

9.2.3.2 Climb Distance

Tables 9-9 and 9-10 show the distance flown below 18,000 feet on departure. The measured distance includes only aircraft performance effects. It does not include any maneuvering for spacing on the jet airways. The Ocean Routing Alternative has an adverse effect on EWR and JFK. The Integrated Airspace Alternative shows a small improvement due to the increased number of departure fixes. The Integrated Airspace with Integrated Control Complex Alternative shows a larger improvement, due to expanded use of piggyback altitudes at the fixes.

In Table 9-9, each airport has two rows. The first row provides climb distance for the high capacity configuration for 2006 (abbreviated as Hi06) and the high capacity configuration for 2011 (abbreviated as Hi11). The second row provides the climb distance for the low capacity configuration for 2006 (abbreviated as Lo06) and the low capacity configuration for 2011 (abbreviated as Lo11). The numbers in bold are the descent distances for the 2011 traffic level.

Table 9-10 shows the weighted effect on the climb distance for the alternatives in comparison to the Future No Action for 2006 and 2011 traffic. Negative numbers in Table 9-10 indicate that the climb distance was less than for the Future No Action, positive numbers indicate the climb distance was greater than for the Future No Action Alternative. Blank entries indicate no change from Future No Action Alternative. Numbers in bold are the descent distance difference for the 2011 traffic level.

Table 9-9. Climb Distance (nmi)

Hi06/**Hi11** Lo06/**Lo11**	**Future No Action**	**Modifications to Existing Airspace**	**Ocean Routing**	**Integrated Airspace**	**Integrated Airspace with ICC**
EWR	64/**65**	56/**56**	75/**76**	55/**55**	**48**
	68/**68**	59/**59**	58/**58**	64/**64**	**56**
JFK	48/**49**	55/**57**	63/**65**	48/**49**	**52**
	61/**62**	68/**69**	60/**61**	61/**62**	**51**
LGA	70/**70**	77/**77**	67/**67**	64/**65**	**54**
	62/**63**	69/**70**	62/**62**	61/**61**	**53**
PHL	52/**52**	53/**55**	52/**52**	52/**51**	**52**
	55/**56**	54/**55**	55/**56**	55/**54**	**54**
TEB	58/**58**	58/**58**	58/**58**	55/**55**	**51**
	66/**66**	58/**58**	66/**66**	60/**60**	**53**

Table 9-10. Effect on Climb Distance (nmi) Weighted

2006/**2011**	**Modifications to Existing Airspace**	**Ocean Routing**	**Integrated Airspace**	**Integrated Airspace with ICC**
EWR	-9/**-9**	2/**2**	-7/**-7**	**-8**
JFK	7/**7**	7/**8**		**-4**
LGA	7/**7**	-2/**-2**	-4/**-4**	**-9**
PHL	0/**1**		0/-2	**1**
TEB	-4/**-4**		-4/**-5**	**-5**

9.2.4 Maximum Inter-facility Handoffs per Hour

Handoffs within a facility are much more flexible than handoffs between facilities. Within a single facility, transfer of control is done by face-to-face communication, which permits continuous adjustment during changing conditions. Between facilities, transfer of control is made according to letters of agreement, which do not change easily. When flexibility is needed, it is achieved through negotiation between traffic management offices. It is not possible to determine via simulation what letters of agreement will be necessary in a redesigned airspace, but a count of how many aircraft will be subject to those letters gives an indication of the importance of such rigid handoffs.

The most direct result of integrating the New York TRACON and New York Center will be a reduction in inter-facility handoffs. This is clearly visible in Figures 9-4 and 9-5. The number of inter-facility handoffs in the Integrated Airspace with Integrated Control Complex Alternative is about 30% lower in all busy hours than in any of the multi-facility alternatives. Arrival inter-facility handoffs in the multi-facility alternatives are nearly identical. Departure handoffs show some variation, since the times of transfer of control are quite a bit different when new departure routes and multiple departure headings are available.

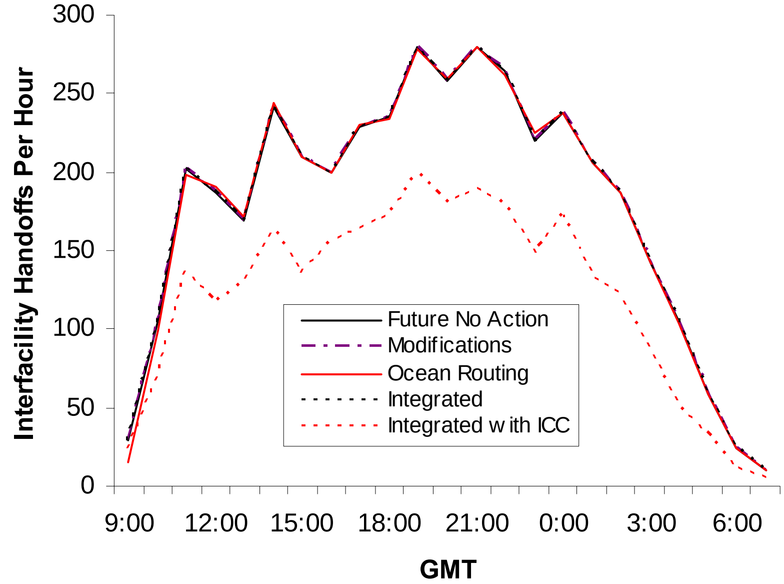

Figure 9-4. Arrival Inter-facility Handoff

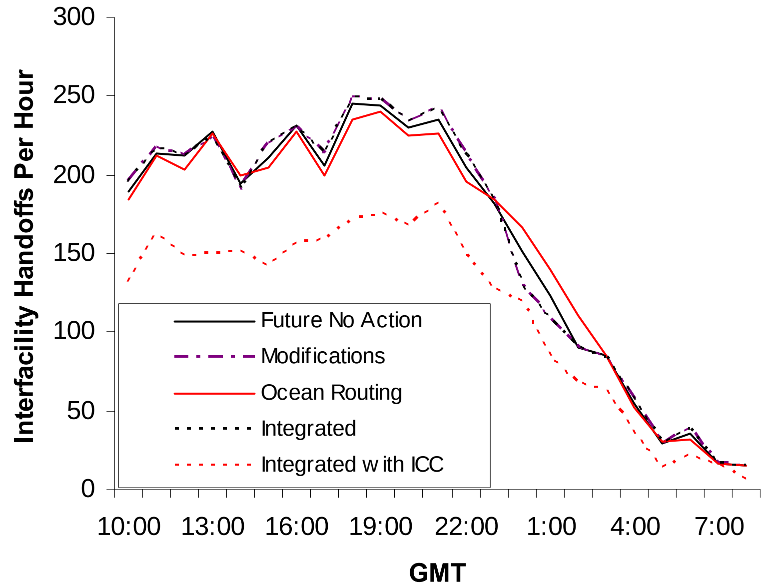

Figure 9-5. Departure Inter-facility Handoff

9.2.5 Arrival and Departure Delays

Airport delay was calculated for both forecast 2006 and 2011 traffic levels. Airport arrival and departure delay is a direct output of the simulation. This section shows daily averages for delay at each modeled airport. Hourly averages can be found in the validation section, above.

9.2.5.1 John F. Kennedy International

The traffic-weighted airport arrival and departure delays for JFK for the 2006 and 2011 timeframes are shown in Figures 9-6 and 9-7. The Ocean Routing Alternative severely increases arrival delay in comparison to the other alternatives and provides the greatest departure delays. The more flexible runway use in the Integrated Airspace with Integrated Control Complex (ICC) Alternative provides the biggest arrival benefit. The Integrated Airspace Alternative and Future No Action Alternatives are similar in results.

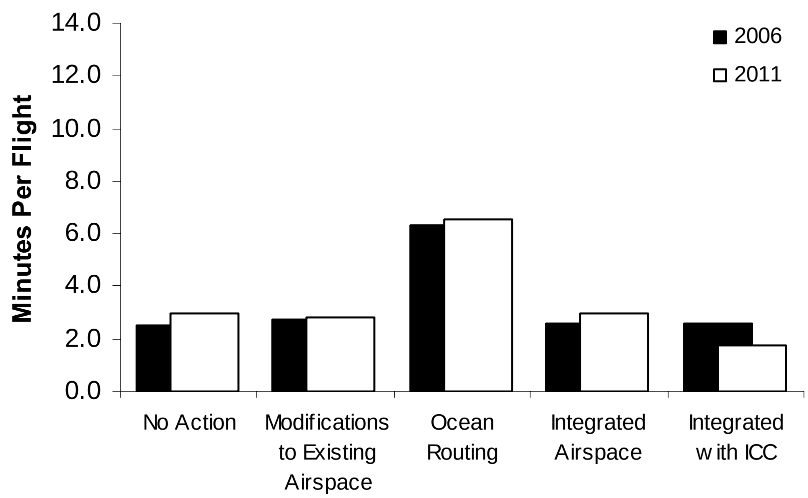

Figure 9-6. JFK Arrival Delays

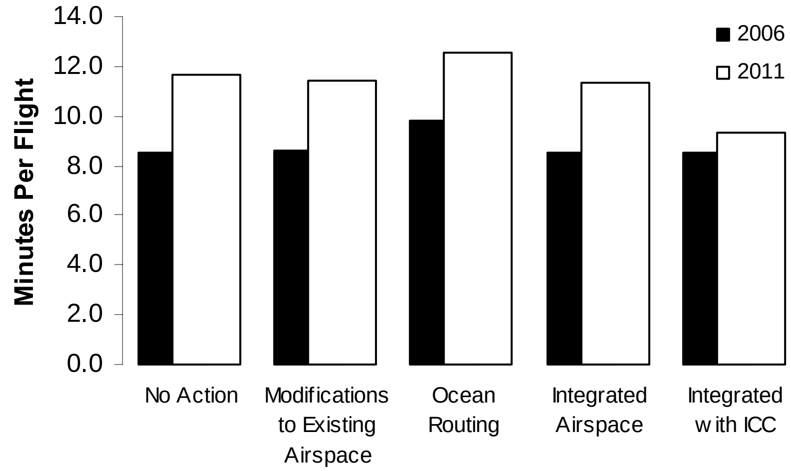

Figure 9-7. JFK Departure Delays

9.2.5.2 LaGuardia

The traffic-weighted airport arrival and departure delays for LGA for the 2006 and 2011 timeframes are shown in Figures 9-8 and 9-9. The arrival delay improves only with the Integrated Airspace with Integrated Control Complex Alternative. With the expanded airspace with the NYICC, aircraft can be sequenced approximately one hour before they arrive. There are small departure improvements in Integrated Airspace and Integrated Airspace with Integrated Control Complex Alternatives due to the additional departure fixes in these alternatives.

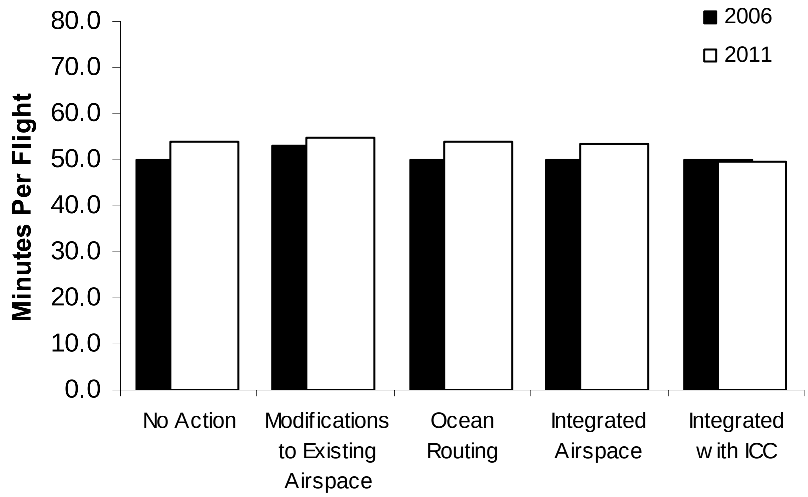

Figure 9-8. LGA Arrival Delays

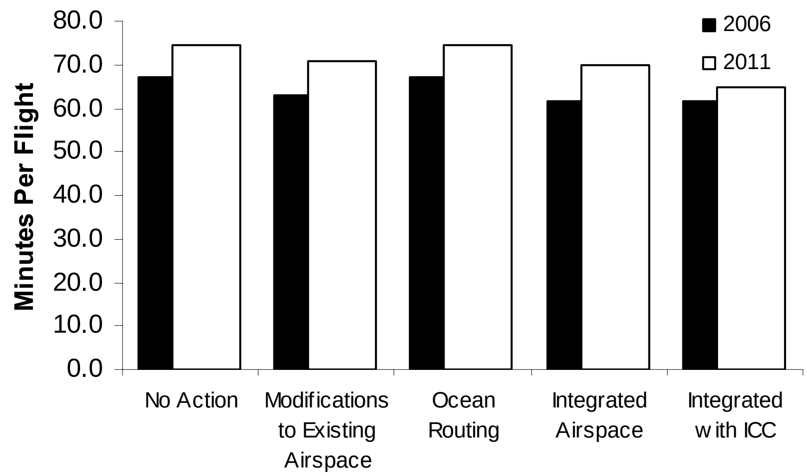

Figure 9-9. LGA Departure Delays

9.2.5.3 Long Island MacArthur

The traffic-weighted airport arrival and departure delays for ISP for the 2006 and 2011 timeframes are shown in Table 9-11. There are no significant improvements with alternatives.

Table 9-11. ISP Airport Delay (Minutes)

	2006		2011	
	Arrival	**Departure**	**Arrival**	**Departure**
Future No Action Alternative	0	1.1	0.1	1.1
Modifications to Existing Airspace Alternative	0	1.1	0.1	1.1
Ocean Routing Alternative	0	1.1	0.1	1.1
Integrated Airspace Alternative	0	1.2	0.1	1.1
Integrated Airspace with Integrated Control Complex Alternative	N/A	N/A	0	1.1

9.2.5.4 Newark Liberty International

The traffic-weighted airport arrival and departure delays for EWR for the 2006 and 2011 timeframes are shown in Figures 9-10 and 9-11. Arrival delay is improved with the Integrated Airspace with Integrated Control Complex Alternative due to the flexible runway use of Runway 22R/04L. Departure delay improves with the Integrated Airspace and Integrated Airspace with Integrated Control Complex Alternatives because of the three heading fanning off of Runway 22R. There are significant departure delays with the Ocean Routing alternative.

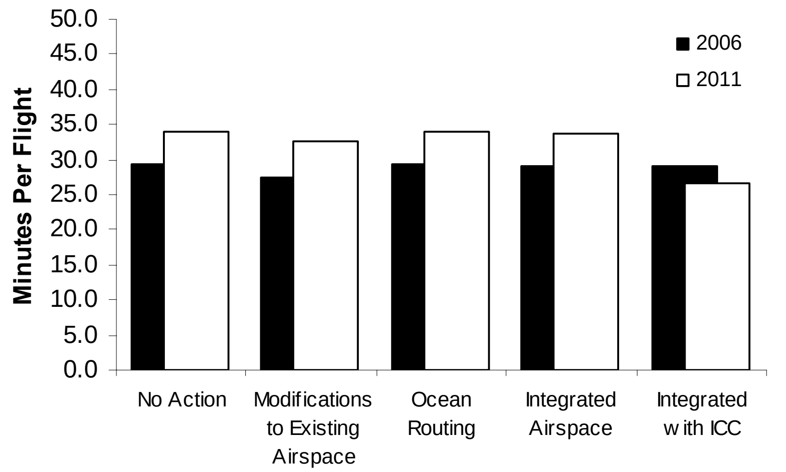

Figure 9-10. EWR Arrival Delays

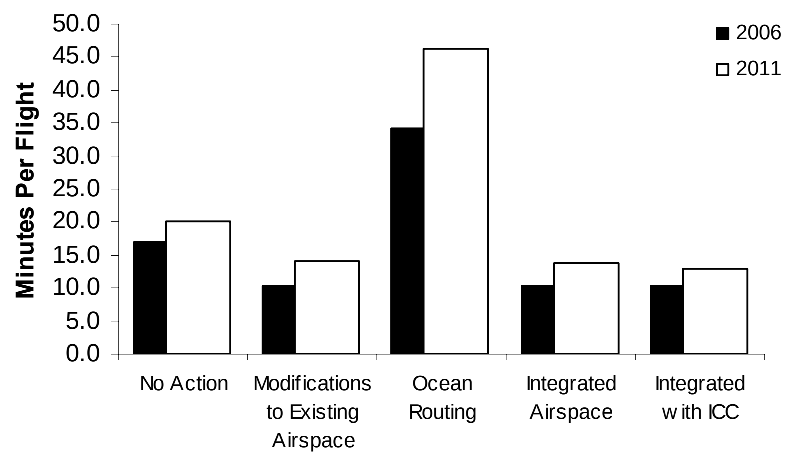

Figure 9-11. EWR Departure Delays

9.2.5.5 Teterboro

The traffic-weighted airport arrival and departure delays for TEB for the 2006 and 2011 timeframes are shown in Figures 9-12 and 9-13. TEB delay is low in 2006, but will likely double from 2006 to 2011 because of growth in demand. As is the case with LGA, arrival delay improves in the Integrated Airspace with Integrated Control Complex Alternative in 2011, because sequencing is more efficient when it begins earlier.

