An Evaluation of Future Routing Initiatives

Case Study: Southern Region

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Investment Analysis and Operations Research (ASD-430)
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Executive Summary

This report presents a methodology and the findings of an Investment Analysis and Operations Research Analysis Division (ASD-400) and Federal Aviation Administration W.J. Hughes Technical Center (FAATC), Advanced Concepts Branch (ACT-540) assessment of current and future air traffic routing initiatives. The purpose of the analysis is to establish and present a framework that provides summary metrics to compare and contrast between a range of realistic routing cases. Each case evaluates four scenario time periods (2000, 2005, 2010, and 2015) by measuring the potential "added value" of expected National Airspace System (NAS) initiatives. The initiatives incorporate the advent of new capabilities such as precision satellite navigation, data link, and conflict probe that will allow more flights to fly along unconstrained routes. This preliminary analysis establishes a structured framework that can be employed for other regions in the NAS.

During the five-year period from 1996 thru 2000, there have been many changes in the NAS. The number of air traffic operations through the Southern Region Air Route Traffic Control Centers (ARTCCs) has increased by 20 percent, in particular, 27 percent at the Jacksonville Center (ZJX), 21 percent at the Miami Center (ZMA), and 14 percent at the Atlanta Center (ZTL) [11]. At the same time, flight times between major airports have gradually increased from 7-10 percent. While the NAS has become more constrained with demand increasing more relative to airport capacity, encouraging steps have taken place, i.e., air carrier participation in the National Route Program (NRP) has evolved with the participation increasing slightly since it's inception in 1995, and additional Area Navigation (RNAV) routes have been developing, e.g., Atlantic High Class A RNAV routes and routes in the Western Region. Much of the recent RNAV thrust has originated from the Aircraft Owners and Pilots Association (AOPA), who are presently working with the FAA on a high priority rulemaking activity for the implementation of a nationwide RNAV program.

In addition, three of the more noteworthy planned FAA acquisitions are expected to provide the majority of the user benefits and/or enable enhanced en route routing capabilities: 1) the User Request Evaluation Tool (URET), which is evolving as the most dominant tool of the Free Flight program, has demonstrated through a conflict probe that more user-preferred routes will be able to be flown through the NAS, 2) the Controller-Pilot Data Link Communications (CPDLC), which is expected to reduce delays and flight inefficiencies caused by voice frequency congestion, and 3) the Wide Area Augmentation System (WAAS), a major capital investment behind the advance towards satellite navigation, will provide increased routing flexibility and more precision approaches.

Furthermore, initiatives that will support more efficient routing include advanced RNAV and domestic Reduced Vertical Separation Minimum (RVSM) are evaluated. These capabilities are emphasized in the FAA's Operational Evolution Plan (OEP), a 10-year modernization plan that the FAA has recently released.

The analysis examines the four cases annotated below in Table ES-1. All cases are additive, i.e., Case 4 incorporates enhancements from the three preceding cases.

Table ES-1: Routing Scenarios

Case[1]	2000	2005	2010	2015	Key Additive Elements
Case 1: Baseline	✓	✓	✓	✓	Current NRP and Southern Region RNAV routes grown by FAA traffic forecasts
Case 2: Baseline + ***Increased RNAV Routes***		✓	✓	✓	Projected growth in Southern Region RNAV routes
Case 3: Baseline + Increased RNAV Routes + ***Increased Direct/Optimized Routes***		✓	✓	✓	Additional wind-optimized and direct routes
Case 4: Baseline + Increased RNAV Routes + Increased Direct/Optimized Routes + ***Domestic RVSM***		✓	✓	✓	Reduction in vertical separation from 2000' to 1000' from FL290 to FL390

The analysis is built from one representative "good weather day". Results for each method are presented for fuel burn, distance, en route time, and conflict alerts. The following three alternative metric measurement methods are applied to compare the results.

1) Scenario analysis by case
2) Marginal scenario analysis
3) Marginal metrics per marginal flight

Scenario analysis measures the various cases, which contain various amounts of sequential routing options, building upon prior scenarios. Therefore, the RVSM case, which includes all three routing options, will always have the greatest benefits. The RVSM case provides the maximum benefits among the three cases based on the assumptions associated with future routing participation in the Southern Region.

Marginal scenario analysis calculates the difference between adjacent scenarios and represents the marginal value added by increasing the use of one type of routing strategy. For example, total fuel use in the RVSM case minus the fuel use in the optimized (Direct/Wind) case represents the marginal fuel use associated with the addition of RVSM routes. Similarly, the fuel savings that result from added wind-optimized flights and direct flights can be measured by subtracting the RNAV case from the optimized (Direct/Wind) case. Lastly, the RNAV case minus the baseline case represents the fuel savings from adding more RNAV routes in the baseline case.

The *marginal metrics per marginal flight* refers to metric savings associated only with an average RNAV flight, average optimized (Direct/Wind) flight, and an average RVSM flight. By making direct flight-to-flight routing comparisons, the results will determine the relative efficiency savings among the routing options.

[1] Each case builds additional capabilities from the previous case, i.e., the "Increased RNAV Routes" (Case 2) builds on the "Baseline" (Case 1), etc.

Scenario Analysis by Case Results

- The RVSM case, which contains all three routing options, leads to reductions of 1.4 - 1.5 percent of the total fuel consumption (128 to 148 pounds per flight), 0.4 - 0.5 percent in distance (2.0 to 2.4 nautical miles (nmi) per flight), and a 0.7 to 0.8 percent in total airborne time (0.7 to 0.8 minutes per flight) from year 2005 to 2015 (see Table ES-2).
- The optimized (Direct/Wind) case represents the second highest level of benefits among the cases, mainly because it includes both additional RNAV routes and optimized (Direct/Wind) flights, but excludes RVSM routing options. With the optimized (Direct/Wind) case, the fuel savings were approximately 0.6 to 0.8 percent of all fuel consumed from year 2005 to 2015, 0.4 to 0.5 percent distance savings, and 0.7 to 0.8 percent airborne time reduction (see Table ES-2).

Marginal Scenario Analysis Results

- The RVSM flights provide between 49 and 59 percent of all of the fuel savings from year 2005 to 2015, 39 to 49 percent from the additional optimized (Direct/Wind) flights, and only 0.8 to 3 percent from additional RNAV routings from year 2005 to 2015.
- The additional optimized (Direct/Wind) flights contribute the largest proportion of the total distance savings, ranging from 91 to 97 percent from year 2005 to 2015. RNAV routes are 3 to 9 percent and RVSM flights are 0.4 to 0.5 percent.
- Over 82 to 97 percent of all timesavings benefits result from the optimized (Direct/Wind) routes with minimal contributions from RNAV routes (2 to 4 percent) in the year 2005 to 2015. RVSM flights comprise approximately 2 percent of the total timesavings benefits.

Marginal Metrics per Marginal Flight Results by Routing Type

- The additional optimized (Direct/Wind) flights, which account for 23-24 percent of the total flights, have the most impact on: a) reducing fuel consumption per marginal flight (232-297 pounds per flight), b) distance savings per marginal flight (8.4 to 9.1 nmi per flight), and c) yielding the greatest timesavings per marginal flight (2.8 to 3.0 minutes per flight).
- Of the additional optimized (Direct/Wind) flights: a) wind-optimized flights save almost twice the fuel per flight as direct routing flights (151 versus 330 pounds per flight), b) direct routes generate more distance savings per flight than wind-optimized by a factor of 10 (16.1 nmi versus 1.6 nmi), and c) direct routes also reduce flight time on average at more than twice the level of wind-optimized flights (4.1 minutes per flight versus 1.7 minutes).
- RVSM leads to the highest reduction of conflicts (65 percent reduction), and significantly reduces them by 74 percent in their most frequent length of duration category, less than 1 minute. Although RVSM does provide significant fuel savings per marginal flight (148 to 184 pounds per flight), RVSM provides almost no distance savings or timesavings per marginal flight (.02 nmi and .02 to .03 minutes per flight).

- RNAV routes yield: a) substantial fuel savings benefits per marginal flight of approximately 155 to 157 pounds per flight, b) 8.0 to 8.2 nmi distance savings per flight, and c) about 1.2 to 1.6 minutes per flight savings.

Table ES-2 presents a summary of the en route fuel, distance, and timesavings per flight for the scenario analysis results.

Table ES-2: Scenario Analysis Results

	Fuel Burn Savings per Flight (lbs)			Distance Savings per Flight (nmi)			Timesavings per Flight (mins)		
	2005	**2010**	**2015**	**2005**	**2010**	**2015**	**2005**	**2010**	**2015**
Base + RNAV	1.0	3.6	3.8	0.1	0.2	0.2	0.01	0.03	0.03
(Percent)	0.01%	0.04%	0.04%	0.01%	0.04%	0.04%	0.01%	0.03%	0.03%
Direct/Wind	53.5	72.2	60.9	2.0	2.2	2.4	0.65	0.69	0.74
(Percent)	0.57%	0.76%	0.62%	0.38%	0.42%	0.45%	0.70%	0.74%	0.78%
RVSM	127.5	141.0	147.5	2.0	2.2	2.4	0.66	0.70	0.76
(Percent)	1.37%	1.48%	1.51%	0.38%	0.42%	0.45%	0.71%	0.75%	0.80%

Table ES-3 summarizes the total savings metrics from the marginal scenario analysis.

Table ES-3: Marginal Scenario Analysis Results

	Total Fuel Burn Savings (lbs)			Total Distance Savings (nmi)			Total En Route Timesavings (hrs)		
	2005	**2010**	**2015**	**2005**	**2010**	**2015**	**2005**	**2010**	**2015**
Base + RNAV	11,952	46,491	52,275	608	2,429	2,761	2.0	6.0	7.0
(Percent)	0.01%	0.04%	0.04%	0.01%	0.04%	0.04%	0.01%	0.03%	0.03%
Direct/Wind	623,250	877,997	783,225	22,656	25,673	30,126	127.0	142.0	163.0
(Percent)	0.56%	0.72%	0.58%	0.37%	0.38%	0.41%	0.69%	0.71%	0.75%
RVSM	878,713	882,215	1,187,118	115	128	129	2.0	2.0	3.0
(Percent)	0.80%	0.72%	0.88%	0.00%	0.00%	0.00%	0.01%	0.01%	0.01%

Table ES-4 contains the metric savings per flight by marginal routing type.

Table ES-4: Marginal Metrics per Marginal Flight Results by Routing Type

	Fuel Burn Savings per Flight (lbs)			Distance Savings per flight (nmi)			En Route Timesavings per flight (mins)		
	2005	**2010**	**2015**	**2005**	**2010**	**2015**	**2005**	**2010**	**2015**
Base + RNAV	157.3	155.5	154.7	8.0	8.1	8.2	1.6	1.2	1.2
(Percent)	1.69%	1.63%	1.58%	1.55%	1.56%	1.54%	1.69%	1.28%	1.31%
Direct/Wind	231.5	297.2	236.6	8.4	8.7	9.1	2.8	2.9	3.0
(Percent)	2.49%	3.11%	2.42%	1.63%	1.67%	1.72%	3.03%	3.07%	3.12%
RVSM	164.0	148.4	184.0	0.02	0.02	0.02	0.02	0.02	0.03
(Percent)	1.76%	1.55%	1.88%	0.00%	0.00%	0.00%	0.02%	0.02%	0.03%

Executive Summary

None of the options yield significant reductions in flight delays. Most of the benefits metrics in terms of distance and time are very minimal in the aggregate relative to the total distance and flight time for all flights. These metrics also only apply to the flights that traversed the Southern Region on a representative day, or about 15 percent of the total daily flights in the NAS.

In summary, based on this preliminary evaluation, there is tremendous potential for the airlines to obtain benefits from expected future routing initiatives. Additional excursions are necessary to better understand the impacts.

Table of Contents

Table of Contents

List of Figures

List of Tables

1.0 INTRODUCTION AND OVERVIEW

This report presents a methodology and the findings of an Investment Analysis and Operations Research Analysis Division (ASD-400) and Federal Aviation Administration W.J. Hughes Technical Center (FAATC), Advanced Concepts Branch (ACT-540) assessment of current and future air traffic routing initiatives. Flights that traverse through the Southern Region are evaluated in this analysis. The purpose of the analysis is to provide summary metrics that identify differences between different scenarios. This preliminary analysis establishes a structured framework that can be employed for other regions in the National Airspace System (NAS) and measures the potential "added value" of future NAS initiatives.

1.1 Background

In 1996 and 1997, ASD-400 conducted a study, titled *"Multi-Center GPS Direct Routes Analysis"*, that evaluated the impact of direct and wind-optimized routing through three contiguous Air Route Traffic Control Centers (ARTCCs) in the Southern Region: Atlanta Center (ZTL)[11], Jacksonville Center (ZJX), and Miami Center (ZMA). The study evaluated several scenarios based on actual flight data from one day, May 3, 1995. Metrics such as flight distance, sector throughput, and proximity alerts (conflicts) were evaluated and reported from the simulation of the modeled day. The results have been referenced in assorted documents when the evaluations of the impacts and benefits of additional direct and wind-optimized routings in the NAS have been presented.

During the subsequent five-year period from 1996 thru 2000, there were many changes in the NAS. The number of air traffic operations through the Southern Region has increased by 20 percent, in particular, 27 percent at ZJX, 21 percent at ZMA, and 14 percent at ZTL. At the same time, flight times between major airports have gradually increased from 7-10 percent. While the NAS has become more constrained with demand increasing more relative to capacity, encouraging steps have taken place, i.e., air carrier participation in the National Route Program (NRP) has evolved with the participation increasing slightly since it's inception in 1995, and additional Area Navigation (RNAV) routes have been developing, e.g., Atlantic High Class A RNAV routes and routes in the Western Region. Much of the recent RNAV thrust has originated from the Aircraft Owners and Pilots Association (AOPA), who are presently working with the FAA on a high priority rulemaking activity for the implementation of a nationwide RNAV program.

In addition, three of the more noteworthy planned FAA acquisitions are expected to provide the majority of the user benefits and/or enable enhanced en route routing capabilities: 1) the User Request Evaluation Tool (URET), which is evolving as the primary tool in the Free Flight program, has demonstrated through a conflict probe that more user-preferred routes will be able to be flown through the NAS in the future, 2) the Controller-Pilot Data Link Communications (CPDLC), which is expected to reduce delays and inefficiencies due to voice frequency congestion, and 3) the Wide Area Augmentation System (WAAS), which is a major capital investment behind the movement towards satellite navigation, will provide increased routing flexibility and many more precision approaches. Furthermore, domestic Reduced Vertical Separation Minimum (RVSM) is assumed to be implemented by year 2005 for all equipped aircraft for flights filed to fly at or above FL290.

The previous ASD-400 study did not examine the fuel savings or the impact from domestic RVSM, nor were future scenarios assessed. The intent of the previous analysis as well as this current analysis is to evaluate the overall impact of the expected routing efficiencies from planned future acquisitions and procedural changes as currently designated in the NAS Architecture and the Operational Evolution Plan (OEP). The analysis does not attempt to isolate the contributions by the specific technologies and/or procedures such as additional direct routings through the conflict probe, voice frequency congestion reduction, and more precise navigation through the Global Positioning System (GPS) and Global Navigation Satellite System (GNSS), and the Flight Management System (FMS), which enables RNAV and the NRP.

1.2 Objective

The primary objective of this task is to evaluate the potential "pools of benefits" of increased utilization of planned en route NAS initiatives in the Southern Region. The task demonstrates a capability of estimating the impacts of future routing capabilities through a range of scenarios by utilizing and applying multiple data sets, tools, and models.

1.3 Scope

Figure 1 shows the sectors in the Southern Region (ZJX, ZTL, and ZMA) where all the flights in the analysis flew through one or more sectors.

Figure 1: Sector Boundaries in the Southern Region

High altitude sectors between FL240 and FL350, and super-high sectors, FL350 and higher, is delineated in Figures 2 and 3 below. The sectors, which are defined in the Adaptation Controlled Environment System (ACES), represent the primary en route airspace in the region. Sector performance summaries are presented in Section 3.8 and Appendix I. Frequently, the sectors are separated by altitude and will appear in both the high and super-high sectors in the figures, e.g., sector ZJX016.

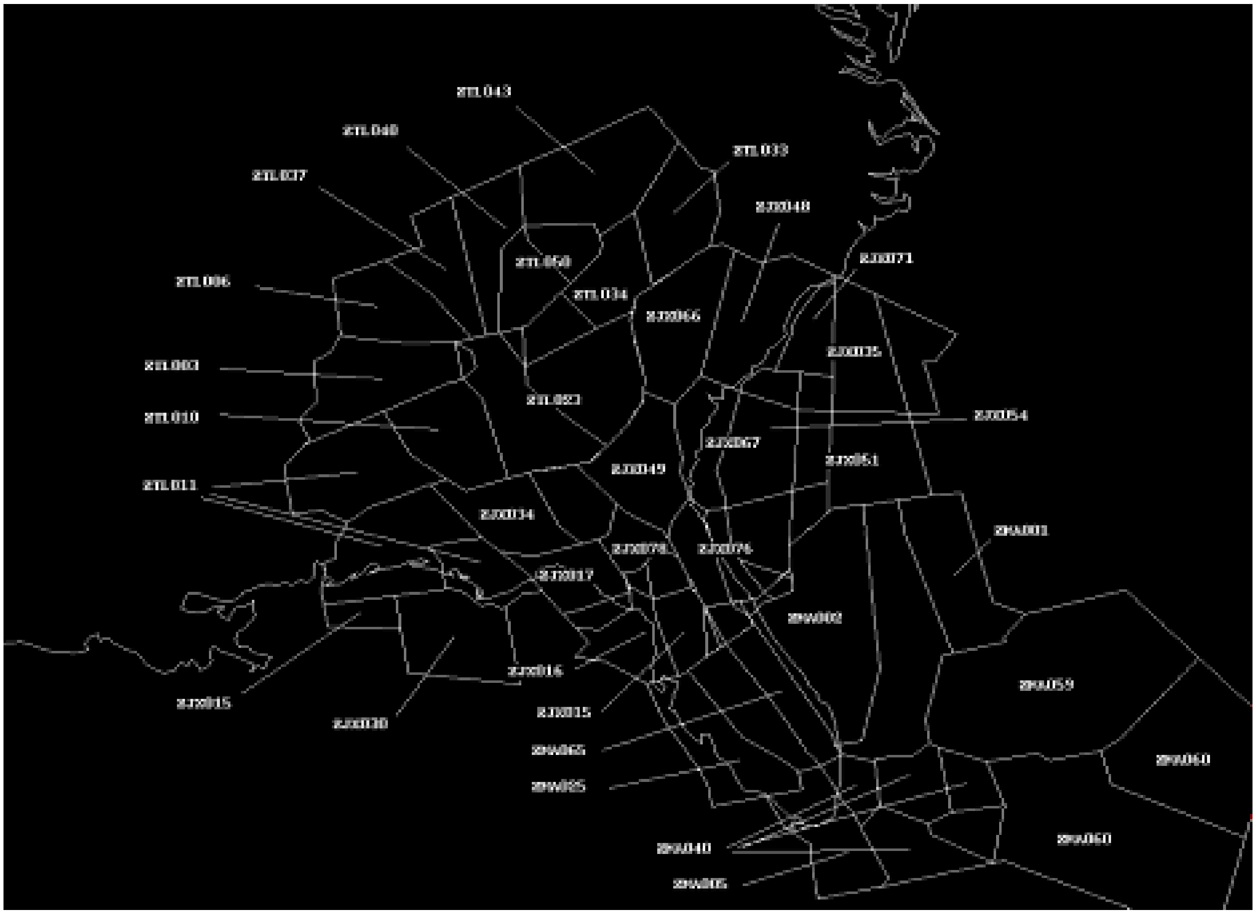

Figure 2: High Sectors in the Southern Region

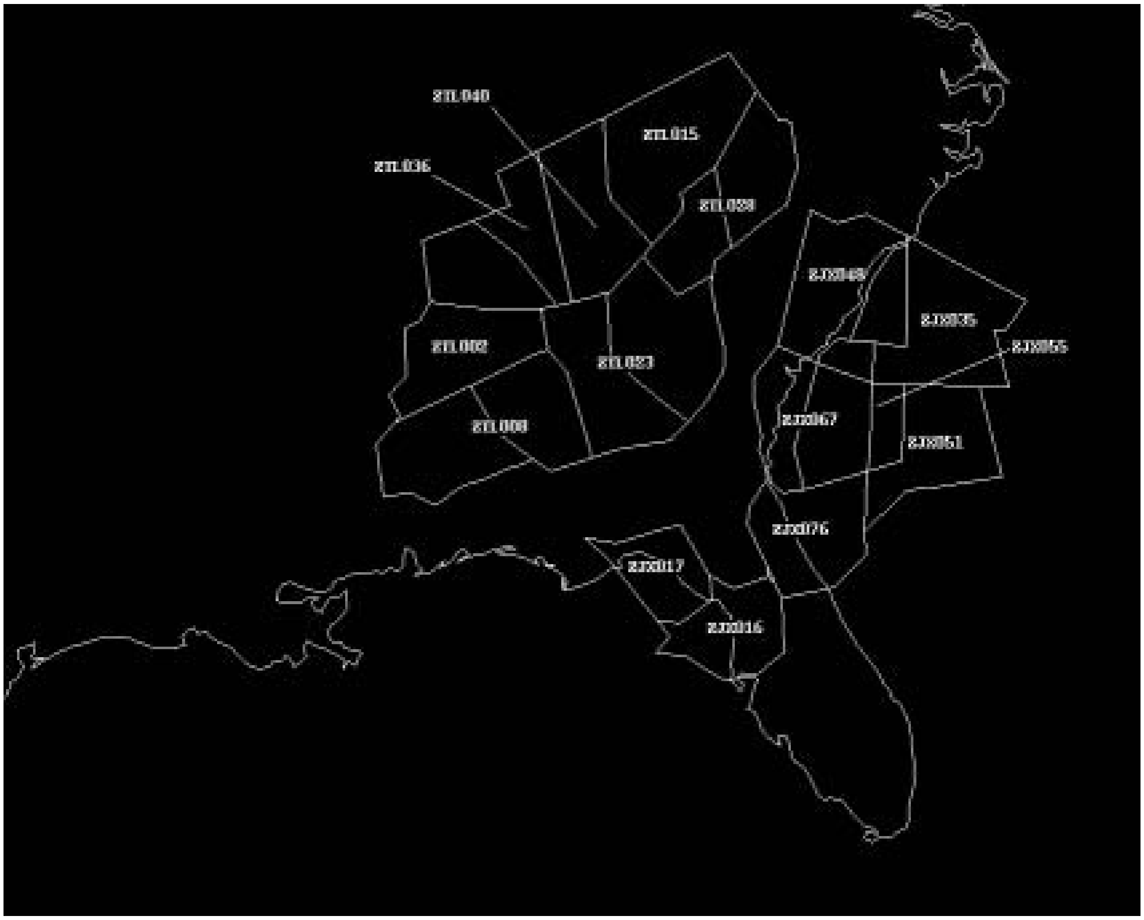

Figure 3: Super-High Sectors in the Southern Region

2.0 METHODOLOGY

This analysis evaluates one day, August 28, 2000, for multiple scenarios (referred to as cases throughout the report). August 28, 2000, was selected from seven other candidate days in the late-August and early-September 2000 timeframe. When compared to other candidate days, August 28 had smaller average block times (gate-to-gate times), less arrival delay, and better weather conditions per National Climatic Data Center (NCDC) surface observations. Furthermore, a quick examination of the Next Generation Weather Radar (NEXRAD) national mosaic reflectivity images indicated good weather at the following major southern airports: Atlanta Hartsfield International Airport (ATL), Daytona Beach International Airport (DAB), Ft. Lauderdale-Hollywood International Airport (FLL), Jacksonville International Airport (JAX), Orlando International Airport (MCO), Miami International Airport (MIA), and Tampa International Airport (TPA).

The selection of a representative scenario day in the Southern Region was established from evaluating all flights that 1) either entered or exited, or visa versa, any of the sectors in the Southern Region during any point in the flight, 2) flew through any sector in the region, and 3) originated and terminated inside the Southern Region. Both intra-sector and inter-sector flights were included in the simulations.

2.1 Scenarios

The following modeling scenarios were applied for both the current and future year. ZTL typically ranks in the top three of the 20 ARTCCs for the number of reported traffic counts, and ZJX and ZMA historically have average levels of traffic. Active Special Use Airspace (SUA) is considered. The SUA boundaries are defined in Order 7400.8HFAA, *Special Use Airspace*. More detail of SUA is presented in Section 2.7.

1. **Baseline Case:** includes current 2000 flights and projected flights in years 2005, 2010, and 2015 participating in the NRP consistent with the current user requirements (per Order 7210.3, Facilities Operation and Administration) and current published RNAV routes, which average about 300 nautical miles (nmi) in the Southern Region[2]. All routes flown under NRP, which average approximately 900 nmi, and RNAV are modeled as great circle routes (direct routes) from departure fix to arrival fix.

2. **Increased RNAV Routes Case (i.e., Base + RNAV):** same as case #1 but includes additional RNAV routes expected in the Southern Region. The expected RNAV routes growth is consistent with the projected growth of the increased usage rate of GPS receivers.

3. **Direct/Optimized Winds Case (i.e., Direct/Wind):** same as case #2 but includes additional candidate flights that can fly optimized routes. All long-haul flights of 750 nmi or greater at an assigned altitude of FL290 and above are considered in this case. Optimized route assumptions were developed by the analysis team consistent with how airlines take advantage of the winds during normal operations. The Optimized Trajectory Generator (OPGEN) tool measured the full impacts due to optimal winds by adjusting flight path (lateral) and/or flight trajectories (vertical) for a given set of constraints. In cases where a wind optimal route cannot be flown it defaults to a direct route with SUA considerations.

4. **Direct/Optimized Winds/Domestic RVSM Case (i.e., RVSM):** same as case #3 but includes domestic RVSM in the future scenarios. RVSM initiatives in domestic airspace are modeled with the Reorganized Air Traffic Control Mathematical Simulator (RAMS) model. FAA's position as of October 2001 is applied to reflect its implementation and potential contribution in the future years.

Table 1 below summarizes the definitions of the cases that were modeled. Note: In each case the enhanced capabilities are bolded in the additive elements.

[2] Information provided by the Southern Region, Air Traffic Division (ASO-500). Specific RNAV routes in other regions, which were not known at the time of this analysis, are not applied in this effort.

Table 1: Modeling Scenarios

Case[3]	2000	2005	2010	2015	Key Additive Elements
Case 1: Baseline	✓	✓	✓	✓	Current NRP and Southern Region RNAV routes grown by FAA traffic forecasts
Case 2: Baseline + ***Increased RNAV Routes***		✓	✓	✓	Projected growth in Southern Region RNAV routes
Case 3: Baseline + Increased RNAV Routes + ***Increased Direct/Optimized Routes***		✓	✓	✓	Additional wind-optimized and direct routes
Case 4: Baseline + Increased RNAV Routes + Increased Direct/Optimized Routes + ***Domestic RVSM***		✓	✓	✓	Reduction in vertical separation from 2,000' to 1,000' from FL290 to FL390

2.2 Overview of Data Sources

The analysis applies a wide range of aviation tools, models, and input data. Most of the data is readily available in ASD-400 and ACT-540 to conduct this type of an analysis. After the study team defined the data inputs and basic approach, ACT-540 applied all the tools and models listed below. The study team received excellent support from the Southern Region who provided the current status and suggestions on expected future RNAV initiatives.

2.2.1 Tools and Models

The following are the primary tools and models used in the analysis.

1. **RAMS:** a discrete-event simulation model developed by the Eurocontrol Experimental Centre's Simulator Developmental Program tailored for regional analysis. It simulates airspace and flights within a defined set of airspace subject to controller interactions and Air Traffic Control (ATC) restrictions.

2. **NAS Performance Analysis Capability (NASPAC):** a discrete-event simulation model that tracks aircraft as they progress through the NAS and measures interactions between many components of the ATC system. NASPAC evaluates NAS-wide system performance based on demand placed on the airspace and airport capacities. It is applied in this analysis to measure the operational delay of a flight leg.

3. **Sector Design and Analysis Tool (SDAT):** a decision support tool that provides the NAS sector geometries, i.e., airspace definition, that are input into the RAMS model.

4. **OPGEN:** a model that attempts to fly an optimum trajectory using wind-optimized routes from both the original flight plan and other flight plan variations, i.e., future demand, given a set of pre-established criteria. These criteria include all flights that fly over 750 nmi that reach FL290 during some point of the flight.

[3] Each case is additive and builds on the preceding case.

5. **Aerospace Engineering and Research Associates LIBrary (AERALIB):** a Commercial-off-the-Shelf (COTS) software package of twelve (12) rigidly, object-oriented libraries that can support virtually all aspects of Communications, Navigation, Surveillance/Air Traffic Management (CNS/ATM) studies and/or analyses. The trajectory library has a conflict prediction class that has the functionality to probe two discrete trajectories (timed flows) for conflicts. The conflict analysis is performed on a discrete-event basis. AERALIB can assess the impact that different automatic conflict resolution techniques have on controller workloads and operational costs on NAS users.

6. **The North Atlantic Systems Implementation Group Cost Effectiveness** (**NICE**) **Programme fuel burn model:** this International Civil Aviation Organization (ICAO) - endorsed model provides fuel consumption rates for specified aircraft type by speed, altitude (climb, cruise, and descent), and weight of aircraft. The information is provided by Lufthansa Airlines. Fuel burn computations were applied during the climb, cruise, and descent phases of the flight. No computations were applied to the takeoff, taxi-out, and taxi-in phases of the flight.

Each of these models and fuel burn sources interact with each other during the modeling process to produce the final metrics (see Section 3.1). This integrated process is illustrated through the corresponding numbers as shown in Figure 4 below.