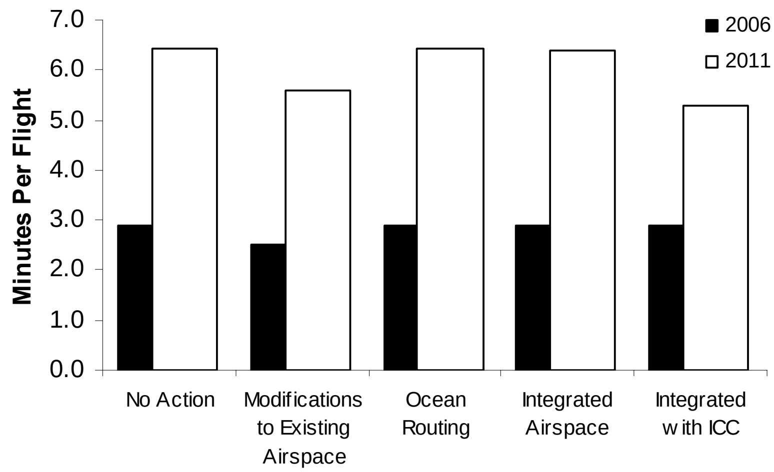

Figure 9-12. TEB Arrival Delays

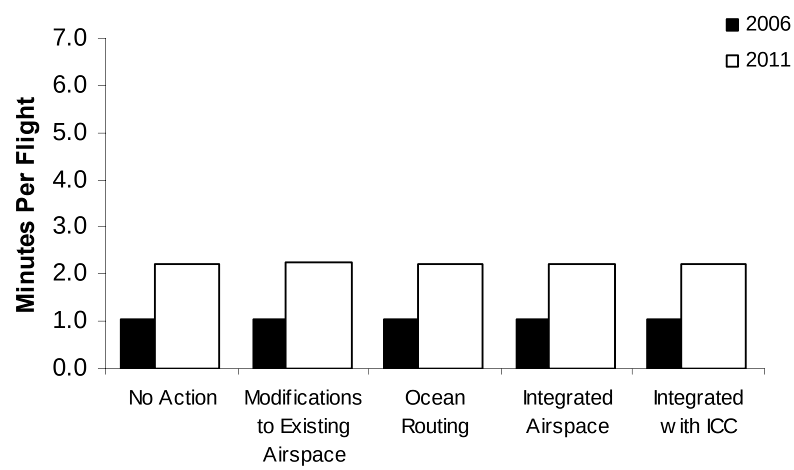

Figure 9-13. TEB Departure Delays

9.2.5.6 Morristown Municipal

The traffic-weighted airport arrival and departure delays for MMU for the 2006 and 2011 timeframes are shown in Table 9-12. Because of the low traffic volume, there are no significant delays at MMU.

Table 9-12. MMU Airport Delay (Minutes)

	2006		2011	
	Arrival	**Departure**	**Arrival**	**Departure**
Future No Action	0.1	1.2	0.2	1.7
Modifications to Existing Airspace	0	1.1	0.1	1.6
Ocean Routing	0.1	1.2	0.2	1.7
Integrated Airspace	0.1	1.1	0.2	1.6
Integrated Airspace with Integrated Control Complex	N/A	N/A	0.1	0.6

9.2.5.7 Philadelphia International

The traffic-weighted airport arrival and departure delays for PHL for the 2006 and 2011 timeframes are shown in Figures 9-14 and 9-15. PHL arrival delay shows no significant change in any alternative. The Modifications and the Integrated alternatives show decreases in departure delay, due entirely to multiple departure headings in High (west) configuration.

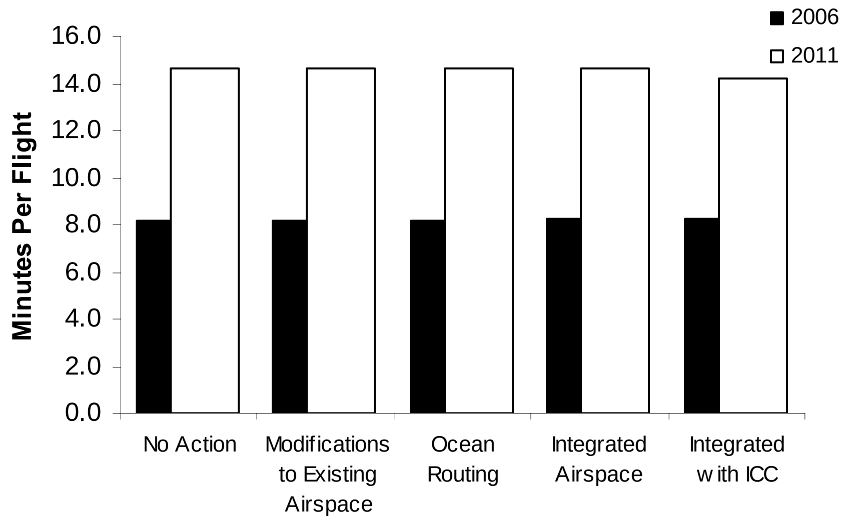

Figure 9-14. PHL Arrival Delays

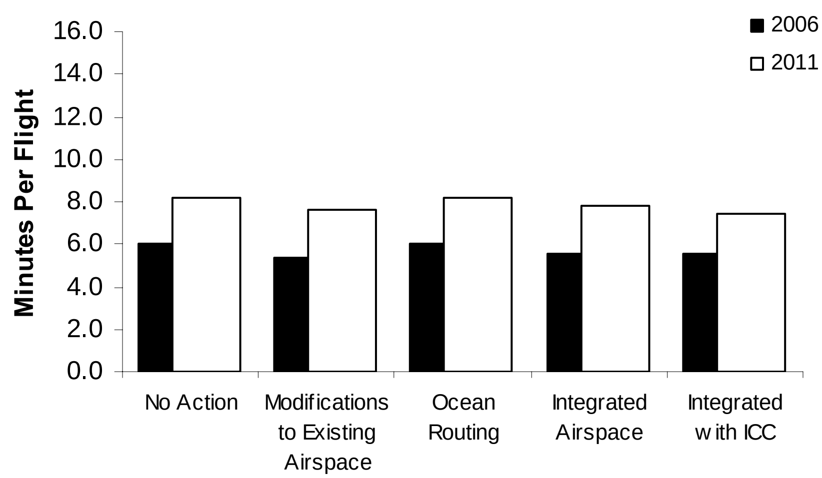

Figure 9-15. PHL Departure Delays

9.2.5.8 Westchester County

The traffic-weighted airport arrival and departure delays for HPN for the 2006 and 2011 timeframes are shown in Table 9-13. Based on the low traffic volume, there are no significant delays at HPN.

Table 9-13. HPN Airport Delay (Minutes)

	2006		2011	
	Arrival	**Departure**	**Arrival**	**Departure**
Future No Action	0	0.9	0	1
Modifications to Existing Airspace	0	0.9	0	1
Ocean Routing	0	0.9	0	1
Integrated Airspace	0.1	0.9	0	1
Integrated Airspace with Integrated Control Complex			0	1

9.2.6 Equity of Fix Traffic Counts

As part of the objective to balance controller workload, the equity of departure fix traffic counts was measured. The departure fix traffic was measured by departure gate. If all the fixes associated with a departure gate have equal traffic, then the traffic imbalance is zero, if one fix has all the traffic associated with a departure gate, the traffic imbalance is one (see Footnote 16 for metric details). The results for the west gate, south gate, north gate and east gate are shown in the following subsections.

PHL departure fixes do not have a comparable metric in this case. Three of the four gates consist of a single fix, and the balance of traffic to the fourth is not affected by any of the alternatives.

9.2.6.1 West Gate

The west gate is the most important departure area from New York, and it is the one most affected by the alternative designs. Figure 9-16 shows the imbalance scores.

The Integrated Airspace with Integrated Control Complex Alternative is the largest improvement over the Future No Action Alternative because ELIOT, the busiest fix, splits into two equal parts. The Integrated Airspace with Integrated Control Complex Alternative shows less improvement, because the addition of piggybacked altitudes to all fixes in the gate makes balance less crucial.

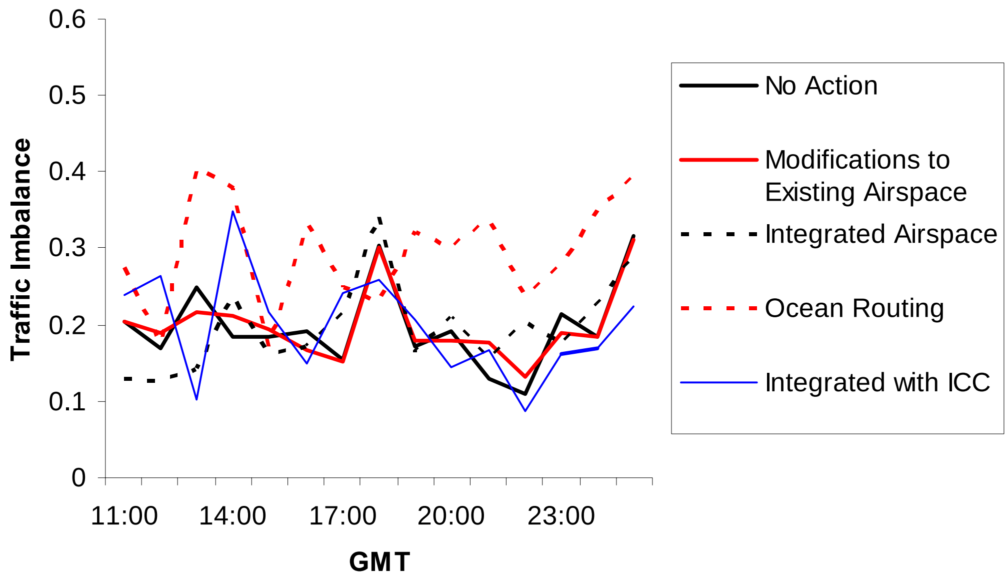

Figure 9-16. West Gate Equity of Fix Traffic

9.2.6.2 South Gate

The south gate consists in all alternatives of two fixes that feed jet airways, plus one fix (DIXIE in the Future No Action Alternative) that combines the functions of a tower en route departure fix and an oceanic gateway for New Jersey airports. Figure 9-17 shows its imbalance scores. The early morning departure rush becomes more imbalanced in the Integrated Airspace with Integrated Control Complex Alternative, but the afternoon imbalance is greatly improved.

This is due to the ability of the integrated facility to send aircraft to their fixes according to their desired jet airway, not their airport of origin. Ocean routing slightly improves the balance by spreading out the departure flows from EWR and JFK into a slow, continuous stream.

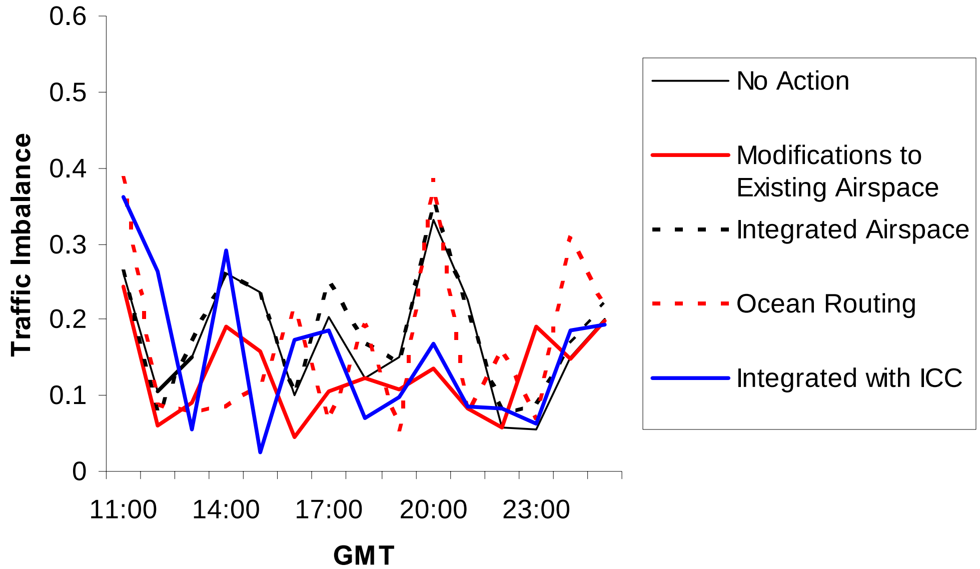

Figure 9-17. South Gate Equity of Fix Traffic

9.2.6.3 North Gate

The north gate changes significantly in different alternatives. Its imbalance score is shown in Figure 9-18.

Because the Integrated Airspace with Integrated Control Complex Alternative has three jet airways fed by a single fix, its imbalance score is the worst. It is possible that piggyback altitudes may ameliorate the imbalance. Other alternatives are similar.

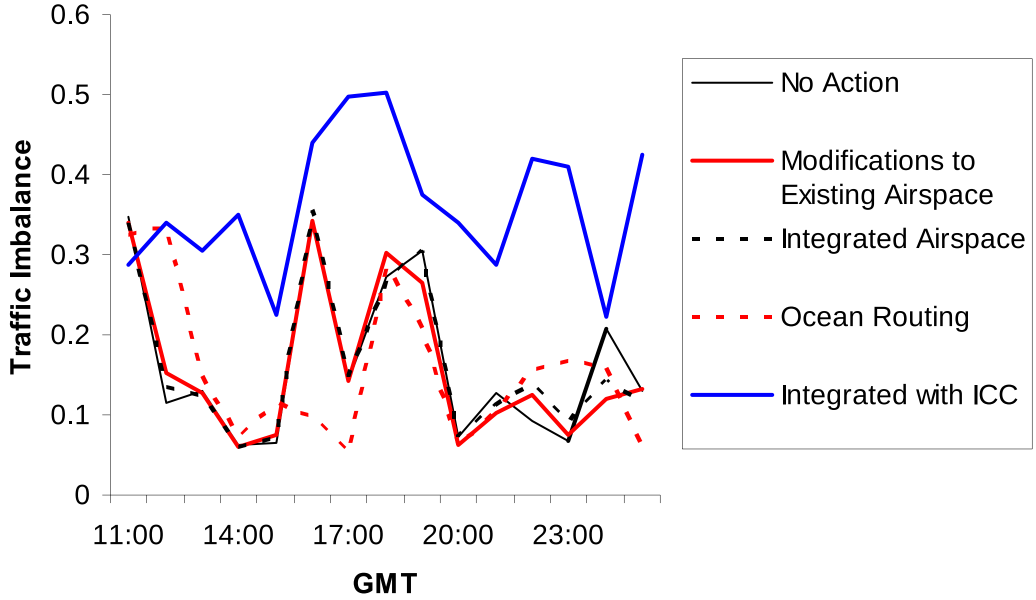

Figure 9-18. North Gate Equity of Fix Traffic

9.2.6.4 East Gate

The east gate has two fixes for long-haul traffic and one for short hops. Its imbalance score is shown in Figure 9-19. During most hours, the Future No Action Alternative has a very low imbalance. During the transatlantic departure peak in the afternoon, however, the imbalance becomes fairly high. The Integrated Airspace with Integrated Control Complex Alternative lowers this peak, but the more balanced hours are raised. Ocean routing upsets the balance as well, but with no corresponding benefit.

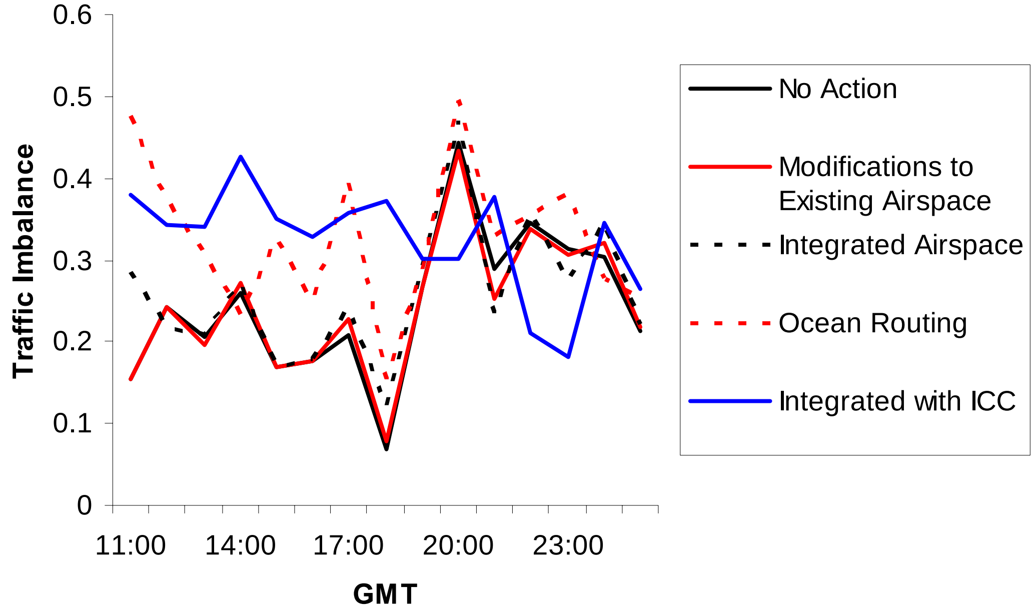

Figure 9-19. East Gate Equity of Fix Traffic

9.2.7 End of Day's Last Arrival Push

When traffic is held constant over all alternatives, user access can be indirectly measured by considering the time at when the day's last arrival push is complete. The later at night it occurs, the more likely that users will be discouraged from scheduling flights. This metric is not significantly affected by the alternatives that do not integrate the current facilities. In the Integrated Airspace with Integrated Control Complex Alternative, improved arrivals at EWR greatly reduce the number of late-night arrivals at EWR and LGA, visible near 0300 GMT in Figure 9-20 and 0400 GMT in Figure 9-21 respectively. The other airports studied (JFK, TEB, MMU, HPN, ISP, and PHL) are not significantly affected.