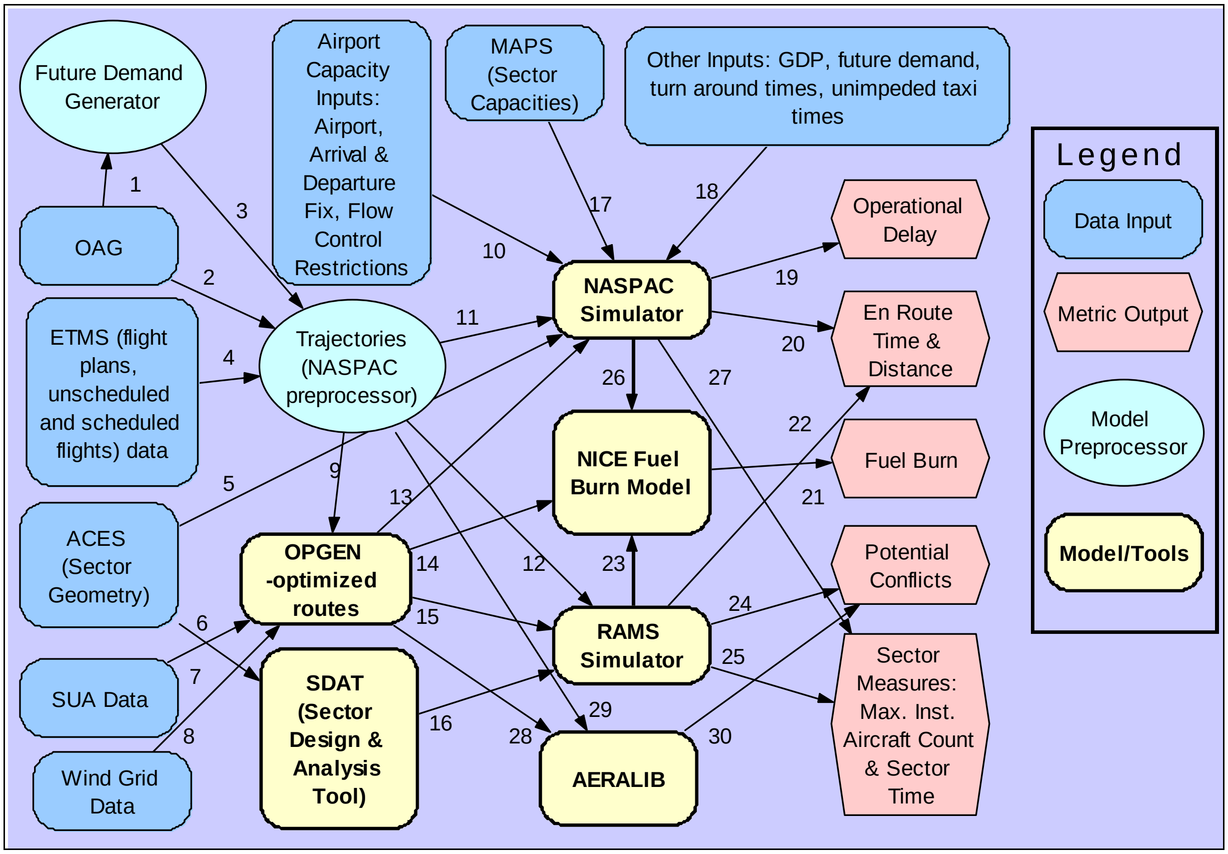

Figure 4: Future Routing Study Flow Diagram

The following are brief descriptions of each link.

1. **Official Airline Guide (OAG) -> Future Demand Generator (FDG)**

   The current OAG schedule is applied to simulate the growth in city pairs through the FDG. The FDG creates individual flights based on growth predictions in airport operations per the growth in the Terminal Area Forecast (TAF).

2. **OAG -> Trajectories (NASPAC Preprocessor)**

   The OAG scheduled demand through city pairs generates flight trajectories (current flight profiles).

3. **FDG -> Trajectories (NASPAC Preprocessor)**

   The FDG increases demand that is used to build future trajectories (future flight profiles). The future trajectories are based on a random draw of existing trajectories for the current origin-destination (O-D) pairs.

4. **Enhanced Traffic Management System (ETMS) -> Trajectories (NASPAC Preprocessor)**

   The ETMS data containing the airspace flight positions are fed into the NASPAC preprocessor to construct trajectories (either as-flown or as-filed trajectories). The data consists of flight information (origin, destination, aircraft type flight ID) and position information. The “as flown” tz position messages are reported every one to five minutes.

5. **Adaptation Controlled Environment System (ACES) -> NASPAC**

   ACES data contain the sector geometries, which are the physical locations or vertices (longitudes and latitudes; ceilings and floors) that make up the sectors in the NAS.

6. **ACES -> SDAT**

   ACES sector coordinates (includes sector name, long/lat, and vertices names) are reformatted into SDAT so it is compatible with RAMS. The February 2001 ACES data set was used for this analysis.

7. **SUA data -> OPGEN**

   SUA data, which has the activation and restriction times of the SUA, is input into OPGEN so flown flights can be optimized around SUAs when they are active.

8. **Wind grid data (National Oceanic and Atmospheric Administration (NOAA))-> OPGEN**

   The wind grid data for August 28, 2000, feeds data representing the winds aloft so the optimizer can develop the optimal tracks.

9. **Trajectories (NASPAC Preprocessor) -> OPGEN**

   After developing routes from the various sets of flight profiles, OPGEN attempts to optimize candidate flights based on winds aloft data for the respective day. If a flight cannot be optimized for winds then it defaults to a great circle route.

10. **Capacity Inputs -> NASPAC**

    Capacity inputs are ground and airborne resources that an aircraft will encounter during a flight. These inputs are either 1) capacity restrictions, (airport and airspace capacities) Monitor Alert Parameter (MAP) thresholds, or 2) flow control restrictions. These include miles-in-trail (MIT) restrictions, which are strategically placed in the NAS to control arrivals for timing purposes. In addition, arrival and departure fixes are used to sequence flights into and out of a terminal area.

11. **Trajectories (NASPAC Preprocessor) -> NASPAC**

    A part of the output from the preprocessor is sent to the find crossings module in NASPAC that determines when and what flights pierce a sector. Find crossings provide altitude, latitude/longitude, and time in positional space based on the flights flight plan (FZ) message. NASPAC uses these times and locations to fly the routes in the simulation.

12. **Trajectories (NASPAC Preprocessor) -> RAMS**

    Same link as noted above in #11. NASPAC uses trajectories to determine when and where airplanes will arrive at those locations. By comparison, RAMS determines time based on location only.

13. **OPGEN -> NASPAC**

    OPGEN outputs the optimized trajectories from the respective flight profile for use in NASPAC. In this study, NASPAC compares the operational delays and maximum instantaneous sector counts between the different flight profiles.

14. OPGEN -> NICE Fuel Burn Model

OPGEN wind-optimized trajectories are inputs to the NICE fuel burn model, which contains fuel burn properties by aircraft type.

15. OPGEN -> RAMS

The wind-optimized trajectories are input into the RAMS model. Metrics such as maximum instantaneous sector counts, conflicts, and sector transit times are generated.

16. SDAT -> RAMS

SDAT provides sector geometries for RAMS (NASPAC has to be developed separately from three files from ACES Automated Observation System (AOS) data) noted in #5. The files include the Navigational Aids (NAVAIDs) by latitude/longitudes, sector names with ceilings, and position descriptions.

17. MAPs -> NASPAC

MAPs contain all airspace capacities for low, high, and super-high altitude sectors in the NAS. During a NASPAC simulation, when the actual number of flights (maximum instantaneous counts) exceeds the sector thresholds, delays in the form of the duration of time waiting in the queues can accrue.

18. Other Inputs: Ground Delay Program (GDP), future fleet mix, turn around times, unimpeded taxi times) -> NASPAC

The GDP is a formal Air Traffic Control Systems Command Center (ATCSCC) response to an airport that is forced to drop its arrival rate because of some adverse phenomenon such as bad weather, equipment outage, etc. Flights are held on the ground or cancelled at the origin airports as a way of managing the airport arrival rate at the destination airports to minimize flight delays. Tail numbers and unimpeded taxi times, which are derived by carrier, are developed from the Airline Service Quality Performance (ASQP), an on-time reporting system to the Department of Transportation (DOT). They are used to sequence takeoffs to build itineraries.

19. NASPAC -> Operational Delay

Output from NASPAC that computes the delay attributed to airlines, due to competition for limited resources both on the ground and in the air. Also, referred to as flight delay in this analysis, it is the sum of the departure, en route, and arrival delays due to the various queuing delays during a flight.

20. NASPAC -> En Route Time and Distance

The average simulated wheels-off to wheels-on time and average distance.

21. NICE Fuel Burn Model -> Fuel Burn

The NICE fuel burn model calculates total fuel burned by aircraft type and altitude. There are 27 types of aircraft in the NICE model. Each of these models is applied in determining fuel burns for the approximately other 200 types of aircraft that fly in the simulation.

22. RAMS -> En Route Time and Distance

Same as #21, this is the wheels-off to wheels-on time.

23. RAMS -> NICE Fuel Burn Model

Outputs of RAMS, which contain detailed summary information of the flights (latitude/longitude, altitude, aircraft type), are used to calculate the fuel burned during a flight. RAMS provides only en route simulation, not the terminal or surface portion of the flight.

24. RAMS -> Potential Conflicts

RAMS provides the location and aircraft ID when the five nmi horizontal separation and 2,000-foot vertical separation are violated in en route airspace. RVSM assumptions apply to all qualifying aircraft that fly at or above assigned altitudes, FL290 with a 1,000-foot vertical separation. Note: RAMS did not give potential conflict results in this analysis; AERALIB was applied (see #30).

25. RAMS -> Sector Maximum Instantaneous Aircraft Count

RAMS flight projections provide maximum instantaneous aircraft counts by sector. Sectors are highlighted whenever this value exceeds the respective MAP. The primary focus in this analysis is the high and super-high sectors.

26. NASPAC -> Fuel Burn Models (NICE and BADA)

Same as #23 but computes fuel for all flights that filed Instrument Flight Rule (IFR) flight plans in the NAS, not just the Southern Region flights like RAMS does.

27. OPGEN ->AERALIB

The wind-optimized trajectories are input into AERALIB. AERALIB provides the proximity alerts (conflicts) results in the analysis.

28. NASPAC -> Sector Maximum Instantaneous Aircraft Count

Same as #25 but captures all IFR flight plans in the NAS, not just the Southern Region like RAMS does. The results are not presented in this analysis.

29. Trajectories (NASPAC Preprocessor) -> AERALIB

The trajectories are converted to a format compatible with AERALIB so conflicts for all cases can be identified.

30. AERALIB -> Potential Conflicts

The AERALIB output provides the number and duration of the conflicts by sector.

2.2.2 Input Data

Several key data inputs were applied to the analysis. Table 2 below identifies the primary ones that impact the results.

Table 2: Key Data Inputs

Data Inputs	Description	Source/Organization
ACES	Definition of the airspace (the sector geometry); includes all sectors in the NAS and key input to both RAMS and NASPAC.	AOS
Air Carrier Fleet Mix	The aircraft type in the simulation also includes set of aircraft by carrier that are assumed to fly RVSM routes in year 2005 and beyond.	ATA-200, AFS
Airport Capacities	The minimum and maximum arrival and departure rates at the major airports in varying weather condition. Different runway configurations are used depending on the weather conditions at the airport.	Airport Capacity Benchmarks, ASD-400/ATP-100 Capacity Survey
Climb and Descent Profiles (Trajectories)	These values are based on profiles between maximum gross takeoff and landing weights broken down into sixteen distinct aircraft type categories. They contain a set of altitude and gradient points giving the steepest rates within distinct altitude bands.	Airlines
Flight Itineraries	Developed for flight legs from tail numbers of 10-12 carriers that report to DOT; other carriers derived by criteria such as aircraft type and turnaround time.	DOT
Flow Control Restrictions	Measures strategically located points in the NAS that have MIT restrictions.	ATCSCC
Fuel burn factors	Aircraft performance attributes applied to aircraft in the NICE model. Analogous aircraft are represented to account for the majority of the large and heavy aircraft.	Eurocontrol, FAATC
Flight Plan (FZ) Messages	"As flown" flight messages from the ETMS on the simulation day, August 28, 2000.	ATA-200
GDP	A strategic traffic flow management program imposed by the ATCSCC. Airport acceptance rates are managed to ensure demand does not exceed capacity. GDPs primarily occur in inclement weather or during adverse events.	ATCSCC
MAPs	Sector capacities: these capacities are defined for low, high, and super-high sectors. There were 907 assigned sectors in the NAS, 158 in the Southern Region.	ATCSCC
Scheduled Demand	The scheduled departures and arrivals from the OAG. Primarily consists of air carriers and air taxi/commuters.	APO
SUA	Airspace in the NAS where activities must be confined at various flight levels and times of day in certain boundaries; includes restricted military areas.	ATA-400
Standard Instrument Departures (SIDs) and Standard Terminal Arrival Routes (STARS)	Official FAA departure and arrival procedures. SIDs limit the capacity of the terminal airspace for departing aircraft; STARS limit the capacity for arriving aircraft.	ATCSCC
Traffic Growth	Traffic forecast by airport (operations and enplanements) from the FAA's 2000 TAF. TAF's annual growth rate is applied in the FDG for the future scenarios.	APO

Table 2: Key Data Inputs, Cont'd

Data Inputs	Description	Source/Organization
Turnaround Time	The time it takes between when an aircraft gets into a gate at a destination airport and when it pushes back from the gate for its next destination.	DOT
Unimpeded Taxi Time	Derived from ASQP data and generally represents the 15^{th}-20^{th} percentile for a particular carrier by airport. Additional service time due to waiting in a queue on the ground is added to the unimpeded time.	APO
Unscheduled Demand	Based on arrivals and departures of General Aviation (GA) and air taxis that file a flight plan per the ETMS, also, includes an adjustment for local VFR traffic. This demand is factored into the NASPAC runs when measuring operational delay.	ATA-200
Wind Grid Data	The winds aloft grid data in the upper atmospheres required for OPGEN runs. Winds are based on forecasted observations every 6 or 12 hours.	NOAA/UCAR

2.3 Ground Rules and Assumptions

There were several key ground rules and assumptions applied in the analysis. They are presented in the following categories: Time, Airport Capacity, Routes, Airspace, Fuel burn, and Equipage/Aircraft.

Time

- The simulation day, August 28, 2000, a day with a high percentage of Visual Meteorological Conditions (VMC) and good flight performance is the baseline day.

- A baseline year 2000 and future years with incremental improvements in years 2005, 2010, and 2015 are assessed.

Airport Capacity

- The airport capacities are based on the FAA Capacity Benchmarks developed by the FAA [12] who was supported by MITRE/CAASD, and the 2000 Airport Capacity Survey conducted by ASD-400 and ATP-100. Current and future capacities are established for VFR, MVFR, and IFR based on the reported NCDC hourly surface observations for August 28, 2000. The capacities are relevant for measuring the operational delay.

Routes

- The current and projected NRP participation and RNAV route establishment in the Southern Region is factored into both the current and future baselines. The number of NRP filed flights grows proportionally with the projected future demand (airport operations). The details are noted in Section 2.5.3.2.

- The routes are developed through the NASPAC trajectory builder. Routes are dependent on climb and descent profiles by one of the assigned aircraft categories. Routes are comprised either of wind-optimized routes, great circle routes (direct routes), or ATC-preferred routes. The direct routes are flown direct from the departure fix to the arrival fix. This slightly overstates the actual flight path of an RNAV or NRP route that may be direct for part of the flight, i.e., between two waypoints or between the departure and arrival fixes.

- Wind-optimized routes are considered as long as the flight level is equal to or exceeds FL290, and the origin-to-destination distance is equal to or greater than 750 nmi. The wind forecasts are derived from wind-gridded data provided by NOAA/UCAR.

- The RVSM initiatives in domestic airspace are consistent with the current FAA position (as of October 2001) of implementation between flight levels 290 and 390.

- All direct routes abide by SUA restrictions. Whenever possible, great circle routes are flown; however, where there is an active SUA in the flight path a minimum distance trajectory is applied to the flight. SUA was only considered within the Southern Region, i.e., a flight outside the region that flew direct might fly through SUA.

Airspace

- The sector geometry, i.e., airspace definition, is developed from the ACES data.

- The sector capacities, the MAPs of the low, high, and super-high sectors are provided by the ATCSCC. These capacities represent a theoretical maximum number of aircraft that can be accepted in a sector at a given time. The sectors and the MAPs remain constant over time.

- Sector boundaries, which are currently being modified through the National Airspace Redesign (NAR), were not adjusted in the future scenarios.

- SIDS and STARS departure and arrival procedures are utilized. These procedures are based on official FAA location IDs for NAVAIDs. They direct the pilot to turn or fly.

- The proximity alerts (conflicts) are identified in the high and super-high sectors whenever a pair of aircraft from two flights exceeds 1) the five-mile horizontal criteria and/or the 2,000-foot vertical separation minima for the non-RVSM case, and 2) the 1,000-foot vertical separation criteria for qualified aircraft (see Appendix H) at or above FL290 in the RVSM case.

Fuel burn

- The fuel burn rate is computed in the airborne phase (climb, cruise, descent) of the flight. Aircraft type, speed, flight level, and weight impact the rate. The combinations of these variables are computed between waypoints. Each flight leg is aggregated to calculate the overall fuel burn.

Equipage/Aircraft

- The future NAS initiatives, specified in the OEP, include increased RNAV equipage and certification, and domestic RVSM for eligible aircraft. Technologies such as data link, conflict probe, and satellite navigation are assumed to support the future enhancements.

- The equipage attributes of commercial, air taxi/commuter, and GA aircraft are defined in the ATC 7110.65 publication. This publication identifies equipage codes by carrier and aircraft type that can offer direct routing capability through multi-sensor FMS and the equipage of GPS receivers.

- There are twenty-seven aircraft types (15 distinct series, e.g., 727) that are candidates to fly optimized (Direct/Wind) routes. See Appendix C, Table C-2, for a mapping of the aircraft types. All eligible aircraft type were converted to equivalent aircraft when applying the OPGEN model.

- The fleet mix for the future years is based on the Boeing forecast of annual aircraft operations.

2.4 Output Metrics

The following six metrics are presented for each of the four cases in the years 2000, 2005, 2010, and 2015 scenarios.

1. **Fuel burn:** the amount of fuel burned for all aircraft that flew through the Southern Region. These values are generated from a combination of the fuel factors of the aircraft that currently reside in the NICE model (see Appendix C).
2. **Flight distance:** the flight distance of all flights that pierced one or more of the sectors in the Southern Region.
3. **Flight time:** the average flight time of all flights that pierced one or more of the sectors in the Southern Region.
4. **Sector throughput to MAP threshold:** the number of minutes the maximum instantaneous sector count (MIAC) of aircraft exceed the MAP threshold at a simulated point in time.
5. **Operational delay:** the aggregate ground and airborne delay of a flight. This is the sum of the departure and arrival queues due to a competition for resources during a given flight.
6. **Proximity alerts:** conflicts between aircraft, which regularly cause maneuvers. The alerts *are identified*, but not resolved, in the high and super-high sectors of the three Centers (i.e., ZTL, ZJX, and ZMA). Differences in both the frequency and duration of the conflicts are identified in the RVSM and non-RVSM cases.

The first five metrics reflect the daily average per flight based on *one flight leg* that passes through any of the three ARTCCs at any point during the flight. The fifth metric, operational delay, will be measured by assessing the impacts of each subsequent flight leg including the leg that traverses through any of the three ARTCCs. The final metric, proximity alerts, is based on aircraft that violate the five-mile horizontal and the 1,000-foot (RVSM case) or 2,000-foot (non-RVSM case) vertical separation in the high and super-high sectors, i.e., at or over FL290.

Note: Dynamic resectorization initiatives that are ongoing with the NAR are beyond the scope of this analysis. Sector boundaries were not adjusted since at the time of the study, there was no firm agency guidance for specifying how the airspace will be restructured.

2.5 Routes

The majority of today's flights are ATC-preferred routes, a set of fixed, pre-determined routes between the respective city pairs. Currently, there are over 2,000 published ATC-preferred routes listed in the Airport/Facility Directory (AFD) [15]. These ATC-preferred flights are often based on charted waypoints and route segments that are preferred and recognized by the ATC. Given that airspace users and operators more than likely have their preference on routes they would prefer to fly between select city-pairs, that may well differ from shortest distance point-to-point routes. This effort attempts to find the incremental improvement in the access to *additional* user-preferred routes and wind-optimal routes with the increases in equipage as well as new technologies.

In the 2000 baseline, there were 10,235 ATC-preferred flights (92 percent) out of 11,082 flights simulated (Table 3). Given that many of today's aircraft are equipped with either FMS or GPS receivers, or both, the next step was to identify all flights that were both eligible and actually flew NRP and RNAV routes. A listing of all the 618 NRP flights that flew in at least one sector in the Southern Region for August 28, 2000, is annotated in Appendix G. These flights serve as the baseline from the state of the current NAS for the flights currently flying NRP. In addition, 42 city pairs with 229 daily flights were identified as flying RNAV routes in the Southern Region in the 2000 baseline.[4] Eleven flights from ATL to MIA were identified as flying on both an RNAV and NRP route. They were assigned to the RNAV pool for this analysis.

Furthermore, in the future scenarios (cases 3 and 4), all flights that reached FL290 in a sector within the region boundary and flew over 750 nmi were candidates to be optimized (Direct/Wind) flights. These flights were identified, and then adjusted by decrementing the NRP flights that met the FL290, 750 nmi criteria. In year 2005, 2,692 flights of the 11,870 flights met the criteria to fly an optimized (Direct/Wind) flight, increasing to 3,310 flights in year 2015. Figure 5 and Table 3 below provides the distribution of the various routes that traversed the Southern Region (regardless of altitude and phase-of-flight) over the one-day simulation period for all cases. The future scenarios reflect an annual growth rate of NAS operations of 1.4 percent per the TAF.

[4] The 229 flights in year 2000 merely served as a starting point for the current RNAV activity in the Southern Region that could be confirmed through expert opinion and ETMS flight plan mapping. The study team did not receive complete flight information from other regions to develop a reasonable "nationwide" estimate of RNAV approved routes.

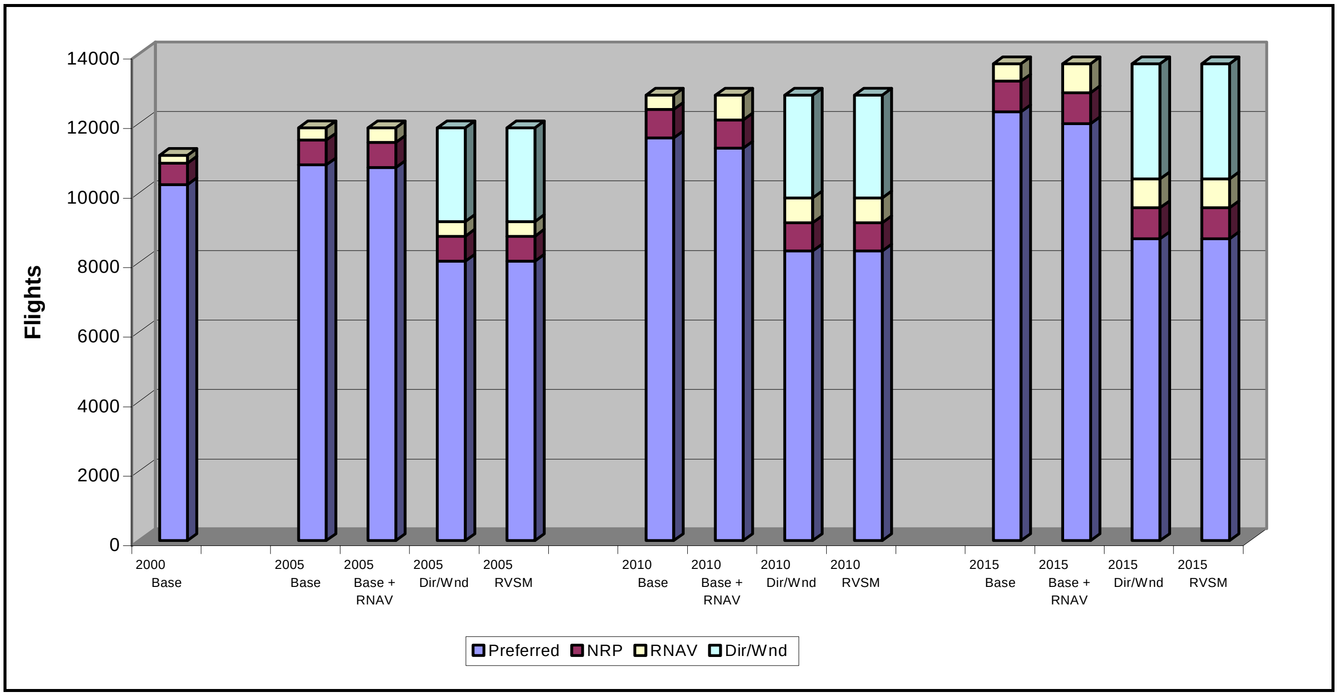

Figure 5: Distribution of Flights Through Southern Region on August 28, 2000

Table 3: Number of Flights Through Southern Region on August 28, 2000

Route Type	2000 Base	2005 Base	2005 Base + RNAV	2005 Dir/ Wnd	2005 RVSM	2010 Base	2010 Base + RNAV	2010 Dir/ Wnd	2010 RVSM	2015 Base	2015 Base + RNAV	2015 Dir/ Wnd	2015 RVSM
ATC-Pref	10,235	10,803	10,727	8,035	8,035	11,581	11,282	8,328	8,328	12,331	11,993	8,683	8,683
NRP	618	722	722	722	722	818	818	818	818	887	887	887	887
RNAV	229	345	421	421	421	414	713	713	713	498	836	836	836
Dir/Wnd				2,692	2,692			2,954	2,954			3,310	3,310
Total	11,082	11,870	11,870	11,870	11,870	12,813	12,813	12,813	12,813	13,716	13,716	13,716	13,716

An overview of the process for selecting routes is illustrated below in Figure 6.

Step 1: Using the ETMS's flight plan (FZ) message determine if the aircraft associated with the air carrier is RNAV-equipped. Flights that are equipped to fly RNAV routes are defined by the codes in Table 4 in Section 2.5.3.1. These flights were identified as the *candidates* to fly RNAV routes.

Step 2: Check if the route is one of the approved RNAV routes provided by the Southern Region *and* matched in the ETMS flight plan (FZ) messages. If the answer is Yes, it can fly an RNAV, if No, check to see if it flew a filed NRP route.

Step 3: If the route is a filed NRP route, then fly it as a direct route, if not, check to see if the flight level flew at or exceeded FL290 and had a flight length of greater than 750 nmi.

Step 4: If the route exceeds 750 nmi and flies at or above an assigned altitude of FL290, try to fly a wind-optimal route, if it cannot take advantage of favorable winds to fly a wind-optimal route, then fly a minimum time/minimum distance flight. [5]

[5] These flights were modeled as direct routes with adjustments for SUA.

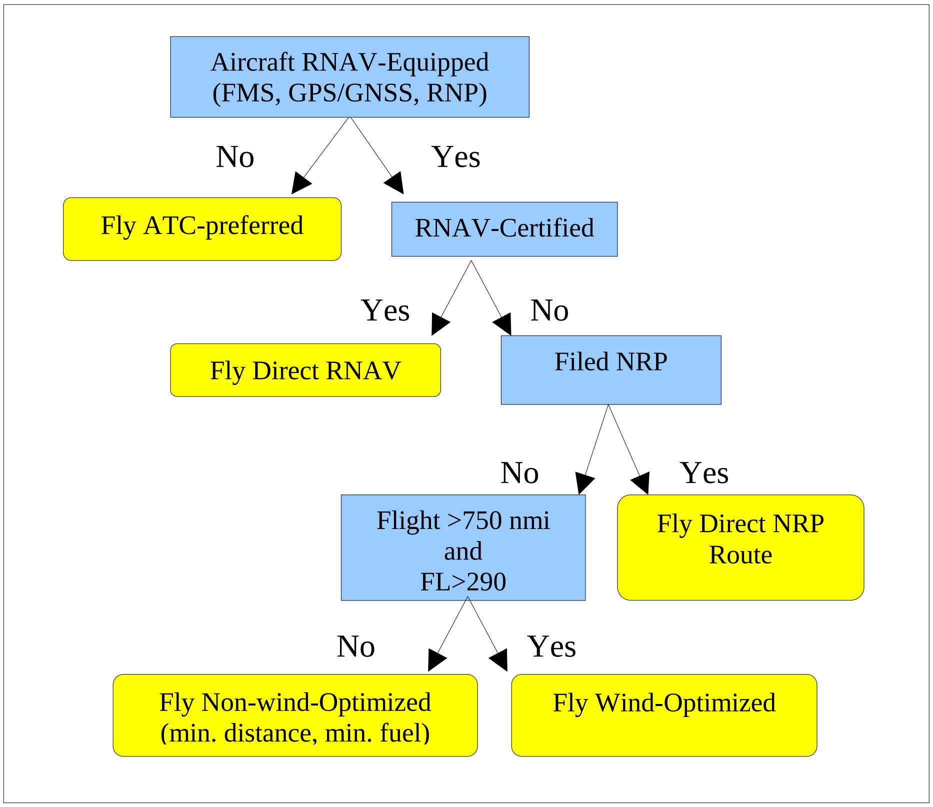

Figure 6: Route Selection Methodology

2.5.1 ATC-Preferred Routes

The majority of the routes flown in each of the scenario years were standard ATC-preferred routes. ATC-preferred routes, also known as preferred IFR routes, are pre-published historical routes designed to achieve balanced traffic flows throughout the NAS. The proportion of these preferred routes is substantially less in the future years (65 percent in year 2010 and 63 percent in year 2015 versus 92 percent in the year 2000 baseline) with the expected growth in the RNAV routes and the expected capability of supporting routing enhancements by flying more direct and wind optimal routes. In case 2, for all scenario years the RNAV routes grew proportionate to the expected increase in RNAV-capable equipage, e.g., GPS receivers.

2.5.2 Wind-Optimized Routes

Expected acquisitions using GPS, data link, and other expected NAS capabilities will continue to enable more accurate navigation; therefore, encouraging the *increased usage* of wind-optimized routes. OPGEN (see Appendix D for a more detailed description) was applied to fly wind-optimized flight trajectories, whenever possible, for eligible flights. The flight trajectory flown minimizes the fuel burn in the cruise mode of the flight subject to meeting the desired en route time.

Eligible flights included all aircraft types that flew city pairs at least 750 nmi with a flight-planned altitude at or above FL290 through some point in the Southern Region. RNAV routes in the Southern Region (there were very few) and NRP routes (most of the flights) that met the 750 nmi and FL290 criteria were not simulated through OPGEN to fly wind-optimal routes. They were modeled to fly direct routes (user-preferred routes instead of ATC-preferred routes). The optimization of the flight was performed as long as it interfaced with a boundary within the Southern Region at some point in the flight at FL290 or above. The candidates for optimized (Direct/Wind) flights through the region accounted for approximately 23-24 percent of the total flights in year 2005 (2,692 flights) through 2015 (3,310 flights). OPGEN maintains a separate set of data that includes the restricted SUAs, activation times for the SUAs, winds aloft, and flight information such as aircraft weight over the course of the flight.

2.5.3 Direct Routes

In the simulation, depending on the case, a percentage of the flights are flown as great circle routes (direct routes) whenever possible except when the flight can be optimized with favoring winds. A great circle route is the shortest distance between two points on the surface of the earth. In the simulation, the great circle route was flown between the departure and arrival fix, *not* the originating airport to destination airport. Furthermore, flights were adjusted for the presence of SUA – the flights could either go left, right, above, or below active SUA.

2.5.3.1 RNAV Routes

RNAV is the capability to randomly navigate between two specific points without requiring an aircraft to fly over a NAVAID. It permits aircraft operation on any desired flight path within the coverage of the NAVAIDs. With the advent of multi-sensor GPS systems and advanced FMS, the FAA is proposing to eliminate the dependency on Very High Frequency Omni Range (VOR)-based navigation. The acceleration toward more RNAV routing is gaining momentum with the AOPA, who are currently working with the FAA to approve these routes. A current rulemaking effort is ongoing to fully implement RNAV routing on a nationwide basis.