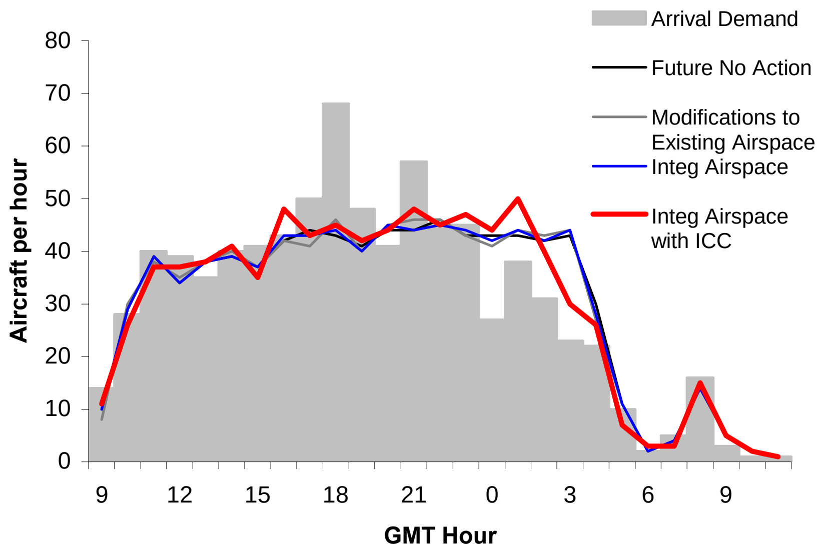

Figure 9-20. EWR 2011 End of Arrival Push

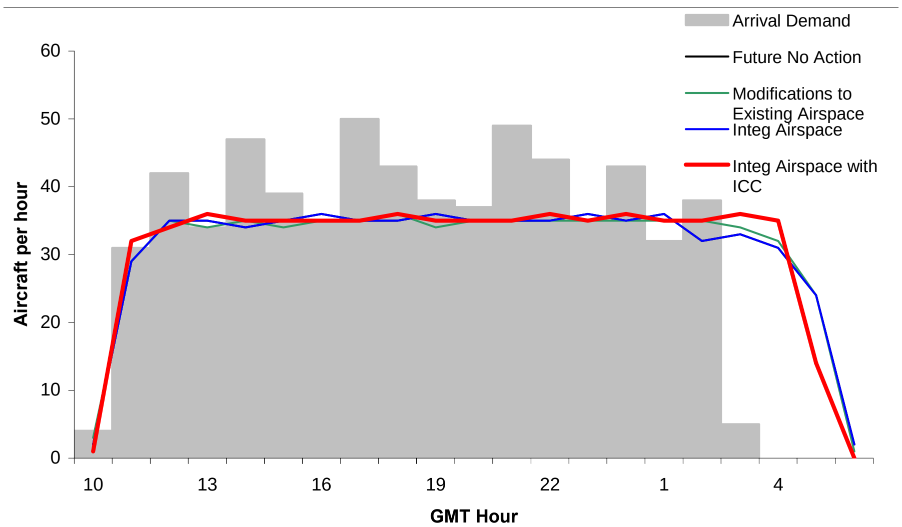

Figure 9-21. LGA 2011 End of Arrival Push

9.2.8 Ground Track Length and Block Time

The existing airspace design appears to have been designed to minimize ground track distance for flights to the major airports. Smaller flows are routed considerably out of their way to avoid the major flows. If the traffic is rerouted to reduce delays at major airports, therefore, it is likely that the flying distances will increase. The time it takes to fly the longer distances must be counted against the delay reduction.

Figure 9-22 shows the changes in ground track length for traffic at each airport. The value for each flight is the ground track length in that alternative minus the ground track length in the Future No Action Alternative. Therefore, positive numbers are a distance penalty. Negative numbers are a benefit. The marker shows the mean change over all flights and the 25^{th} and 75^{th} percentile points in the distribution of changes. That is, the route length changes for half the flights to and from that airport in that alternative lie between the ends of the bar.

As anticipated, route lengths increase at most airports. The conspicuous exception is ISP. In the Future No Action Alternative, arrivals to ISP from the west are routed far out of the way to avoid New York City traffic. In the Integrated Airspace with Integrated Control Complex Alternative, ISP shares the more direct LENDY route with JFK traffic.

Ocean routing shows an enormous negative effect on EWR. Note that the increased route length includes both arrivals and departures, and one configuration that is relatively unaffected averaged in with another heavily-affected configuration. If the impacted EWR departures alone were shown in Figure 9-22 for Ocean Routing, the chart would show a route-length penalty approximately four times as large as the weighted value.

Figure 9-23 shows the changes in block time that result from the combination of delay reduction and increased route length. The quantities are computed the same way as for ground track length, but the minutes between flight start and landing are used instead. Traffic flow management delays at LGA and PHL are included in the block time metric.

EWR shows the biggest benefits in the Integrated Airspace with Integrated Control Complex Alternative, since the changes in runway use dominate the increased flying distance. The enormous penalties of ocean routing are also visible. ISP shows a benefit due purely to ground track length. LGA shows a benefit due to improved sequencing in the Integrated Airspace with Integrated Control Complex Alternative. At other airports, changes in route length are balanced by changes in delay times, on average.

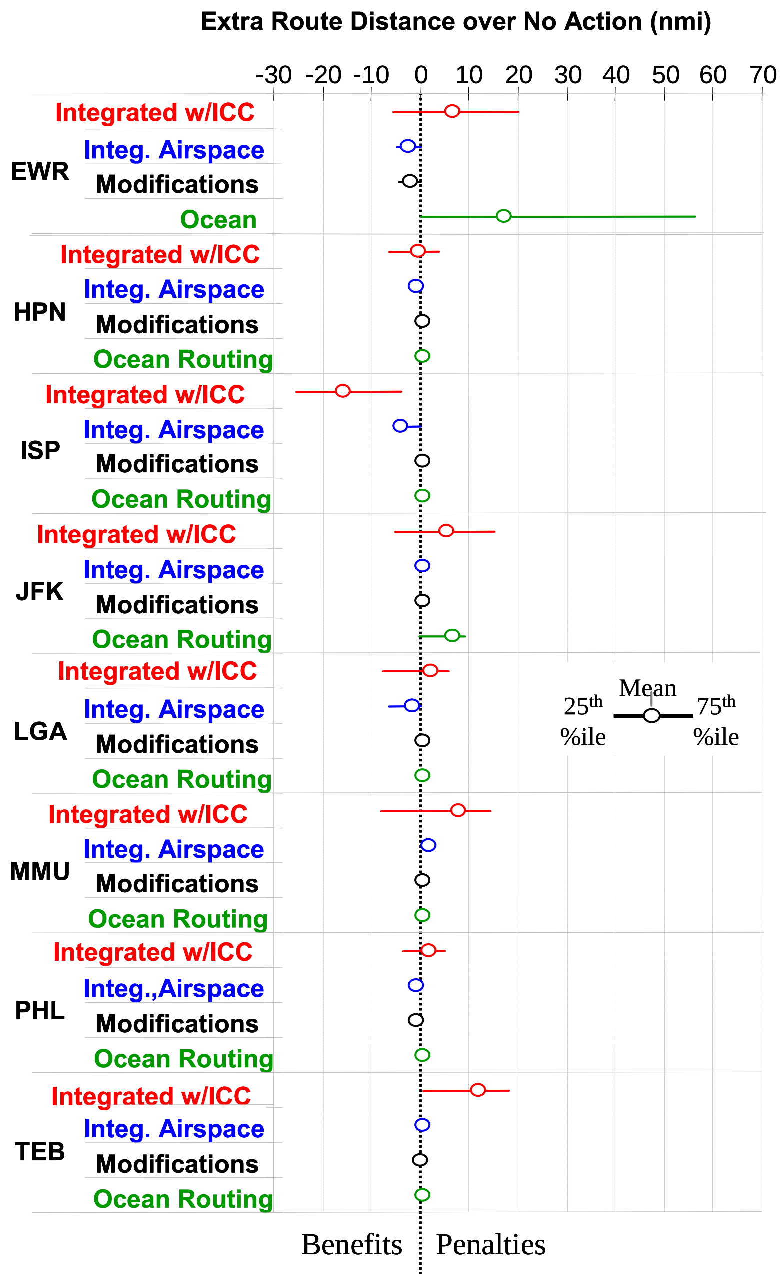

Figure 9-22. Route Length Changes

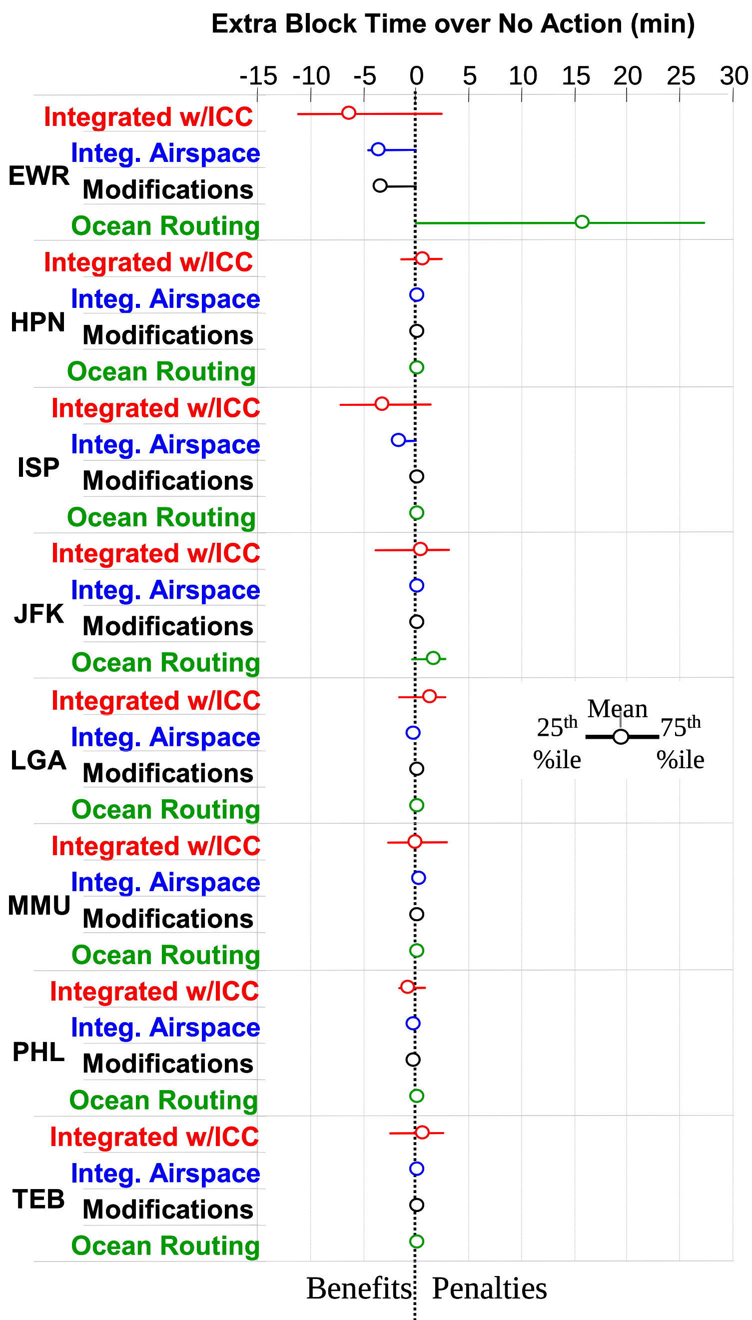

Figure 9-23. Block Time Changes

9.2.9 Flexibility Qualitative Assessment

As defined in Section 9.1.7, factors that contributed to the qualitative assessment of flexibility included:

- The number of runways available
- The number of arrival and departure fixes available
- The number of arrival and departure routes available
- The absence of equipment restrictions on routes

9.2.10 Total Maximum Sustainable Throughput

Maximum sustainable throughput is perhaps the most important metric for any efficiency study because it translates directly into increased activity for users of the airports and airspace. The total throughput, weighted by configuration, for the capacity-limited modeled airports in each alternative is shown in Figure 9-24.

The modeled airports that are not capacity-limited, MMU, ISP, and HPN, are not included in the figure or in the metric. Their throughput is determined primarily by the pattern of demand, which is held constant across the alternatives. Therefore they will show no difference.

The largest changes are seen in departure throughput. All the New York Metro airports show benefits of the increased number of departure fixes. EWR benefits to a great extent, typically two departures per hour, from fanned departures in the modification and both integrated alternatives. JFK and LGA can fan some departures in the Future No Action Alternative, so their benefits are less, about 1 departure per hour. JFK benefits from access to the west gate and more flexible runway use in the Integrated Airspace with Integrated Control Complex Alternative, which adds 1 more departure per hour. EWR departure throughput is significantly reduced by ocean routing; the sustainable throughput drops from 55 to 38 per hour. JFK's maximum departure rate is not reduced by ocean routing, because its maximum departure operation is primarily in other directions.

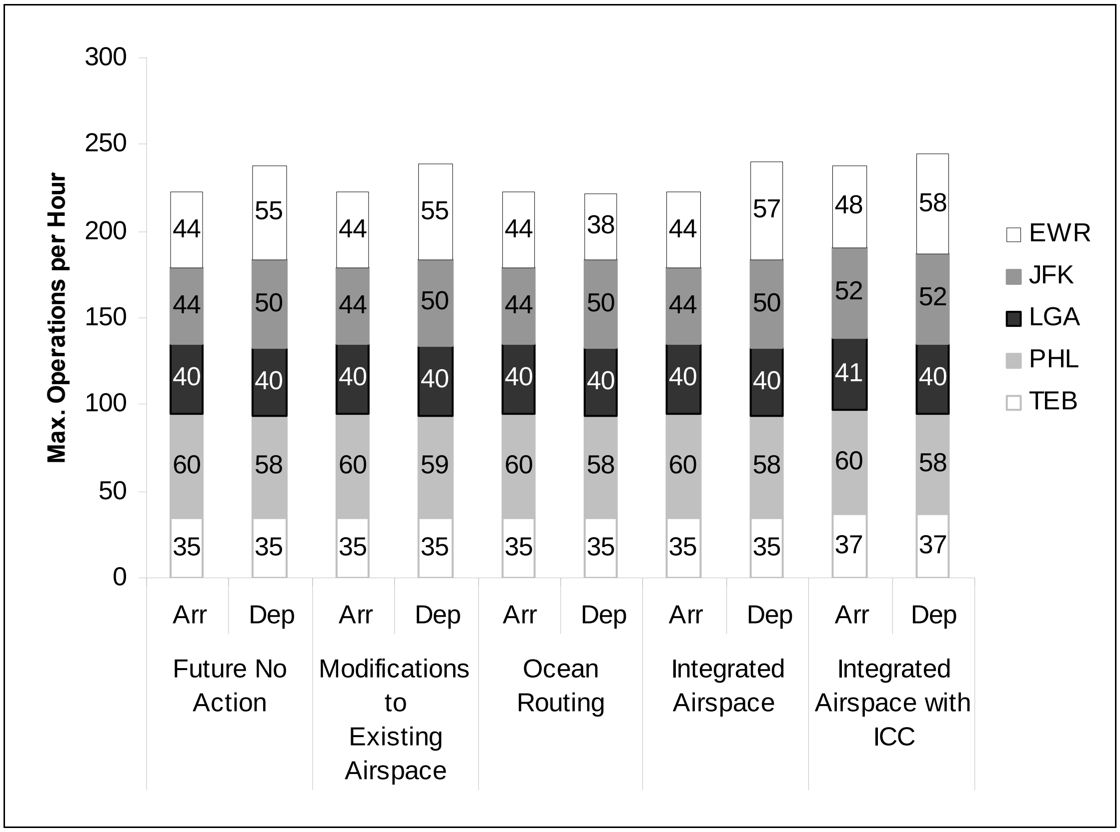

Figure 9-24. Maximum Sustainable Throughput

Enhancements to arrival throughput occur only in the Integrated Airspace with Integrated Control Complex Alternative. EWR gains in runway flexibility, so it shows an improvement of 4 arrivals per hour. JFK, where runway usage patterns are also improved, shows an increase of 4 arrivals per hour as departures interfere less with the arrival stream. LGA and TEB obtain smaller benefits, since sequencing can begin earlier in the arrival process. The result is one additional arrival per hour at each airport.

The airspace changes studied here are not large enough at PHL to affect this metric.

9.3 Summary

The simulation results obtained above were combined according to the definitions in Table 9-1 to generate the metrics needed to support the system improvements. A summary of the metric results is presented in Table 9-14. The best results for each metric are shown in **bold**.