Several flights are candidates (based on their equipage) for the selection of RNAV routes. Equipment codes /E, /F, and /G were identified for all aircraft equipped to fly advanced FMS and GPS. In addition, codes I and R were identified since they also enable RNAV equipage. The applicable equipment codes identified from the flight plan (FZ) message in the ETMS are defined in Table 4 below.

Table 4: Equipment Capable of Flying RNAV Routes

Aircraft Equipment Suffix	Description
/E	*FMS with en route capability*. Equipment requirements are a) dual FMS which meets the specifications of AC Management systems in Transport Category of Airplane, b) a flight director and autopilot control system capable of following the lateral and vertical FMS flight path, c) a least dual inertial reference unit, and d) a database containing the waypoints for the speed/altitude constraints for the route and/or procedure to be flown that is automatically loaded into the FMS flight plan.
/F	A *single FMS with en route, terminal, and approach capability* that meets the equipment requirements of /E, a through d.
/G	*GPS/GNSS-equipped aircraft* with en route and terminal capability.
/I	*Long Range Navigation System (LORAN), VOR/Distance Measuring Equipment (DME) or Inertial Navigational Reference (INS), transponder with Mode C.*
/R	*Required Navigation Performance* (RNP) (denotes capability to operate in RNP-designated airspace and routes).

The aircraft from these five codes comprise about 57% (33,340 out of 57,993 flights) of the total flights that filed IFR flight plans on August 28. However, just because the aircraft are equipped does not mean that the aircraft will fly an RNAV route.

The OEP [3] cited that 32 percent of the aircraft are equipped (codes E, F, and G) to fly advanced RNAV. The ASD-400 study team found 35% of the flights with those three codes were equipped on August 28th. When codes A, I (transponders with Mode C), and R (RNP) are used, the percentage of RNAV-equipped aircraft is substantially higher at 85%. Code A, which represents DME with a Mode C transponder, is not considered RNAV-equipped. However, several flights that flew RNAV routes through the region utilized ground-based navigation and were identified as Code A flights. Since these flights can also fly RNAV utilizing GPS or FMS, they were included in the RNAV pool. This designation is based on the above aircraft equipment codes from the flight plan (fz) messages in the ETMS.

Yet, of these RNAV-equipped aircraft, a small percentage of the flights were certified to fly approved, published RNAV routes. At the time of this report, there were over 80 proposed Southern Region RNAV routes (see Appendix F). Also, there was very limited information on the specifics of RNAV routes in other regions. The routes, based on input from the Southern Region, are reflected in the current scenario. It is critical that future studies reflect any updated estimates in their analysis so the establishment of RNAV routes can be accounted for.

Once the 2000 baseline was established, it is assumed that the RNAV equipage growth rate will be consistent with the forecast growth in IFR-certified GPS receivers. From an air carrier survey documented in the Satellite Navigation Investment Analysis Report, September 1999 [16], the number of approved RNAV routes were projected to grow consistent with the growth rates annotated in the report, i.e., from 23 percent in year 2000 to 34 percent in year 2005 to 54 percent in 2010, etc. On August 28, 2000, there were 229 RNAV flights identified as being actually flown. Based on the report's growth rate assumptions in GPS receivers, 411 RNAV flights were projected in year 2005, 713 in year 2010, and 836 in 2015. The city pairs with the approved routes are annotated in Appendix F, Table F-1. An example of an active RNAV multi-center route is the FLL to ATL route. Out of 17 flights on August 28, six flights were identified to fly RNAV routes. The sequence of the waypoints and fixes in this RNAV route is ARKES, ORL, CHESN, BAXLY, DBN, and SINCA3 into ATL. This route bypasses the KIZER airspace fix, which was used before the RNAV route was established. The change allows the aircraft to reduce its distance from the original preferred route by 10 miles [17].

The list of 80+ city pairs originally provided by the Southern Region with associated routes and their respective fixes and waypoints are presented in Appendix F. The analysts working with the Southern Region were able to match 42 of these city pairs as being flown on the simulation day. Of the 42 RNAV identified routes in the region, 36 either originated or terminated to/from ATL. The majority of these multi-center routes flies within the region and have an average stage length of approximately 325 nmi[6]. In the future, excursions can easily be done to measure the impact of other RNAV routes as they are approved.

[6] This is in contrast to flights that flew NRP routes and had two percent less than 400 nmi, 44 percent between 400 and 1,000 nmi, and 54 percent greater than 1,000 nmi.

The year 2005 scenario was developed per Southern Region input to reflect the fact that U.S. Airways will have several additional routes between the submitted O-D pairs that were not identified as matched in the year 2000 baseline. In addition, 55 RNAV routes originating from CLT and to/from the seven previously noted Florida airports were factored into the year 2005 scenario. The year 2010 and 2015 RNAV Southern route levels were adjusted as follows: 1) city pairs that were already represented grew proportionally from the RNAV growth rate, and 2) other routes were introduced that included routes of other previously non-represented city pairs from Atlanta and Charlotte, typically for flights within the Southern Region of less than 600 nmi. At this time, there is not an established nationwide RNAV airway[7], but the input from the Southern Region served as the basis for the RNAV contribution estimate in the 2000 baseline.

2.5.3.2 NRP Routes

The Air Traffic Airspace Management Program, Planning and Analysis Division (ATA-200) supplied the August 28th NRP routes to the analysis team. The source data was identified by the "NRP" designation in the ETMS flight plan (FZ) messages. The NRP routes are alternatives to the ATC-preferred routes. At all times, they are supposed to occur for city pairs with flight lengths over 400 nmi that fly over FL290. The provisions for these routes are defined in the FAA Advisory Circular 90-91 and FAA Orders 7110.128 and 7210.3. The flight dispatcher initiates an NRP flight. If the dispatcher feels there is no need to file a route other than the ATC-preferred route, then no action is taken. However, if the fuel burn on a minimum fuel route is significantly less than the burn on the ATC-preferred route, then an "NRP" route, typically a minimum fuel route is submitted.

The routes identified were both eligible and actual flown NRP routes. About 98 percent of the routes actually flew what was filed in the flight plan. This implies that on the simulation day, which appeared to be a very good VFR day, 2 percent of the flights were rerouted, or for some reason, flew an ATC-preferred route. Typically, more flights will submit amendments and not adhere to the originally filed NRP route, e.g., a flight may reroute to avoid traffic congestion at the northwest corner post into Dallas during a thunderstorm.

Of the 2,300+ flights that were identified as flying NRP on August 28, 2000, 54 percent of the flights had a stage length over 1,000 nmi, 44 percent were greater than 400 nmi and less than 1000 nmi, and 2 percent had no match or were less than 400 nmi[8]. The aforementioned breakdown by distance is plausible since the current NRP guidelines stipulate that the flight must be planned on an ATC-preferred route within 200 nmi of the departure airport and within 200 nmi of the designation airport. Overall, on the simulation day, there were 618 flights representing 205 city pairs that flew NRP routes that traversed through the Southern Region.

[7] Per the AOPA web site, there are current RNAV routes established in the Northwest and Western-Pacific Regions; however, the study team did not have sufficient detail to factor these routes into the analysis.

[8] Subsequent analysis of 10 days in late-August and early-September 2001 identified between 1,700 and 2,100 NRP flights. This will be explored further with the baseline being adjusted as necessary.

Therefore, of the 2,300+ flights that were NRP through the NAS on the simulation day, 618 flew NRP routes through one or more of the 158 Southern Region sectors in the baseline year. The logic employed was to fly these routes as direct routes (great circle routes) from the departure fix to arrival fix while considering SUA restrictions and decrementing them from the pool of candidates that flew optimized (Direct/Wind) routes. A complete listing of the NRP city pairs that interacted with a sector within the Southern Region is presented in Appendix G.

Since there is convincing evidence (through the ETMS data) that the NRP participation level has remained fairly stable, the proportion of the NRP routes in the future years grew at the same rate as the projected future demand, 1.4 percent annually in the baseline cases. The number of NRP flights remained the same for each of the cases for the given scenario year.

2.6 Domestic RVSM Assumptions

The potential application of domestic RVSM was applied in future years 2005, 2010, and 2015. The approach in this analysis can be considered a concept of exploration methodology with the goal of presenting a rough-order-of magnitude (ROM) estimate in an area that needs more study. At present, the FAA has committed to working with the airline industry to develop the domestic RVSM implementation and schedule by year 2005 [14]. Flights that cruise at or above FL290 were assumed to be *candidates* to cruise at the even altitudes (providing five additional flight levels, FL300, FL320, FL340, FL360, and FL380)[9]. Currently, flights at or above FL290 feet maintain a 2,000-foot vertical separation and are required to use the odd altitudes based on direction of flight and availability. The 2005, 2010, and 2015 scenarios for case 4 allow a 1,000-foot separation between flight levels 290 and 390. In addition, under the RVSM scenario all aircraft maintain a 60-nmi lateral separation, a 10-minute in-trail separation, and a 15-minute crossing separation [1].

Two flights that are separated by 1,000 feet vertically must adhere to FAA policy that sets standards on vertical separation minimum. These policies are based on direction of flight and navigation aboard an aircraft that will enable it to maintain a 1,000-foot separation from another qualifying RVSM aircraft.

The Aviation Flight Standards, Service Flight Technologies and Procedures Division (AFS-400) provided the study team with a distribution of RVSM-eligible aircraft types from nine of the major air carriers that currently have and are expected to have domestic RVSM capability. Additionally, aircraft types expected to be retired by year 2005 and subsequent years were identified. These retired aircraft include the fleet of Continental's and American's DC-10s, Delta's L1011s, and B727-200s. In Appendix H, Table H-2 identifies the aircraft by carrier that are assumed to fly domestic RVSM in year 2005. In Appendix H, Table H-3 shows a breakdown of the same information by aircraft type. Note: A query of equipment codes with RVSM capability (Q-RVSM and W- an indication of approval or application of Required Navigation Performance (RNP) or RVSM) revealed only 767 flights; 272 flights were code Q and 495

[9] If the decision is made to implement domestic RVSM up to FL410, then one additional flight level, FL400, will be created.

flights were code W. The majority of the flights were international flights. This implies that the codes used in the ETMS does not accurately reveal the equipage like the AFS input. One reason could be that aircraft that fit into multiple equipment code categories are assigned to only one code, e.g., a code F could also be an RVSM-equipped aircraft. This finding needs to be investigated in subsequent analyses.

Almost 50 percent of the simulated flights flew at or above FL290 in each of the simulation years; therefore, if the aircraft at a given flight level and 2,000 feet above that flight level was equipped, the aircraft at the lower flight level moved up 1,000 feet. In year 2005, 1,822 flights out of 5,541 flights moved up to an even altitude; in year 2010, 1,972 flights out of 6,123 moved up to an even altitude; and in year 2015, 2,207 flights out of 6,652 moved up to an even altitude. The remainder of the flights, which included flights without qualifying aircraft, stayed at the same altitude.

The logic of selection of the cruise altitude was based on direction of flight, availability, and whether fuel could be reduced from a different flight level that was recorded in the ETMS data. Availability depends on the longitudinal separation between successive flights along a desired path and direction of the flight. For instance, if a flight was recorded at cruise FL350, the algorithm would examine the feasibility of moving this flight up to FL360. A B757, which represents an average size aircraft, burns 130.5 pounds per minute at FL350; at FL360 it burns 129.5 per minute, a 0.7 percent improvement [13].

In addition to removing certain aircraft types that are expected to be retired by year 2005, the TAF annual growth rate of approximately 1.5 percent was applied to the traffic increase between city pairs for the future scenarios. Boeing provided future aircraft fleet mix projections.

2.7 Special Use Airspace

SUA consists of airspace of defined dimensions identified by an area on the surface of the earth where limitations are imposed upon aircraft operations. The information goes into four primary groupings: boundaries, designated altitudes, time of designation, and controlling agency. The boundaries include the vertical limits, measured by designated altitude floors and ceilings, and horizontal limits, measured by boundaries described by geographic coordinates. In addition, the time designation that the SUA is in effect and/or prohibited is stated.

OPGEN applies the SUA activities file on a flight-by-flight basis to determine if the flight passes through active SUA. The flight can go either left, right, above, or below SUA. If SUA imposes significant restrictions, the optimizer avoids interacting with the SUA. Listed below is an example of how an SUA is denoted in Air Traffic Order 7400.8HFAA, *Special Use Airspace*. It is presented for a representative area along the east.

R-2936 West Palm Beach, FL

Boundaries: The airspace within a one nmi radius centered at lat 26 degrees, 5', 10" N, long 80 degrees 22'55"W

Designated Altitudes: Surface to and including 10,000 feet MSL

Time of Designation: Intermittent by Notice to Airmen (NOTAM)

Controlling Agency: FAA PALM BEACH ATCT

Using Agency: United Technologies, Pratt and Whitney Company, West Palm Beach, Fl

3.0 RESULTS FROM THE SOUTHERN REGION

Several metrics from the activity in the Southern Region were evaluated for scenario years 2000 through 2015. The results for fuel burn, distance, and time are presented in each sub-section in three different variations: 1) Scenario Analysis: total metric savings or benefits by scenario/case relative to the baseline, 2) Marginal Scenario Analysis: metric savings by routing type, and 3) Marginal Metrics per Marginal Flight. Additionally, metrics on conflicts, sector activity, and operational delay are also presented.

Scenario/case (relative to the baseline) analysis: measures the difference between an alternative case and the reference case. Each of the alternative cases is sequentially built upon the previous case and only adds additional routing types; therefore, this measure of metrics evaluates combinations of alternative routing strategies. For example, the RNAV case uses the same assumptions as the baseline except that the RNAV case adds additional RNAV flights. The optimized (Direct/Wind) case adds flights that are candidates for optimized (Direct/Wind) flights to the previous RNAV case. Lastly, the RVSM case adds domestic RVSM flights to the optimized (Direct/Wind) flights. Therefore, comparing the RVSM case to the baseline yields a total metric for the addition of all RNAV, optimized (Direct/Wind), and RVSM routings. This metric assesses the maximum savings associated with the implementation of all of the advanced routing types. Similarly, the total metric savings from the optimized (Direct/Wind) case measures the benefits from additional optimized (Direct/Wind) and RNAV flights above the baseline. The RNAV case represents the contribution to total benefits from adding only more RNAV flight routings beyond the baseline. Metrics may be presented as total savings or savings per flight.

Marginal scenario analysis: refers to metric savings associated only with a particular type of routing option. Since the RVSM case consists of three routing types (i.e., RNAV, optimized (Direct/Wind), and RVSM) and the optimized (Direct/Wind) case consists of two routing types (i.e., RNAV and optimized (Direct/Wind)), by subtracting the optimized (Direct/Wind) case metrics from the RVSM case metrics results in the marginal metrics associated with the additional RVSM flights. Subsequently, if the RNAV case metrics are subtracted from the optimized (Direct/Wind) case metrics, the marginal metrics represent those arising from additional optimized (Direct/Wind) flights only.

Marginal metrics per marginal flight: refers to metric savings associated only with an average RNAV flight, average optimized (Direct/Wind) flight, and an average RVSM flight. By making direct flight-to-flight routing comparisons, the results will determine the relative efficiency savings among the routing options. These results will be discussed in detail in section 3.4.

Table 5 presents a summary of the fuel, distance, and timesavings per flight for the different cases; Table 6 summarizes the total savings metrics from the marginal scenario analysis; and Table 7 below contains the metric savings per flight by marginal routing type.

Table 5: Scenario Analysis Results

	Fuel Burn Savings per Flight (lbs)			Distance Savings per Flight (nmi)			Timesavings per Flight (mins)		
	2005	**2010**	**2015**	**2005**	**2010**	**2015**	**2005**	**2010**	**2015**
Base + RNAV	1.0	3.6	3.8	0.1	0.2	0.2	0.01	0.03	0.03
(Percent)	0.01%	0.04%	0.04%	0.01%	0.04%	0.04%	0.01%	0.03%	0.03%
Direct/Wind	53.5	72.2	60.9	2.0	2.2	2.4	0.65	0.69	0.74
(Percent)	0.57%	0.76%	0.62%	0.38%	0.42%	0.45%	0.70%	0.74%	0.78%
RVSM	127.5	141.0	147.5	2.0	2.2	2.4	0.66	0.70	0.76
(Percent)	1.37%	1.48%	1.51%	0.38%	0.42%	0.45%	0.71%	0.75%	0.80%

Table 6: Marginal Scenario Analysis Results

	Total Fuel Burn Savings (lbs)			Total Distance Savings (nmi)			Total En Route Timesavings (hrs)		
	2005	**2010**	**2015**	**2005**	**2010**	**2015**	**2005**	**2010**	**2015**
Base + RNAV	11,952	46,491	52,275	608	2,429	2,761	2.0	6.0	7.0
(Percent)	0.01%	0.04%	0.04%	0.01%	0.04%	0.04%	0.01%	0.03%	0.03%
Direct/Wind	623,250	877,997	783,225	22,656	25,673	30,126	127.0	142.0	163.0
(Percent)	0.56%	0.72%	0.58%	0.37%	0.38%	0.41%	0.69%	0.71%	0.75%
RVSM	878,713	882,215	1,187,118	115	128	129	2.0	2.0	3.0
(Percent)	0.80%	0.72%	0.88%	0.00%	0.00%	0.00%	0.01%	0.01%	0.01%

Table 7: Marginal Metrics Savings per Marginal Flight Results by Routing Type

	Fuel Burn Savings per Flight (lbs)			Distance Savings per Flight (nmi)			En Route Timesavings per Flight (mins)		
	2005	**2010**	**2015**	**2005**	**2010**	**2015**	**2005**	**2010**	**2015**
Base + RNAV	157.3	155.5	154.7	8.0	8.1	8.2	1.6	1.2	1.2
(Percent)	1.69%	1.63%	1.58%	1.55%	1.56%	1.54%	1.69%	1.28%	1.31%
Direct/Wind	231.5	297.2	236.6	8.4	8.7	9.1	2.8	2.9	3.0
(Percent)	2.49%	3.11%	2.42%	1.63%	1.67%	1.72%	3.03%	3.07%	3.12%
RVSM	164.0	148.4	184.0	0.02	0.02	0.02	0.02	0.02	0.03
(Percent)	1.76%	1.55%	1.88%	0.00%	0.00%	0.00%	0.02%	0.02%	0.03%

The majority of the city pairs benefited from additional direct and/or wind-optimized routing. Table 8 below provides a representative sample on the baseline day of several key city pairs that traversed the Southern Region. Average daily fuel burn and distances are shown. As an illustration, ATL to MIA, a flight that flew within the Southern Region averaged 551 miles with a fuel burn of 13,403 pounds on an ATC-preferred route; 535 miles with a fuel burn of 12,844 pounds on a direct route; differences of about 4 percent in both fuel burn and distance. An illustration of fuel burn for representative aircraft type is presented in Appendix C, Table C-3.

Table 8: Illustration of Difference in Direct and ATC-Preferred Routing

	ATC-Preferred Route		Direct/Wind Opt		Pct Difference	
City Pair	Fuel burn (lbs)	Dist (nmi)	Fuel burn (lbs)	Dist (nmi)	Fuel burn (lbs)	Dist (nmi)
ATL - MIA	13,403	551	12,844	535	4.4%	3.9%
MIA - JAX	2,325	305	2,295	284	1.3%	7.4%
MIA - IAD	17,478	846	17,445	825	1.9%	2.5%
DFW - TPA	16,855	852	16,834	836	1.9%	0.1%
MSY - ORD	17,500	809	15,862	752	10.3%	7.6%
FLL - MCO	3,102	165	3,002	160	3.3%	3.1%

3.1 Fuel Burn

3.1.1 Scenario Analysis: Total Fuel Burn Savings

Figure 7 displays years 2005 through 2015 fuel savings from the three cases: Base + RNAV, Direct/Wind, and RVSM. The RVSM case, which contains all three routing options (direct routing, optimized (Direct/Wind), and RVSM), provides the greatest total fuel savings of approximately 1.51 – 2.02 million pounds of fuel per day or 1.4 - 1.5 percent of all daily fuel use in the Southern Region between years 2005 and 2015. If only direct routing and wind-optimized routes are expanded (the Dir/Wnd case), then fuel savings approach 0.64 - 0.92 million pounds of fuel per day. With only increased RNAV flights represented by the Base + RNAV case, the fuel savings only amount to 0.01 to .05 million pounds of fuel per day.

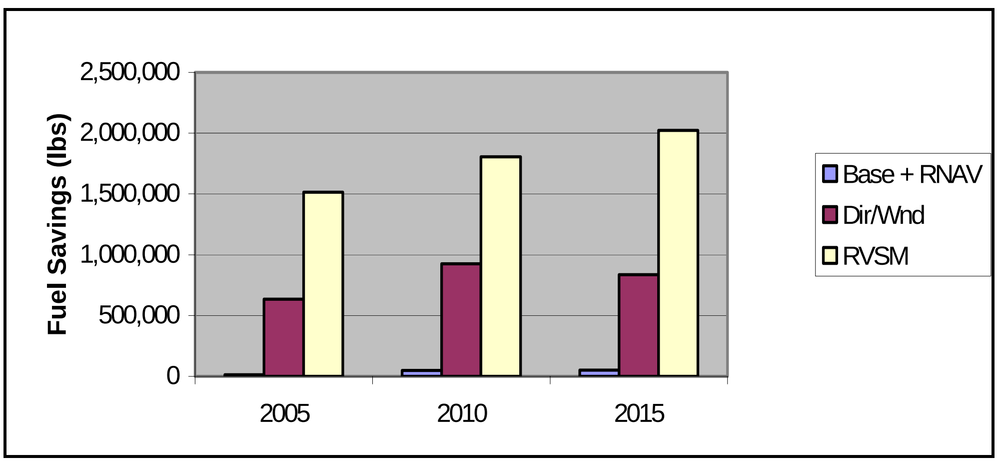

Figure 7: Total Fuel Savings by Scenario Analysis Case

3.1.2 Scenario Analysis: Average Fuel Savings per Flight

The average fuel burn per flight in the en route phase is depicted in Figure 8. The average fuel burn in the baseline increased slightly to almost 9,800 pounds by 2015, due to an increased demand in the relatively longer haul common city pairs, while GA traffic, typically short flights in turboprop aircraft, remained constant.

On a per flight basis, the RVSM case provides the largest fuel savings of about 128 to 148 pounds of fuel or 1.4 to 1.5 percent of all fuel consumed per flight in years 2005 and 2015. The most significant difference on a per flight basis was between the RVSM case and the optimized

(Direct/Wind) case in 2015, since approximately 47 percent of the flights flew an RVSM route, typically at a higher flight level minimizing fuel use. The fuel savings per flight in the Direct/Wind case also generated significant fuel savings, also due to over 23 percent of the flights flying Direct/Wind, which usually represent the highest fuel savings per flight. Since there was little change in the average per flight metric between the baseline and the Base + RNAV case, it can be concluded that the additional optimized flights in the Direct/Wind case and the RVSM flights significantly contributed to the overall decline in fuel burn per flight. RNAV flights comprise only 6 percent of all flights. The marginal analysis below will discuss this phenomenon in more detail.

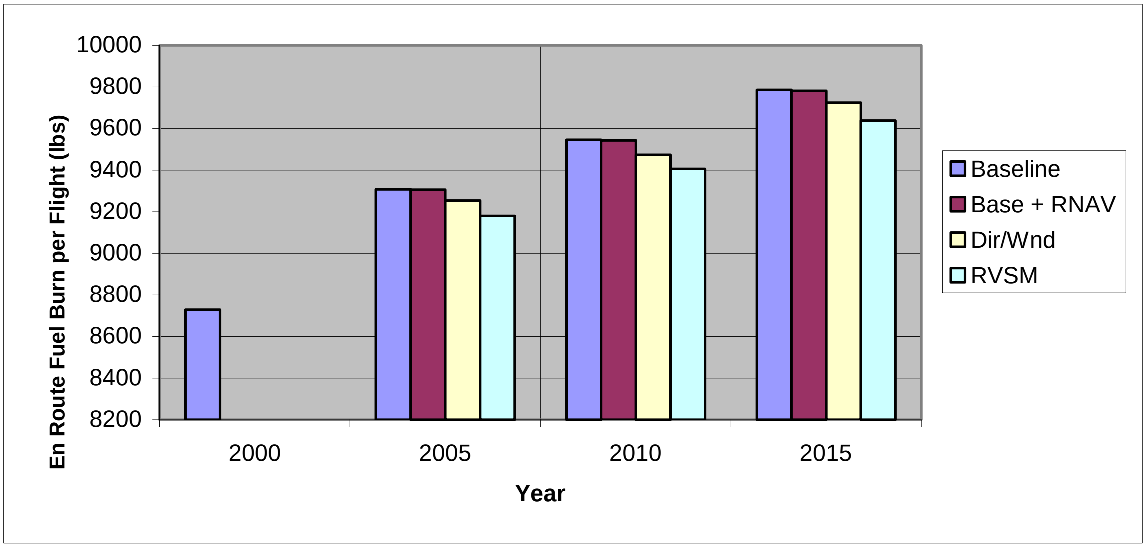

Figure 8: Scenario Analysis: En Route Fuel Burn per Flight

3.1.3 Marginal Scenario Analysis: Fuel Burn Savings by Routing Type

Alternatively, metrics can be viewed by analyzing differences in metrics by routing type rather than by scenario case (Figure 9). By measuring the marginal differences between sequential cases, an approximation can be estimated of the value in total metrics from the addition of a particular routing type. The RVSM flights provide over 59 percent of all of the fuel savings by 2015, 39 percent from additional Direct/Wind routings, and only 3 percent from additional RNAV routings. These results appear to be consistent with the number flights, as 59 percent flew RVSM, 39 percent flew optimized (Dir/Wnd flight), and only 6 percent flew RNAV.

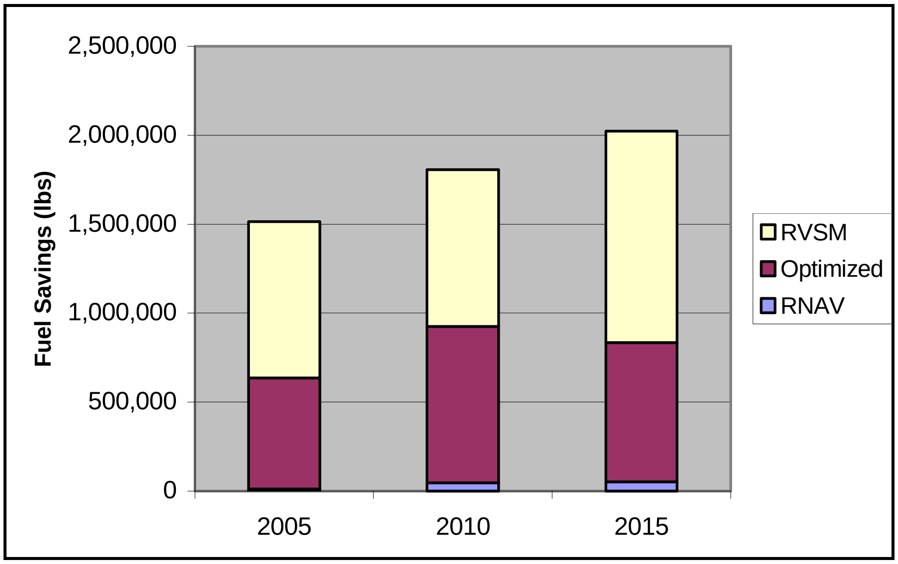

Figure 9: Marginal Scenario Analysis: Fuel Savings by Type of Route

3.2 En Route Distance

Figure 10 illustrates that the average en route distance of flights in the Southern Region is estimated to increase from approximately 516 miles in 2000 to 530 miles by 2015. The TAF contains future trends of longer distances per flight, which provides greater opportunities to save distance by alternative routing methods in the future.

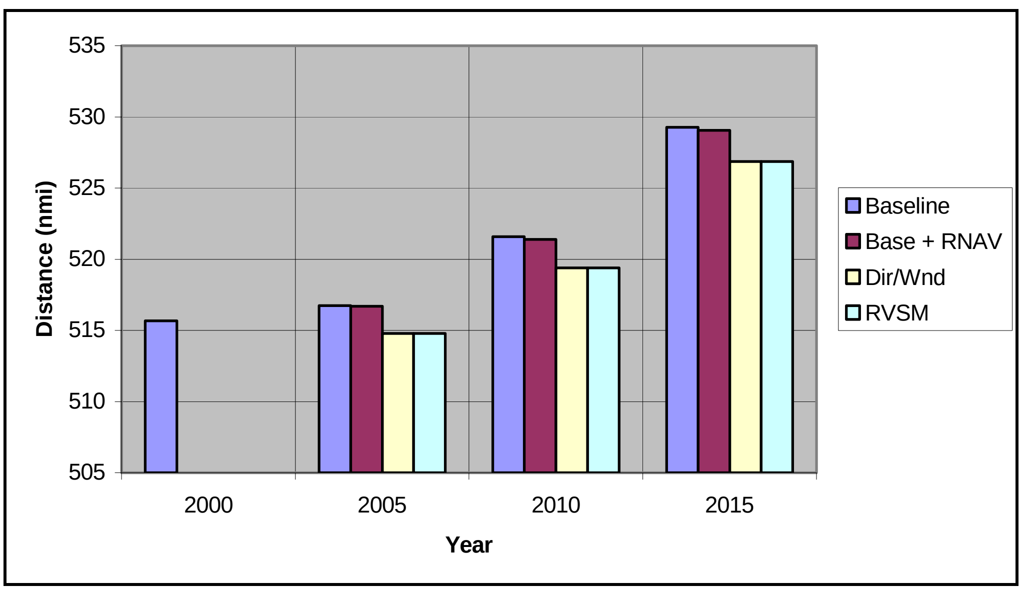

Figure 10: Scenario Analysis: Average En Route Distance per Flight

3.2.1 Scenario Analysis: Average Distance Savings per Flight

Although total distance saved in the most optimistic scenario (RVSM case) grows almost 150 percent from years 2005 to 2015, the total distance saved represents only 0.45 percent of the total distance flown in year 2015.

The most optimistic RVSM case only yields approximately 2.0 - 2.4 nmi saving per flight from year 2005 to 2015 (Figure 11). By comparison, the optimized case (Direct/Wind) provides the same overall distance savings per flight as the RVSM case, at 2.0 - 2.4 nmi on average from year 2005 to 2015. Additional RVSM flights in the RVSM case do not provide any additional distance savings per flight. Distance savings are also minimal from the RNAV (Base + RNAV) case at 0.1 to 0.2 nmi per flight from year 2005 to 2015. Therefore, it appears that the greatest contribution to distance savings originates from the optimized flights, which is borne out in the marginal scenario analysis by routing type section below.