Table 9-14. Summary of Metric Results

System Improvements	Metric	Future No Action	Modifications to Existing Airspace	Ocean Routing	Integrated Airspace	Integrated Airspace with ICC
Reduce complexity	*Jet route delays + time below 18,000 ft (min)*	12	12	12	11	**10**
	Arrival Distance below 18,000 ft (nmi)	96	**95**	99	96	102
Reduce voice communications	*Max Inter-facility handoffs per hour*	525	525	521	529	**382**
Reduce delay	*traffic-weighted Arrival Delay 2011*	22.9	22.6	23.6	22.8	**19.9**
	traffic-weighted Departure Delay 2011	23.3	20.9	29.5	20.8	**19.2**
Balance controller workload	*Equity of westgate fix traffic counts*	0.37	0.37	0.37	0.34	**0.30**
Meet system demands and Improve user access to system	*End of day's last arrival push*	23:54	23:54	23:54	23:54	**23:00**
Expedite arrivals and departures	*Time below 18,000 ft (min)*	18.5	**18.2**	18.8	18.2	18.6
	Change in Route Length per flight (nmi)	0.0	0.0	4.5	**-1.2**	3.7
	Change in block time (minutes per flight)	0.0	- 0.9	3.9	-1.0	**-1.4**
Flexibility in routing	*Qualitative Assessment*	0	0	–	0	+
Maintain airport throughput	*Arrivals*	223	223	223	223	**238**
(total of maximum sustainable throughput)	*Departures*	238	239	221	240	**245**

Section 10

Conclusions and Recommendations

The purpose of the NY/NJ/PHL airspace redesign is to maintain safety and increase the efficiency of air traffic operations in the area. This broad purpose was refined by the FAA's redesign team into a set of system improvements that they wished to accomplish with their designs. The system improvements are to:

- Reduce Complexity,
- Reduce Voice Communications,
- Reduce Delay,
- Balance Controller Workload,
- Meet System Demands and Improve User Access to System,
- Expedite Arrivals and Departures,
- Increase Flexibility in Routing, and
- Maintain Airport Throughput.

CAASD modeled and evaluated five airspace alternatives for the NY/NJ/PHL Metropolitan Area Airspace Redesign for eight airports (JFK, LGA, ISP, MMU, EWR, PHL, TEB, and HPN):

1. Future No Action Alternative, which is based on today's airspace and routing
2. Modifications to Existing Airspace Alternative, which assumes minor modifications to today's airspace and routing
3. Ocean Routing Alternative, which keeps departures over water until noise is not a problem
4. Integrated Airspace Alternative, which assumes integrated routes and airspace but without constructing a new proposed ATC facility, the NYICC)
5. Integrated Airspace with Integrated Control Complex Alternative, which assumes integrated routes and airspace and the NYICC

CAASD evaluated the system improvements in terms of quantifiable metrics.

Overall, these metrics slightly favor the **Integrated Airspace with Integrated Control Complex** Alternative. The improvements on airspace delays are significant. The expanded west gate has no departure fixes with more than 30 minutes of delay per day. Airspace delays on the north gate are essentially eliminated. J80 and its offset partner are no more restrictive than other jet airways in this alternative. The change to the south gate, which permits J79 traffic to be placed on the west side of J209 departures while still under New York departure control, balances the departure delay on the replacement fixes for WHITE and WAVEY. Moreover, while the majority of flights fly longer distances with the Integrated Airspace with Integrated Control Complex, users see a net benefit in terms of shorter block times in comparison to the other alternatives. EWR shows the biggest benefits in this alternative, since the benefits associated with the use of dual arrival streams dominate the increased flying distance. Fanned departure headings also contribute significantly to delay reduction.

The Integrated Control Complex also significantly decreases the voice communications associated with the number of interfacility handoffs. With the integrating of the New York TRACON and New York Center, the peak number of interfacility handoffs is up to 30% lower per hour in the Integrated Airspace with Integrated Control Complex Alternative than in any of the multi-facility alternatives.

At the extremely-high demand levels forecast for 2011, this airspace is the recommended alternative. However, we must note that the penalties caused by longer routes are a fixed cost that is proportional to the number of flights. The benefits due to improved airport operations increase faster than linearly as traffic increases. Therefore, there is a break-even point. If traffic is above that level, which is somewhere between the median and the 90th percentile day in 2011, this alternative is a net benefit. If the forecast demand levels do not materialize, there is a risk that this alternative will not reach the break-even point.

The **Integrated Airspace** Alternative has two major differences from the Future No Action Alternative. First, departures are fanned off the runways, reducing departure delay significantly. Second, a second departure fix is created out of New York to share ELIOT traffic from the New York airports, and a parallel airway to J80 handles arrivals to Indianapolis Center. These changes cut the J80 delay by 20%, reduce departure fix delay at MXE by half, and eliminate ELIOT as a source of congestion. The net is a reduction of airspace delay by about one-third.

One minor feature of this alternative is the change to ISP south departures. Though this change affects only about a dozen flights, the impact on airspace delay is substantial. Airspace delays at the south gate are reduced by almost a third. In addition with this alternative, flights benefit in terms of flying slightly shorter distances than in Future No

Action (1.2 nmi), with a small decrease in block time (-0.4 minutes). Departure delay is decreased by approximately 2 minutes per flight.

The **Modifications to Existing System** Alternative shows benefits relative to the **Future No Action** Alternative from the fanning of departure headings. West departures from the New York metropolitan airports and Philadelphia have an additional jet route, similar to that in the **Integrated Airspace** Alternative. This jet route is used for arrivals to the Indianapolis and Cleveland ARTCC internal airports. The **Modifications to Existing System** Alternative reduces airspace delays by about one-third, compared to the current published procedures.

The **Modifications to Existing System** and **Integrated Airspace** alternatives are very similar from the perspective of benefits to users of the airspace. The split of J80 into two airways is the critical change in each case. The primary difference is the interface between the New York TRACON and the split jet airway. In the **Modifications to Existing System** Alternative, as in the current system, the single fix ELIOT feeds several jet airways from two altitudes. The analysis in this report shows that a single fix with two altitudes is more efficient for users than splitting ELIOT into two fixes, each of which will feed an airway that is tightly constrained in the lateral dimension. If it is operationally feasible, the single fix with two altitudes would be a better transitional design to the **Integrated Airspace with Integrated Control Complex** Alternative, since the latter alternative has two altitudes on all the west gate fixes.

In the **Oceanic Routing** Alternative, Newark departures are negatively impacted by longer distances (15 nmi) and extra block time (25 minutes) in comparison to the **Future No Action** Alternative. The **Ocean Routing** Alternative removes the delay on the west gate out of New York, since this gate is no longer available to Newark departures in the high-capacity configuration. However, in its place is a new delay point to the south of NY. The result is a small reduction in airspace delay due to the ocean routing, but with a corresponding huge increase in airport departure delay. There is an additional complication in the en route airspace, as the proposed routing of Newark and Kennedy departures passes just north of the main departure fix out of Philadelphia. As Newark departures are pushed later in the day by the airspace capacity limits that traffic coincides with the evening departure push out of Philadelphia. The result is increased complexity in the en route airspace to the southwest of NY, which is already a bottleneck in the en route system. The **Oceanic Routing** Alternative does not meet the objectives of the airspace redesign. Based on these operational results, CAASD recommends that this alternative not be considered further.

The delay metrics in the **Future No-Action** Alternative show severe airport congestion that will be costly to users of the airspace. To meet the anticipated demand, changes must be made to the current system.

The simulations reported in this document show several changes that can ameliorate future conditions and bring the system closer to the stated needs:

- Airspace constraints that limit the use of available runways must be removed;
- Departures should be permitted to fly dispersed headings as close to the runway as feasible;
- Departure fixes should not have to serve more than one airway;
- Multiple altitudes should be available at departure fixes;
- Sequencing decisions for arrivals should be made as early as possible, and coordination between arrival streams should be seamless.

Of the remaining alternatives, all have benefits. However, only one alternative incorporates enough of the changes listed above to be worth the effort and expense of implementing an airspace redesign of this magnitude. Therefore, the **Integrated Airspace with Integrated Control Complex** Alternative is the recommended choice.

Appendix A

Calculation of Airspace Delay Metric

A.1 Introduction

There is no universally-accepted numerical measure of complexity for air traffic control systems. When an airspace design is intended to reduce complexity, therefore, some model must be applied to generate quantitative metrics. In this work, the indicator of complexity is a mismatch among (1) the demand on an airspace resource, (2) the desired output of that resource, and (3) the amount of delay that the resource can absorb. A "resource" can be a sector, an airway, or a fix. The desired output is expressed as miles or minutes between successive aircraft, possibly per altitude or per transition. Typically, the minimum spacing of the desired output is 8 miles, which allows for a comfortable margin above the en-route separation requirement.

Complexity exceeds acceptable levels when the demand, either in total number or in small bursts, congests a resource in such a way that required delays for spacing are greater than can be absorbed by the controller of the resource without coordination. As we model that occurrence, delays are passed back to other resources or to the ground. Delays are passed back in the form of a lower desired output of upstream resources. This is intrinsically less efficient than case-by-case delays, so the complexity causes higher delay in the airspace than the theoretical minimum. This delay, including the excess, is called "airspace delay".

Off-the-shelf simulation software falls short of the capabilities needed to analyze the process by which airspace complexity translates into airborne and ground delays. All the individual parts are available, but no single package combines them. The analysis required the ability to space traffic at a dependent network of critical points in the airspace (like SIMMOD) using a dynamically-adaptable logic to pass restrictions upstream in the flows (like Eurocontrol Reorganized ATC Mathematical Simulator [RAMS] or TAAM), with aircraft trajectories that are sensitive to details of vectoring in the terminal (like TAAM). Therefore, auxiliary processing of simulation data would be necessary with any simulator. The last characteristic is the most difficult to reproduce externally, so TAAM was chosen as the simulation backbone. Airspace delay was computed externally to the simulation, and fed back into the simulation input where necessary (see Section 9).

A.2 Arrivals and Departures

As a general rule, one runway can not overload one jet airway. Under optimum conditions, a runway can handle slightly less than one departure per minute. At cruising speeds above 30,000 ft, the separation of aircraft off the runway becomes about 8 MIT, which is an acceptable spacing even before altitude separation is considered. On the arrival side, a sustained rate of perhaps 45 per hour is the maximum that a single runway can handle. A single jet airway can deliver more than that as a single stream.

The NY/PHL corridor has many airports that share departure airways, so it is common to see as many as five aircraft launching simultaneously toward the same airway with similar altitude preferences. Departure airspace can be the limiting factor in throughput of the system. Liberty Area in the current New York TRACON was created to do the job of lining up and separating aircraft onto jet airways.

Each busy airport in the corridor, by contrast, has its own set of dedicated arrival airways. Typically there are three or four arrival airways per airport, though some airports in some of the alternatives have only two. Each busy airport (except JFK) has just one independent arrival runway, though some have a lower-capacity overflow runway as well. With several airways feeding one runway, the limiting factor on arrival throughput is the runways. Airport delays, which are addressed in Section 9 dominate the arrival operation. Arrival airspace delays will be close to zero, as long as visual meteorological conditions hold.

This analysis is restricted to departure airspace delays, which are additive to the airport departure delays discussed in Section 9.

A.3 The Merging Model

Merges are the part of the airspace where delay is inevitable. Crossing traffic can be resolved with altitudes, so delay is unpredictable and much smaller than in the merging case.

Figure A-1 illustrates the concept of delay at a merging point. In this example, the merge point is a departure fix, which will show all the important features of the model. The logic is the same en route, though the parameters may be different. Aircraft from each stream approaching the merge point are spaced according to the separation requirement at the airport, with expansion of the space as the aircraft accelerate (left panel). For either stream, this would be enough to meet the separation requirement at the jet airways, but for the combined stream more space will be needed. Small delays for a single aircraft are handled by vectors and larger delay may require holds (center panel). If the delayed aircraft is at the front of a closely spaced group, successive flights in the group will also be delayed sufficiently to maintain the desired output (right panel).

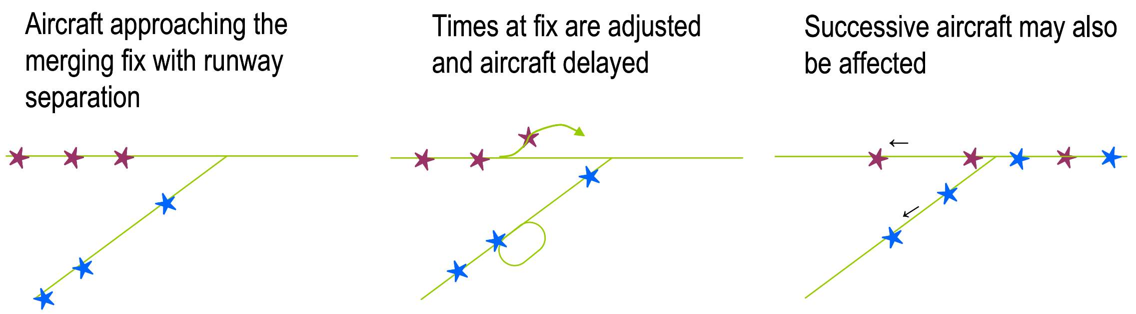

Figure A-1. Delay at Merging Point

Holding in departure airspace, or at a high-altitude merge between two jet airways, is undesirable. Therefore, just before the loading for which meeting the required output spacing will require a hold, a restriction is passed back to upstream fixes. Excessive delay at the departure fix is passed back to the airports. This model applies the upstream restriction, in multiples of 5 miles in trail, for the shortest time possible to resolve the congestion.

The study focused on the differences in the airspace delays among alternatives for the departures from New York Metropolitan Airports for which operational modeling was conducted - JFK, LGA, ISP, MMU, EWR, PHL, TEB, and HPN, and PHL. The first seven airports share departure fixes as well as jet airways, so it will frequently be necessary to refer to them collectively as NY metropolitan airports. The airport traffic was modeled in high capacity configuration to place the greatest stress possible on the airspace.

The airspace delay metric was estimated by calculating the sum of the individual delays of each aircraft at merging points, namely at departure fixes and at fixes on jet routes.

A.4 Airspace Delay Calculation Process

Obtaining the airspace delay estimate is a six-step process.

A.4.1 Select the Fixes Where Delay is to be Calculated

For departure fix delay, departure fixes from the NY metropolitan airports and PHL are used. For jet route delay, a fix on each of the selected jet routes was used. The jet route fix was selected from the first few named waypoints at which departures were required to be merged on the jet route. Figure A-1 shows, for example, the fixes used in the airspace delay calculation of the Future No Action Alternative. In the modeling of each alternative, a detailed description of the fixes used is included at the start.

A.4.2 Set the Separation Parameters at the Fix

The separation parameter, i.e., the desired output spacing to be used in delay calculations was determined for each fix. The separation parameter is calculated based on the purpose of the fix, the number of altitudes available at the fix, and the possible presence of overflight traffic on the jet airway connected to the fix. Only fixes that feed en route airspace were included. Tower-en-route fixes were not included, nor was tower-en-route traffic beneath a stream to a jet airway.

Overflight traffic was included in the desired output spacing by increasing the spacing from the minimum of eight miles. For example, if overflight traffic was one half the number of NY/PHL departures, spacing would be increased from 8 to 12 miles to accommodate it.

A.4.3 Calculate the Delay at the Departure Fix

The unimpeded time over the departure fix is obtained from the history file of the airport-only TAAM simulations.

The delay at the departure fix is calculated using the separation parameter set in the previous step. The algorithm used in delay calculation is described in detail in a later section. The time at fix of the trailing aircraft is adjusted if it needs to absorb any delay.

A geometrical analysis of Liberty West and Liberty North sectors in the current New York TRACON was conducted to calculate a maximum vectoring time. (Zero winds were assumed. Air traffic controllers can use the wind to increase this time, but an airspace design must be robust enough to function even when this is not possible.) Approximately four minutes can be absorbed for any given flight; if more is needed, departure restrictions are enforced on the airport model.

A.4.4 Adjust the Time at the Jet Route Fix and Calculate the Delay

The unimpeded time at the jet route fix is obtained from the history file of the airport-only TAAM simulations. Using the adjusted time at the fix from the previous step, the time at the jet route fix is updated for each affected aircraft. The delay at the jet route fix is then calculated using the same method as for the departure fix. For each fix, the maximum and total delay in every 15 minute time period is analyzed to determine whether the delay at the jet route fix is small enough to be absorbed in the airspace by slowing, and vectoring.

In the en route airspace, the maximum vectoring time was estimated from the minimum time for a hold. The minimum holding time with one minute legs and turns of three degrees per second is four minutes. This was used as the threshold after which holding would be needed.

If slowing and vectoring are insufficient to achieve the desired output spacing, the time period when the delay needs to be passed back to the departure fix is determined.

A.4.5 Adjust the Separation Parameter at the Departure Fix and Calculate the Delay

During the time period identified by the previous step, the separation parameter of affected departure fixes is increased. The delay is calculated for the departure fix and aircraft time at the fix is updated.

A.4.6 Readjust the Time at the Jet Route Fix and Calculate the Delay

With the increased separation at the departure fix, aircraft will approach the jet route fix with larger spacing. Jet route delay is analyzed again, and Steps 4 and 5 are repeated until the delay observed at a jet route fix is small enough to be absorbed in the en route airspace. Once the parameters have relaxed into an acceptable solution, the input times are randomized and the process is repeated fifty times to get an average delay. This last step is necessary because delays are typically experienced by fewer than ten aircraft in a group, and the calculated delay could be sensitive to their exact order. Randomization typically produced a standard deviation in the delay metric of about 10 percent of the mean for a single fix.

A.4.7 Exceptions

In most of the alternatives, there is at least one departure fix that serves more than one jet airway. In the event of congestion on only one of those jet airways, traffic bound for the congested airway is subjected to a different separation criterion from the fix as a whole. For example, the desired output from ELIOT might be 5 MIT for all aircraft, but 10 MIT for J80 departures. The merge model accommodated such cases by calculating the distance between aircraft pairs and ensuring that not only the aircraft pair affected by larger separation criteria are separated but also that each aircraft pair are separated by the normal separation criteria. As a result, the order of aircraft reaching the fix was sometimes changed after the time adjustment.