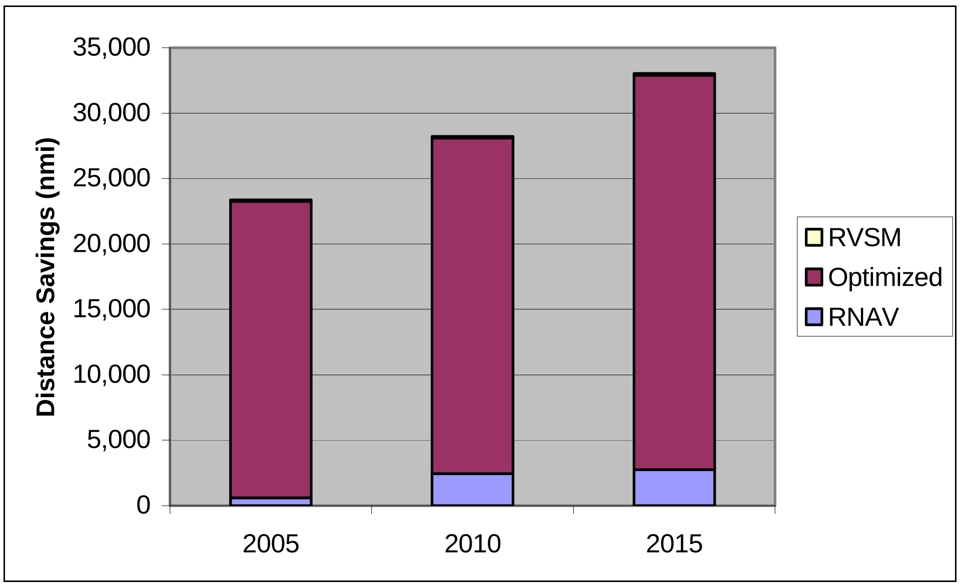

Figure 11: Marginal Scenario Analysis: Distance Savings by Routing Type

3.2.2 Marginal Scenario Analysis: Distance Savings by Routing Type

The marginal scenario analysis confirms the conclusions that optimized flights (from the Direct/Wind case) contribute the largest portion of the total distance savings. Optimized (Direct/Wind) flights provided 91.3 percent of the distance savings, with RVSM routes at 0.4 percent and RNAV flights with 8.4 percent by year 2015.

3.3 En Route Time

Figure 12 below shows that the extrapolation of the time metrics to the NAS would not be appropriate since the average en route time in the Southern Region is 94-95 minutes, less than the rest of the NAS on August 28, 2000, of approximately 101 minutes. Furthermore, the flights that flew through the Southern Region comprise about 20 percent of the flights that fly through the NAS.

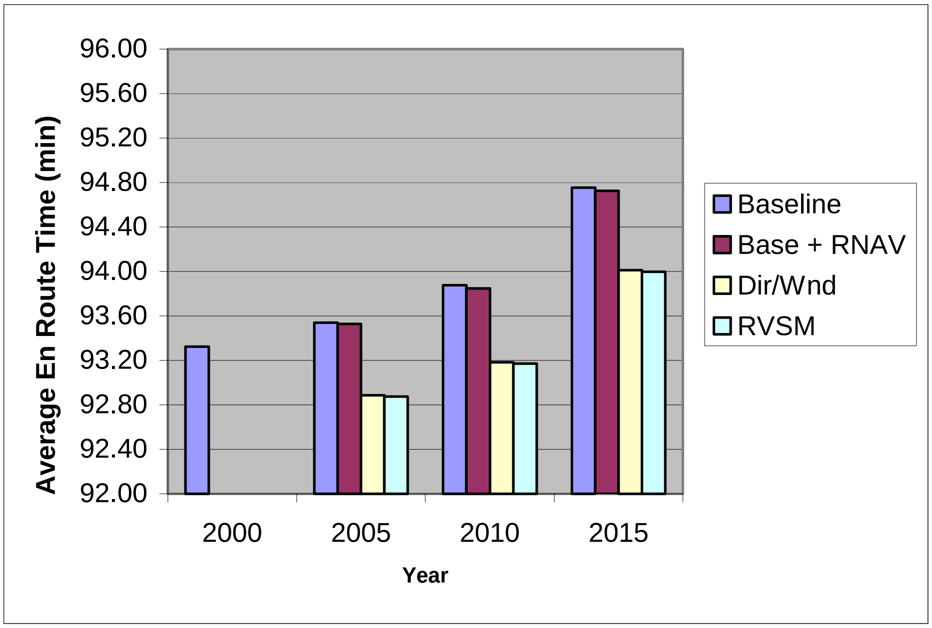

Figure 12: Scenario Analysis: Average En Route Time per Flight

3.3.1 Scenario Analysis: Average Timesavings per Flight

The timesaving metric mirrors the results in the distance saving metric. The largest timesavings per flight occur with the RVSM case, but yield only 0.66 to 0.76 minutes timesavings between years 2005 and 2015. These savings amount to only 0.8 percent of the total en route time in year 2015. The optimized Direct/Wind case provides between 0.65 to 0.74 minutes savings per flight from years 2005 to 2015. Because of the small increase in timesavings between the RVSM and the Direct/Wind case, it can be concluded that the additional RVSM flights do not contribute much to the timesavings overall. (See marginal scenario analysis below). Minimal timesavings also come from the RNAV case, 0.01 to 0.03 minutes per flight over the same time period.

3.3.2 Marginal Scenario Analysis: Timesavings by Routing Type

Although almost similar timesavings benefit contributions result from both the RNAV (4.1 percent) and RVSM routes (1.7 percent) in the 2015 time period, the vast majority of the total timesaving benefits originate from the addition of optimized flights (Direct/Wind case). These optimized flights in the Direct/Wind case comprise over 94.2 percent of the total timesavings benefits (see Figure 13).

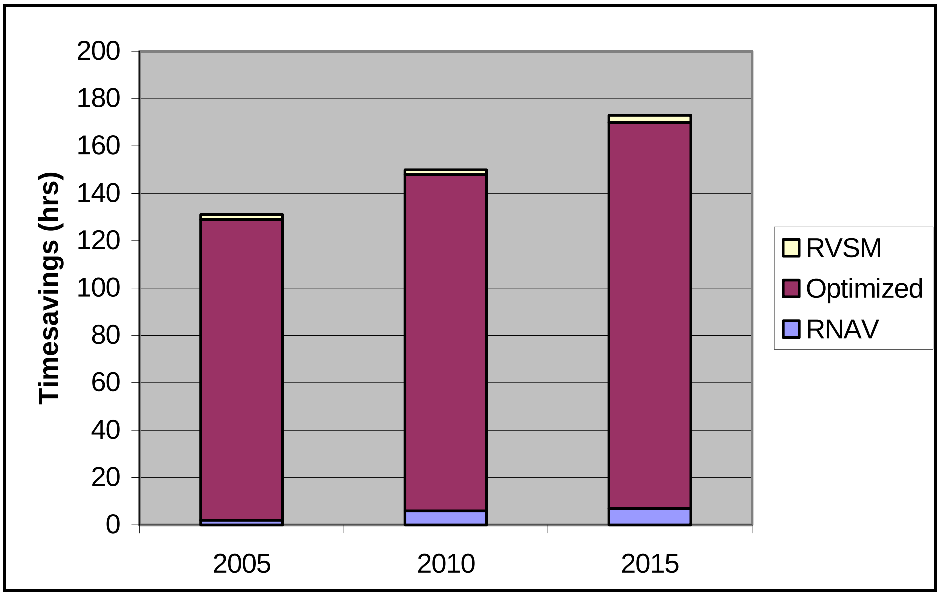

Figure 13: Marginal Scenario Analysis: En Route Timesavings by Routing Type

3.4 Marginal Metrics per Marginal Flight Comparisons

The previous measures of metrics were calculated by dividing the number of total flights into the total metric savings, which yielded metrics on a per flight basis. Listing the total metric savings associated with each scenario case and each routing type provided comparisons. Although these comparisons permit analysis of each routing option's contribution to the total metric savings and the contribution of combinations of programs, both are a function of the relative penetration of the enabling equipage rates and the potential opportunities for application of the routing options. If a plane is not equipped to fly direct routing or if the prevailing winds are not available, then routing options would have to default to the preferred routing. Furthermore, using a per flight metric is deceiving because the total metric savings are diluted by the total number of flights, even those that did not provide the metric savings.

A quick glance at the flight distributions across the cases will lead to a very different picture of the relative benefits of each type of routing option. The flight distributions contained in Figure 14 indicate that there are approximately 3,310 additional optimized (Direct/Wind) flights in year 2015 or more than three times the number of RNAV flights at 836. Likewise, there are over 6,450 RVSM flights by year 2015, almost twice the number of optimized flights. Therefore, *a priori* one would expect that all of the RVSM flights (and to a lesser extent the optimized Direct/Wind flights) provide the greatest benefits regardless of the metric. This conclusion was borne out through the previous metric sections.

However, if a metric is calculated based on estimating the marginal metric savings (as in the marginal scenario analysis sections), and then dividing it by the additional routing flights that contributed the savings, then this allows a direct comparison between routing options on a per flight basis. The pertinent question then becomes, "Which routing option provides the greatest marginal benefits or metrics per flight?"

3.4.1 Marginal Fuel Burn Metrics by Marginal Flight by Routing Type

By contrast to the marginal scenario analysis section (which found that the RVSM flights in total contributed the most to fuel savings), fuel savings per marginal flight is the greatest for optimized Direct/Wind flights, which is one of the major reasons commercial airlines fly optimized flights. On average, in the Southern Region from year 2005 to 2015, optimized flights save approximately 232 to 297 pounds of fuel per flight or 2.4 - 3.1 percent of the fuel burned per flight. By comparison, the RVSM flights save 148 to 184 pounds of fuel per flight or 1.6 to 1.9 percent of fuel consumed per flight from year 2005 to 2015. The differential is approximately 52 pounds of fuel per flight savings for optimized Direct/Wind over RVSM flights. This represents almost a 29 percent additional fuel savings per flight for optimized flights above the RVSM flights (see Figure 14).

RNAV flights also provide significant fuel savings for those flights that fly direct RNAV routes. Approximately 155 – 157 pounds of fuel per flight are saved from year 2005 to 2015, which equates to between 1.6 and 1.7 percent of the total fuel consumed per flight. The Direct/Wind flights represent those flights that are greater than 750 nmi and are longer haul than RNAV flights that average approximately 300 nmi. The longer flight length of the Direct/Wind flights provides greater opportunity to generate fuel savings. Furthermore, the Direct/Wind flights are comprised of both longer haul direct routing flights and wind-optimized, in which the latter generate the largest fuel savings per flight of any routing option. (This will be discussed further in the Optimized Direct/Wind Flights Analysis section).

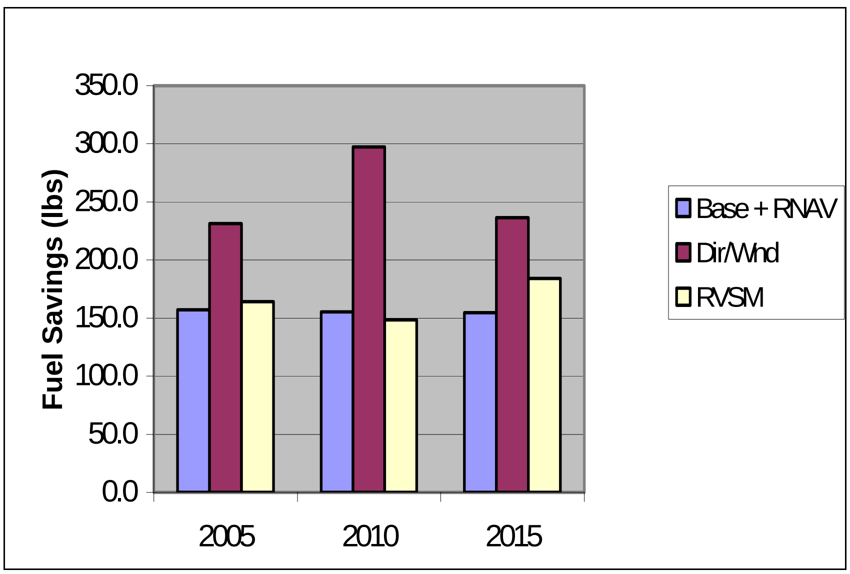

Figure 14: Marginal Fuel Savings per Marginal Flight by Routing Type

3.4.2 Marginal En Route Distance Metrics per Marginal Flight by Routing Type

The optimized (Direct/Wind) routing flights also provide the greatest distance savings per flight of about 8.4 - 9.1 nmi per flight from year 2005 to 2015. Direct RNAV routing yields approximately 8.0 – 8.2 nmi per flight, similar to the magnitude achieved with the optimized (Direct/Wind) flights. RVSM yields almost no distance savings per flight, which was also confirmed by the scenario analysis in the previous sections. Therefore, if distance is the metric used to evaluate potential routing benefits, optimized (Direct/Wind) flights and RNAV direct routing provide the highest level of benefits as measured by distance savings per flight (see Figure 15).

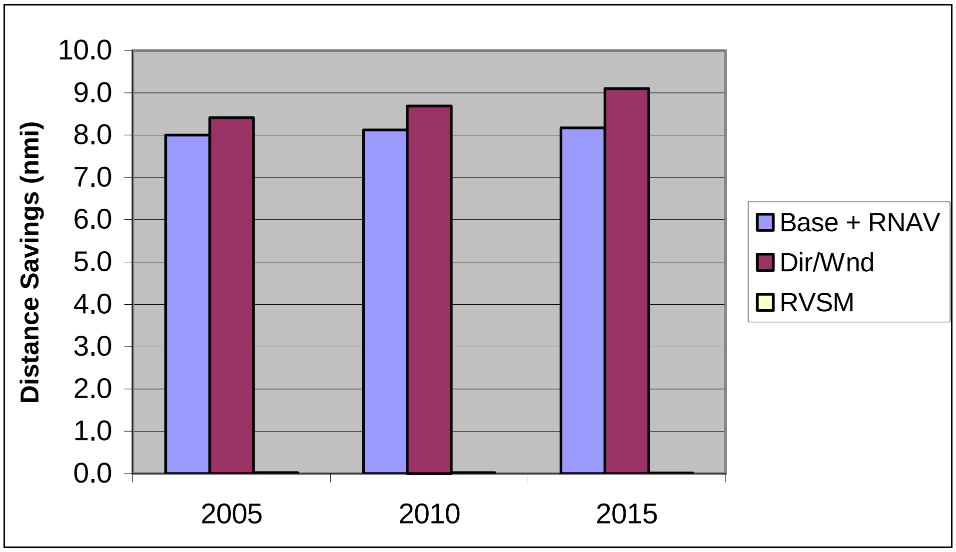

Figure 15: Marginal Distance Savings per Marginal Flight by Routing Type

3.4.3 Marginal En Route Time Metrics per Marginal Flight by Routing Type

Similar to the distance metrics, optimized (Direct/Wind) routing generates the most en route timesavings per flight, on the order of approximately 2.8 to 3.0 minutes per flight compared to RNAV direct flights at 1.2 to 1.6 minutes per flight between years 2005 and 2015. The optimized (Direct/Wind) flights therefore provide additional benefits beyond the RNAV flights (see Figure 16). This result would certainly be expected given that the optimized (Direct/Wind) flights represent longer haul flights that could potentially provide more opportunities to save en route flight time. Wind-optimized flights, which are contained as a subset of the optimized (Direct/Wind) flights, may also save flight time, because they only fly wind-optimized when the winds are favorable. When the winds are not favorable, these potential wind-optimized flights may possibly fly direct instead.

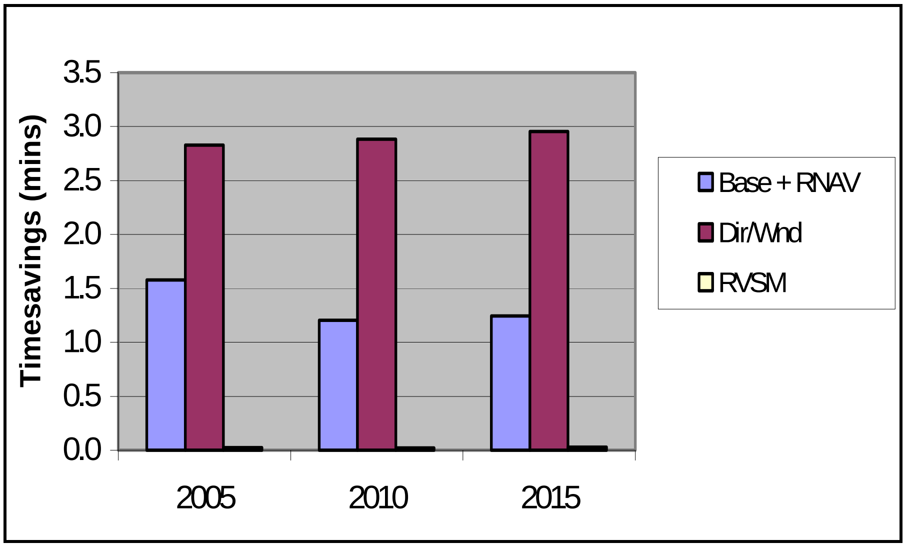

Figure 16: Marginal Timesavings per Marginal Flight by Routing Type

3.5 Optimized Direct/Wind Flights Analysis

In the previous section, the results indicated that the optimized (Direct/Wind) flights provided the greatest benefits per flight among the three routing options. These optimized flights are a combination of both longer haul direct routing and wind-optimized flights. Approximately 52 - 53 percent of all optimized flights are long haul direct flights and the remaining flights comprise the wind-optimized category, 47 percent (see Table 9).

Table 9: Marginal Metric Savings per Optimized Flights in the Direct/Wind Case

Metric per Flight	Year		
	2005	2010	2015
Direct Routes			
Fuel (lbs)	150.00	143.73	150.50
Distance (nmi)	14.58	15.26	16.06
Time (min)	3.83	3.96	4.08
Wind Routes			
Fuel (lbs)	323.48	325.00	330.02
Distance (nmi)	1.46	1.49	1.56
Time (min)	1.71	1.70	1.74

Although the following analysis does not exactly compare the same flights, the results are valid estimates for comparative purposes. Rather than examining a hypothetical situation of exact matching of flights, the analysis below attempts to make comparisons based on flights that optimize their metrics given actual flights from ETMS and TAF projections. Therefore, the resulting metrics are more meaningful because they are based on actual flights.

3.5.1 Fuel Savings Metrics for Optimized (Direct/Wind case) Flights

Although both direct and wind-optimized flights provide significant fuel savings per flight, wind-optimized flights from the optimized Direct/Wind category yield more than twice the fuel savings as the direct routing flights. On average, wind-optimized flights saved approximately 323 to 330 pounds of fuel per flight, while the direct routes ranged from 144 to 151 pounds per flight. Fuel savings are one of the main reasons that commercial airlines engage in wind-optimized flights.

3.5.2 Distance Metrics for Optimized (Direct/Wind case) Flights

The average distance saved by direct routes within the optimized Direct/Wind flights is approximately 14.6 to 16.1 nmi per flight. This represents a significant improvement over wind-optimized Direct/Wind flights, nearly a factor of 10 times the distance savings per flight as wind-optimized flights (which save about 1.5 to 1.6 nmi).

When compared to shorter haul RNAV flights, these longer haul direct Direct/Wind flights yield almost twice the distance savings, 16.1 nmi versus 9.1 nmi in 2015.

3.5.3 Timesaving Metrics for Optimized (Direct/Wind case) Flights

When comparing timesavings, again, the Direct/Wind flights produce more than twice (2.3X) the savings as wind-optimized Direct/Wind flights. These longer haul direct routes save about 3.8 to 4.1 minutes per flight, while the wind-optimized flights are half the savings at 1.7 minutes per flight.

The shorter haul RNAV flights do not provide as much of an opportunity to save time as the longer haul Direct/Wind flights that are over 750 nmi. These longer haul direct flights save approximately 4.1 minutes per flight, while the shorter haul RNAV flights from the Base + RNAV case reduce flight time on average by 1.2 minutes.

3.6 Comparisons to Actual ETMS Data

A randomly chosen day was evaluated to determine if the above metric savings were within actually achievable limits based on NRP direct routing flights in the Southern Region. On September 4, 2001, the following selected flights from POET, which contains ETMS actual flight messages, were found in the NAS to closely correspond with the results found in this study. (See Table 10)

Table 10: ETMS NRP Routes versus ATC-preferred Routes: Time and Distance Metrics

Departure Airport	Arrival Airport	Number of Flights	ATC-Pref Route Distance (nmi)	NRP Route Distance (nmi)	Actual Air Timesavings (mins)	Actual Distance Savings (nmi)
FLL	ATL	14	516	494	4.5	22
SFO	ATL	5	1876	1857	7.0	19
ATL	MSP	2	807	785	7.0	22

3.7 Conflicts

Figure 17 depicts the reduction in conflicts associated with each of the four cases. By far, the largest reduction in conflicts results in the RVSM case of almost 849 fewer conflicts in total. This is tantamount to over a 65 percent reduction in conflicts relative to the base case in 2010. It is also important to determine the time length of the conflict, because the longer the period of the conflict, the greater the chance for the conflict to increase in severity from a distance perspective and possibly lead to an operational error. The distribution across varying conflict time lengths in the baseline case is shown in Figure 18 for the year 2010. It is clear that the vast majority of the conflicts occur in the less than one-minute time period, approximately representing over 81 percent of all conflicts. As shown in Figure 18 below, it is also evident that the greatest reduction in total conflicts (693 less conflicts) occurs in the less than one-minute duration segment leading to a 74 percent reduction in conflicts. Therefore, RVSM significantly reduces total conflicts, but also eliminates them in the time duration where most of the conflicts occur.

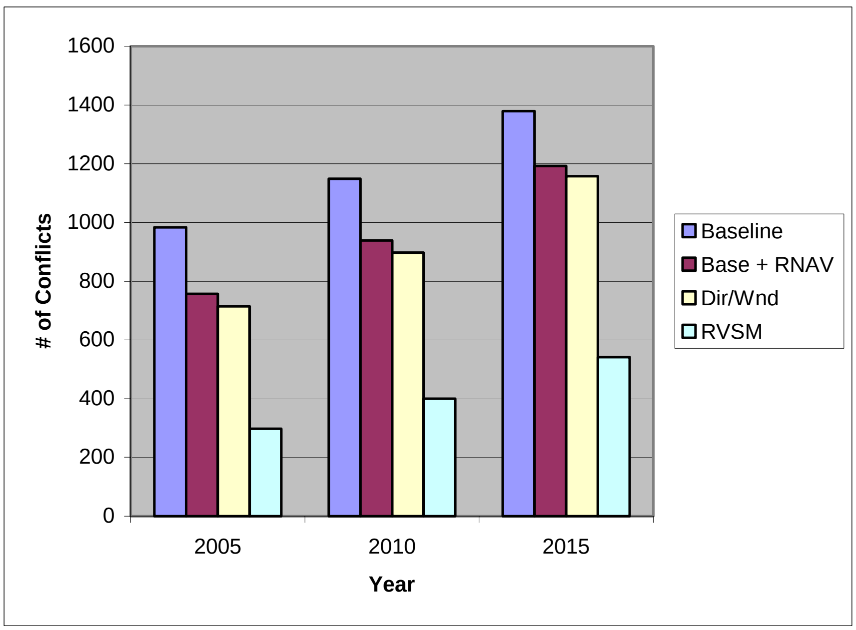

Figure 17: Total Conflicts Above FL290

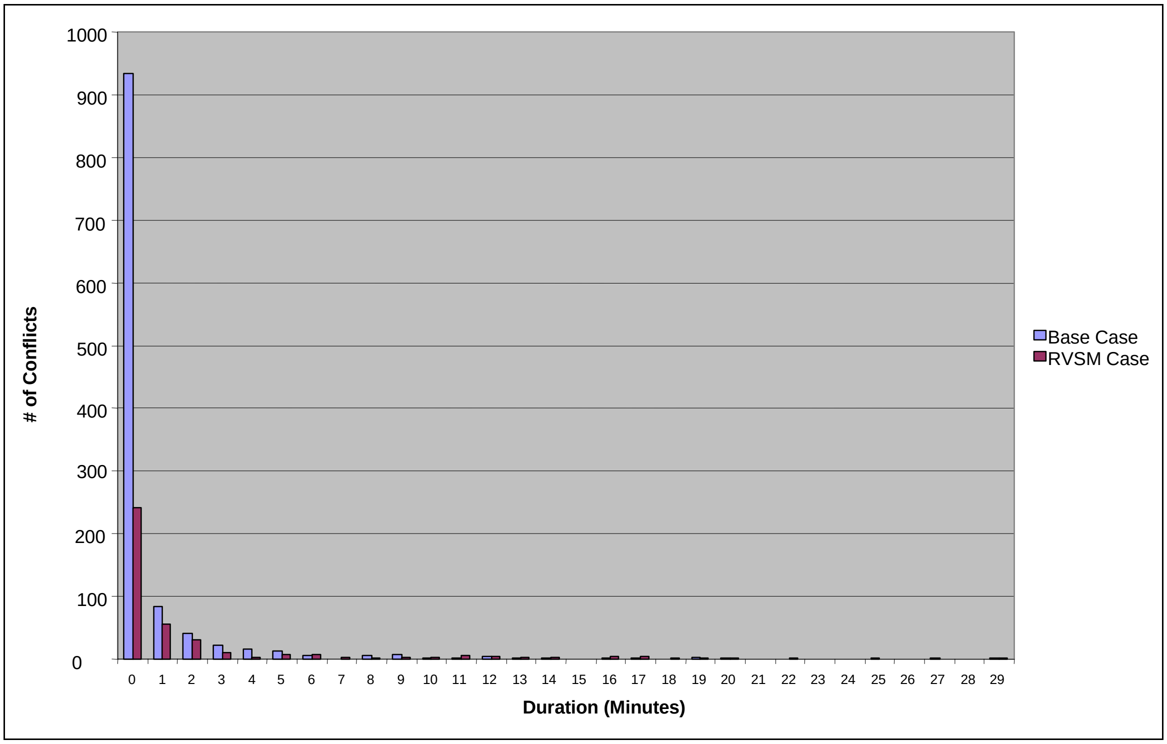

Figure 18: Duration of Conflicts (2010 Case)

3.8 Sector Attributes

There are 158 sectors in the Southern Region that had traffic on the simulation day. Of these 158 sectors, 37 sectors were identified as either high (FL240-FL350) or super-high sectors (higher than FL350) in the three regions. A breakdown of these sectors with the average daily sector throughput for the baseline and RVSM cases is presented below in Table 11.

Table 11: Sector Throughput

Sector	2005		2010		2015	
	Base	RVSM	Base	RVSM	Base	RVSM
ZJX015	568	694	653	653	727	885
ZJX016	572	661	634	634	707	772
ZJX017	515	433	579	579	649	504
ZJX030	287	342	322	317	371	483
ZJX033	335	356	410	382	427	393
ZJX034	503	384	563	558	619	374
ZJX035	130	100	122	161	170	250
ZJX048	226	290	256	290	346	582
ZJX049	379	437	384	487	508	829
ZJX051	404	330	435	431	458	314
ZJX055	16	105	17	22	22	396
ZJX066	445	436	487	467	502	364
ZJX067	229	229	283	317	394	485
ZJX076	405	323	497	539	668	623
ZJX077	298	316	311	310	332	351
ZJX078	460	642	614	509	554	873

Table 11: Sector Throughput, Cont'd

Sector	2005		2010		2015	
	Base	RVSM	Base	RVSM	Base	RVSM
ZMA002	417	462	498	509	491	536
ZMA005	267	268	276	272	321	296
ZMA025	364	336	404	411	459	313
ZMA040	242	245	242	241	242	247
ZMA059	157	155	154	151	156	153
ZMA060	256	253	256	262	256	251
ZMA065	299	330	333	368	487	515
ZTL002	515	489	630	692	762	715
ZTL003	628	678	710	675	729	756
ZTL006	548	552	601	685	651	558
ZTL008	288	221	345	374	382	298
ZTL010	400	318	434	423	451	265
ZTL011	333	315	354	344	319	305
ZTL015	366	372	456	473	569	690
ZTL023	462	433	537	567	687	734
ZTL033	576	571	604	587	631	585
ZTL034	283	275	298	334	328	356
ZTL036	216	251	272	276	398	509
ZTL037	505	590	530	510	635	609
ZTL040	479	412	618	665	756	627
ZTL043	654	623	672	665	701	597
ZTL050	741	735	765	720	881	892

Table 12 shows the sectors that where maximum instantaneous counts exceeded the MAP thresholds in the RVSM scenario. Virtually all of them occurred in the high and super-high ZTL sectors. All cases are shown for each scenario year. Table 12 also illustrates that the ZTL sectors show the greatest amount of disruption on the flights. The majority of delays in the simulation were on the ground and in the terminal area.

Table 12: High and Super-High Sectors Exceeding MAP

Sector	MAP Threshold	2000 Base	2005 RVSM	2010 RVSM	2015 RVSM
ZJX015	18			X (18)	X (22)
ZTL003	15		X (16)		
ZTL006	13			X (15)	
ZTL015	18			X (18)	X (19)
ZTL023	18			X (20)	X (19)
ZTL033	17			X (18)	
ZTL037	13		X (14)	X (14)	
ZTL040	18			X (20)	
ZTL043	13	X (14)	X (16)	X (14)	
ZTL050	15		X (17)	X (17)	

Figure 19 shows the number of minutes the MAP thresholds were exceeded in the high and super-high sectors in the region. The time exceeding the MAPS are considerably less in Direct/Wind and RVSM cases than in the baseline cases. The MAPs were kept constant. Sensitivity analysis can be conducted to examine the impacts given slight increases in the MAPs.

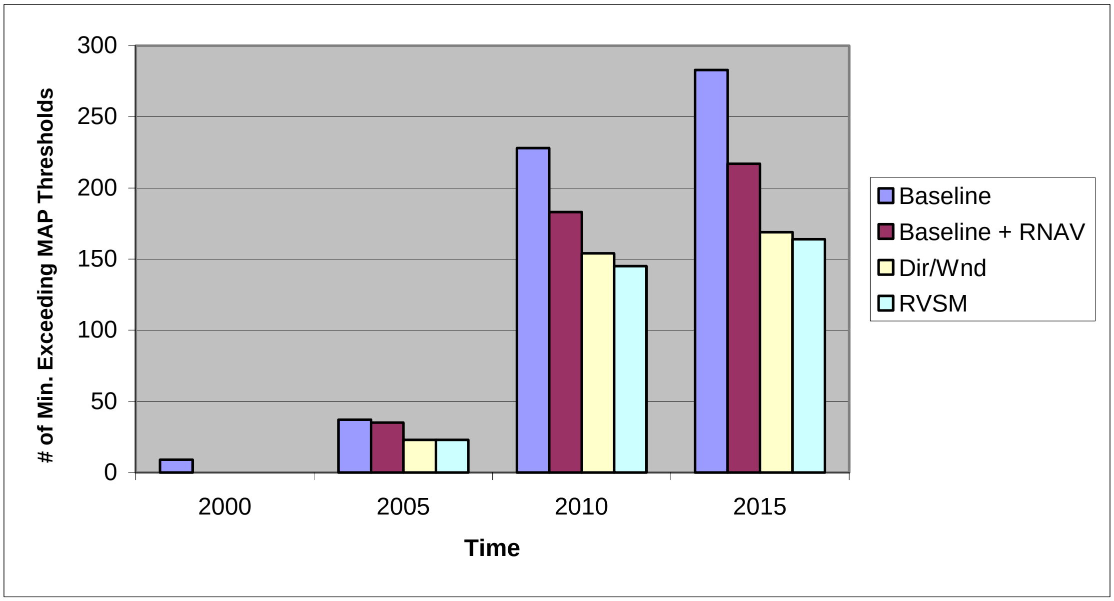

Figure 19: Number of Minutes Exceeding MAPs in Southern Region

3.9 Extrapolation of Results to the NAS

NASPAC was applied to the flight profiles in all cases to provide a sense of the impact on delay throughout the NAS from the various routing initiatives. In the baseline year, 67,092 flights were flown, growing to 71,552 in year 2005, 78,820 in year 2010, and 85,683 in year 2015; an average of a 1.5 percent annual increase. The average en route flight time (wheels-off to wheels-on) in the region was 94-95 minutes, slightly less than the NAS average of 101 minutes from over 48,000 other flights. It is beyond the scope of this analysis to take the results for one day from one region on a good VFR day in the NAS and project the impact on an annual basis. Perhaps, with a sample of more candidate days, a range estimate specifically of the daily and annual fuel burn and flight timesavings, can be provided. In the future, excursions can be performed to measure the impact on a national basis.