A.5 Future No Action Alternative

Figure A-2 illustrates the fixes used in airspace delay calculation in the Future No Action Alternative. The NY TRACON departure fixes used in the delay calculation include three north gate fixes (GAYEL, NEION, and COATE), five west gate fixes (ELIOT, PARKE, LANNA, BIGGY, and RBV), two south gate fixes (WHITE and WAVEY), three east gate fixes (BAYYS, MERIT, and GREKI), and three oceanic departure fixes (SHIPP, HAPIE, and BETTE). JFK satellite departures to the south merge with JFK departures at south of WAVEY, but JFK dominates the traffic sufficiently that the delay was measured at WAVEY with no loss of accuracy.

A few simplifications to the en-route flow were made to facilitate calculation. HAPIE and BETTE are both used for North Atlantic departures. Availability of HAPIE is limited by coordination with military users of the Warning Area, so frequently the streams are combined. Therefore, HAPIE and BETTE are treated as one departure fix. Since this is an analysis of good-weather operations, it was assumed that no traffic would need severe weather avoidance routes and the delay entering the Off-Shore Radar Routes was not calculated.

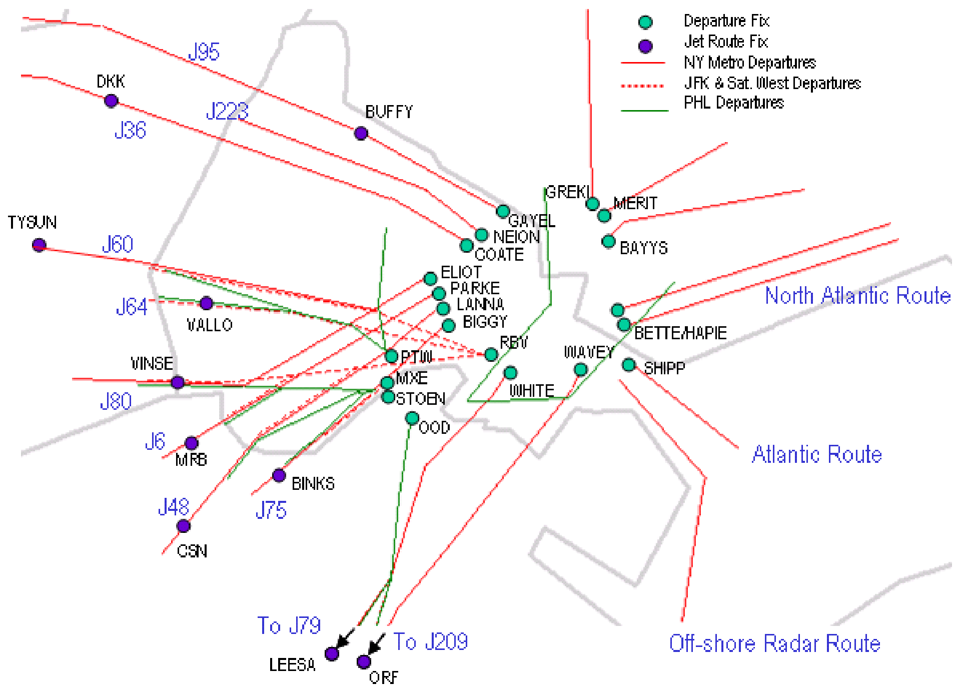

Figure A-2. Delay on J80 Passed Back to Departure Fixes in Future No Action Alternative

PHL departures via MXE, STOEN, and OOD were included in the delay calculation because they merge with departures from New York departures on jet routes within the study area. PHL northeast departures are not extensively modeled because they are not in trail with New York traffic within the study area. It was verified in the simulation output that PHL traffic alone does not congest those airways.

Jet routes used in the delay calculations are J95, J36, J60, J64, J80, J6, J48, J75, J79, and J209. Delay was not calculated for flights departing from New York via NEION and J223 because they have no merging flows, so separation at NEION was sufficient to ensure the en route separation. Departures to the West Atlantic Route System merge with the traffic from facilities other than the NY TRACON at a great distance from the departure fix (SHIPP) and those departures are also out of the study area.

East gate departures (BAYYS, MERIT, and GREKI) were not analyzed for jet route delay because arrivals to Boston Logan and its satellites are a large fraction of the traffic.

Boston ARTCC and Boston TRACON can handle the congestion using more flexible techniques than a pure jet-airway system. The remaining traffic, to the North Atlantic routes, is insufficient to congest a radar-covered jet airway.

A.5.1 Separation at Departure Fixes

The list of departure fixes used and their parameter values is in Table A-1.

Table A-1. Future No Action Alternative Departure Fix Separations

Departure Fix	Separation (nmi)
GAYEL	8
NEION	8
COATE	8
ELIOT	5
PARKE	8
LANNA	8
BIGGY	8
RBV	8
WHITE	10
WAVEY	10
BAYYS	5
BETTE/HAPIE	8
SHIPP	8
MERIT	8/5
GREKI	5
MXE	8
STOEN	8
OOD	10

Currently, the minimum separation of aircraft that is handed off from terminal airspace to center airspace is 8 nmi. This was the value used for departure fix delay calculation with the following exceptions:

- ELIOT was set to five nmi to simulate two altitudes. In practice, the piggyback streams are not quite independent. Therefore two independent 8 mile streams could not be used.
- WHITE and WAVEY were set to 10 nmi to accommodate the departures from ZBW merging shortly beyond these fixes.
- East departures destined for airports in ZBW were set to five nmi because they are usually handed off to ZBW at lower altitude and with minimal separation, except for departures to overseas destinations which need to merge with NY overflights in ZBW.

A.5.2 Separation on jet Route

Delay on jet routes was calculated by measuring the separation between aircraft at certain fix on the jet route. The fix was selected such that all NY TRACON and PHL departures are already merged on the jet route. At these distances from New York, all jet airways contain a mixture of other traffic, so ten nmi was used as the base required separation to calculate the delay on a jet route. For jet routes containing a large of traffic from airports other than New York and PHL, the following adjustments were made.

- 13 nmi was used for J60, J80, and J75 because the traffic from NY TRACON and PHL comprises only 75% to 80% of the total traffic, which includes overflights from other centers.
- 15 nmi was used for J79 (south bound over land) and J209 (south bound over water) because the traffic from NY TRACON and PHL consists of approximately 50% of the total traffic.

Table A-2. Future No Action Alternative Jet Route Separations

Jet Route	Fix Used	Separation (nmi)
J95	BUFFY	10
J36	DKK	10
J60	TYSUN	13
J64	VALLO	10
J80	VINSE	13
J6	MRB	10
J48	CSN	10
J75	BINKS	13
J79	LEESA	15
J209	ORF	15

Delays on J80 and J209 exceeded the threshold, so increased separation values at their departure fixes were passed back during certain times of the day. Figures A-3 and A-4 illustrate the fixes that caused delay pass back and the departure fixes that are affected. After several iteration of delay calculations at the departure fix and the jet route fix.

- 20 nmi is used for J80 departures via ELIOT and RBV, and J80/J6 departures via MXE during 1120-1400, 1600-1700, 1920-2040, and 2340-0140 (all GMT).
- 15 nmi is used for WHITE, WAVEY, and OOD departures during 1100-1920 GMT. Following the current practice between NY Center and NY TRACON, flights to ZDC internal airports were exempt.

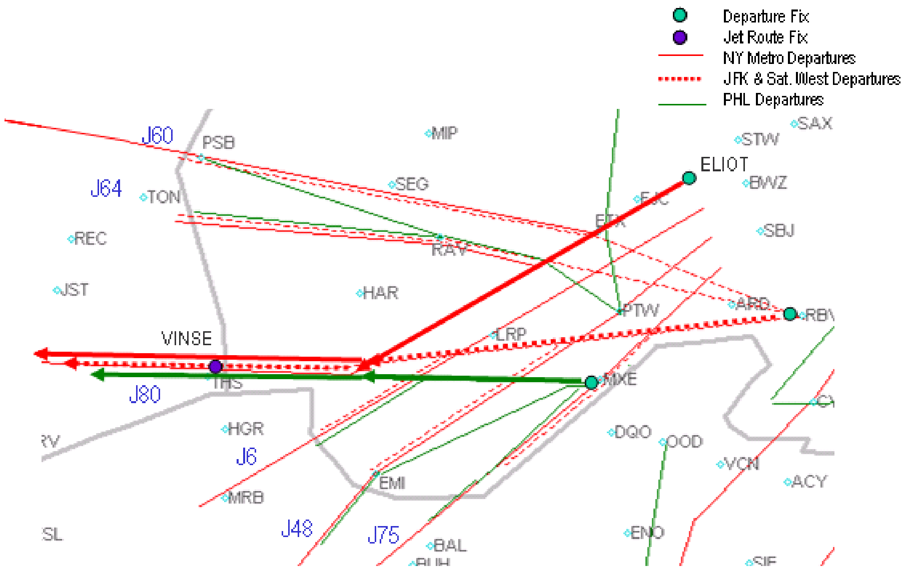

Figure A-3. Delay on J80 Passed Back to Departure Fixes in Future No Action Alternative

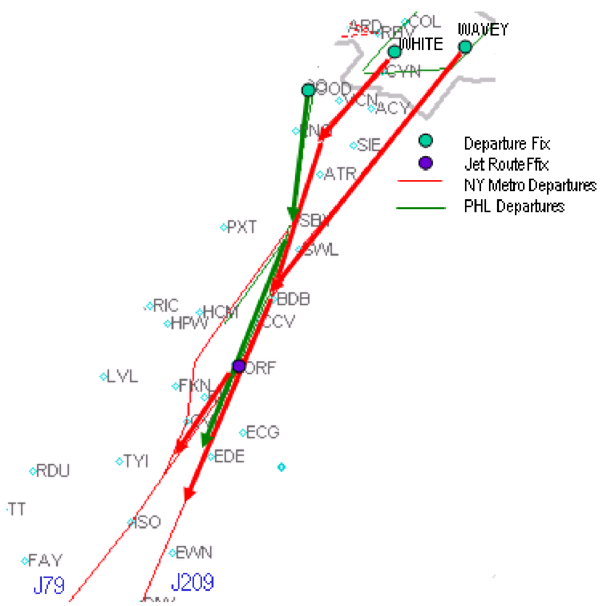

Figure A-4. Delay on J209 Passed Back to Departure Fixes in Future No Action Alternative

Table A-3 summarizes the separation parameter values including the increased separation for pass back delay.

Table A-3. Future No Action Alternative Delay Passback to Departure Fixes

Departure Fix	Normal Separation (nmi)	Increased Separation (nmi)	Delay Passed Back From
GAYEL	8	-	-
NEION	8	-	-
COATE	8	-	-
ELIOT	5	20	J80
PARKE	8	-	-
LANNA	8	-	-
BIGGY	8	-	-
RBV	8	20	J80
WHITE	10	15	J209
WAVEY	10	15	J209
BAYYS	5	-	-
BETTE/HAPIE	8	-	-
SHIPP	8	-	-
MERIT	8/5	-	-
GREKI	5	-	-
MXE	8	20	J80
STOEN	8	-	-
OOD	10	15	J209

A.6 Modifications to Existing Airspace Alternative

The Modifications to Existing Airspace Alternative has one additional west bound route that is used for arrivals to ZID and/or ZOB internal airports. Figure A-5 shows the fixes used in delay calculations.

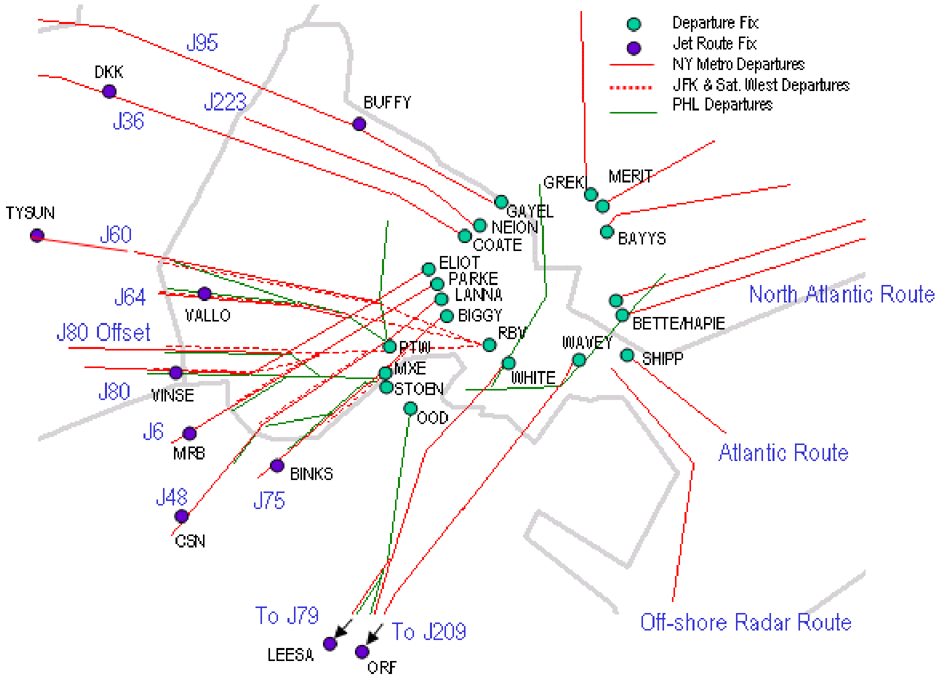

Figure A-5. Fixes Used in Airspace Delay Calculations (Modifications to Existing Airspace)

A.6.1 Separation at Departure Fixes

In this alternative, departure fixes are the same as in the Future No Action Alternative.

Table A-4. Modifications to Existing Airspace Alternative Departure Fix Separations

Departure Fix	Separation (nmi)
GAYEL	8
NEION	8
COATE	8
ELIOT	5
PARKE	8
LANNA	8
BIGGY	8
RBV	8
WHITE	10
WAVEY	10
BAYYS	5
BETTE/HAPIE	8
SHIPP	8
MERIT	8/5
GREKI	5
MXE	8
STOEN	8
OOD	10

A.6.2 Separation on Jet Route

The same fixes and parameters were used to calculate airspace delay in this alternative except for an additional en route fix to calculate the delay on the additional jet route parallel to and north of J80. The same parameter as J80, 13 nmi, was assigned to this fix.

Table A-5. Modifications to Existing Airspace Alternative Jet Route Separations

Jet Route	Fix Used	Separation (nmi)
J95	BUFFY	10
J36	DKK	10
J60	TYSUN	13
J64	VALLO	10
J80 Offset	North of THS	13
J80	VINSE	13
J6	MRB	10
J48	CSN	10
J75	BINKS	13
J79	LEESA	15
J209	ORF	15

The delays observed on J80 and J209 exceeded the threshold, as in Future No Action, so increased separation values at their departure fixes were passed back during certain times of the day. Figure A-6 shows the passback from J80. After several iteration of delay calculations at the departure fix and the jet route fix, the following conclusion was reached.

- 15 nmi is used for J80 departures via ELIOT and RBV, and J80/J6 departures via MXE during 1100-1220 and 1620-1720 (all GMT).
- 20 nmi is used for J80 departures via ELIOT and RBV, and J80/J6 departures via MXE during 1220-1340 (all GMT).

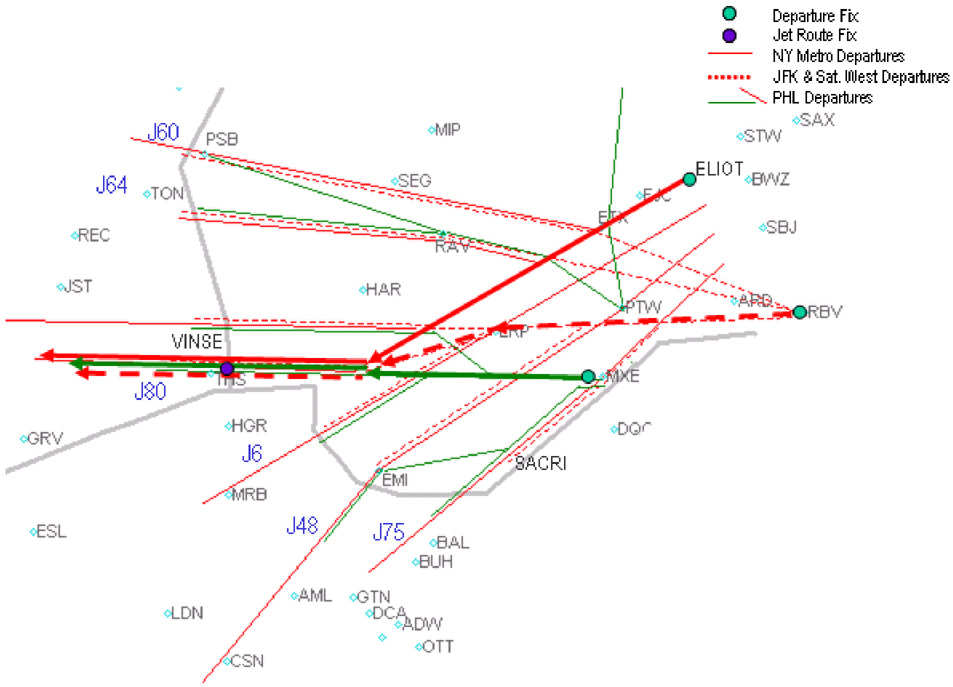

Figure A-6. Delay at J80 Passed Back to Departure Fixes in Modifications to Existing Airspace Alternative

South departures are the same as the Future No Action Alternative and the separation at WHITE, WAVEY, and OOD is increased from 10 nmi to 15 nmi during 1100-1920 GMT. Figure A-7 illustrates the delay at J209 being passed back to WHITE, WAVEY, and OOD.

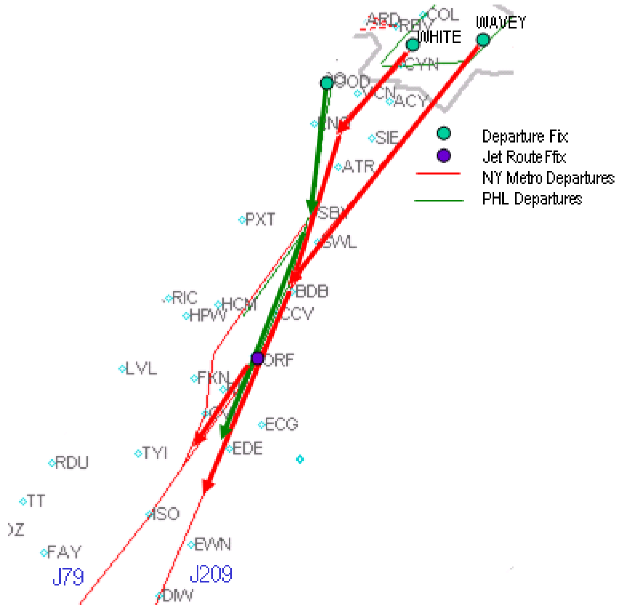

Figure A-7. Delay at J209 Passed Back to Departure Fixes in Modifications to Existing Airspace Alternative

For other fixes, the separation parameters are shown in Table A-6. They are generally identical to the parameters in the Future No Action Alternative.

Table A-6. Modifications to Existing Airspace Alternative Delay Passback to Departure Fixes

Departure Fix	Normal Separation (nmi)	Increased Separation (nmi)	Delay Passed Back From
GAYEL	8	-	-
NEION	8	-	-
COATE	8	-	-
ELIOT	5	15/20/15	J80
PARKE	8	-	-
LANNA	8	-	-
BIGGY	8	-	-
RBV	8	15/20/15	J80
WHITE	10	15	J209
WAVEY	10	15	J209
BAYYS	5	-	-
BETTE/HAPIE	8	-	-
SHIPP	8	-	-
MERIT	8/5	-	-
GREKI	5	-	-
MXE	8	15/20/15	J80
STOEN	8	-	-
OOD	10	15	J209

A.7 Ocean Routing Alternative

Figure A-8 shows the fixes used in the delay calculations in Ocean Routing Alternative. The Ocean Routing Alternative has two additional departure fixes. The en route fixes used for delay calculation are the same as for the Future No Action Alternative, but the ways in which traffic arrives at them are different.

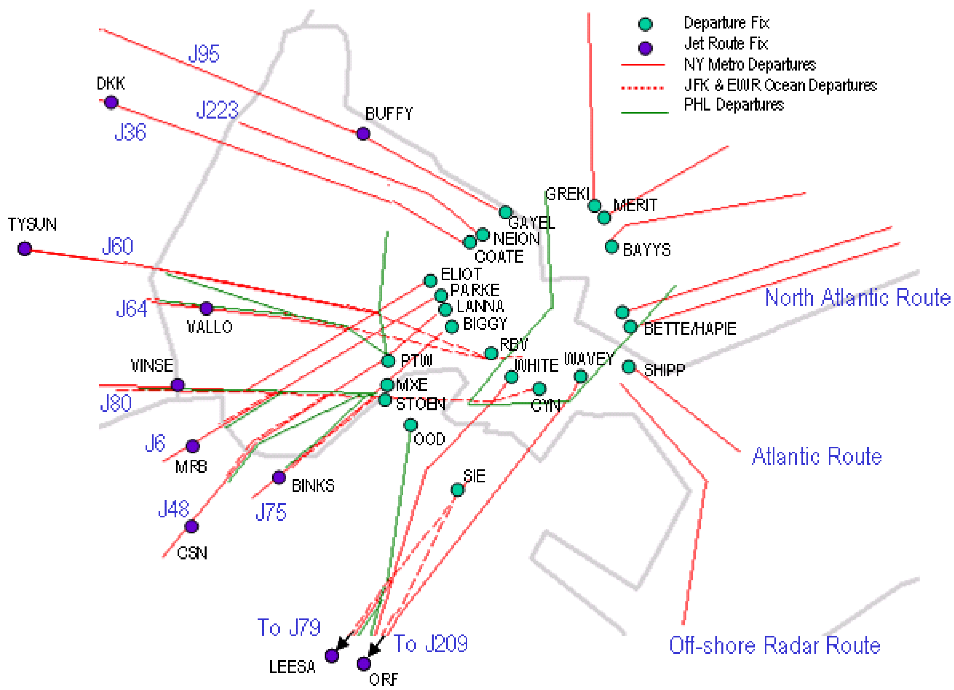

Figure A-8. Fixes Used in Airspace Delay Calculation (Ocean Routing Alternative)

A.7.1 Separation at Departure Fixes

The Ocean Routing Alternative adds two additional departure fixes, CYN and SIE, to the set of departure fixes in Future No Action, as shown in Table A-7. EWR departures to J80, J6, J48, and J75 are routed east, south and then west to CYN in place of the west gate fixes. JFK departures to J80, J6, J48, and J75 use CYN in place of RBV. SIE is the departure fix used by EWR departures to J79 and J209 in place of WHITE in the Future No Action Alternative.

Eight nmi was used in calculating delay at CYN and SIE; these fixes have no overflight traffic with which to merge.

Table A-7. Ocean Routing Alternative Departure Fix Separations

Departure Fix	Separation (nmi)
GAYEL	8
NEION	8
COATE	8
ELIOT	5
PARKE	8
LANNA	8
BIGGY	8
RBV	8
CYN	8
WHITE	10
WAVEY	10
SIE	8
BAYYS	5
BETTE/HAPIE	8
SHIPP	8
MERIT	8/5
GREKI	5
MXE	8
STOEN	8
OOD	10

A.7.2 Separation on Jet Routes

The same set of en route fixes and parameters as was used in the Future No Action Alternative was used in this alternative. Table A-8 recapitulates. Jet route delay calculations indicate that there is no need to increase the separation parameter values for RBV, WHITE, WAVEY, OOD, nor SIE. However, the delay observed on J80 indicates that the separation at three departure fixes, ELIOT, MXE, and CYN, needs to be increased. 20 nmi was used for J80 departures via ELIOT, CYN, and J80/J6 departures via MXE during 1920-2100 and 2240-0200 (all GMT). Figure A-9 illustrates the delay on J80 being passed back to ELIOT, MXE, and CYN. For other fixes, the same parameters as in the Future Future No Action Alternative were used as shown in Table A-9.

Table A-8. Ocean Routing Alternative Jet Route Separations

Jet Route	Fix Used	Separation (nmi)
J95	BUFFY	10
J36	DKK	10
J60	TYSUN	13
J64	VALLO	10
J80	VINSE	13
J6	MRB	10
J48	CSN	10
J75	BINKS	13
J79	LEESA	15
J209	ORF	15

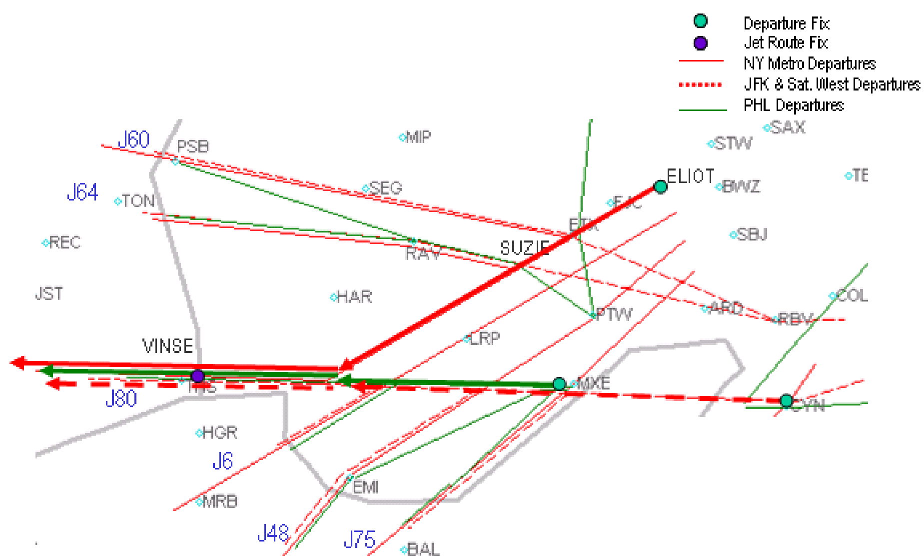

Figure A-9. Delay at J80 Passed Back to Departure Fixes in Ocean Routing Alternative

Table A-9. Ocean Routing Alternative Delay Passback to Departure Fixes

Departure Fix	Normal Separation (nmi)	Increased Separation (nmi)	Delay passed back from
GAYEL	8	-	-
NEION	8	-	-
COATE	8	-	-
ELIOT	5	20	J80
PARKE	8	-	-
LANNA	8	-	-
BIGGY	8	-	-
RBV	8	-	-
CYN	8	20	J80
WHITE	10	-	-
WAVEY	10	-	-
SIE	10	-	-
BAYYS	5	-	-
BETTE/HAPIE	8	-	-
SHIPP	8	-	-
MERIT	8/5	-	-
GREKI	5	-	-
MXE	8	20	J80
STOEN	8	-	-
OOD	10	-	-

A.8 Integrated Airspace Alternative

The Integrated Airspace Alternative has one additional west gate departure fix and one additional west bound route. Also, JFK satellite departures to J79 and J209 are given a separate route from JFK departures. Figure A-10 shows the fixes used in delay calculations in the Integrated Airspace Alternative.

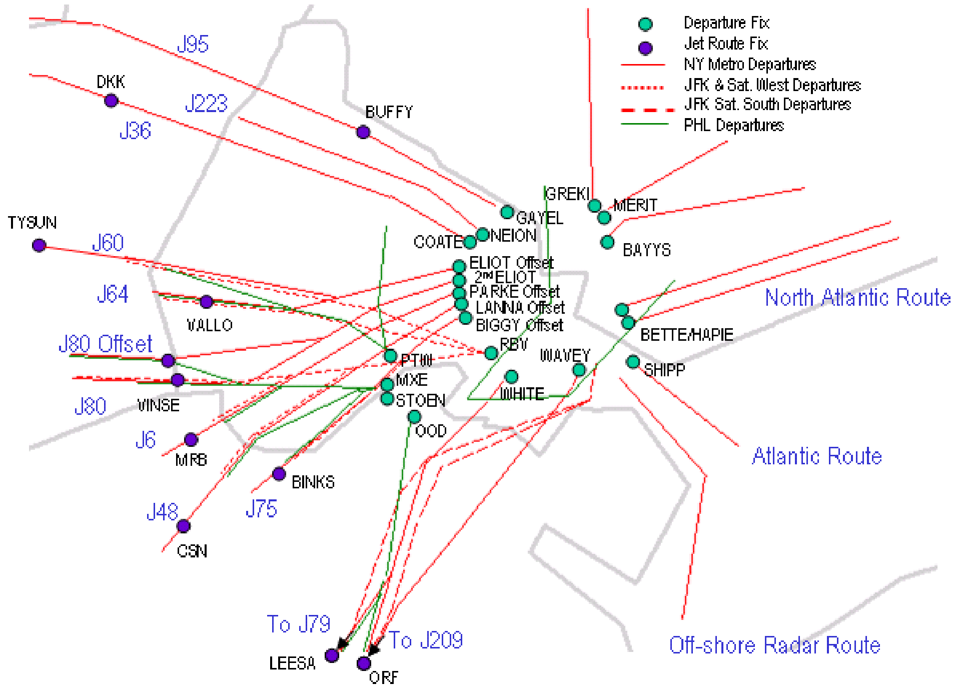

Figure A-10. Fixes Used in Airspace Delay Calculations for Integrated Airspace Alternative

A.8.1 Separation at Departure Fixes

In the Integrated Airspace Alternative, west gate consists of five departure fixes instead of four in the Future Future No Action Alternative. The additional fix (2nd ELIOT) serves departures to J80. ELIOT was shifted slightly to the north (ELIOT Offset) and it serves J60 and J64 departures. The rest of the west gate departure fixes (PARKE, LANNA, and BIGGY) were moved slightly to the south to accommodate 2nd ELIOT. The separation parameter for ELIOT offset and 2nd ELIOT were set to eight nmi because they are single streams like the other fixes (Table A-10).

Table A-10. Integrated Airspace Alternative Departure Fix and Separations

Departure Fix	Separation (nmi)
GAYEL	8
NEION	8
COATE	8
ELIOT Offset	8
2nd ELIOT	8
PARKE Offset	8
LANNA Offset	8
BIGGY Offset	8
RBV	8
WHITE	10
WAVEY	10
BAYYS	5
BETTE/HAPIE	8
SHIPP	8
MERIT	8/5
GREKI	5
MXE	8
STOEN	8
OOD	10

A.8.2 Separation on Jet Routes

The same fixes and parameters were used to calculate airspace delay in this alternative except for an additional en route fix to calculate the delay on the additional jet route parallel to and north of J80. The same parameter as J80, 13 nmi, was assigned to this fix.

Table A-11. Integrated Airspace Alternative Jet Route Fix and Separations

Jet Route	Fix Used	Separation (nmi)
J95	BUFFY	10
J36	DKK	10
J60	TYSUN	13
J64	VALLO	10
J80 Offset	North of THS	13
J80	VINSE	13
J6	MRB	10
J48	CSN	10
J75	BINKS	13
J79	LEESA	15
J209	ORF	15

The delays observed on J80 indicate that the separation values at its departure fixes need to be increased during certain times of the day. After several iterations of delay calculations at the departure fix and the jet route fix, the following conclusion was reached.

- 15 nmi is used for J80 departures via ELIOT and RBV, and J80/J6 departures via MXE during 1100-1220 and 1620-1720 (all GMT).
- 20 nmi is used for J80 departures via ELIOT and RBV, and J80/J6 departures via MXE during 1220-1340 (all GMT).

Figures A-11 and A-12 illustrate the fixes that caused delay pass back and the departure fixes that are affected. South departures are the same as the Future No Action Alternative . The separation at WHITE, WAVEY, and OOD is increased from 15 nmi from 1100 to 1920 GMT.

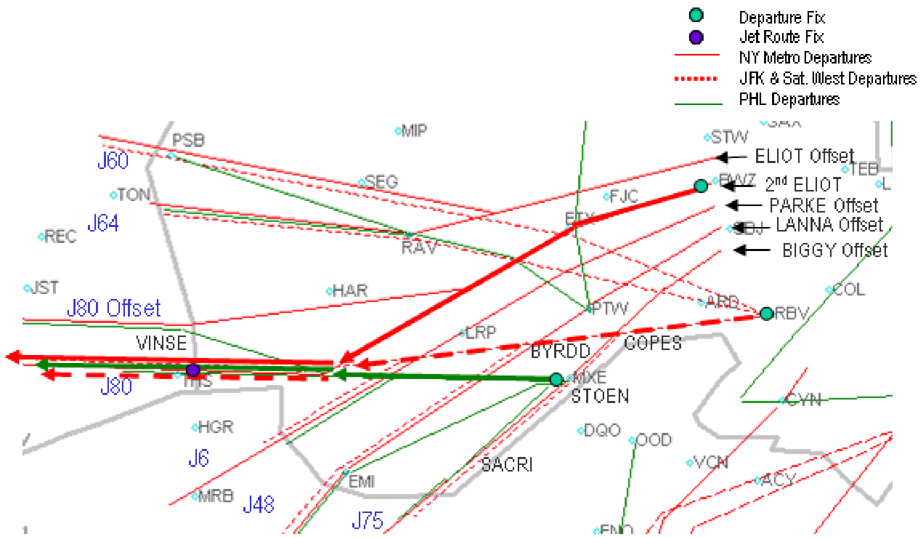

Figure A-11. Delay at J80 Passed Back to Departure Fixes in Integrated Airspace Alternative

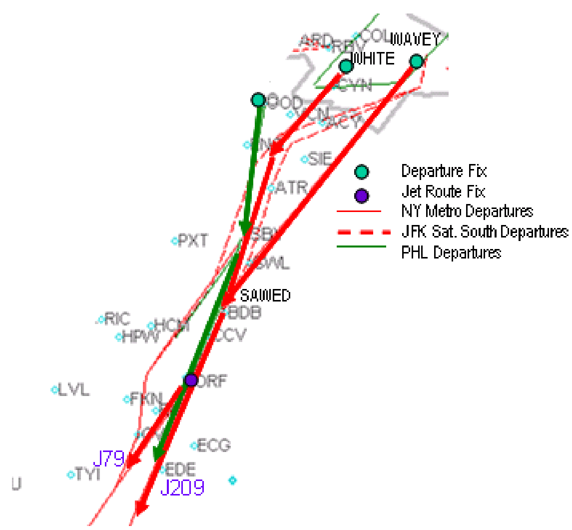

Figure A-12. Delay at J80 Passed Back to Departure Fixes in Ocean Routing Alternative

For other fixes, the same parameters as in the Future No Action Alternative were used as shown in Table A-12.