3.10 NAS Results

Operational delay occurs when an aircraft competes for constrained airport and/or airspace resources. The delays occur both on the ground and in the air. These delays include: taxi delay, en route restrictions, terminal restrictions at departure and arrival fixes, and holding for gates. An example of operational delay is when an aircraft spends time in the taxi queue beyond its unimpeded taxi-time and experiences an airborne hold at an arrival fix. Each of these flight inefficiencies is totaled into an operational delay on a per flight basis.

In the simulation, the delays stayed relatively constant for all cases in a given year. Yet, the delays are increasing between scenario years, i.e., years 2005 to 2010 (see Figure 20). This is primarily due to the increased demand-to-capacity ratio, i.e., demand is increasing at a faster rate than airport capacity is projected to grow. The operational delays in 2015 may be slightly overstated since the airport capacity projections in the model were not adjusted beyond 2010 when the demand was increasing. Typically, there is an average of 3-4 flight legs per aircraft.

Regardless of whether or not the flight in the simulation is the first, second, third, or fourth, the operational delay addresses only one flight leg. Downstream or rippling impacts are typically seen when flights arrive late causing the next flight to be later, and so forth. This impact is reflected in the passenger delay that is not reported in the analysis.

There may be other reasons for this result. Most of the benefits metrics in term of distance and time are very minimal in the aggregate or on a per flight basis, using total flights not marginal flights. As discussed earlier, the average distance saved was only .05 percent of the total distance or 2-3 miles, and the timesavings amounted to only .0002 percent or less than one second of a flight's total time even by the year 2015. Part of this can be explained by the dilution factor, which occurs because of the limited interaction between the Southern Region and all other flights throughout the NAS, and even within the Southern Region, the technology penetration equipage rate may not have reached a high enough level yet to significantly impact other flights. Furthermore, even those individual flights that achieve timesavings en route may not ultimately reduce operational delay, because of the vast majority of flights that do not fly advanced routing which may be the bottleneck to the queue, especially at the terminal area. Finally, the simulation day was a good VFR day so the airport was able to handle the majority of the flights adequately. Therefore, en route timesavings may not translate to operational delay reduction because the terminal area delays are still operative.

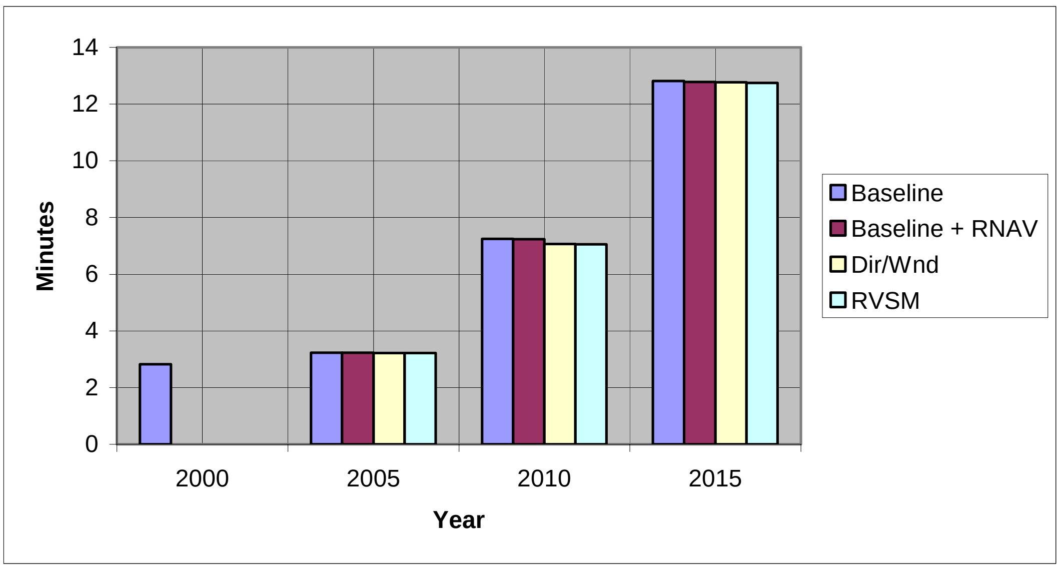

Figure 20: NAS Operational Delay

4.0 SUMMARY AND CONCLUSIONS

Three alternative routing options have been analyzed in this study: direct routing (RNAV flights), optimized (Direct/Wind) flights, and domestic RVSM flights. The RNAV case increases the current number of RNAV flights from approximately 229 in the Southern Region to about 836 by year 2015. The optimized (Direct/Wind) case assumes the same number of RNAV flights as the RNAV case and additionally adds more optimized (Direct/Wind) flights (up to 3,310 additional flights). Finally, the RVSM case uses the same RNAV and optimized (Direct/Wind) flights as the optimized (Direct/Wind) case, but adds approximately 50 percent more RVSM flights by year 2015.

4.1 Total Savings from the Most Optimistic Case

The RVSM case will always yield the highest overall total benefits because it contains all of the most optimistic routing options with 33-37 percent of the flights being either direct (RNAV or NRP) or optimized (Direct/Wind) in the future years. Approximately 1.95 million pounds of fuel are saved per day by 2015 in the Southern Region, which represents about 1.4 percent of total fuel consumption. Distance saved is 59,500 nmi or almost .82 percent of the total distance travel per day in the Southern Region. Total time saved is approximately 193 hours or about .88 percent of total time traveled.

On a per flight basis, the implementation of all three routing options yields an average per flight savings by year 2005 of 127 pounds of fuel, 2.0 nmi and .66 minutes; in year 2010, 141 pounds of fuel, 2.2 nmi and .70 minutes, and by 2015, 147 pounds of fuel, 2.4 nmi and .76 minutes.

4.2 Largest Savings by Routing Option Case

Of the three routing options, given the assumptions of technology equipage rates and availability of routing options, the optimized (Direct/Wind) flights provide the largest savings.

Fuel savings in 2015 amount to 1.29 million pounds of fuel per day in the Southern Region, which represents over 66 percent of the total fuel savings if all three routing options were implemented. RVSM flights provide 28 percent of total fuel savings and only 5 percent from RNAV flights in 2015.

The total distance saved in 2015 by the optimized (Direct/Wind) routing option is 34,371 nmi, which amounts to 58 percent of the total distance saved from all options. Because of the larger number of RVSM flights, RVSM saves about 28 percent of the total distance saved, while the RNAV routes provide about 15 percent of all the distance savings.

Of the total timesavings per flight for all routing options of .84 minutes by year 2015, 39 percent is attributable to the optimized (Direct/Wind) routing, 37 percent from RVSM, and 23 percent as a result of the direct RNAV routing.

4.3 Highest Savings per Flight by Marginal Routing Flight Option

Because the previous metrics measures have a tendency to dilute the total savings by all flights and are driven by the assumptions for the penetration rates of new technology, the following metric was created to discern which of the three routing options provide the greatest marginal savings benefits per flight.

Still, the optimized (Direct/Wind) routing generates the greatest fuel burn savings, which provided about 390 pounds of fuel saved per flight. Direct RNAV routing was about 81 percent of the optimized (Direct/Wind) fuel savings level.

RNAV flights provide the greatest benefits for distance saved and timesavings per flight. The distance saved by RNAV flights is about 8.2 miles per flight, which is almost 2.5 times the distance savings resulting from optimized (Direct/Wind) flights. Timesavings for direct routing RNAV flights are a little over 1.6 minutes per flight or slightly greater than 1.2 times the timesavings from optimized (Direct/Wind) flights.

4.4 Conflicts

By far, the largest reduction in conflicts results in the RVSM case of almost 849 fewer conflicts in total. This is tantamount to over a 65 percent reduction in conflicts relative to the base case in 2010. Furthermore, a reduction of about 74 percent occurs where the most conflicts occur, in the less than a one-minute duration.

4.5 Policy Issues

With the current initiatives identified in the OEP, and the FAA's movement towards nationwide RNAV and user-preferred routing, it appears there is tremendous potential to provide both distance and timesavings to NAS users.

If distance and timesavings are the important performance metrics for the FAA, then clearly, increasing RNAV and longer haul direct optimized flights would be advantageous over the current NAS that is comprised primarily of ATC-preferred routes. However, RNAV procedures and longer haul direct routes will take time to develop, coordinate, approve, and certify. Understanding the scope of required equipage levels is crucial if policymakers expect the airlines user-preferred routing capabilities to increase over time. Policy will have to address these issues in the near future because equipage rates require capital upgrades, which takes time to penetrate the existing fleet of aircraft.

For that reason, further study should be conducted to estimate the upper limit based on the current information, to generate more RNAV routes and longer haul direct routes in the future, and to determine what the implications of those savings might be. Furthermore, when assessing the potential benefits, it is critical to address the proposed changes in the airspace structure, e.g., dynamic resectorization as the agency is considering adopting and implementing high-dollar capital investments such as URET, WAAS, ADS-B, CPDLC, Collaborative Decision Making (CDM)/Collaborative Routing and Coordination Tools (CRCT), Traffic Management Advisor (TMA) and NEXCOM.

As the airspace is expected to get more congested in the future, domestic RVSM will provide the potential to reduce aircraft conflicts. Also, if RVSM were to achieve the technology penetration and usage rates assumed in this study, it will provide significant fuel savings to the airlines as well. Therefore, airlines and the FAA will need to continue to collaborate to take advantage of the potential contributions of domestic RVSM.

5.0 NEXT STEPS AND RECOMMENDATIONS

In the future, the following areas can be expanded when conducting this type of analysis.

- **Additional sensitivity runs need to be incorporated into the analysis. Metrics were measured from individual simulation runs represented by discrete one-day events.**

    - No attempt was made to measure the variability associated with key model assumptions and inputs and their resultant impacts upon the metrics. Multiple model runs to capture uncertainty via sensitivity analysis were not performed due to time constraints. Although this would require significant time with the runs and ensuing analysis, the authors recommend that future analyses attempt to incorporate uncertainty in the modeling process.

- **Better information gathering is critical to improving the integrity of some of the key input drivers. Several results can be tied to a lack of robustness of the assumptions.**

    - For example, assumed RNAV activity was constrained because of a lack of information of the current nationwide participation level. The Southern Region team, who has been very proactive with establishing and identifying RNAV routes, certainly gave the analysis a good starting point. However, when conducting a macroscopic analysis such as this, attempting to precisely measure the contribution of RNAV routing initiatives in the NAS is hard to gauge until the additional certified and approved routes are identified and measured. Furthermore, RNAV growth is a sensitivity framework that can be increased to the critical point in which RNAV flights contribute significantly to the total metrics. Sensitivity with the activity and growth would at least provide a boundary on the total benefits associated with the maximum level of RNAV flights.

    - Similarly, in the analysis the NRP routes were assumed to stay at a relatively constant percentage of total flights over the forecast period. Although, the assumption is certainly justified from the airlines historical participation in the past few years, NRP route growth rates could be increased/decreased in a simulation run if there are indications that the program is changing.

- **Future analysis should capture the benefits during a "bad weather day" or a larger mix of varying days.**

    - This study used a "good weather day". During bad weather, RVSM has been cited as having the potential to provide greater marginal benefits than under good weather conditions. Although the throughput declines during bad weather conditions, which would limit the overall cumulative benefits, the marginal benefits may be greater because RVSM permits assigned and known flight patterns leading to higher throughput compared to ATC-preferred flights, which might enable better dispatcher, controller, and pilot communications via tools such as CPDLC.

- **A sensitivity analysis needs to be considered to the MAP sector thresholds over time so adjustments in airspace capacity are incorporated into the analysis.**

    - By excluding expected increases in airspace capacity in the sectors, this study, which kept the MAPs constant, may be overstating the benefits associated with future routing initiatives. The OEP states that airspace capacity should be increased as some of the planned initiatives are implemented.

- **More post-implementation evaluation needs to be done when measuring how the analysis is measuring the flights through modeling versus how they actually performed.**

    - At this time, the easiest way to model the RNAV routes is by measuring the performance of flying direct from departure fix to arrival fix. This slightly overstates the benefits since the RNAV routes do not eliminate all the waypoints or fixes during the entirety of the flight. Future approaches to map lat/longs to waypoints will need to be identified.

    - The NRP routes, which were modeled as direct routes, need to be established and modeled as either direct or wind-optimized for minimum fuel, minimum cost. Future excursions need to be consistent with the distribution between these types of routes on actual days.

    - The actual flight performance, i.e., actual en route time versus filed estimated time en route of the NRP routes needs to be examined against any simulation result.

- **Future analysis should include application to the entire NAS to measure the potential benefits when applied to the NAS Architecture and the OEP. However, caution should be exercised when extending this specific study to the NAS, as the Southern Region is not comparable in many aspects to the rest of the NAS. There is a need to quantify the systematic impacts of RNAV and RVSM as mentioned in the OEP.**

In conclusion, it is recommended that a similar framework and methodology be applied when identifying other acquisition's baselines (reference case) and subsequent alternatives for other acquisitions that are claiming enhanced en route routing benefits through increased user-preferred routing. Whether it is a program rebaseline or an Investment Analysis candidate program, i.e., FFP2, WAAS, or CPDLC, the post-implementation evaluation should follow this framework and apply some of the metrics used in this analysis when trying to gauge the various ranges of flight efficiency "benefit pools". Apportioning benefits between the respective planned Investment Analysis acquisitions is extremely difficult and was beyond the scope of this analysis.

Appendix A: Reorganized Air Traffic Control (ATC) Mathematical Simulator (RAMS)

RAMS is a fast-time, discrete-event simulation model used for the study of airspace design, ATC systems, and future ATC concepts. It was developed by the Eurocontrol Experimental Centre's Simulator Development Programme (SDP) located in Breignty-sur-Orge Cedex, France. The model is largely data driven and contains a resolution rule system that uses forward chaining artificial intelligence to represent and solve conflicts. The rule base was designed to provide operationally correct flight maneuvers that are used by ATC experts. RAMS can resolve[10] conflicts of two or more flights by using vectors, changes in flight level, speed adjustments, and/or moving a flight to a holding pattern.

RAMS airspace description consists of sectors, shelves, and NAVAIDs (all possible waypoints including VORs, fixes, etc.) In the simulation, each flight moves along a specified trajectory through the airspace. RAMS determines aircraft longitudinal and vertical speeds based on the aircraft type and flight altitudes.

The model was designed to mimic the planning and tactical controller functions of the ATC system. The model records tasks performed by controllers and are grouped into the following five categories: conflict search, coordination, flight data management, communication, and radar resolution. A weighting scheme applied to each of the subtasks was developed at Eurocontrol to predict controller workload. These tasks can be globally defined over an entire airspace, specialized by center, sector, NAVAIDs, or airport.

The simulation engine models 4-D flight profiles for 300 currently supported aircraft types. All aspects of the airspace, such as general or specific separation minima, special use airspace (SUA), airport and runway activity, approach sequencing, holding patterns, restriction for Standard Instrument Departures (SIDs), and Standard Terminal Arrival Routes (STARS) requirements are modeled to achieve the closest possible replica of the ATC system. RAMS uses advanced conflict detection algorithms, combined with a rule base system to achieve conflict detection and resolution. The model maneuvers flights using vectors, level changes, speed manipulation, path stretching, or air/ground holding as a means of separating aircraft. RAMS records position information, tasks of a controller, and general statistics concerning the flight dynamics of all simulated flights.

RAMS produces several output files that describe flight characteristics of each individual flight in the scenario, and records detailed interaction of flights within the simulation time frame. These interactions include flights in conflict, location of conflict, resolution applied because of the conflict, and all flight maneuvers considered but not rendered due to the creation of new conflicts. In addition, several activity files are produced during each run of RAMS that include a conflict search log file, a resolution file, a position report file, and a summary of all the tasks performed during the run.

[10] Conflict resolution by controllers was not applied in this analysis.

Appendix B: National Airspace Performance Analysis Capability (NASPAC) Model Overview

This appendix provides additional details and insights into the NASPAC Simulation Modeling System (SMS) that provided the results for the system delay metric, annotated as ***operational delay*** in this report. NASPAC is a discrete-event simulation model that tracks aircraft as they progress through the NAS and compete for ATC resources. Resources in the model include airports, sectors, flow control restrictions, and arrival and departure fixes. NASPAC evaluates system performance based on the demand placed on resources modeled in the NAS and records statistics at 80 of the nation's busiest airports. NASPAC simulates system-wide performance and provides a quantitative basis for decision making related to system improvements and management. The model supports strategic planning by identifying air traffic flow congestion problems and examining solutions.

NASPAC analyzes the interactions between many components of the ATC system and the system's reaction to projected demand and operational changes given airport and airspace capacities. The model was designed to study nationwide system performance rather than localized airport changes in detail. Airports are modeled at an aggregate level. An aircraft's itinerary may consist of many flight legs that an aircraft will traverse during the course of a day. If an aircraft is late on any of its flight legs, then successive flight legs may be affected. This is the way the model captures the rippling effect of passenger delay.

NASPAC records two different types of delay: passenger and operational. Passenger delay is the difference between the scheduled arrival time and the actual arrival time in the Official Airline Guide (OAG). Passenger delay is *not reported* in this analysis. Operational delay is the amount of time that an aircraft spends waiting to use an ATC system resource. It is discussed in more detail in Section 3.10. Resources, whether they are in the departure phase, cruise phase or arrival phase include: airports, arrival and departure fixes, flow control restrictions, and sectors. Since NASPAC builds flight itineraries from the OAG and the DOT's Airline Service Quality Performance (ASQP), one of the strengths of the model is providing a quantitative assessment of how delay at one airport will affect the delay at subsequent airports defined in the flight itinerary.

In this analysis, the flight profiles are developed through NASPAC's trajectory builder and Future Demand Generator (FDG). The trajectory builder algorithm develops flight profiles from positional information (latitude, longitude, altitude, and time) contained in the Enhanced Traffic Management System (ETMS). Each NAVAID (waypoint) recorded at five-minute (or less) intervals, serves as position information for each flight from which a route is developed. Intermediate positions are interpolated as a result of a flight in transition (climbing or descending). A great circle (direct point-to-point) trajectory is constructed for flights that are missing from the ETMS data. Flight profiles are also developed for optimized (Direct/Wind) tracks through the OPGEN program or from a user-defined set of waypoints.

The FDG is used to develop flight itineraries for the future years (2005, 2010, and 2015). The program references the TAF to determine growth rates at over 400 of the nations largest airports. Flights for the 80 NASPAC airports are increased over the current number of departures and arrivals based on the growth rates from the TAF. The departure and arrival times of these additional flights are centered near the most desirable times for passengers, without exceeding the acceptance rate of the airport. When the maximum capacity of the airport has been exceeded for that hour the new flights are moved one hour before or after the exceeded time. Flights are then aligned together to form a flight itinerary that describes the day's activity. These itineraries are based on aircraft type and minimum turnaround times for that airport.

Appendix C: North Atlantic Systems Implementation Group Cost Effectiveness (NICE) Fuel Burn Model

The fuel burn consumption was calculated for each flight as a postprocessor to the simulation. Aircraft performance, aircraft weight, and flight trajectory are the key factors in the fuel burn computations. Table C-1 lists fuel factors available for 27 types of aircraft types.

Table C-1: NICE Aircraft Types

Aircraft Type Label	Aircraft Type	Aircraft Type Label	Aircraft Type
1	B767-200	15	A320
2	B747-100	16	DC9-50
3	B737-200	17	A330
4	DC10-30	18	MD11
5	B727-100	19	MD88
6	DC8-63	20	DC10-30
7	L1011	21	DC8-63
8	B757-200	22	B747-200
9	B747SP	23	EA31
10	Jetstar (NICE Jet)	24	B777
11	Citation II	25	B777-400
12	DC9-30	26	DC86-300
13	A300	27	DC9-80
14	A310		

These types of aircraft do not represent all aircraft flown in the simulation. 195 aircraft types were modeled in the simulation; 61 aircraft types were associated with one of the types in the table. The remaining aircraft type, which were predominantly turboprops and props used for GA, were derived by a least squares regression on the fuel flow that considered the average weight with the average fuel consumption.

Table C-2 below lists analogous or equivalent aircraft assigned to the aircraft above; therefore, all aircraft flown in the simulation are represented by aircraft that have similar performance characteristics.

Table C-2: Aircraft Mapping to Equivalent Aircraft

Aircraft Type Label	Aircraft Type (ETMS)	Aircraft Type Label	Aircraft Type (ETMS)	Aircraft Type Label	Aircraft Type
1	B767	9	B74T	11	LR55
2	B747	10	AJ25	11	N265
2	B74F	10	C21	11	P3
2	C141	10	JSTR	12	DC9
2	C5	10	BA14	14	A310
2	C5A	10	BA31	14	EA31
2	EA34	10	BA41	15	A320
3	B737	10	BA46	15	EA32
3	B73F	11	CL60	17	EA33
3	B73J	11	CL61	18	MD11
4	DC10	11	DA50	18	MD80
4	KC10	11	DA90	18	MD83
5	B707	11	EA6	19	MD90
5	B727	11	G2	22	C17
6	C130	11	G3	24	B777
6	C135	11	G4	26	DC86
6	C141	11	HS25	26	DC8F
6	DC8	11	LR25		
6	KR35	11	LR28		
7	L101	11	LR31		
8	B757	11	LR35		
9	B74S	11	LR36		

Table C-3 presents an illustration of fuel burn rates for some aircraft flown in the simulation.

Table C-3: Fuel Burn Rates

Aircraft Type	FL 290 (lbs/min)	FL310 (lbs/min)	Savings (FL290 and FL310) (Pct)	FL330 (lbs/min)	FL350 (lbs/min)	Savings (FL330 and FL350) (Pct)	FL370 (lbs/min)	FL390 (lbs/min)	Savings (FL370 and FL390) (Pct)
MD80	112.7	109.8	2.5	106	103.2	2.7	101.4	NR	-
B757	136	136.2	-0.2	132.5	130.3	1.7	129	129.2	-0.2
B737-6/7/8	122.6	122.6	0	123.5	120.4	2.5	118.4	117.7	0.6
CARJ	45.4	42.5	6.3	39.9	37.7	5.5	36.2	34.8	3.7
B767	190.9	185.4	2.9	181	178.1	1.6	177.2	177.9	-0.4
A300	219.4	213.4	2.7	207.7	203.7	1.9	201.9	202.4	-0.2
DC9	120.6	114	5.5	108.2	103.2	4.7	NR	NR	-

Appendix D: Optimal Trajectory Generator (OPGEN) Model

The OPGEN is a trajectory model that provides the capability to generate optimized (Direct/Wind) flight trajectories based on the aircraft type and performance (fuel flow and weight), scheduled arrival times, desired time en route, SUA, prevailing winds and other weather situations, delays and other ATC restrictions, but subject to meeting the overall flight schedule. OPGEN also compares each flight's projected trajectory with other flight profiles and readjust trajectories to resolve conflicts. Various thresholds may be input into the model, which allow delays to increase up to the threshold chosen.

OPGEN computes an optimized flight trajectory, which minimizes the en route fuel burn subject to meeting the desired time en route. In certain cases, due to the violation of constraints such as SUAs, the optimized trajectory will minimize the time en route.

OPGEN uses a SUA Activity file, which contains the find crossings information on when and where aircraft enter and exit a given sector. Traffic and trajectory files must be generated through a preprocessor using ETMS data. In this analysis, in order to qualify as a potential optimized (Direct/Wind) flight, specific cutoff flight level, e.g., FL290 and minimum flight length, e.g., 750 nmi must be specified. Flights that are at or above the cutoff flight level and at or above the minimum flight length receive full optimization. However, those flights that are below the cutoff flight level and above the minimum flight length receive partial optimization. Another input required for an OPGEN run is the Band file, which contains the permissible flight levels by direction. The last input file needed by OPGEN is the Wind file with the winds aloft data used by the optimization process to reduce fuel burn.

The aircraft types depicted in Appendix C, Table C-1 had sufficient fuel and performance to support OPGEN's data input requirements to fly optimized (Direct/Wind) routes.

Appendix E: Aerospace Engineering and Research Associates LIBrary (AERALIB)

AERALIB is a comprehensive C++ object-oriented library designed to support both the fast- and real-time Air Traffic Management System simulations and the development and operational analyses of all next generation air traffic control systems and/or enhancements thereto. AERALIB, per se, supports analyses of the design concepts of total-flow on a total system basis. It is fully capable of meeting both the R,E&D rapid-prototyping and the operational implementation requirements of next generation systems.

AERALIB permits high-fidelity use of several tasks. They include: 1) all airspace structure such as control sectors, center boundaries, SUA, etc., terminal configurations, routes, etc., 2) impact of changes in separation criteria and/or in capacity throughout the NAS, and 3) winds aloft and weather modeling.

To date, the primary use of AERALIB in this analysis was the comprehensive statistical analysis of en route conflicts under different flight profiles and separation criteria. AERALIB's comprehensive trajectory library provides classes that can be used to represent different generic airspaces and the total-flow movement of all aircraft objects within these four-dimensional generic airspaces.

Appendix F: Southern Region Area Navigation (RNAV) Routes

Table F-1 includes all city pairs that are modeled to fly RNAV routes in the year 2000, 2005, 2010, and 2015 scenarios. The number of flights is annotated with each year. 42 Southern Region city pairs had either intra-regional or inter-regional flights. There were 109 RNAV city pairs in year 2005 and 134 city pairs in the year 2010 and 2015 scenarios. The MD80, B737, CARJ, DC9, and B757 accounted for over 75 percent of the aircraft types that flew RNAV routes.

Table F-1: RNAV Routes by City Pair

City Pair	2000	2005	2010	2015	Distance (nmi)
AGS ATL		3	4	4	143
ATL AGS	9	10	11	13	143
ATL AUS		2	3	4	703
ATL AVL	9	10	11	13	164
ATL BNA			4	4	185
ATL CLE	12	13	14	16	502
ATL CLT			10	11	197
ATL CMH			5	6	388
ATL CRP	2	2	3	3	762
ATL DAB	1	1	1	2	317
ATL DHN	7	7	8	9	171
ATL DSM	3	3	4	5	645
ATL DTW	16	17	18	21	555
ATL EVV	1	1	1	2	348
ATL FAY		2	2	2	287
ATL FLL	6	6	7	8	516
ATL FWA	3	3	5	6	449
ATL GNV	4	4	5	6	302
ATL GPT		2	3	3	305
ATL HOU		2	3	3	604
ATL ICT			4	4	677
ATL ISP	3	2	4	5	689
ATL JAN	1	1	2	2	306
ATL JAX	1	1	2	2	234
ATL LEX	5	5	6	7	263
ATL MCO	1	1	2	2	380
ATL MGM			9	10	128
ATL MIA	11	12	13	15	542
ATL MLB		2	3	3	386
ATL MOB			5	6	255
ATL MSY			6	7	362
ATL MYR		2	3	3	273

Table F-1: RNAV Routes by City Pair, Cont'd

City Pair	2000	2005	2010	2015	Distance (nmi)
ATL PBI	8	9	10	12	495
ATL PFN		2	3	3	216
ATL ROA		2	3	3	309
ATL SAT	1	1	1	2	767
ATL SDF		2	3	3	279
ATL SWF		1	2	2	785
ATL TOL	1	2	3	3	548
ATL TPA	2	2	3	3	365
ATL TYS			7	9	140
ATL VPS	13	14	15	18	222
ATL XNA	5	5	6	7	511
AUS ATL		2	3	3	703
AVL ATL	8	8	10	12	164
BNA ATL			4	4	288
CHS CLT		2	4	5	179
CLE ATL		2	3	3	481
CLT ATL			10	11	197
CLT CHS		2	4	5	179
CLT CSG			4	4	257
CLT CVG		3	5	6	333
CLT DAB		3	5	6	362
CLT DCA			5	6	287
CLT FLL		3	4	5	633
CLT JAX		3	4	5	334
CLT MCO		3	5	6	462
CLT MIA		3	5	6	651
CLT MYR		3	5	6	153
CLT ORF			6	7	250
CLT PBI		3	5	6	591
CLT RDU		3	5	6	117
CLT RIC		3	5	6	255
CLT RWI			4	4	149
CLT SAV		3	5	6	214
CLT SDF		2	4	5	335
CLT TPA		3	5	6	509
CMH ATL			5	6	388
CRP ATL	2	2	4	5	762
CSG CLT			4	4	257
CVG CLT		2	4	5	333

Table F-1: RNAV Routes by City Pair, Cont'd

City Pair	2000	2005	2010	2015	Distance (nmi)
DAB ATL	6	6	8	9	326
DAB CLT		3	5	6	362
DAB FLL		3	5	6	192
DAB MIA		3	5	6	206
DCA CLT			4	4	288
DHN ATL	7	7	9	11	171
DTW ATL		5	7	8	525
EVV ATL	6	6	8	10	348
FAY ATL			9	10	287
FLL ATL	6	6	8	10	516
FLL CLT		2	3	3	550
FLL JAX		19	20	23	272
FLL MCO	8	9	10	12	161
FLL TPA	1	1	2	2	196
FWA ATL		2	4	5	449
GNV ATL		2	4	5	262
GPT ATL		2	4	5	306
HOU ATL		2	4	5	604
ICT ATL			4	4	677
ISP ATL	2	2	4	5	690
JAN ATL		2	4	5	295
JAX ATL	17	18	20	23	239
JAX CLT		2	4	4	290
JAX FLL		3	5	6	272
JAX MIA		2	4	5	286
LEX ATL	6	6	8	10	281
MCO ATL		3	5	6	345
MCO CLT		3	5	6	401
MCO FLL		2	4	5	161
MCO MIA		2	4	5	173
MGM ATL		7	9	11	128
MIA ATL	11	12	13	15	550
MIA CLT		2	3	3	651
MIA JAX	1	1	2	2	280
MIA MCO		2	4	5	199
MIA TPA		2	4	5	177
MLB ATL		2	4	5	386
MOB ATL			5	6	260
MSY ATL			6	7	362

Table F-1: RNAV Routes by City Pair, Cont'd

City Pair	2000	2005	2010	2015	Distance (nmi)
MYR ATL		2	4	5	273
MYR CLT		2	4	5	133
ORF CLT			5	6	250
PBI ATL	9	9	11	13	508
PBI CLT		2	4	5	514
PFN ATL		2	4	5	216
RDU CLT		2	4	5	117
RIC CLT		2	4	5	222
ROA ATL		2	4	5	309
RWI CLT			4	4	149
SAT ATL	2	3	4	5	754
SAV CLT		2	4	5	214
SDF ATL		2	4	5	279
SDF CLT		2	4	5	335
SWF ATL		2	4	5	785
TOL ATL	3	3	4	5	495
TPA ATL	2	2	4	5	377
TPA CLT		2	4	5	509
TPA FLL		2	4	5	313
TPA MIA		2	4	5	177
TRI ATL		2	4	5	197
TYS ATL			7	9	140
VPS ATL	7	7	8	9	224
XNA ATL			5	6	511
Total	229	421	713	836	Average: Approx. 325

The following list contains identified multi-center advanced navigation routes by city pair[11] that were effective in October 2001. Currently, the majority of the routes originates and departs to/from several airports that include DAB, ATL, JAX, MCO, MIA, PBI, TPA, and ATL. The 42 bolded/italicized routes were included in the 2000 baseline of 229 flights identified as flying RNAV on the simulation day.

[11] The bolded, italicized, underlined city pairs were identified, both through Southern Region input and ETMS matching criteria as currently flying RNAV routes. The city pairs without any associated values were not identified to fly RNAV on the simulation day, e.g., no RNAV flights flew from JAX to CLT in the 2000 scenario.

1) ATL-DAB
ATL.SOONE..MCN..CRG..OMN..DAB

2) ATL-FLL
ATL.SOONE..MCN..CMIKE..BKINI..DOMES..TRIPL..DUBBL..MRLIN.MRLIN4.FLL

ATL.SOONE..WALET..FAGAN..TEPEE..FORTL..KUBIC.FORTL4.FLL

ATL.SOTWO..LUCKK..HEVVN..FORTL..KUBIC.FORTL4.FLL

3) ATL-JAX
ATL.SOONE..MCN..AMG..ONEEL.AMG1.JAX

4) ATL-MCO
ATL.SOONE..WALET..EMPEE..UGENE..COAXE..ALADN..LEESE..ORL..MCO

5) ATL-MIA
ATL.SOONE..MCN..CMIKE..BKINI..OAKIE..HEATT.HEATT5.MIA

ATL.SOONE..WALET..FAGAN..TEPEE..DEEDS..WORPP.CYY3.MIA

ATL.SOTWO..LUCKK..HEVVN..PIE..WORPP.CYY3.MIA

6) ATL-PBI
ATL.SOONE..MCN..CMIKE..GUMPE..SURFN.SURFN7.PBI

ATL.SOONE..WALET..FAGAN..LEWRD..LLAKE..PHK.LLAKE2.PBI

ATL.SOTWO..LUCKK..HEVVN..BUCKS..LAL..LLAKE..PHK.LLAKE2.PBI

7) ATL-TPA
ATL.SOTWO..LUCKK..HEVVN..LEGGT..TABIR.DARBS1.TPA

8) DAB-ATL
DAB..ROYES..CHESN..BAXLY..DBN.SINCA3.ATL

9) DAB-FLL
DAB..DUBBL..MRLIN.MRLIN4.FLL

10) DAB-MIA
DAB..HEATT.HEATT5.MIA

11) FLL-ATL
FLL..ARKES..KIZER..CHESN..BAXLY..DBN.SINCA3.ATL

FLL..GILBT..THNDR..WYATT..LGC.LGC8.ATL

12) FLL-JAX
FLL..ARKES..PAOLA..SHINR..BASSS.POGIE1. JAX

13) FLL-MCO
FLL..ARKES.. BAIRN.GOOFY4.MCO

14) FLL-TPA
FLL..THNDR..BRDGE.BRDGE5.TPA

15) JAX-ATL
JAX..BAXLY..DBN.SINCA3.ATL

16) JAX-FLL
JAX.. TRIPL..DUBBL..MRLIN.MRLIN4.FLL

17) JAX-MIA
JAX..SGJ..HEATT..LONNI.HEATT5.MIA

18) MCO-ATL
MCO..MATEO..CHESN..BAXLY.SINCA3.ATL

19) MCO-FLL
MCO..DUBBL..MRLIN.MRLIN4.FLL

20) MCO-MIA
MCO..VRB..HEATT.HEATT5.MIA

21) MIA-ATL
MIA..HEDLY..KIZER..CHESN..BAXLY..DBN.SINCA3.ATL

MIA..WINCO..LAL..WYATT..LGC.LGC8.ATL

22) MIA-JAX
MIA..HEDLY..ORL..SHINR..BASSS.POGIE1.JAX

23) MIA-MCO
MIA..HEDLY..BAIRN.GOOFY4.MCO

24) MIA-TPA
MIA..WINCO..BRDGE.BRDGE5.TPA

25) PBI-ATL
PBI..TBIRD..KIZER..CHESN..BAXLY..DBN.SINCA3.ATL

PBI..TBIRD..WYATT..LGC.LGC8.ATL

26) TPA-ATL
TPA..ELTOR..WYATT..LGC.LGC8.ATL

27) TPA-FLL
TPA..RSW..KUBIC.FORTL3.FLL

28) TPA-MIA
TPA..RSW..WORPP.CYY3.MIA

II. The following city pairs contain advanced RNAV routes for Atlantic Southeast Airlines.

City Pairs	Approved by ATC
1) ***ATL/AVL***	NOTWO HRS SUG AVL (FL210)
2) ***AVL/ATL***	AVL ODF MACEY2 ATL (FL220)
	AVL GRD IRQ SINCA SINCA3 ATL (FL220)
3) ATL/CLE	NOTWO VXV J91 BULEY J91
4) CLE/ATL	CLE MFD APE J186 ODF MACEY2 ATL (FL310)
5) ***ATL/DTW***	NOTWO FLM DQN MIZAR3 DTW (FL350)
6) DTW/ATL	DTW CAVVS ROD J43 VXV MACEY2 ATL (FL350)
7) ATL/FAY	EATWO ROWEL FAY (FL330)
8) FAY/ATL	FAY SINCA3 ATL (FL310)
9) ***ATL/GNV***	SOONE OTK GNV (FL290)
10) GNV/ATL	GNV AMG DBN SINCA3 ATL (FL280)
11) ATL/GPT	WEONE SCALY GPT (FL310)
12) GPT/ATL	GPT TIROE LGC8 ATL (FL290)
13) ATL/MYR	EATWO MYR (FL330)
14) MYR/ATL	MYR SINCA SINCA3 ATL (FL310)
15) ATL/PFN	SOTWO CSG PFN (FL260)
16) PFN/ATL	PFN TIROE LGC8 ATL (FL250)
17) ATL/ROA	EAONE ROA FL330)
18) ROA/ATL	ROA ODF MACEY2 ATL (FL350)
19) ATL/SDF	NOONE HCH LVT DARBY2 SDF (FL310)
20) SDF/ATL	SDF BWG RMG2 ATL (FL330)
21) ATL/SWF	EAONE PSB J49 J70 LVZ LHY V408 V34 FILPS SWF (with restriction to expect to cross LHY @ or below 17,000 feet) FL330)
22) SWF/ATL	WEARD V706 LHY KURRZ J49 PSB ODF MACEY2 ATL (FL350)
23) ATL/TRI	NOTWO TRI (FL230) (SOT MOA inactive) NOTWO VXV HMV TRI (FL230) (SOT MOA active)
24) TRI/ATL	ODF MACEY2 ATL (FL260)
25*)* ***ATL/VPS***	SOTWO CSG CEW VPS (FL260)
26) ***VPS/ATL***	VPS TIROE LGC8 ATL (FL250)

III. The following additional flights are advanced RNAV routes approved by Atlantic Southeast Airlines in late 2000.

GROUP II

City Pairs	Approved By ATC	REQ ALT
1) ***ATL/AGS***	EATWO..AGS	FL190
2) AGS/ATL	ANNAN..SINCA..ATL	FL180
3) ATL/AUS	WEONE..LFK..CLL..CWK..AUS	FL280
4) AUS/ATL	LFK..MEI..LGC..ATL	FL290
5) ***ATL/CRP***	WEONE..LCH..PSX..CRP	FL280
6) ***CRP/ATL***	PSX..LCH..MCB..LGC..ATL	FL290
7) ***ATL/DAB***	SOONE..AMG..OMN..DAB	FL290
8) DAB/ATL	MATEO..CHESN..DBN.. SINCA..ATL	FL280
9) ***ATL/DHN***	SOTWO..CSG..RRS..DHN	FL280
10) DHN/ATL	NO CHANGE PROPOSED	FL270
11) ATL/DSM	NOONE..BNA..MWA..STL	FL280
12) DSM/ATL	STL..MWA..BNA..RMG..ATL	FL290
13) **ATL/EVV**	NOONE..GQO..EVV	FL280
14) EVV/ATL	NO PROPOSED CHANGE	FL290
15) ***ATL/FWA***	NOONE..IIU..BIGXX..FWA	FL280
16) FWA/ATL	VHP..BWG..DRAKK..RMG..ATL	FL290
17) ATL/HOU	WEONE..DAS..DAYBO..HOU	FL280
18) HOU/ATL	VUH..LCH..MCB..LGC..ATL	FL290
19) ATL/ICT	WETWO..EOS..ICT	FL280
20) ICT/ATL	OSW..ARG..SALMS..RMG..ATL	FL290
21) ***ATL/ISP***	EATWO..GRD.J209.ORF..SIE.V139	FL290
22) ISP/ATL	BEADS..RBV.J230.BTRDD.J48	FL280
23) ***ATL/JAN***	WEONE..JAMMR..JAN	FL280
24) JAN/ATL	MEI..YARBE..LGC..ATL	FL290

25) ***<u>ATL/LEX</u>***	NOTWO..LEX	FL290
26) ***<u>LEX/ATL</u>***	NO CHANGE PROPOSED	FL280
27) ***ATL/MLB***	SOONE..CRG..OMN..MLB	FL290
28) MLB/ATL	KISER..MATEO..CHESN.. DBN..SINCA..ATL	FL280
29) ***<u>ATL/SAT</u>***	WEONE..LFK..MARCS.SAT	FL280
30) ***<u>SAT/ATL</u>***	SEEDS..ELA..LGC..ATL	FL290
31) ***<u>ATL/TOL</u>***	NOTWO..VXV..VWV..TOL	FL290
32) ***<u>TOL/ATL</u>***	VXV..MACEY..ATL	FL280
33***<u>) ATL/VPS</u>***	SOTWO..CSG..CEW..VPS	FL280
34) ***<u>VPS/ATL</u>***	CORKY..LGC..ATL	FL290
35) ***<u>ATL/XNA</u>***	WETWO..GAD..MEM..RZC	FL280
36) ***<u>XNA/ATL</u>***	NO CHANGE PROPOSED	FL290

Appendix G: National Route Program (NRP) Routes

FAA Order 7210.3 Facility Operation and Administration defines the NRP routing. Key sections of the order are annotated below:

Section 17. NATIONAL ROUTE PROGRAM

17-17-1. PURPOSE

The National Route Program (NRP) provides the users of the NAS greater flexibility in flight plan filing at or above 29,000 feet (FL290).

17-17-5. USER REQUIREMENTS

a. International operators filing through Canadian airspace, at or east of Sault St. Marie (SSM), to destinations within the conterminous United States will be required to file over one of the following inland fixes to be eligible to participate in the NRP: SSM, TAFFY, EBONY, ALLEX, BRADD, TOPPS, TUSKY, YXU, and QUBIS.

b. International operators filing through Canadian airspace, west of SSM, to destinations within the conterminous United States may utilize any inland navigational fix west of SSM within 30 NM north of the common Canada/United States airspace geographical boundary to be eligible to participate in the NRP.

c. Flights shall be filed and flown via any instrument departure procedure (DP), standard terminal arrival route (STAR) for the departure/arrival airport respectively, or published preferred IFR routes, for at least that portion of flight which is within 200 NM from the point of departure (egress) or destination (ingress). If the procedure(s) above do not extend to 200 NM, published airways may be used for the remainder of the 200 NM. If procedure(s) above do not exist, published airways may be used for the entire 200 NM.

d. Operators that file a flight plan that conforms to a published preferred IFR route shall not enter "NRP" in the remarks section of that flight plan.

e. Operators shall ensure that the route of flight contains no less than one waypoint, in the FRD format, or NAVAID, per each ARTCC that a direct route segment traverses and these waypoints or NAVAIDs must be located within 200 NM of the preceding ARTCC's boundary. Additional route description fixes for each turning point in the route shall be defined.

f. Operators shall ensure that the route of flight avoids active restricted areas and prohibited areas by at least 3 NM unless permission has been obtained from the using agency to operate in that airspace and the appropriate air traffic control facility is advised.

g. Operators shall ensure that "NRP" is entered in the remarks section of the flight plan for each flight participating in the NRP program.

Listed below in Table G-1 are the city pairs that flew NRP routes (Source: ATA-200) through the Southern Region on August 28, 2000. The table gives a breakdown with the number of flights, distances in nmi (from departure fix to arrival fix) and the flight distance differences for each city pair. Note: This table does not represent filed NRP optimized routes that does not fly direct routes.

Table G-1: NRP Routes

Org	Dest	ATC Pref Dist	Direct Dist	Count	Diff (Miles)	Diff (Pct)
ATL	BOS	836.38	822.2	14	14.18	1.7%
ATL	DEN	1068.38	1048.27	11	20.11	1.9%
ATL	EWR	668.29	647.4	3	20.89	3.2%
ATL	FLL	517	504.65	3	12.35	2.4%
ATL	IAH	601.1	597.54	3	3.56	0.6%
ATL	LAS	1528.33	1513.56	1	14.77	1.0%
ATL	LAX	1694.97	1687.53	1	7.44	0.4%
ATL	MIA	516.57	504.59	11	11.98	2.4%
ATL	MSP	806.93	787.85	7	19.08	2.4%
ATL	ORD	550.53	527.76	2	22.77	4.3%
ATL	PBI	484.53	474.02	5	10.51	2.2%
ATL	PIT	465.81	458.17	5	7.64	1.7%
ATL	SFO	1857.77	1853.34	1	4.43	0.2%
BDL	MCO	925.82	913.47	1	12.35	1.4%
BNA	EWR	659.86	647.51	1	12.35	1.9%
BNA	MCO	542.2	535.59	1	6.61	1.2%
BNA	MIA	700.84	688.49	1	12.35	1.8%
BOS	IAH	1399.34	1386.99	3	12.35	0.9%
BOS	MCO	987.53	975.18	1	12.35	1.3%
BWI	IAH	1086.02	1072.04	3	13.98	1.3%
BWI	JAX	598.16	575.99	2	22.17	3.8%
BWI	MCO	698.28	685.13	5	13.15	1.9%
BWI	TPA	754.41	732.63	7	21.78	3.0%
CLT	DEN	1180.57	1168.22	2	12.35	1.1%
CLT	DFW	822.87	810.52	3	12.35	1.5%
CLT	FLL	557.68	549.35	6	8.33	1.5%
CLT	IAH	812.34	791.34	4	21	2.7%
CLT	JAX	289.45	284.8	6	4.65	1.6%
CLT	LAS	1659.94	1659.94	2	0	0.0%
CLT	LAX	1858.09	1842.06	5	16.03	0.9%
CLT	MCI	713.27	700.92	3	12.35	1.8%
CLT	MIA	567.95	555.6	5	12.35	2.2%
CLT	MSP	819.51	807.16	2	12.35	1.5%
CLT	MSY	577.82	559.71	4	18.11	3.2%
CLT	PBI	524.5	513.75	5	10.75	2.1%
CLT	PHX	1542.8	1530.45	2	12.35	0.8%

Table G-1: NRP Routes, Cont'd

Org	Dest	ATC Pref Dist	Direct Dist	Count	Diff (Miles)	Diff (Pct)
CLT	PVD	615.81	593.89	2	21.92	3.7%
CLT	SAN	1811.41	1799.06	2	12.35	0.7%
CLT	SEA	1987.19	1974.84	2	12.35	0.6%
CLT	SFO	2001.49	1989.14	4	12.35	0.6%
CVG	FLL	821.26	808.91	1	12.35	1.5%
DCA	IAH	1060.22	1048.68	5	11.54	1.1%
DCA	MCO	673.6	661.25	3	12.35	1.9%
DCA	MIA	805.33	792.98	2	12.35	1.6%
DEN	ATL	1058.54	1048.27	6	10.27	1.0%
DEN	CLT	1184.31	1168.22	3	16.09	1.4%
DEN	MCO	1361.13	1348.78	4	12.35	0.9%
DEN	MIA	1494.43	1477.33	3	17.1	1.2%
DEN	TPA	1326.81	1314.46	2	12.35	0.9%
DFW	ATL	645.78	633.13	1	12.65	2.0%
DFW	CLT	815.85	810.52	1	5.33	0.7%
DFW	EWR	1202.38	1190.03	11	12.35	1.0%
DFW	JFK	1218.95	1206.6	1	12.35	1.0%
DFW	PBI	967.93	955.58	1	12.35	1.3%
DTW	CLT	448.05	434.48	1	13.57	3.1%
DTW	FLL	992.75	980.4	2	12.35	1.3%
DTW	JAX	725.49	706.79	2	18.7	2.6%
DTW	MCO	844.92	832.57	5	12.35	1.5%
DTW	MIA	997.63	985.28	4	12.35	1.3%
DTW	PBI	957.72	945.37	2	12.35	1.3%
DTW	RSW	955.75	943.4	1	12.35	1.3%
DTW	TPA	867.04	854.69	2	12.35	1.4%
EWR	ATL	655.81	647.4	3	8.41	1.3%
EWR	DFW	1202.38	1190.03	7	12.35	1.0%
EWR	FLL	940.41	925.77	2	14.64	1.6%
EWR	IAH	1237.43	1214.8	8	22.63	1.9%
EWR	JAX	727.8	712.12	1	15.68	2.2%
EWR	MCO	827.67	815.32	8	12.35	1.5%
EWR	MIA	944.64	937.53	2	7.11	0.8%
EWR	PBI	900.28	890.31	1	9.97	1.1%
FLL	CVG	829.49	808.91	2	20.58	2.5%
FLL	DTW	991.23	980.4	2	10.83	1.1%
FLL	EWR	938.12	925.77	1	12.35	1.3%
FLL	ORD	1040.67	1028.32	3	12.35	1.2%
FLL	PIT	888.23	864.61	2	23.62	2.7%
FLL	STL	936.38	926.4	4	9.98	1.1%
GPT	ATL	319.66	304.55	1	15.11	5.0%

Table G-1: NRP Routes, Cont'd

Org	Dest	ATC Pref Dist		Count	Diff (Miles)	Diff (Pct)
IAD	IAH	1044.97	1033.05	2	11.92	1.2%
IAD	MCO	686.35	659.35	9	27	4.1%
IAD	MIA	805.69	793.34	3	12.35	1.6%
IAD	MSY	836.48	824.13	2	12.35	1.5%
IAD	TPA	717.67	704.73	3	12.94	1.8%
IAH	ATL	614.09	597.54	1	16.55	2.8%
IAH	BOS	1399.34	1386.99	5	12.35	0.9%
IAH	BWI	1089.03	1072.04	5	16.99	1.6%
IAH	DCA	1061.03	1048.68	5	12.35	1.2%
IAH	EWR	1227.15	1214.8	2	12.35	1.0%
IAH	GSO	868.7	856.35	1	12.35	1.4%
IAH	IAD	1049.42	1033.05	3	16.37	1.6%
IAH	LGA	1242.04	1229.69	5	12.35	1.0%
IAH	PHL	1162.57	1150.22	5	12.35	1.1%
IAH	RDU	916.95	904.6	2	12.35	1.4%
JAX	EWR	719.89	712.12	1	7.77	1.1%
JAX	MEM	511.36	499.01	2	12.35	2.5%
JAX	ORD	763.68	751.33	2	12.35	1.6%
JFK	MCO	833.2	820.85	1	12.35	1.5%
JFK	MSY	1027.38	1021.28	1	6.1	0.6%
JFK	TPA	885.66	873.31	1	12.35	1.4%
LAS	CLT	1667.05	1659.94	1	7.11	0.4%
LAX	ATL	1699.88	1687.53	1	12.35	0.7%
LAX	CLT	1854.41	1842.06	6	12.35	0.7%
LAX	MCO	1934.8	1922.45	3	12.35	0.6%
LAX	MIA	2031.55	2019.2	2	12.35	0.6%
LGA	IAH	1251.42	1229.69	6	21.73	1.8%
LGA	MIA	973.62	948.17	1	25.45	2.7%
MCO	BOS	987.53	975.18	6	12.35	1.3%
MCO	CMH	711.96	698.87	3	13.09	1.9%
MCO	CVG	669.04	656.69	4	12.35	1.9%
MCO	DCA	681.18	661.25	3	19.93	3.0%
MCO	DEN	1365.95	1348.78	6	17.17	1.3%
MCO	DTW	844.92	832.57	6	12.35	1.5%
MCO	EWR	840.01	815.32	2	24.69	3.0%
MCO	IAD	675.24	659.35	5	15.89	2.4%
MCO	LAX	1946.83	1922.45	3	24.38	1.3%
MCO	MKE	926.68	926.68	1	0	0.0%
MCO	MSP	1147.42	1138.38	3	9.04	0.8%
MCO	ORD	886.86	874.51	8	12.35	1.4%
MCO	PHX	1607.76	1595.41	1	12.35	0.8%
MCO	PIT	729.67	725.63	1	4.04	0.6%

Table G-1: NRP Routes, Cont'd

Org	Dest	ATC Pref Dist	Direct Dist	Count	Diff (Miles)	Diff (Pct)
MCO	SDF	631.15	625.19	3	5.96	1.0%
MCO	SFO	2140.49	2119.63	1	20.86	1.0%
MCO	STL	796.38	774	6	22.38	2.9%
MEM	BOS	991.42	988.22	2	3.2	0.3%
MEM	EWR	842.86	819.52	2	23.34	2.8%
MEM	JAX	501.04	499.01	2	2.03	0.4%
MEM	MCO	605.95	593.73	4	12.22	2.1%
MIA	BWI	828.03	815.68	1	12.35	1.5%
MIA	CVG	824.09	811.74	2	12.35	1.5%
MIA	DCA	805.33	792.98	2	12.35	1.6%
MIA	DEN	1489.68	1477.33	1	12.35	0.8%
MIA	DTW	997.63	985.28	3	12.35	1.3%
MIA	IAD	805.69	793.34	4	12.35	1.6%
MIA	LAX	2031.55	2019.2	2	12.35	0.6%
MIA	LGA	960.52	948.17	2	12.35	1.3%
MIA	MEM	746.62	734.27	2	12.35	1.7%
MIA	MSP	1304.3	1291.95	2	12.35	1.0%
MIA	ORD	1042.07	1029.72	13	12.35	1.2%
MIA	RDU	613.69	601.34	2	12.35	2.1%
MIA	SFO	2241.35	2229	2	12.35	0.6%
MIA	STL	936.55	924.2	4	12.35	1.3%
MKE	MCO	929.89	926.68	1	3.21	0.3%
MSP	ATL	808	787.85	6	20.15	2.6%
MSP	CLT	811.78	807.16	2	4.62	0.6%
MSP	MCO	1155.47	1138.38	1	17.09	1.5%
MSP	MIA	1304.3	1291.95	2	12.35	1.0%
MSP	TPA	1159.43	1135.43	2	24	2.1%
MSY	BWI	874.34	861.99	2	12.35	1.4%
MSY	CLT	571.59	559.71	4	11.88	2.1%
MSY	DCA	852.63	837.19	2	15.44	1.8%
MSY	IAD	836.48	824.13	2	12.35	1.5%
MSY	LGA	1043.67	1022.82	1	20.85	2.0%
MSY	PHL	961.45	940.69	2	20.76	2.2%
MSY	PIT	805.9	793.55	2	12.35	1.6%
ORD	FLL	1040.67	1028.32	2	12.35	1.2%
ORD	JAX	768.77	751.33	2	17.44	2.3%
ORD	MCO	888.29	874.51	5	13.78	1.6%
ORD	MIA	1042.07	1029.72	6	12.35	1.2%
ORD	PBI	1014.13	995.87	1	18.26	1.8%
ORD	RSW	996.74	975.18	1	21.56	2.2%
ORD	TPA	902.11	880.59	5	21.52	2.4%
PBI	CVG	797.38	775.29	2	22.09	2.8%

Table G-1: NRP Routes, Cont'd

Org	Dest	ATC Pref Dist	Direct Dist	Count	Diff (Miles)	Diff (Pct)
PBI	DTW	957.72	945.37	2	12.35	1.3%
PBI	LGA	913.24	900.89	1	12.35	1.4%
PBI	ORD	1008.22	995.87	1	12.35	1.2%
PBI	STL	917.71	897.97	1	19.74	2.2%
PHF	ATL	453.93	441.58	1	12.35	2.8%
PHL	IAH	1162.57	1150.22	2	12.35	1.1%
PHL	JAX	660.45	645.12	1	15.33	2.4%
PHX	CLT	1534.97	1530.45	2	4.52	0.3%
PIT	FLL	874.9	864.61	3	10.29	1.2%
PIT	MCO	727.14	725.63	8	1.51	0.2%
PIT	MIA	884.23	871.88	2	12.35	1.4%
PIT	PBI	841.72	828.63	2	13.09	1.6%
PIT	RSW	858.83	840.45	2	18.38	2.2%
RDU	DFW	932.33	919.98	5	12.35	1.3%
RDU	ORD	573.56	561.21	2	12.35	2.2%
RSW	CVG	769.39	762.73	3	6.66	0.9%
RSW	DTW	955.75	943.4	2	12.35	1.3%
RSW	LGA	952.55	940.2	1	12.35	1.3%
RSW	PHL	876.44	864.09	3	12.35	1.4%
RSW	STL	871.06	859.37	2	11.69	1.4%
SAN	CLT	1812.47	1799.06	1	13.41	0.7%
SDF	ATL	292.56	280.21	1	12.35	4.4%
SFO	ATL	1876.25	1853.34	1	22.91	1.2%
SFO	CLT	2012.51	1989.14	4	23.37	1.2%
SFO	MCO	2131.98	2119.63	1	12.35	0.6%
SFO	MIA	2241.35	2229	1	12.35	0.6%
SRQ	STL	807.88	793.28	1	14.6	1.8%
STL	FLL	938.75	926.4	2	12.35	1.3%
STL	MCO	786.35	774	6	12.35	1.6%
STL	MIA	936.55	924.2	4	12.35	1.3%
STL	PBI	917.78	897.97	1	19.81	2.2%
STL	RSW	871.72	859.37	2	12.35	1.4%
STL	SRQ	805.63	793.28	1	12.35	1.6%
STL	TPA	775.97	763.62	4	12.35	1.6%
TPA	BOS	1042.32	1029.97	3	12.35	1.2%
TPA	CLE	810.38	806.53	2	3.85	0.5%
TPA	CVG	688.85	670.59	3	18.26	2.7%
TPA	DEN	1326.81	1314.46	2	12.35	0.9%
TPA	DTW	867.04	854.69	4	12.35	1.4%
TPA	EWR	893.9	866.82	2	27.08	3.1%
TPA	JFK	885.66	873.31	2	12.35	1.4%
TPA	MEM	591.4	569.95	3	21.45	3.8%
TPA	MSP	1147.78	1135.43	1	12.35	1.1%
TPA	ORD	892.94	880.59	7	12.35	1.4%
TPA	STL	779.56	763.62	4	15.94	2.1%

Table G-2 provides a breakdown by city and aircraft type. All these flights comprised the baseline 2000 NRP number used in the analysis. 214 unique city pairs flew NRP through the Southern Region airports on August 28, 2000.