Table A-12. Integrated Airspace Delay Passback to Departure Fixes

Departure Fix	Normal Separation (nmi)	Increased Separation (nmi)	Delay Passed Back From
GAYEL	8	-	-
NEION	8	-	-
COATE	8	-	-
ELIOT Offset	8	15/20/15	J80
2nd ELIOT	8	-	-
PARKE Offset	8	-	-
LANNA Offset	8	-	-
BIGGY Offset	8	-	-
RBV	8	15/20/15	J80
WHITE	10	15	J209
WAVEY	10	15	J209
BAYYS	5	-	-
BETTE/HAPIE	8	-	-
SHIPP	8	-	-
MERIT	8/5	-	-
GREKI	5	-	-
MXE	8	15/20/15	J80
STOEN	8	-	-
OOD	10	15	J209

A.9 Integrated Airspace with Integrated Control Complex Alternative

In the Integrated Airspace with Integrated Control Complex Alternative, the number of departure routes to the west is increased to eight and the number of departure fixes in the west gate is increased to six. PHL has one additional west departure fix that serves J80 offset departures. The number of departure fixes in the north gate is the same as the Future No Action Alternative; however, 5 routes are served by those 3 departure gates. Figure A-13 shows the fixes used in delay calculation in the Integrated Airspace with Integrated Control Complex Alternative.

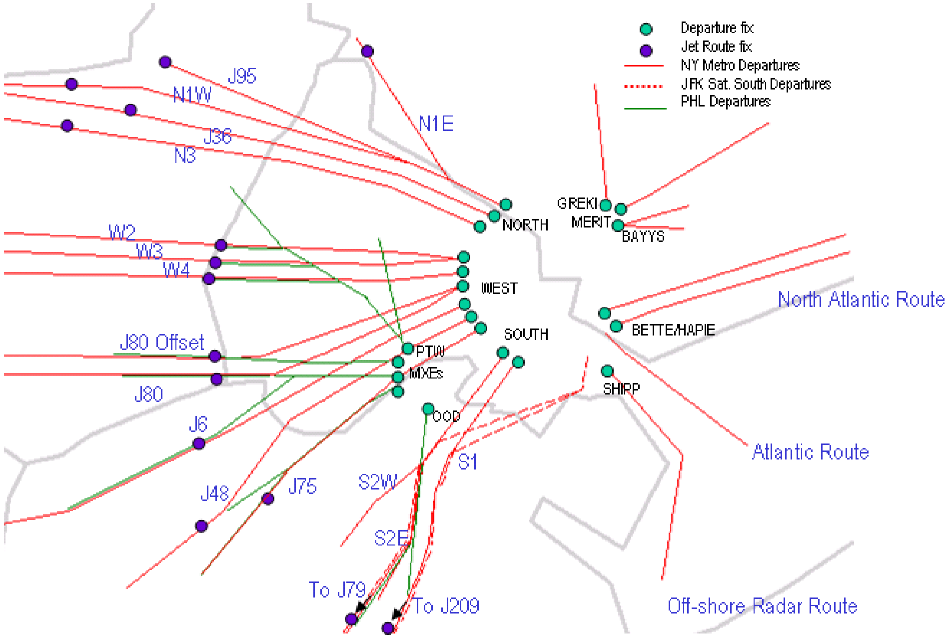

Figure A-13. Fixes Used in Airspace Delay Calculation for Integrated Airspace with Integrated Control Complex Alternative

A.9.1 Delays at Departure Fixes

In the Integrated Airspace with Integrated Control Complex Alternative, each of the north and west gate departure fixes accept traffic in two layers, therefore five nmi was used to calculate delay at the fix, by analogy with the current ELIOT fix. Separation parameters are shown in Table A-13. For the rest of the fixes, the same parameter was used as in the Future No Action Alternative: Two south departure fixes were set to 10 nmi, and east departures were set to five nmi.

Table A-13. Integrated Airspace with Integrated Control Complex Alternative Departure Fix Separations

Departure Fix	Separation (nmi)
[North]	5
[West]	5
[South]	10
BETTE/HAPIE	8
SHIPP	8
BAYYS	5
MERIT	8/5
GREKI	5
MXE North	8
MXE South	8
OOD Offset	10

A.9.2 Separation on Jet Route

The same fixes and parameters were used to calculate airspace delay in the Integrated Airspace with Integrated Control Complex Alternative except for an additional fix to calculate the delay on the additional jet route parallel to and north of J80 as shown in Table A-14. The same parameter as J80, 13 nmi, was assigned to this fix. S2W is used for only departures to airports in Washington ARTCC (RDU, for example). Traffic is light, therefore no delay was calculated for this fix.

The Integrated Airspace with Integrated Control Complex Alternative did not require any passbacks of jet route delay to departure fixes.

Table A-14. Integrated Airspace with Integrated Control Complex Alternative Jet Route Separations

Route	Fix Used	Separation (nmi)
N1E	SYR	10
J95	BUF	10
N1W	YQO	10
J36	DKK	10
N3	PSI	10
W2	ETG	10
W3	OXI	10
W4	FWA	10
J80 Offset	North of THS	13
J80	THS	13
J6	MRB	10
J48	CSN	10
J75	GVE	13
J79	LEESA Offset	15
J209	ORF Offset	15

A.10 Results

The delay results generated by the methods described in this Appendix are presented in Section 9.

Appendix B

Traffic Sensitivity Analysis

B.1 Background

The demand that drives the operational analysis is a forecast of air traffic in 2006 and 2011 extrapolated from observed operations in 2000. The primary change in the fleet mix that was foreseen in 2000 was the replacement of turboprop aircraft with regional jets (RJs).

The ongoing restructuring in the airline industry has led to changes in aircraft types on many routes. The need to reduce operating costs has resulted in the retirement of older, less efficient aircraft. Customer demand for increased frequency of service, combined with the retirement of older aircraft, has led to the replacement of many large narrow body and wide body jets with regional jets. The same forces have caused many intercontinental jets (B747, DC10, and the Concorde) to be replaced with less-expensive twinjets.

These changes in the NY/NJ/PHL fleet mix are expected to continue, so it is necessary to investigate their implications on the conclusions of the operational analysis. This Appendix describes a comparative analysis of the forecast fleet mix with the fleet observed in 2004, the changes that were necessary to correct the forecast, and the operational results obtained from changing the input fleet mix.

B.2 Approach

The approach used to evaluate whether the operational conclusions derived from the forecast fleet mix are representative of current air traffic forecasts in terms of the distribution of RJs and jumbo jets was a four-step process.

1. Analyze the distributions in current 2004 Official Airline Guide (OAG) data for each of the airports included in the analysis.
2. Compare the 2004 OAG distribution of RJs and jumbo jets to the distributions in the 2006 and 2011 air traffic forecasts used for the operational analysis.
3. If the 2006 and 2011 air traffic forecasts are not representative of the 2004 OAG fleet distribution (i.e., there are too few RJs or there are too many jumbo jets), update the forecast to use the 2004 OAG fleet distribution of RJs and jumbo jets.
4. Rerun the NY/NJ/PHL simulations with the updated air traffic forecasts to determine whether the overall results are affected by the fleet mix change.

A recent day of OAG data for each airport was used to calculate the distribution of RJs and jumbo jets. These distributions were compared to the air traffic forecast used for the operational analysis for 2006 and 2011. Figure B-1 provides these distributions for the 2004 OAG data and the 2006 and 2011 air traffic forecasts for each airport.

Figure B-1. NY Fleet Mix Distributions

The OAG contains information on scheduled flights only. Since most of the flights at TEB and MMU are unscheduled, flight data from the Enhanced Traffic Management System (ETMS) were analyzed. A majority of the turbojet flights to and from these airports are business jets, which is reflected in both the air traffic forecasts and the ETMS data. There are no RJs or jumbo jets at either airport.

The distributions of jumbo jets in the 2006 and 2011 forecast fleet mix for all of the airports are all less than or equal to the corresponding distributions in the 2004 OAG data. Since there are not too many jumbo jets in the forecast fleet mix for the airports in the study, no changes to the jumbo jet traffic mix were made.

The distributions of RJs in the 2006 and 2011 forecast fleet mix for JFK, LGA, ISP, PHL and HPN are all greater than or equal to the corresponding distributions in the 2004 OAG data, so further analysis of these airports was not necessary.

EWR was the only airport that had a lower percentage of RJs in the air traffic forecasts than the 2004 OAG data. RJs accounted for 16% and 17%, respectively, in the 2006 and 2011 air traffic forecasts, while the distribution in the 2004 OAG data was about 38%. Only at EWR did the air traffic forecast require changes to more accurately represent the current distribution of RJs.

B.3 Converting Older Aircraft to RJs at EWR

The approach used to update the EWR traffic forecasts to more accurately reflect the 2004 OAG distribution of RJs was to convert other aircraft in the forecast to RJs, specifically from the following aircraft types:

- B757
- B73B
- DC9
- B73A
- MD80
- DC10

Of the aircraft types being converted from the above list, only flights traveling to or from nearby Air Route Traffic Control Centers (ARTCCs) were converted to RJs, the assumption being that RJs would not fly the longer distances beyond these centers. These ARTCCs are highlighted in Figure B-2. Flights to and from Canadian airports in Ontario and eastward were also eligible for substitution. For the 2006 air traffic forecast, 312 flights were converted to RJs; for 2011, 308 flights were converted to RJs.

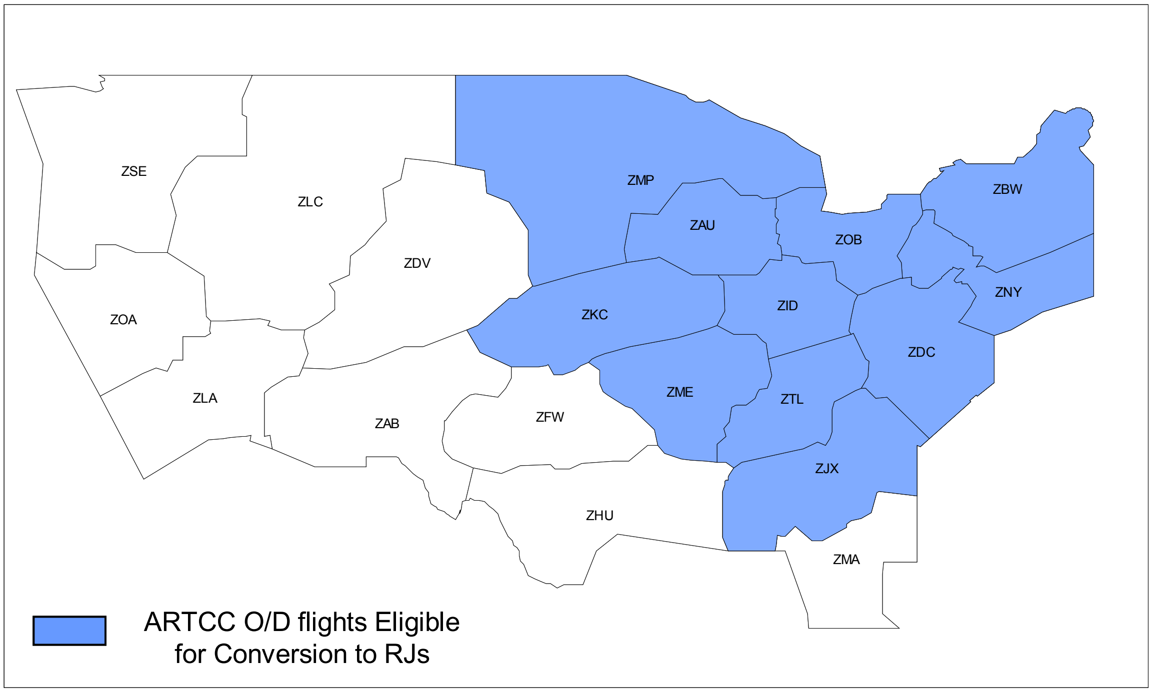

Figure B-2. ARTCC Origins/Destinations (O/D) Eligible for Conversions to RJs

B.4 EWR Results

Though there were small differences in delay and throughput using the 2004 fleet mix, the operational conclusions of the study are the same as those with the original forecast fleet mix. Figure B-3 shows the traffic-weighted EWR arrival delay comparing the forecast fleet mix to the 2004 OAG fleet mix for 2006 and 2011. The traffic-weighted delay results are calculated using 55% of the High Capacity configuration results and 45% of the Low Capacity configuration results to accurately reflect the usage of both configurations. The arrival delay results of the forecast fleet mix and the 2004 OAG fleet mix are within 10% of each other. Figure B-4 shows the traffic-weighted EWR departure delay comparing the forecast fleet mix to the 2004 OAG fleet mix for 2006 and 2011. The departure delay results of the forecast fleet mix and the 2004 OAG fleet mix are also within 10% of each other, except for the Ocean Routing Alternative. The differences between the results are discussed in more detail in the paragraphs below.

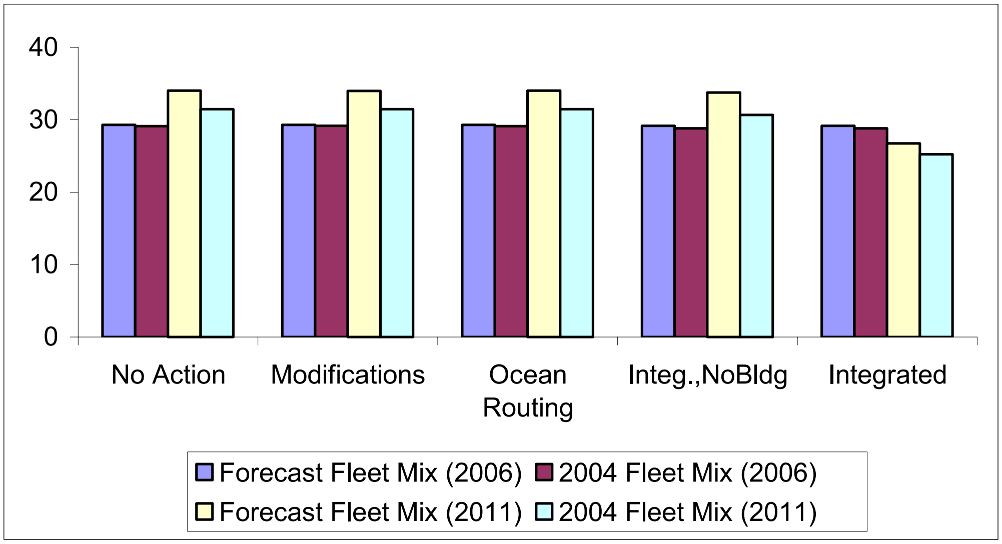

Figure B-3. EWR Average Arrival Delay

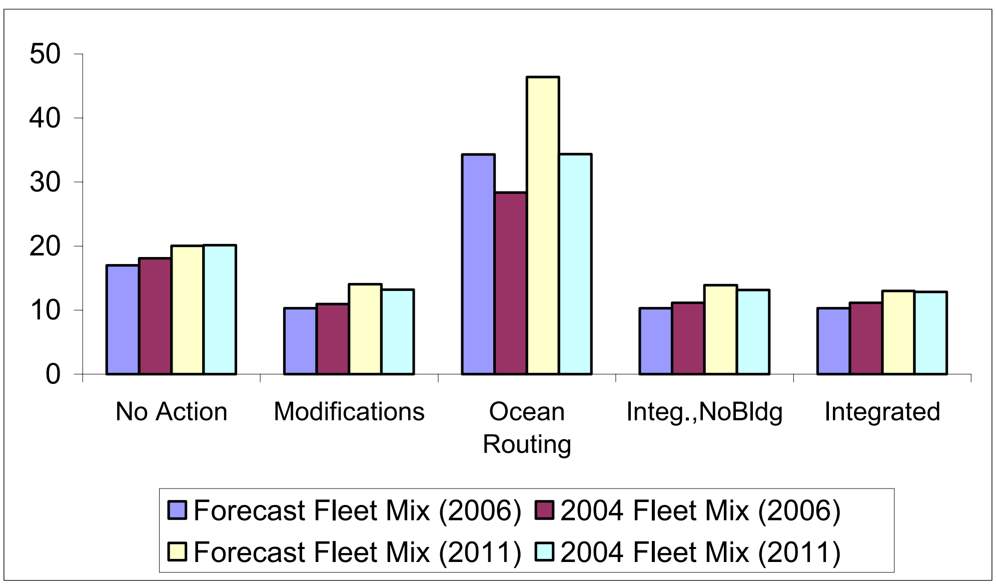

Figure B-4. EWR Average Departure Delay

The overflow runways at EWR, Runway 11 for arrivals and Runway 29 for departures, carry more operations with the increased number of regional jets in the 2004 fleet mix. The usage of Runways 11 and 29 is limited to propeller-driven aircraft and small or regional jets. Runway 29 is open for departures from 10:00 – 16:00 GMT to accommodate the morning departure push. Runway 11 is open for arrivals for the remainder of the day. With the increased number of regional jets in the 2004 fleet mix, there are more flights available to use the overflow runways. This study assumes that the regional jet pilots will accept the use of the overflow runway. With the increased usage of the overflow runways, there is lower demand on the main runway(s), which decreases the overall delay during the time that the overflow runway is open.

Figures B-5 and B-6 show the arrival throughput by runway for the Future No Action Alternative in the Low Capacity configuration based on the 2011 forecast fleet mix and the 2004 fleet mix, respectively. Runway 11 usage is shown as the difference between the 04R line and the all runways line on the graph. With the 2011 forecast fleet mix, 40 flights use Runway 11; while in the case of the 2004 fleet mix, 64 flights use Runway 11.