Table G-2: NRP Routes by Aircraft Type

DEPT_APRT	ARR_APRT	ACFT_TYPE	Count of Freq
ATL	BOS	B72Q	3
ATL	BOS	B752	5
ATL	BOS	B762	1
ATL	BOS	B763	3
ATL	BOS	MD80	2
ATL	DEN	B727	3
ATL	DEN	B737	2
ATL	DEN	B752	1
ATL	DEN	B762	2
ATL	DEN	B763	2
ATL	DEN	MD80	1
ATL	EWR	B752	1
ATL	EWR	MD80	2
ATL	FLL	B763	2
ATL	FLL	L101	1
ATL	IAH	B733	1
ATL	IAH	B735	1
ATL	IAH	B737	1
ATL	LAS	B72Q	1
ATL	LAX	A319	1
ATL	MIA	B722	3
ATL	MIA	B752	3
ATL	MIA	B762	2
ATL	MIA	B763	1
ATL	MIA	L101	1
ATL	MIA	MD80	1
ATL	MSP	B727	1
ATL	MSP	B752	1
ATL	MSP	DC9Q	2
ATL	MSP	MD80	3
ATL	ORD	F100	1
ATL	ORD	MD80	1
ATL	PBI	B752	3
ATL	PBI	B762	1
ATL	PBI	MD80	1
ATL	PIT	B73Q	1
ATL	PIT	DC9Q	3
ATL	PIT	F100	1
ATL	SFO	A320	1
BDL	MCO	B732	1
BNA	EWR	B735	1

Table G-2: NRP Routes by Aircraft Type, Cont'd

DEPT_APRT	ARR_APRT	ACFT_TYPE	Count of Freq
BNA	MCO	B73Q	1
BNA	MIA	B722	1
BOS	IAH	B733	3
BOS	MCO	MD80	1
BWI	IAH	B738	1
BWI	IAH	MD80	2
BWI	JAX	B73Q	2
BWI	MCO	B73Q	5
BWI	TPA	B73Q	7
CLT	DEN	A319	2
CLT	DFW	A319	2
CLT	DFW	B734	1
CLT	FLL	B733	2
CLT	FLL	B734	1
CLT	FLL	B73Q	1
CLT	FLL	B752	1
CLT	FLL	MD80	1
CLT	IAH	B733	2
CLT	IAH	B734	2
CLT	JAX	A319	1
CLT	JAX	A320	1
CLT	JAX	B733	1
CLT	JAX	B734	1
CLT	JAX	B73Q	1
CLT	JAX	B762	1
CLT	LAS	A319	1
CLT	LAS	A320	1
CLT	LAX	A319	1
CLT	LAX	A320	1
CLT	LAX	B752	3
CLT	MCI	B734	1
CLT	MCI	MD80	2
CLT	MIA	B733	1
CLT	MIA	B734	3
CLT	MIA	MD80	1
CLT	MSP	B733	2
CLT	MSY	B733	2
CLT	MSY	B734	2
CLT	PBI	B733	2
CLT	PBI	MD80	3
CLT	PHX	A319	2
CLT	PVD	A319	1
CLT	PVD	B733	1
CLT	SAN	A319	1

Table G-2: NRP Routes by Aircraft Type, Cont'd

DEPT_APRT	ARR_APRT	ACFT_TYPE	Count of Freq
CLT	SAN	A320	1
CLT	SEA	B752	2
CLT	SFO	A319	1
CLT	SFO	B752	3
CVG	FLL	MD80	1
DCA	IAH	B733	1
DCA	IAH	B735	1
DCA	IAH	B737	2
DCA	IAH	B73J	1
DCA	MCO	B733	1
DCA	MCO	MD80	2
DCA	MIA	B727	1
DCA	MIA	MD80	1
DEN	ATL	B727	4
DEN	ATL	B72Q	1
DEN	ATL	B737	1
DEN	CLT	A319	2
DEN	CLT	A320	1
DEN	MCO	B737	2
DEN	MCO	B752	1
DEN	MCO	B767	1
DEN	MIA	A320	1
DEN	MIA	B757	1
DEN	MIA	MD80	1
DEN	TPA	B737	1
DEN	TPA	B752	1
DFW	ATL	B752	1
DFW	CLT	MD80	1
DFW	EWR	B722	2
DFW	EWR	B735	2
DFW	EWR	B752	1
DFW	EWR	MD80	6
DFW	JFK	MD80	1
DFW	PBI	MD80	1
DTW	CLT	DC9Q	1
DTW	FLL	DC9Q	2
DTW	JAX	DC9Q	2
DTW	MCO	B752	2
DTW	MCO	DC9Q	3
DTW	MIA	A320	1
DTW	MIA	B722	1
DTW	MIA	B72Q	2
DTW	PBI	DC9Q	2
DTW	RSW	DC9Q	1

Table G-2: NRP Routes by Aircraft Type, Cont'd

DEPT_APRT	ARR_APRT	ACFT_TYPE	Count of Freq
DTW	TPA	A320	1
DTW	TPA	B72Q	1
EWR	ATL	B733	2
EWR	ATL	B737	1
EWR	DFW	B735	4
EWR	DFW	B73J	1
EWR	DFW	B752	1
EWR	DFW	MD80	1
EWR	FLL	B757	1
EWR	FLL	MD80	1
EWR	IAH	B733	2
EWR	IAH	B738	1
EWR	IAH	B73S	1
EWR	IAH	B752	1
EWR	IAH	DC10	3
EWR	JAX	B735	1
EWR	MCO	B738	1
EWR	MCO	B752	5
EWR	MCO	MD80	2
EWR	MIA	MD80	2
EWR	PBI	MD80	1
FLL	CVG	B752	2
FLL	DTW	DC9	1
FLL	DTW	DC9Q	1
FLL	EWR	B752	1
FLL	ORD	B737	1
FLL	ORD	MD80	2
FLL	PIT	B734	1
FLL	PIT	MD80	1
FLL	STL	MD80	4
GPT	ATL	B712	1
IAD	IAH	B735	2
IAD	MCO	A319	1
IAD	MCO	B727	2
IAD	MCO	B732	2
IAD	MCO	B733	1
IAD	MCO	B737	1
IAD	MCO	B73Q	1
IAD	MCO	B757	1
IAD	MIA	A320	1
IAD	MIA	B737	1
IAD	MIA	B767	1
IAD	MSY	A319	1
IAD	MSY	B727	1

Table G-2: NRP Routes by Aircraft Type, Cont'd

DEPT_APRT	ARR_APRT		Count of Freq
IAD	TPA	B727	2
IAD	TPA	B72Q	1
IAH	ATL	B733	1
IAH	BOS	B733	1
IAH	BOS	B735	1
IAH	BOS	B737	1
IAH	BOS	MD80	2
IAH	BWI	B738	1
IAH	BWI	B73C	1
IAH	BWI	MD80	3
IAH	DCA	B735	1
IAH	DCA	B737	4
IAH	EWR	DC10	1
IAH	EWR	MD80	1
IAH	GSO	B735	1
IAH	IAD	B735	3
IAH	LGA	B733	4
IAH	LGA	B738	1
IAH	PHL	B733	3
IAH	PHL	B734	1
IAH	PHL	B735	1
IAH	RDU	B733	1
IAH	RDU	B735	1
JAX	EWR	B735	1
JAX	MEM	DC9Q	2
JAX	ORD	B737	2
JFK	MCO	MD80	1
JFK	MSY	MD80	1
JFK	TPA	MD80	1
LAS	CLT	A320	1
LAX	ATL	A319	1
LAX	CLT	A319	3
LAX	CLT	B752	3
LAX	MCO	A320	3
LAX	MIA	A320	1
LAX	MIA	B777	1
LGA	IAH	B733	6
LGA	MIA	B727	1
MCO	BOS	B73Q	6
MCO	CMH	B73Q	3
MCO	CVG	B752	2
MCO	CVG	B763	1
MCO	CVG	MD80	1
MCO	DCA	B733	2

Table G-2: NRP Routes by Aircraft Type, Cont'd

DEPT_APRT	ARR_APRT	ACFT_TYPE	Count of Freq
MCO	DCA	MD80	1
MCO	DEN	A320	1
MCO	DEN	B727	5
MCO	DTW	A320	1
MCO	DTW	B752	3
MCO	DTW	DC10	1
MCO	DTW	DC9Q	1
MCO	EWR	B752	1
MCO	EWR	MD80	1
MCO	IAD	B727	3
MCO	IAD	B737	2
MCO	LAX	A319	1
MCO	LAX	A320	2
MCO	MKE	DC9Q	1
MCO	MSP	A320	1
MCO	MSP	B727	1
MCO	MSP	B72Q	1
MCO	ORD	B737	1
MCO	ORD	B738	1
MCO	ORD	B757	2
MCO	ORD	B767	2
MCO	ORD	MD80	2
MCO	PHX	B752	1
MCO	PIT	B752	1
MCO	SDF	B73Q	3
MCO	SFO	B757	1
MCO	STL	B752	5
MCO	STL	MD80	1
MEM	BOS	B72Q	1
MEM	BOS	DC10	1
MEM	EWR	DC9Q	1
MEM	EWR	MD11	1
MEM	JAX	DC9Q	2
MEM	MCO	A320	1
MEM	MCO	B72Q	1
MEM	MCO	B752	1
MEM	MCO	DC9Q	1
MIA	BWI	B727	1
MIA	CVG	B752	1
MIA	CVG	MD80	1
MIA	DCA	B737	1
MIA	DCA	B752	1
MIA	DEN	MD80	1
MIA	DTW	A319	1
MIA	DTW	B72Q	2

Table G-2: NRP Routes by Aircraft Type, Cont'd

DEPT_APRT	ARR_APRT	ACFT_TYPE	
MIA	IAD	B722	1
MIA	IAD	B727	3
MIA	LAX	A320	1
MIA	LAX	B777	1
MIA	LGA	B737	1
MIA	LGA	MD80	1
MIA	MEM	A320	1
MIA	MEM	B72Q	1
MIA	MSP	A320	2
MIA	ORD	A320	2
MIA	ORD	B738	2
MIA	ORD	B752	3
MIA	ORD	B757	1
MIA	ORD	B763	1
MIA	ORD	B767	1
MIA	ORD	B777	1
MIA	ORD	MD80	2
MIA	RDU	MD80	2
MIA	SFO	B763	1
MIA	SFO	B767	1
MIA	STL	MD80	4
MKE	MCO	DC9Q	1
MSP	ATL	B72Q	2
MSP	ATL	B752	2
MSP	ATL	DC9Q	2
MSP	CLT	B733	2
MSP	MCO	B752	1
MSP	MIA	A320	2
MSP	TPA	A320	2
MSY	BWI	B73Q	2
MSY	CLT	B733	2
MSY	CLT	B734	2
MSY	DCA	B733	1
MSY	DCA	B734	1
MSY	IAD	A320	1
MSY	IAD	B727	1
MSY	LGA	B734	1
MSY	PHL	B734	2
MSY	PIT	B733	1
MSY	PIT	F100	1
ORD	FLL	B737	1
ORD	FLL	MD80	1
ORD	JAX	B737	2
ORD	MCO	B727	4
ORD	MCO	B767	1

Table G-2: NRP Routes by Aircraft Type, Cont'd

DEPT_APRT	ARR_APRT	ACFT_TYPE	Count of Freq
ORD	MIA	B738	2
ORD	MIA	B752	1
ORD	MIA	B777	1
ORD	MIA	MD80	2
ORD	PBI	B737	1
ORD	RSW	B727	1
ORD	TPA	A319	1
ORD	TPA	B72Q	1
ORD	TPA	B737	1
ORD	TPA	B738	1
ORD	TPA	MD80	1
PBI	CVG	MD80	2
PBI	DTW	DC9Q	2
PBI	LGA	MD80	1
PBI	ORD	B737	1
PBI	STL	MD80	1
PHF	ATL	DC9	1
PHL	IAH	B735	2
PHL	JAX	B734	1
PHX	CLT	A319	1
PHX	CLT	A320	1
PIT	FLL	B733	2
PIT	FLL	MD80	1
PIT	MCO	B733	3
PIT	MCO	B752	3
PIT	MCO	MD80	2
PIT	MIA	B734	1
PIT	MIA	MD80	1
PIT	PBI	MD80	2
PIT	RSW	B734	2
RDU	DFW	B722	1
RDU	DFW	B763	1
RDU	DFW	MD80	3
RDU	ORD	MD80	2
RSW	CVG	B72Q	1
RSW	CVG	MD80	2
RSW	DTW	DC9Q	2
RSW	LGA	B733	1
RSW	PHL	B733	1
RSW	PHL	B734	2
RSW	STL	MD80	2
SAN	CLT	A319	1
SDF	ATL	B712	1
SFO	ATL	A319	1
SFO	CLT	A319	1

Table G-2: NRP Routes by Aircraft Type, Cont'd

DEPT_APRT	ARR_APRT	ACFT_TYPE	Count of Freq
SFO	CLT	B752	3
SFO	MCO	B757	1
SFO	MIA	B767	1
SRQ	STL	MD80	1
STL	FLL	MD80	2
STL	MCO	B752	4
STL	MCO	MD80	2
STL	MIA	MD80	4
STL	PBI	MD80	1
STL	RSW	MD80	2
STL	SRQ	MD80	1
STL	TPA	MD80	4
TPA	BOS	B73Q	3
TPA	CLE	B733	1
TPA	CLE	MD80	1
TPA	CVG	B72Q	1
TPA	CVG	MD80	2
TPA	DEN	B727	2
TPA	DTW	A320	2
TPA	DTW	B72Q	2
TPA	EWR	B738	1
TPA	EWR	MD80	1
TPA	JFK	B722	1
TPA	JFK	MD80	1
TPA	MEM	A320	3
TPA	MSP	A320	1
TPA	ORD	B727	3
TPA	ORD	B737	1
TPA	ORD	B738	1
TPA	ORD	MD80	2
TPA	STL	MD80	4

Appendix H: Aircraft Type Distribution Through the Southern Region

Table H-1 lists the aircraft that flew through the Southern Region. The bolded entries in each year's column reflect all the associated mapped equivalent aircraft. The "Year 2000" quantities associated with each aircraft type reflects the ones captured on the August 28, 2000, simulation day. The quantities in the future years are driven by the growth rates and fleet mix adjustments with the Boeing air carrier forecast.

Table H-1: Aircraft Type Distribution Southern Region

Year 2000		Year 2005		Year 2010		Year 2015	
Actyp	Number	Actyp	Number	Actyp	Number	Actyp	Number
A10	8	A10	8	A10	8	A10	8
A300	123	***A300***	129	***A300***	147	***A300***	156
A310	10	***A310***	10	***A310***	13	***A310***	11
A4	7	A4	7	A4	7	A4	7
A6	4	A6	4	A6	4	A6	4
AA5	3	AA5	3	AA5	3	AA5	3
AC12	1	AC12	1	AC12	1	AC12	1
AC14	1	AC14	1	AC14	1	AC14	1
AC21	2	AC21	2	AC21	2	AC21	2
AC69	14	AC69	14	AC69	14	AC69	14
AJ25	10	***AJ25***	9	***AJ25***	9	***AJ25***	9
AT42	283	AT42	287	AT42	297	AT42	322
B707	9	B707	9	B707	12	B707	9
B727	812	***B727***	806	***B727***	805	***B727***	805
B737	1387	***B737***	1385	***B737***	1385	***B737***	1385
B73F	13	***B73F***	41	***B73F***	79	***B73F***	122
B73J	116	***B73J***	215	***B73J***	331	***B73J***	366
B73S	90	***B73S***	217	***B73S***	282	***B73S***	419
B747	38	***B747***	44	***B747***	42	***B747***	44
B757	764	***B757***	878	***B757***	1019	***B757***	1233
B767	243	***B767***	***232***	***B767***	292	***B767***	286
B777	7	***B777***	1	***B777***	9	***B777***	23
BA14	156	***BA14***	190	***BA14***	205	***BA14***	209
BA31	2	***BA31***	2	***BA31***	2	***BA31***	2
BA41	30	***BA41***	37	***BA41***	34	***BA41***	33
BA46	45	***BA46***	45	***BA46***	47	***BA46***	58
BE02	351	BE02	335	BE02	352	BE02	379
BE10	26	BE10	26	BE10	26	BE10	26
BE18	9	BE18	9	BE18	9	BE18	9
BE20	145	BE20	146	BE20	146	BE20	150
BE23	2	BE23	2	BE23	2	BE23	2
BE30	41	BE30	41	BE30	41	BE30	41
BE33	18	BE33	18	BE33	19	BE33	19
BE35	16	BE35	16	BE35	16	BE35	16
BE36	36	BE36	37	BE36	38	BE36	39
BE3B	6	BE3B	6	BE3B	6	BE3B	6
BE40	23	BE40	23	BE40	23	BE40	25
BE55	40	BE55	40	BE55	40	BE55	53
BE58	98	BE58	98	BE58	99	BE58	101
BE5R	1	BE5R	1	BE5R	1	BE5R	1
BE60	3	BE60	3	BE60	3	BE60	3
BE76	5	BE76	5	BE76	5	BE76	5
BE8T	8	BE8T	8	BE8T	8	BE8T	8
BE90	86	BE90	88	BE90	87	BE90	89
BE95	3	BE95	3	BE95	3	BE95	3
BE99	2	BE99	2	BE99	2	BE99	4
BE9F	2	BE9F	2	BE9F	2	BE9F	2
BEST	2	BEST	2	BEST	2	BEST	2
BN2	3	BN2	3	BN2	3	BN2	3

Table H-1: Aircraft Type Distribution Southern Region (Cont'd)

Year 2000		Year 2005		Year 2010		Year 2015	
Actyp	Number	Actyp	Number	Actyp	Number	Actyp	Number
C10	1	C10	1	C10	1	C10	1
C12	24	C12	24	C12	24	C12	24
C130	47	C130	47	C130	47	C130	47
C135	2	***C135***	2	***C135***	2	***C135***	2
C141	12	***C141***	12	***C141***	12	***C141***	12
C172	66	***C172***	66	***C172***	66	***C172***	71
C177	6	***C177***	5	***C177***	6	***C177***	8
C180	1	C180	1	C180	1	C180	1
C182	42	C182	44	C182	44	C182	44
C206	2	C206	2	C206	2	C206	2
C208	1	C208	1	C208	1	C208	1
C21	22	***C21***	22	***C21***	22	***C21***	22
C210	40	C210	40	C210	40	C210	40
C23	1	C23	1	C23	1	C23	1
C26	2	C26	2	C26	2	C26	2
C310	114	C310	114	C310	114	C310	115
C335	2	C335	2	C335	2	C335	2
C337	6	C337	6	C337	6	C337	6
C340	18	C340	18	C340	18	C340	18
C401	5	C401	5	C401	5	C401	5
C402	4	C402	4	C402	4	C402	4
C414	31	C414	31	C414	32	C414	31
C421	29	C421	29	C421	29	C421	30
C425	15	C425	15	C425	15	C425	15
C441	31	C441	31	C441	31	C441	32
C5	7	C5	7	C5	7	C5	7
C500	19	C500	19	C500	19	C500	19
C501	17	C501	17	C501	17	C501	17
C525	6	C525	6	C525	6	C525	6
C550	68	C550	69	C550	70	C550	72
C560	57	C560	57	C560	57	C560	57
C650	21	C650	21	C650	21	C650	21
C9	27	C9	27	C9	27	C9	27
C9B	2	C9B	2	C9B	2	C9B	2
CH46	3	CH46	3	CH46	3	CH46	3
CL60	16	***CL60***	16	***CL60***	16	***CL60***	16
CL61	12	***CL61***	14	***CL61***	12	***CL61***	12
CRJ	45	***CRJ***	72	***CRJ***	143	***CRJ***	166
CV44	1	CV44	1	CV44	1	CV44	1
CV58	3	CV58	3	CV58	5	CV58	3
D28	3	D28	3	D28	3	D28	3
D328	59	D328	63	D328	65	D328	68
DA01	15	DA01	15	DA01	16	DA01	16
DA02	7	DA02	7	DA02	7	DA02	7
DA05	6	DA05	6	DA05	6	DA05	6
DA10	1	DA10	1	DA10	1	DA10	1
DA20	8	DA20	8	DA20	8	DA20	8
DA50	3	***DA50***	3	***DA50***	3	***DA50***	3
DA90	3	***DA90***	4	***DA90***	4	***DA90***	4
DC10	19	***DC10***	18	***DC10***	24	***DC10***	32
DC3	7	DC3	7	DC3	7	DC3	7
DC4	1	DC4	1	DC4	1	DC4	1
DC6	2	DC6	2	DC6	2	DC6	2
DC8	5	***DC8***	5	***DC8***	5	***DC8***	5
DC86	113	***DC86***	139	***DC86***	135	***DC86***	174
DC9	562	***DC9***	521	***DC9***	453	***DC9***	324
DH6	41	DH6	41	DH6	41	DH6	41
DH8	18	DH8	23	DH8	36	DH8	84

Table H-1: Aircraft Type Distribution Southern Region (Cont'd)

Year 2000		Year 2005		Year 2010		Year 2015	
Actyp	Number	Actyp	Number	Actyp	Number	Actyp	Number
E110	21	E110	29	E110	22	E110	21
E120	533	E120	505	E120	616	E120	588
E2	1	E2	1	E2	1	E2	1
EA32	124	***EA32***	129	***EA32***	150	***EA32***	188
EA33	16	***EA33***	16	***EA33***	28	***EA33***	17
EA34	1	***EA34***	1	***EA34***	1	***EA34***	2
EA6	1	EA6	1	EA6	1	EA6	1
F14	5	F14	5	F14	5	F14	5
FA27	1	FA27	1	FA27	1	FA27	1
FA28	55	FA28	61	FA28	59	FA28	62
FK10	196	FK10	210	FK10	231	FK10	263
G159	2	G159	2	G159	2	G159	2
G2	13	***G2***	14	***G2***	14	***G2***	15
G3	13	***G3***	13	***G3***	13	***G3***	13
G4	5	***G4***	5	***G4***	5	***G4***	5
G73	7	G73	7	G73	7	G73	7
H57	1	H57	1	H57	1	H57	1
HS25	82	***HS25***	82	***HS25***	83	***HS25***	83
HU25	9	HU25	9	HU25	9	HU25	9
KC10	3	***KC10***	3	***KC10***	3	***KC10***	3
KR35	6	***KR35***	11	***KR35***	11	***KR35***	12
L101	110	***L101***	110	***L101***	111	***L101***	111
L188	9	L188	13	L188	9	L188	9
L1F	2	L1F	2	L1F	2	L1F	2
L329	9	L329	9	L329	9	L329	13
L382	2	L382	2	L382	1	L382	1
LR24	17	***LR24***	17	***LR24***	17	***LR24***	17
LR25	29	***LR25***	31	***LR25***	32	***LR25***	32
LR28	1	***LR28***	1	***LR28***	1	***LR28***	1
LR31	12	***LR31***	12	***LR31***	12	***LR31***	12
LR35	92	***LR35***	95	***LR35***	84	***LR35***	85
LR36	2	***LR36***	2	***LR36***	2	***LR36***	2
LR55	21	***LR55***	21	***LR55***	22	***LR55***	23
LR60	6	***LR60***	6	***LR60***	5	***LR60***	4
M11	11	M11	11	M11	11	M11	11
MD80	1116	***MD80***	1218	***MD80***	1331	***MD80***	1475
MD83	3	***MD83***	3	***MD83***	3	***MD83***	3
MD90	13	***MD90***	14	***MD90***	17	***MD90***	18
MH6	1	MH6	1	MH6	1	MH6	1
MO20	42	MO20	42	MO20	42	MO20	42
MO2K	1	MO2K	1	MO2K	1	MO2K	1
MU2	27	MU2	27	MU2	27	MU2	27
MU3	16	MU3	16	MU3	15	MU3	15
MU30	3	MU30	3	MU30	3	MU30	3
N265	27	N265	27	N265	40	N265	42
P3	14	P3	14	P3	14	P3	14
PA23	6	PA23	6	PA23	6	PA23	6
PA24	12	PA24	12	PA24	12	PA24	12
PA28	47	PA28	48	PA28	47	PA28	48
PA30	11	PA30	11	PA30	11	PA30	11
PA31	70	PA31	70	PA31	72	PA31	73
PA32	58	PA32	59	PA32	59	PA32	59
PA34	42	PA34	43	PA34	44	PA34	45
PA41	1	PA41	1	PA41	2	PA41	2

Table H-1: Aircraft Type Distribution Southern Region (Cont'd)

Year 2000		Year 2005		Year 2010		Year 2015	
Actyp	**Number**	**Actyp**	**Number**	**Actyp**	**Number**	**Actyp**	**Number**
PA42	4	PA42	4	PA42	4	PA42	5
PA44	23	PA44	25	PA44	27	PA44	30
PA46	4	PA46	4	PA46	4	PA46	4
PA60	27	PA60	25	PA60	25	PA60	26
PA61	1	PA61	1	PA61	1	PA61	1
PARO	9	PARO	10	PARO	11	PARO	12
PASE	6	PASE	6	PASE	6	PASE	6
PAYE	46	PAYE	45	PAYE	46	PAYE	47
PAZT	13	PAZT	13	PAZT	13	PAZT	13
RC12	1	RC12	1	RC12	1	RC12	1
RU21	6	RU21	6	RU21	6	RU21	6
S3	3	S3	3	S3	3	S3	3
SF34	219	SF34	219	SF34	210	SF34	228
SH7	94	SH7	94	SH7	94	SH7	94
SHD3	3	SHD3	3	SHD3	4	SHD3	3
SW2	4	SW2	4	SW2	4	SW2	4
SW3	4	SW3	4	SW3	4	SW3	4
SW4	9	SW4	5	SW4	6	SW4	6
T2	19	T2	19	T2	19	T2	19
T34	21	T34	21	T34	21	T34	21
T38	24	T38	24	T38	24	T38	24
T39	9	T39	9	T39	9	T39	9
T44	1	T44	1	T44	1	T44	1
TA4	5	TA4	5	TA4	5	TA4	5
TB20	1	TB20	1	TB20	1	TB20	1
U21	8	TB70	1	TB70	1	TB70	1
UH1	1	U21	8	U21	8	U21	8
UH60	7	UH1	1	UH1	1	UH1	1
UNKN	185	UH60	7	UH60	7	UH60	7
WW24	14	WW24	14	WW24	14	WW24	14
YS11	6	YS11	6	YS11	6	YS11	6
Total	**10510**		**10860**		**11647**		**12398**
Unknown	**572**		**1010**		**1166**		**1318**
Total + Unknown	**11082**		**11870**		**12813**		**13716**

* Note: Difference between these totals and total flights simulated are represented in unknown aircraft type.

Table H-2 presents RVSM-equipped aircraft for major carriers that had information available. Note: Many of the older turbo-prop aircraft were not considered eligible (due to a lack of information) for domestic RVSM.

Table H-2: Aircraft Eligible to Fly RVSM by Carrier

Carrier	Aircraft	RVSM-Equipped 2000	RVSM-Equipped 2005
American	777-200	25	45
	MD-11	8	0
	DC10	8	0
	A300	35	35
	737-800	48	75
	757-200	102	123
	767-200	30	30
	767-300	49	49
	MD80	276	264
	F100	75	75
Continental	737-700/800	110	131
	757-200	40	40
	767-200	5	10
	767-400	2	24
	777-200	17	18
	MD80	66	66
Delta	727-200	75	0
	737-200	54	54
	737-300	26	26
	737-800	35	132
	757-200	113	121
	767-200	15	15
	767-300	87	87
	767-400	16	21
	777-200	8	13
	L1011	17	0
	MD11	15	15
	MD80	120	120
	MD90	16	16
FEDEX	A300	36	36
	DC10	93	104
	MD11	30	52
Northwest	747-100/200	31	31
	747-400	14	14
	DC-10	44	44
Southwest	737-200	34	34
	737-300	194	194
	737-500	25	25
	737-700	86	86
TWA	717	15	50
	757-200	26	36
	767-200	16	16
	DC9	35	0
	MD80	100	68
	A319	0	50

Table H-2: Aircraft Eligible to Fly RVSM by Carrier, Cont'd

Carrier	Aircraft	RVSM-Equipped 2000	RVSM-Equipped 2005
United	727-200	75	0
	737-200	24	0
	737-300/500	158	158
	747-200	6	0
	747-400	44	44
	757-200	99	99
	767-200	19	19
	767-300	50	50
	777-200	46	56
	A319	35	47
	A320	65	86
	DC10	10	0
USA	737-200	53	53
	737-300/400	139	139
	757-200	34	34
	767-200	12	12
	A319	50	50
	A320	22	22
	A330	5	5
	DC9-30	27	0
	F100	40	40
	MD80	31	31

Source: AFS-400 (October 2001)

Table H-3 provides a breakdown by aircraft type that are RVSM-equipped per input from AFS-400. The lists in the two tables served as the basis for Case 4 in the analysis.

Table H-3: RVSM-Equipped Aircraft

RVSM-2000		RVSM-2005	
Acft Type	Total	Acft Type	Total
MD80	593	MD80	551
757-200	404	757-200	453
737-300	220	737-300	359
767-300	186	737-700/800	217
737-200	165	737-800	207
737-300/500	158	767-300	186
727-200	150	737-300/500	158
737-300/400	139	A319	147
F100	115	737-200	141
DC10	111	777-200	132
737-700/800	110	F100	115
767-200	97	A320	108
777-200	96	DC10	104
A320	87	767-200	102
737-700	86	A300	71
A319	85	MD11	67
737-800	83	747-400	58
A300	71	717	50
747-400	58	767-400	45
MD11	45	DC-10	44

RVSM-2000		RVSM-2005	
Acft Type	Total	Acft Type	Total
DC-10	44	747-100/200	31
DC9	35	737-500	25
747-100/200	31	MD90	16
DC9-30	27	A330	5
737-500	25		
767-400	18		
L1011	17		
MD90	16		
717	15		
MD-11	8		
747-200	6		
TOTAL:	3301	TOTAL:	3392

Appendix I: Sector Attributes

The tables below provide all the attributes for each sector in the Southern Region. The sectors are from the ACES data. Scenario years 2000, 2005, 2010, and 2015 are presented. The columns presented in each of the tables are defined as follows.

Sector - one of the sectors in ZJX, ZTL, or ZMA, e.g., ZJX001.

MAP - the sector threshold for capacity. When the number of aircraft exceeds this number, there most likely will be a delay in the form of number of minutes exceeded.

Throughput - the maximum number of flights in a given point in time that traverse a sector on the simulation day.

Transit Time - the average amount of time an aircraft traverses in the sector on the simulation day.

Maximum Instantaneous Aircraft Counts (MIAC) - the maximum number of aircraft in a sector within any given point in time on the simulation day.

Min exceeded (Min exe, Exe_map, or DurPastMAP) - the amount of minutes the number of aircraft were either equal to or exceeded the MAP.

Table I-1: Year 2000 Sector Attributes

Sector	Throughput	Transittime	MIAC	Min exe	MAP
ZJX001	233	13.13	8	0	20
ZJX002	151	10.42	7	0	20
ZJX003	99	9.33	5	0	20
ZJX004	192	9.08	6	0	20
ZJX005	103	11.31	6	0	20
ZJX006	78	9.14	4	0	20
ZJX007	93	10.73	5	0	20
ZJX008	153	10.86	6	0	20
ZJX009	212	10.84	9	0	20
ZJX011	416	14.84	17	0	20
ZJX012	491	13.96	16	3	16
ZJX013	63	6.95	4	0	20
ZJX014	612	12.15	16	0	18
ZJX015	616	10.85	17	0	18
ZJX016	636	9.03	16	0	18
ZJX021	92	10.18	6	0	20
ZJX022	1062	8.44	20	8	20
ZJX023	96	13.35	5	0	20
ZJX024	519	12.08	17	0	20
ZJX025	91	11.05	4	0	20
ZJX026	188	14.56	10	0	20
ZJX027	32	11.5	4	0	20
ZJX030	292	22.73	14	0	21
ZJX047	401	13.84	17	0	21
ZJX048	372	16.32	19	0	21
ZJX050	414	11.84	15	0	18
ZJX051	183	13.74	10	0	21
ZJX052	214	11.74	9	0	21
ZJX053	108	9.8	6	0	18
ZJX055	44	9.2	3	0	20
ZJX056	12	15.08	2	0	20
ZJX060	8	8.38	2	0	20
ZJX070	15	15.87	3	0	20
ZJX088	47	7.57	3	0	20

Sector	Throughput	Transittime	MIAC	Min exe	MAP
ZJX010	180	11.13	7	0	18
ZJX017	519	11.3	14	0	20
ZJX028	274	17.16	12	0	18
ZJX029	94	18.28	8	0	18
ZJX033	286	10.08	10	0	18
ZJX034	431	11.84	15	0	21
ZJX035	52	15.62	4	0	20
ZJX049	371	12.58	12	0	18
ZJX054	344	12.61	12	0	18
ZJX057	433	7.8	10	0	15
ZJX058	320	11.21	11	0	16
ZJX065	212	14.19	13	0	21
ZJX066	307	12.18	14	0	21
ZJX067	407	13.84	17	0	18
ZJX068	380	13.12	12	0	21
ZJX071	440	9.94	15	0	16
ZJX072	409	10.58	13	0	16
ZJX073	419	12.34	13	0	17
ZJX074	338	10.39	11	0	17
ZJX075	356	9.89	12	0	16
ZJX076	372	11.57	12	0	21
ZJX077	312	10.74	12	0	16
ZJX078	525	8.38	13	0	16
ZJX079	211	13.27	9	0	20
ZJX084	77	8.21	4	0	20
ZMA001	121	12.3	7	0	18
ZMA002	318	16.58	14	0	21
ZMA003	65	10.43	4	0	15
ZMA004	142	12.26	6	0	15
ZMA005	271	8.05	9	0	15
ZMA006	147	12.76	10	0	15
ZMA007	256	9.44	7	0	13
ZMA008	319	20.12	15	1	15

Table I-1: Year 2000 Sector Attributes, Cont'd

Sector	Throughput	Transittime	MIAC	Min exe	MAP
ZMA020	272	9.25	8	0	15
ZMA021	153	11.59	8	0	15
ZMA022	310	11.39	12	0	15
ZMA024	502	9.69	12	0	15
ZMA025	292	10.33	10	0	15
ZMA026	215	14.39	9	0	20
ZMA031	184	7.41	7	0	20
ZMA036	11	6.91	1	0	20
ZMA032	11	5.82	2	0	20
ZMA033	81	33.74	12	0	20
ZMA034	28	8.36	2	0	20
ZMA039	160	20.11	9	0	20
ZMA038	22	11.32	2	0	20
ZMA040	250	10.41	11	0	15
ZMA041	221	9.86	9	0	15
ZMA042	216	12.25	10	0	15
ZMA043	82	20.38	6	0	20
ZMA045	77	12.05	6	0	10
ZMA046	453	8.03	11	2	9
ZMA047	434	10.69	12	3	10
ZMA059	153	11.69	11	0	20
ZMA060	251	24.62	15	0	20
ZMA061	268	19.96	15	0	15
ZMA062	211	34.78	17	0	21
ZMA063	75	29.49	8	0	21
ZMA067	409	9.72	11	0	15
ZMA066	73	11.85	5	0	15
ZMA064	303	9.24	11	0	14
ZMA065	334	12.72	14	0	15
ZMA090	406	8.72	13	0	20
ZMA095	852	8.73	15	0	20
ZMA096	1820	9.12	38	5	38
ZMA097	357	7	9	0	20
ZTL070	2416	8.71	47	0	99
ZTL071	383	8.98	11	0	20
ZTL072	177	10.36	10	0	20
ZTL073	1237	7.04	23	6	20
ZTL074	129	11.65	5	0	20
ZTL075	264	9.83	9	0	20

Sector	Throughput	Transittime	MIAC	Min exe	MAP
ZTL076	450	9.23	13	0	20
ZTL077	140	12.42	8	0	20
ZTL078	130	11.02	5	0	20
ZTL079	256	10.02	7	0	20
ZTL080	147	15.49	9	0	20
ZTL082	116	12.03	6	0	20
ZTL089	152	9.11	7	0	20
ZTL001	158	13.04	9	0	18
ZTL002	269	12.52	12	0	17
ZTL003	542	11.58	16	0	15
ZTL004	380	8.98	10	0	13
ZTL005	412	7.77	11	0	18
ZTL006	390	8.93	11	0	13
ZTL008	178	12.85	7	0	18
ZTL009	402	12.14	14	0	38
ZTL010	337	10.9	11	0	13
ZTL011	328	12.19	11	6	17
ZTL012	248	7.77	11	0	12
ZTL013	244	12.64	11	0	18
ZTL014	272	13.04	10	0	18
ZTL015	262	14.27	10	0	18
ZTL016	470	10.47	14	0	15
ZTL017	119	14.34	7	0	18
ZTL018	115	15.57	7	0	18
ZTL019	288	10.32	9	0	18
ZTL020	369	9.93	10	0	15
ZTL021	345	10.13	11	0	13
ZTL022	555	11.25	16	0	18
ZTL023	255	13.64	11	0	18
ZTL024	292	10.59	10	0	17
ZTL025	54	10.72	3	0	20
ZTL028	212	14.31	8	0	18
ZTL029	310	7.13	9	0	10
ZTL030	428	6.93	11	1	11
ZTL031	402	8.44	11	0	13
ZTL032	445	9.24	13	1	13

Sector	Throughput	Transittime	MIAC	Min exe	MAP
ZTL033	512	9.75	17	0	17
ZTL034	256	8.36	7	0	13
ZTL036	176	7.94	5	0	13
ZTL037	473	10.24	13	0	13
ZTL038	387	8.52	15	0	13
ZTL039	536	10.21	15	3	15
ZTL040	193	10.92	7	0	18
ZTL041	277	11.73	9	0	18
ZTL042	315	10.79	15	3	15
ZTL043	503	10.16	14	3	13
ZTL044	406	9.63	11	0	15
ZTL045	331	11.78	10	0	17
ZTL046	280	10.74	9	0	18
ZTL047	371	9.29	12	0	15
ZTL048	186	13.37	11	0	18
ZTL049	508	12.85	19	0	38
ZTL050	544	9.24	15	0	15

Table I-2: Year 2005 Sector Attributes

Baseline						Baseline + RNAV				Direct/Wind				Direct/Wind with RVSM			
Sector	MAP	Throughput	Transittime	MIAC	Min exe	Throughput	Transittime	MIAC	Min exe	Throughput	Transittime	MIAC	Min exe	Throughput	Transittime	MIAC	Min exe
ZJX001	20	254	12.56	9	0	254	12.55	9	0	255	12.56	8	0	251	12.64	8	0
ZJX002	20	192	9.46	7	0	192	9.45	7	0	195	9.32	6	0	184	9.49	6	0
ZJX003	20	128	8.64	6	0	128	8.64	6	0	129	8.41	7	0	129	8.43	6	0
ZJX004	20	240	8.3	9	0	240	8.3	9	0	241	8.22	9	0	234	8.24	8	0
ZJX005	20	102	11.63	6	0	102	11.63	6	0	102	11.66	6	0	105	11.36	6	0
ZJX006	20	82	8.9	4	0	82	8.9	4	0	82	8.89	4	0	82	9.09	4	0
ZJX007	20	101	10.47	7	0	101	10.45	7	0	102	10.4	7	0	101	10.57	5	0
ZJX008	20	408	9.48	14	0	408	9.46	14	0	416	9.39	15	0	418	9.46	14	0
ZJX009	20	209	11.18	9	0	209	11.17	9	0	217	11.35	9	0	217	11.17	8	0
ZJX011	20	484	12.97	20	4	484	12.97	19	0	489	13.12	19	0	482	13.59	18	0
ZJX012	16	751	11.56	20	27	751	11.55	20	22	627	13.24	19	20	612	13.32	19	19
ZJX013	20	74	6.59	4	0	74	6.59	4	0	69	6.55	4	0	65	6.71	4	0
ZJX014	18	646	11.33	17	0	646	11.33	17	0	637	11.38	18	0	642	11.48	18	0
ZJX015	18	568	10.82	15	0	568	10.82	15	0	630	10.4	16	0	694	10.43	15	0
ZJX016	18	572	8.15	14	0	572	8.14	14	0	638	8.28	16	0	661	8.46	16	0
ZJX021	20	84	10.57	6	0	84	10.57	6	0	84	10.56	6	0	84	10.56	6	0
ZJX022	20	1377	8.05	21	19	1377	8.05	20	14	1377	8.21	22	16	1369	8.24	23	15
ZJX023	20	109	12.91	6	0	109	12.9	6	0	113	12.36	6	0	111	12.24	6	0
ZJX024	20	520	12.37	18	0	520	12.35	18	0	520	12.26	17	0	528	12.13	16	0
ZJX025	20	101	10.45	5	0	101	10.44	5	0	101	10.32	5	0	101	10.32	5	0
ZJX026	20	163	15.53	10	0	163	15.53	10	0	163	15.56	10	0	177	15.16	10	0
ZJX027	20	36	11.58	4	0	36	11.56	4	0	36	11.61	3	0	36	11.58	4	0
ZJX030	21	287	24.48	16	0	287	24.46	16	0	323	23.62	18	0	342	22.7	17	0
ZJX047	21	415	16.44	20	0	415	16.42	20	0	417	13.63	16	0	437	12.88	17	0
ZJX048	21	226	15.18	10	0	226	15.18	10	0	249	13.19	9	0	290	13.95	10	0
ZJX050	18	424	13.45	17	0	424	13.45	17	0	452	13	19	0	466	12.34	16	0
ZJX051	21	404	13.68	16	0	404	13.67	16	0	383	13.73	15	0	330	13.39	15	0
ZJX052	21	290	16.92	13	0	290	16.62	13	0	486	13.66	16	0	508	12.97	16	0
ZJX053	18	91	10.52	6	0	91	10.52	6	0	163	10.04	8	0	173	9.86	7	0
ZJX055	20	16	10.88	2	0	16	10.87	2	0	96	14.66	8	0	105	14.37	8	0
ZJX056	20	6	23.83	2	0	6	23.63	2	0	6	26.67	2	0	8	21.12	2	0
ZJX060	20	8	8.5	2	0	8	8.5	2	0	8	8.75	3	0	8	8.75	2	0
ZJX070	20	15	15.67	3	0	15	15.67	3	0	15	15.8	3	0	15	15.87	3	0
ZJX088	20	60	7.23	4	0	60	7.23	4	0	60	7.2	4	0	56	7.36	3	0
ZJX010	18	468	13.17	20	8	468	13.16	20	8	461	13.06	18	5	451	13.12	19	6
ZJX017	20	515	11.96	16	0	515	11.96	16	0	431	11.92	14	0	433	11.77	13	0

Table I-2: Year 2005 Sector Attributes, Cont'd

	Baseline					Baseline + RNAV				Direct/Wind				Direct/Wind with RVSM			
Sector	MAP	Throughput	Transittime	MIAC	Min exe	Throughput	Transittime	MIAC	Min exe	Throughput	Transittime	MIAC	Min exe	Throughput	Transittime	MIAC	Min exe
ZJX028	18	320	18.87	14	0	320	18.84	14	0	312	18.22	14	0	299	17.8	12	0
ZJX029	18	90	18.44	8	0	90	18.44	8	0	90	18.43	8	0	90	18.57	8	0
ZJX033	18	335	10.27	11	0	335	10.27	11	0	361	10.1	14	0	356	10.19	15	0
ZJX034	21	503	11.84	15	0	503	11.54	15	0	396	11.76	14	0	384	11.65	14	0
ZJX035	20	130	16.66	10	0	130	16.36	10	0	133	15.75	9	0	100	14.49	10	0
ZJX049	18	379	13.22	12	0	379	13.21	12	0	396	12.18	11	0	437	12.03	11	0
ZJX054	18	287	12.1	11	0	287	12.1	11	0	441	13.67	11	0	470	13.76	11	0
ZJX057	15	678	7.17	13	0	678	7.17	13	0	593	7.22	14	0	545	7.45	12	0
ZJX058	16	554	11.28	18	7	554	11.28	18	6	549	10.03	14	0	521	9.9	13	0
ZJX065	21	207	14	16	0	207	14	16	0	207	13.33	11	0	214	13.52	11	0
ZJX066	21	445	13.99	21	1	445	13.97	21	1	442	12.93	20	0	436	12.39	19	0
ZJX067	18	229	16.08	12	0	229	16.08	12	0	198	14.24	10	0	249	13.35	11	0
ZJX068	21	458	16.69	17	0	458	16.69	17	0	339	14.61	12	0	348	13.46	12	0
ZJX071	16	383	10.06	13	0	383	10.06	13	0	490	9.9	15	0	543	9.57	15	0
ZJX072	16	456	10.72	13	0	456	10.72	13	0	492	8.97	13	0	497	8.68	13	0
ZJX073	17	448	12.04	15	0	448	12	15	0	442	12.23	14	0	444	12.22	13	0
ZJX074	17	364	10.26	13	0	364	10.26	13	0	365	10.29	11	0	377	10.24	11	0
ZJX075	16	344	9.58	12	0	344	9.55	12	0	293	9.58	9	0	313	9.7	10	0
ZJX076	21	405	9.11	14	0	405	9.1	14	0	314	9.18	12	0	323	9.92	12	0
ZJX077	16	298	11.46	11	0	298	11.46	11	0	310	11.49	11	0	316	11.2	10	0
ZJX078	16	460	10.82	14	0	460	10.82	14	0	597	10.75	15	0	642	10.15	15	0
ZJX079	20	223	14.09	10	0	223	14.09	10	0	225	13.77	8	0	221	13.57	8	0
ZJX084	20	81	8.19	4	0	81	8.19	4	0	76	8.55	4	0	76	8.55	4	0
ZMA001	18	245	23.71	18	7	245	23.45	16	0	204	20.62	13	0	170	17.98	12	0
ZMA002	21	417	21.09	18	0	417	21.02	18	0	462	20.47	17	0	462	19.63	16	0
ZMA003	15	81	11.85	5	0	81	11.84	5	0	81	11.8	5	0	81	11.84	5	0
ZMA004	15	144	12.39	7	0	144	12.39	7	0	129	12.89	6	0	133	12.59	6	0
ZMA005	15	267	8.16	10	0	267	8.16	10	0	267	8.14	10	0	268	8.08	10	0
ZMA006	15	154	12.98	8	0	154	12.98	8	0	154	13.01	8	0	159	12.76	8	0
ZMA007	13	246	10.16	7	0	246	10.16	7	0	222	8.2	7	0	236	7.91	6	0
ZMA008	15	320	18.78	14	0	320	18.72	12	0	329	19.03	13	0	332	19.47	12	0
ZMA020	15	327	8.19	10	0	327	8.19	10	0	410	7.24	9	0	404	7.46	10	0
ZMA021	15	302	8.37	13	0	302	8.37	13	0	267	8.84	10	0	229	9.31	9	0
ZMA022	15	323	11.67	10	0	323	11.64	10	0	326	10.95	10	0	337	10.89	11	0
ZMA024	15	336	11.01	10	0	336	11.01	10	0	380	10.18	10	0	423	10.04	11	0
ZMA025	15	364	11.4	12	0	364	11.3	11	0	360	10.79	10	0	336	10.7	10	0
ZMA026	20	259	14.41	9	0	259	14.41	9	0	259	14.44	10	0	258	14.66	11	0
ZMA031	20	184	7.43	7	0	184	7.43	7	0	184	7.43	8	0	184	7.4	7	0
ZMA036	20	11	6.82	1	0	11	6.82	1	0	11	6.91	1	0	11	6.91	2	0
ZMA032	20	11	5.91	2	0	11	5.9	2	0	11	5.73	2	0	11	5.73	2	0
ZMA033	20	84	33.8	13	0	84	33.5	13	0	84	33.7	13	0	84	33.48	13	0

Table I-2: Year 2005 Sector Attributes, Cont'd

Baseline						Baseline + RNAV				Direct/Wind				Direct/Wind with RVSM			
Sector	MAP	Throughput	Transittime	MIAC	Min exe	Throughput	Transittime	MIAC	Min exe	Throughput	Transittime	MIAC	Min exe	Throughput	Transittime	MIAC	Min exe
ZMA034	20	27	8.26	3	0	27	8.26	3	0	27	8.37	3	0	27	8.37	2	0
ZMA039	20	159	19.83	9	0	159	19.82	9	0	159	19.82	9	0	159	19.94	9	0
ZMA038	20	22	11.27	2	0	22	11.27	2	0	22	11.36	2	0	22	11.41	2	0
ZMA040	15	242	10.48	13	0	242	10.38	12	0	242	10.45	11	0	245	10.41	11	0
ZMA041	15	214	9.77	8	0	214	9.77	8	0	214	9.71	7	0	221	9.99	9	0
ZMA042	15	221	12.28	10	0	221	12.28	10	0	221	12.3	8	0	221	12.06	9	0
ZMA043	20	84	21.14	6	0	84	21.14	6	0	84	21.11	7	0	84	20.71	7	0
ZMA045	10	68	13.54	5	0	68	13.54	5	0	68	13.53	5	0	69	13.38	5	0
ZMA046	9	446	9.41	11	19	446	9.31	11	15	363	6.75	8	0	391	6.59	9	0
ZMA047	10	476	9.28	12	21	476	9.28	12	18	599	10.17	12	15	591	10.25	12	14
ZMA059	20	157	11.82	11	0	157	11.82	11	0	157	11.8	11	0	155	11.73	11	0
ZMA060	20	256	24.55	15	0	256	24.54	15	0	256	24.55	15	0	253	24.58	15	0
ZMA061	15	269	19.99	15	0	269	19.99	15	0	269	20.01	14	0	267	20.01	15	0
ZMA062	21	208	35.98	15	0	208	34.98	15	0	208	35	15	0	210	34.75	15	0
ZMA063	21	73	30.48	8	0	73	30.46	8	0	73	30.44	8	0	73	29.71	7	0
ZMA067	15	437	9.91	15	6	437	9.9	15	5	490	10.61	15	4	476	10.49	15	4
ZMA066	15	74	12.69	5	0	74	12.69	5	0	72	12.85	5	0	71	13.15	5	0
ZMA064	14	315	8.37	11	0	315	8.37	11	0	388	8.01	12	0	379	8.47	12	0
ZMA065	15	299	13.1	13	0	299	13.1	13	0	310	11.59	9	0	330	11.85	10	0
ZMA090	20	425	8.25	13	0	425	8.25	13	0	420	8.34	13	0	419	8.47	13	0
ZMA095	20	988	8.87	19	0	988	8.86	18	0	985	8.69	17	0	980	8.66	17	0
ZMA096	38	1958	9.13	41	34	1958	9.13	41	32	1786	8.76	40	27	1820	8.72	41	28
ZMA097	20	313	7.48	10	0	313	7.48	10	0	304	7.51	10	0	318	7.45	10	0
ZTL070	99	3275	9.35	62	0	3275	9.34	60	0	3017	8.99	60	0	3021	8.87	58	0
ZTL071	20	421	8.74	11	0	421	8.72	11	0	424	8.73	12	0	418	8.76	11	0
ZTL072	20	180	10.36	9	0	180	10.34	9	0	180	10.36	9	0	177	10.46	9	0
ZTL073	20	1364	6.72	24	26	1364	6.71	24	23	1256	6.65	24	17	1344	6.77	24	16
ZTL074	20	135	11.99	6	0	135	11.56	6	0	144	11.42	6	0	144	11.44	6	0
ZTL075	20	299	9.44	13	0	299	9.44	13	0	304	9.38	15	0	300	9.39	13	0
ZTL076	20	406	9.72	11	0	406	9.72	11	0	399	9.72	11	0	428	9.47	11	0
ZTL077	20	145	12.53	8	0	145	12.53	8	0	146	12.42	8	0	146	12.49	8	0
ZTL078	20	131	11.04	5	0	131	11.01	5	0	137	11.02	5	0	136	11.07	5	0
ZTL079	20	264	9.97	8	0	264	9.97	8	0	267	9.88	8	0	264	9.86	8	0
ZTL080	20	141	15.71	9	0	141	15.71	9	0	141	15.72	9	0	141	15.69	9	0
ZTL082	20	120	11.93	6	0	120	11.91	6	0	124	11.58	5	0	124	11.57	5	0
ZTL089	20	181	8.96	6	0	181	8.96	6	0	171	8.77	6	0	172	8.81	7	0
ZTL001	18	149	13.42	9	0	149	13.4	9	0	149	13.4	9	0	153	13.21	9	0
ZTL002	17	515	10.33	13	0	515	10.31	13	0	552	9.35	14	0	489	9.68	13	0
ZTL003	15	628	11.71	17	5	628	11.7	17	5	656	11.08	15	5	678	11.14	16	6
ZTL004	13	463	8.48	11	0	463	8.48	11	0	454	8.46	12	0	453	8.57	12	0
ZTL005	18	474	6.4	11	0	474	6.4	11	0	501	6.2	11	0	512	6.44	12	0

Table I-2: Year 2005 Sector Attributes, Cont'd

	Baseline					Baseline + RNAV				Direct/Wind				Direct/Wind with RVSM			
Sector	MAP	Throughput	Transittime	MIAC	Min exe	Throughput	Transittime	MIAC	Min exe	Throughput	Transittime	MIAC	Min exe	Throughput	Transittime	MIAC	Min exe
ZTL006	13	548	8.88	13	0	548	8.85	13	0	568	8.66	13	0	552	8.8	13	0
ZTL008	18	288	13.09	17	0	288	13.09	17	0	237	11.14	10	0	221	11.19	8	0
ZTL009	38	651	14.47	23	0	651	14.44	23	0	652	13.44	23	0	656	13.42	23	0
ZTL010	13	400	10.19	14	1	400	10.19	14	1	333	9.54	11	0	323	9.5	10	0
ZTL011	17	333	11.14	14	0	333	11.14	14	0	315	10.42	12	0	318	10.91	11	0
ZTL012	12	265	8.54	11	0	265	8.54	11	0	260	8.22	11	0	259	7.95	12	0
ZTL013	18	324	11.15	13	0	324	11.15	13	0	335	11.12	13	0	342	10.84	12	0
ZTL014	18	279	13.35	13	0	279	13.34	13	0	291	13.2	13	0	289	13.24	12	0
ZTL015	18	366	16.39	16	0	366	16.37	16	0	381	15.89	16	0	372	14.8	16	0
ZTL016	15	629	9.41	17	23	629	9.41	17	22	630	9.09	17	17	622	9.26	17	15
ZTL017	18	117	14.53	7	0	117	14.53	7	0	117	14.54	7	0	117	14.52	7	0
ZTL018	18	113	15.68	7	0	113	15.68	7	0	116	15.4	7	0	116	15.45	7	0
ZTL019	18	231	9.61	8	0	231	9.51	8	0	311	7.6	9	0	319	7.76	10	0
ZTL020	15	468	10.14	14	0	468	10.14	14	0	522	9.51	13	0	501	9.33	12	0
ZTL021	13	576	9.5	14	4	576	9.5	14	3	511	10.43	15	2	507	10.4	14	2
ZTL022	18	618	11.74	16	0	618	11.74	16	0	590	11.85	16	0	587	11.64	17	0
ZTL023	18	462	12.26	17	0	462	12.24	17	0	431	12.44	16	0	433	12.68	15	0
ZTL024	17	286	11.31	10	0	286	11.31	10	0	275	10.57	9	0	288	10.26	9	0
ZTL025	20	51	11.08	3	0	51	11.08	3	0	51	11.08	3	0	51	11.06	3	0
ZTL028	18	314	15.47	15	0	314	15.45	15	0	318	15.1	16	0	303	13.94	12	0
ZTL029	10	378	6.57	8	0	378	6.57	8	0	370	6.66	9	0	353	6.74	10	0
ZTL030	11	526	6.99	13	7	526	6.99	13	7	534	6.87	15	6	523	6.68	13	6
ZTL031	13	429	8.24	13	3	429	8.24	13	3	425	8.6	15	3	426	8.62	13	2
ZTL032	13	667	9.54	15	5	667	9.52	15	4	661	9.16	15	2	616	9.22	16	2
ZTL033	17	576	9.97	17	8	576	9.97	17	7	571	9.75	15	0	575	9.69	16	0
ZTL034	13	283	6.08	7	0	283	6.08	7	0	281	5.92	7	0	275	6.57	7	0
ZTL036	13	216	8.65	7	0	216	8.65	7	0	247	7.79	9	0	251	7.85	9	0
ZTL037	13	505	9.89	15	2	505	9.86	13	2	577	9.28	14	2	590	9.33	14	2
ZTL038	13	652	8.14	15	6	652	8.14	15	6	493	8.37	14	5	488	8.35	13	4
ZTL039	15	678	10.8	16	14	678	10.8	15	13	657	9.91	17	11	661	10.11	16	9
ZTL040	18	479	10.39	15	0	479	10.39	15	0	477	9.79	15	0	412	10.09	12	0
ZTL041	18	257	12.12	9	0	257	12.1	9	0	269	12.35	9	0	269	12.48	9	0
ZTL042	15	178	11.46	7	0	178	11.46	7	0	171	10.63	6	0	241	10.22	9	0
ZTL043	13	654	11.88	16	12	654	11.88	16	11	630	11.28	16	10	623	10.93	16	9
ZTL044	15	452	9.88	14	0	452	9.84	14	0	421	10.26	13	0	443	10.01	13	0
ZTL045	17	355	11.59	10	0	355	11.56	10	0	345	11.41	10	0	342	11.51	10	0
ZTL046	18	316	10.84	11	0	316	10.84	11	0	307	10.24	9	0	304	10.2	8	0
ZTL047	15	427	9.77	13	0	427	9.77	13	0	409	9.26	14	0	406	9.22	13	0
ZTL048	18	186	13.91	13	0	186	13.91	13	0	186	13.93	12	0	182	14.08	13	0
ZTL049	38	662	11.25	17	0	662	11.25	17	0	620	9.64	17	0	633	10.14	18	0
ZTL050	15	741	9.1	16	8	741	9.1	16	8	741	8.72	16	6	735	8.9	17	6

Table I-3: Year 2010 Sector Attributes

Baseline						Base + RNAV				Direct/Wind				Direct/Wind with RVSM			
Sector	MAP	Throughput	Transittime	MIAC	Exe_map	Throughput	Transittime	MIAC	Exe_map	Throughput	Transittime	MIAC	Exe_map	Throughput	Transittime	MIAC	Exe_map
ZJX001	20	259	12.35	10	0	260	12.31	8	0	260	12.3	8	0	239	12.32	8	0
ZJX002	20	200	9.43	7	0	204	9.28	6	0	204	9.27	6	0	204	9.35	7	0
ZJX003	20	132	8.64	6	0	135	8.35	7	0	145	8.33	7	0	142	8.68	6	0
ZJX004	20	251	8.07	10	0	252	8	10	0	252	7.99	10	0	261	8.07	10	0
ZJX005	20	102	11.89	6	0	102	11.91	6	0	102	11.9	6	0	97	11.91	6	0
ZJX006	20	84	9.11	5	0	84	9.1	5	0	84	9.1	5	0	82	9.13	5	0
ZJX007	20	100	10.77	6	0	101	10.7	6	0	101	10.7	5	0	104	10.7	5	0
ZJX008	20	465	9.47	17	0	473	9.34	17	0	473	9.34	16	0	458	9.44	14	0
ZJX009	20	209	11.15	9	0	217	11.29	11	0	217	11.21	11	0	207	10.59	9	0
ZJX011	20	525	13.03	18	0	531	13.18	18	0	531	13.18	18	0	524	13.03	18	0
ZJX012	16	814	11.31	19	32	672	13.22	19	31	726	13.22	18	30	812	11.3	20	28
ZJX013	20	75	6.57	4	0	70	6.7	4	0	70	6.6	3	0	75	7	4	0
ZJX014	18	700	11.3	20	4	690	11.17	17	4	690	11.17	17	0	703	11.31	16	0
ZJX015	18	653	11.36	20	21	713	10.67	19	19	713	10.67	19	16	647	11.37	18	15
ZJX016	18	634	8.23	14	0	707	7.53	15	0	707	7.51	15	0	647	8.37	15	0
ZJX021	20	84	10.58	6	0	84	10.55	6	0	84	10.55	6	0	83	10.55	6	0
ZJX022	20	1630	8.37	24	3	1630	8.34	22	3	1562	8.14	21	2	1641	8.38	22	2
ZJX023	20	109	13.03	6	0	113	12.93	8	0	113	12.7	8	0	103	12	7	0
ZJX024	20	563	11.98	18	0	563	11.84	16	0	563	11.84	16	0	557	11.31	15	0
ZJX025	20	102	10.69	6	0	102	10.5	6	0	102	10.5	5	0	101	10.9	7	0
ZJX026	20	164	15.69	12	0	164	15.54	10	0	164	15.54	10	0	162	15.7	10	0
ZJX027	20	37	11.43	3	0	37	11.41	3	0	37	11.38	3	0	37	11.43	3	0
ZJX030	21	322	24.62	19	0	362	23.24	18	0	365	23.04	18	0	317	22.76	15	0
ZJX047	21	449	16.34	17	0	438	13.6	15	0	438	13.6	15	0	415	16.36	13	0
ZJX048	21	256	15.93	13	0	287	13.6	12	0	287	13.6	12	0	290	15.68	14	0
ZJX050	18	475	13.98	19	0	471	13.53	15	0	471	13.48	15	0	423	13.76	15	0
ZJX051	21	435	14	17	0	411	13.63	16	0	411	13.63	16	0	431	14.14	14	0
ZJX052	21	333	16.56	14	0	539	13.36	17	0	539	13.36	17	0	291	13.23	14	0
ZJX053	18	96	10.33	6	0	203	9.61	9	0	203	9.61	9	0	98	10.3	6	0
ZJX055	20	17	13.29	2	0	134	13.34	10	0	134	13.34	11	0	22	12.38	3	0
ZJX056	20	6	28.83	2	0	6	25.33	2	0	6	25.21	2	0	6	24.12	2	0
ZJX060	20	8	8.75	2	0	8	8.62	2	0	8	8.62	2	0	8	8.5	2	0
ZJX070	20	15	15.87	3	0	15	15.8	3	0	15	15.8	3	0	15	15.8	3	0
ZJX088	20	61	7.05	4	0	61	7.02	4	0	77	7.01	4	0	60	7.03	4	0
ZJX010	18	530	13.49	17	0	523	13.56	17	0	523	13.26	16	0	527	12.49	17	0

Table I-3: Year 2010 Sector Attributes, Cont'd

Baseline						Base + RNAV				Direct/Wind				Direct/Wind with RVSM			
Sector	MAP	Throughput	Transittime	MIAC	Exe_map	Throughput	Transittime	MIAC	Exe_map	Throughput	Transittime	MIAC	Exe_map	Throughput	Transittime	MIAC	Exe_map
ZJX017	20	579	12.01	16	0	486	11.92	15	0	486	11.76	14	0	569	11	15	0
ZJX028	18	338	19.3	18	0	330	18.32	12	0	330	18.32	12	0	342	17	15	0
ZJX029	18	91	18.66	8	0	91	18.6	8	0	91	18.54	8	0	91	18	8	0
ZJX033	18	410	10.28	13	0	410	10.1	11	0	398	10.1	11	0	382	10.33	13	0
ZJX034	21	563	12.06	17	0	442	11.94	15	0	428	11.94	14	0	558	11.1	12	0
ZJX035	20	122	16.73	8	0	137	14.86	7	0	137	14.82	7	0	161	14.21	6	0
ZJX049	18	384	13.94	15	0	444	12.8	15	0	444	12.8	15	0	445	13.77	17	0
ZJX054	18	318	11.97	10	0	472	13.44	16	0	472	13.44	16	0	309	11.9	12	0
ZJX057	15	792	7.83	18	11	684	7.68	15	10	684	7.68	14	0	787	7.81	18	5
ZJX058	16	646	11.51	22	6	638	10.86	19	5	638	10.66	18	4	646	11.47	17	4
ZJX065	21	227	14.33	12	0	240	13.44	9	0	240	13.23	9	0	263	14.35	11	0
ZJX066	21	487	14.53	23	19	476	13.39	20	0	476	13.37	19	0	452	14.19	20	0
ZJX067	18	283	16.08	14	0	244	13.75	12	0	244	13.75	11	0	314	13.21	14	0
ZJX068	21	503	16.74	19	0	369	14.55	14	0	371	14.55	14	0	482	14	12	0
ZJX071	16	512	10.11	12	0	520	9.93	14	0	516	9.9	14	0	512	8	12	0
ZJX072	16	510	10.78	18	5	516	8.94	17	5	516	8.94	16	4	514	8	16	3
ZJX073	17	461	12.21	14	0	455	12.44	14	0	455	12.44