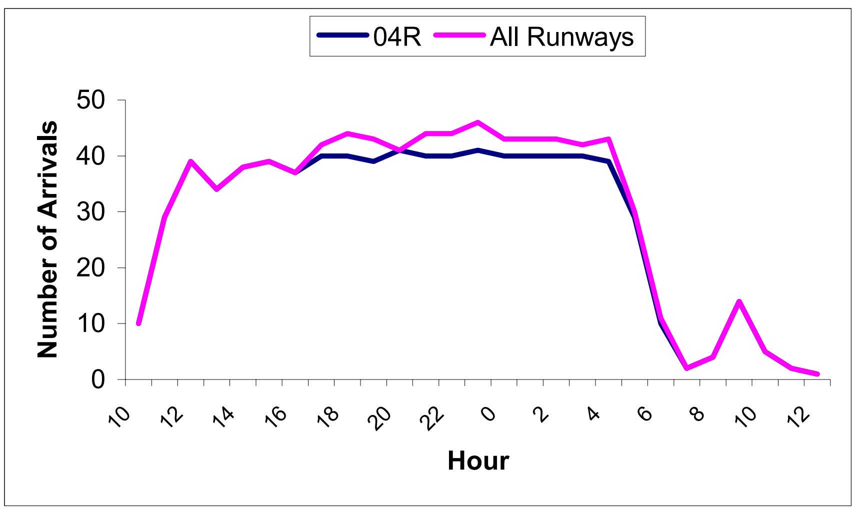

Figure B-5. EWR Arrival Throughput by Runway - 2011 Forecast Fleet Mix

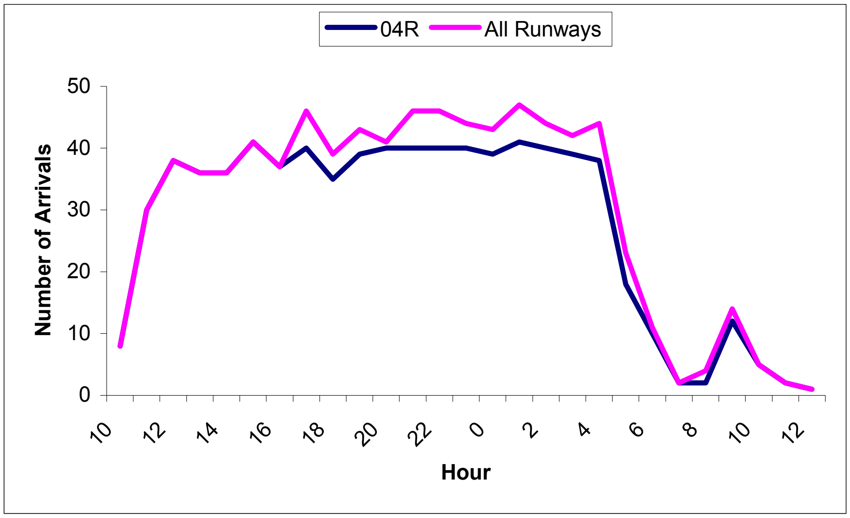

Figure B-6. EWR Arrival Throughput by Runway - 2004 Forecast Fleet Mix

As a result of the increased arrival throughput on Runway 11, which is open for a majority of the day, the overall arrival delay is lower with the 2004 fleet mix. Figure B-7 shows the average arrival delay per aircraft for the 2011 forecast fleet mix and the 2004 fleet mix.

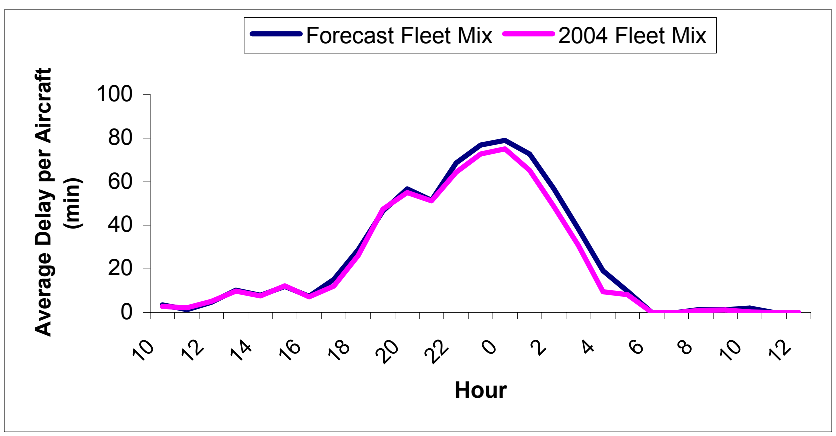

Figure B-7. EWR Future No Action Alternative Average Arrival Delay (Low Capacity Configuration)

Figures B-8 and B-9 show the departure throughput by runway for the Future No Action Alternative in the Low Capacity configuration based on the 2011 forecast fleet mix and the 2004 fleet mix, respectively. Runway 29 usage is shown as the difference between the 04L line and the all runways line on the graph. With the 2011 forecast fleet mix, 44 flights use Runway 29; while in the case of the 2004 fleet mix, 86 flights use Runway 29.

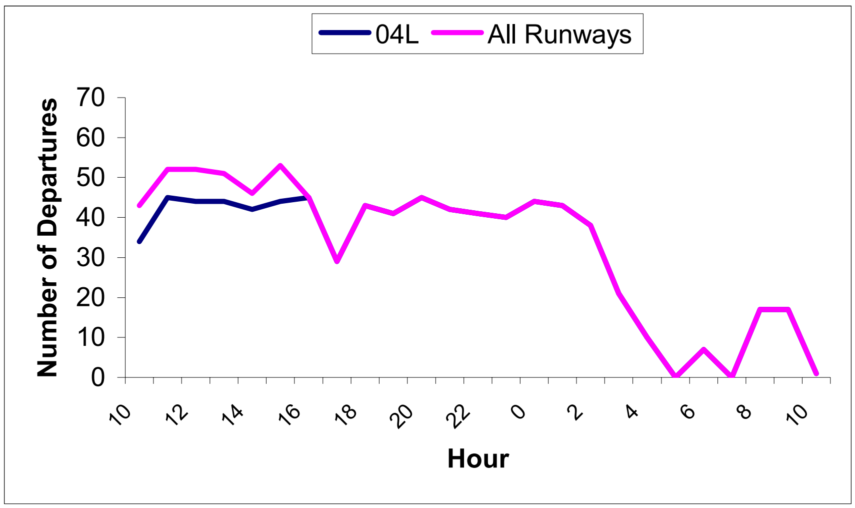

Figure B-8. EWR Departure Throughput by Runway - 2011 Forecast Fleet Mix

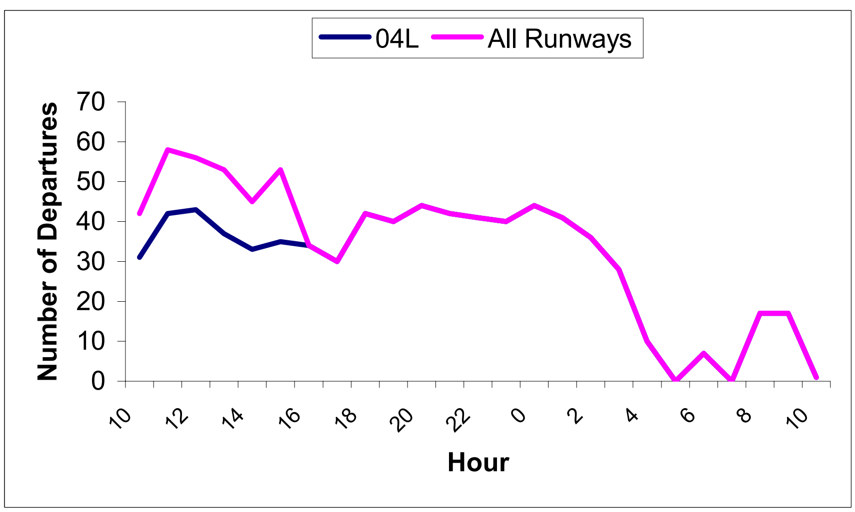

Figure B-9. EWR Departure Throughput by Runway - 2004 Fleet Mix

Departure delay for the main runway is about the same when fanned departure headings are used (Integrated Airspace Alternative and Integrated Airspace with Integrated Control Complex Alternative in the High Capacity configuration). Figure B-10 shows the average departure delay for the Integrated Airspace Alternative in the High Capacity configuration with the 2011 forecast and 2004 fleet mix. During the hours of 10:00 - 16:00 GMT, the delay is lower with the 2004 fleet mix because of the increased usage of the overflow runway. For the remaining hours of the day, the overflow runway is closed for departures and the average departure delay on Runway 22R is about the same with the 2011 forecast fleet mix and the 2004 fleet mix.

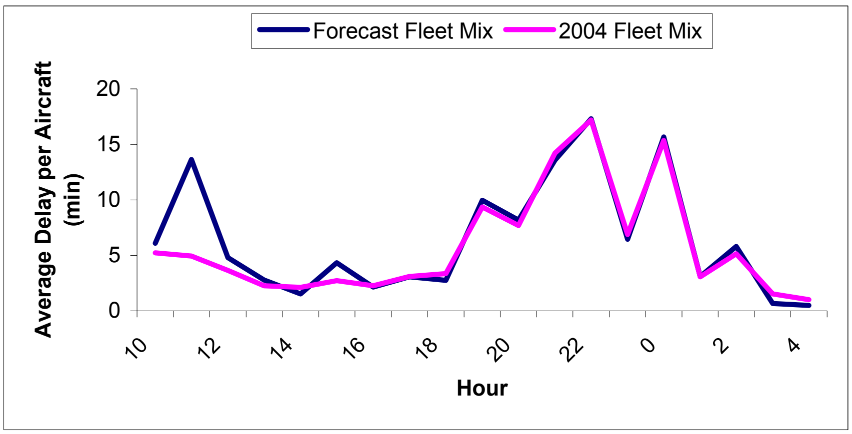

Figure B-10. EWR Integrated Airspace with Integrated Control Complex Alternative Average Departure Delay (High Capacity Configuration)

In the Future No Action Alternative when fanned headings are not used, there is increased departure delay on the main runway with the 2004 fleet mix. This increased departure delay occurs because the number of regional jets in the fleet mix is increased and their climb-out speed is slower than the aircraft type they were converted from in the forecast fleet mix. The slower climb-out speed of the RJs increases the delay of the aircraft waiting behind them. Figure B-11 shows the average departure delay for the Future No Action Alternative in the High Capacity configuration with the 2011 forecast fleet mix and the 2004 fleet mix. During the hours of 10:00 - 16:00 GMT, the delay is lower with the 2004 fleet mix because of the increased usage of the overflow runway. For the remaining hours of the day, the overflow runway is closed for departures. The average delay per departure after 16:00 GMT is generally higher, thus the net result is slightly higher delay with the 2004 fleet mix.

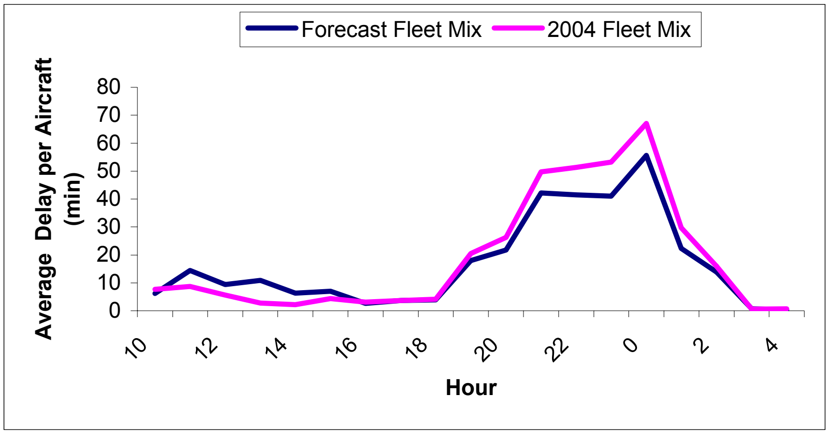

Figure B-11. EWR Future No Action Alternative Average Departure Delay (High Capacity Configuration)

For the Ocean Routing Alternative with no fanned headings on departures, the departure delay is higher with the forecast fleet mix than with the 2004 fleet mix. Figure B-12 shows the average departure delay for the Ocean Routing Alternative in the High Capacity configuration with the 2011 forecast fleet mix and the 2004 fleet mix. In this alternative, increased departure separation is required on the main runway because departures to the south and west are kept in trail for much longer than in the Future No Action Alternative. With this restriction, the departure throughput on the main runway is reduced from the Future No Action Alternative. With the 2004 fleet mix, more of these flights can depart on Runway 29 in the early hours, thus reducing the demand on the main runway. The effect of the reduced demand on the main runway in the early hours continues throughout the day, resulting in lower delay than with the forecast fleet mix.

There is always the question of whether the RJ pilots are willing to depart on the shorter runway (Runway 29). Faced with the long delays on the main runway in the Ocean Routing Alternative, the shorter runway may become more attractive to these pilots leading to higher usage of Runway 29.

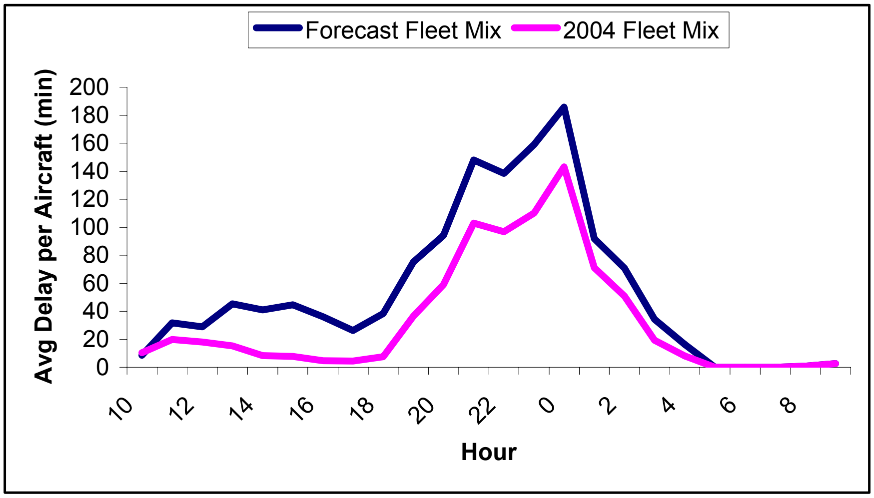

Figure B-12. EWR Ocean Routing Alternative Average Departure Delay (High Capacity Configuration)

B.5 Summary

The distribution of jumbo jets at all the airports in the study indicates that the forecast fleet mix does not have too many jumbo jets as compared to the current 2004 fleet mix distribution. An analysis of the distribution of RJs for all airports but EWR indicates that the forecast fleet mix has enough RJs as compared to the current 2004 fleet mix distributions.

Only at EWR did the original traffic forecast need updating to accommodate the changes in demand patterns of the past few years. EWR did not have enough RJs and so further analysis was conducted to determine the impact of the operational results if the distribution of RJs was increased to reflect the current distribution of RJs at EWR. The results show that the relative ranking of the various metrics evaluated is not affected by the changes in the forecast fleet mix. At EWR, the increase in regional jet traffic makes it possible to decrease overall delays due to runway congestion, assuming maximum use of the overflow runway. Any delay improvements shown in Figures B-2 and B-3 reflect an upper bound, assuming that all aircraft that can use Runways 11 and 29 do so.

Glossary

Airspace Delay

Delay caused by the requirement to organize aircraft into structured flows. It may be taken in the air, or in the event of passed-back separation requirements, on the ground before departure.

Airborne Delay

Delay taken by an aircraft after departure. It may be due to any cause.

Ground Delay

Delay taken by an aircraft before liftoff. It may be due to any cause.

Airport Delay

Delay caused by runway or taxiway capacity limitations. Airport delay of departures is taken on the ground at the airport that caused it. Airport delay of arrivals may be taken in the air or on the ground at the origin airport.

Arrival Airspace Delay

Airspace delay taken by arriving aircraft. It is caused by capacity limits in the last en-route center through which a flight passes. Arrival airspace delays are typically much smaller than airport delays.

Airport Departure Delay

Airport delay taken by departing aircraft.

Departure Airspace Delay

Airspace delay taken by departures. It may be due to departure fix capacity or jet airway capacity in the first en-route center through which the flight passes.

Departure Fix Delay

Delay caused by the requirement to create one or more streams of aircraft for handoff from departure control to an en-route center. Small delays are taken in the air at low altitudes; larger delays are passed back to the airport surface.

Jet Route Delay

Delay caused by the requirement to form aircraft into a single stream on a jet airway. It is taken in the air, in a sector containing a merge point. It has a maximum value of roughly four minutes for any flight, before it must be passed back to the departure fix or the departure airport.

Acronyms

AIM	Aeronautical Information Manual
ARTCC	Air Route Traffic Control Center
ARTS	Automated Radar Terminal System
ATC	Air Traffic Control
CAASD	Center for Advanced Aviation System Development
CATER	Computerized Analysis of Terminal Records
FAA	Federal Aviation Administration
FL	Flight Level
FMS	Flight Management System
GA	General Aviation
IFR	Instrument Flight Rules
MINIT	Minutes in Trail
MIT	Miles in Trail
NAR	National Airspace Redesign
NAVAID	Navigational Aid
NEPA	National Environmental Policy Act
NYICC	New York Integrated Control Complex
OAG	Official Airline Guide
RAPTOR	Radar Audio Playback Terminal Operations Recording
RNAV	Area Navigation
SAR	System Analysis Recording
SDAT	Sector Design and Analysis Tool
TAAM	Total Airspace and Airport Modeller
TEC	Tower En route Control
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions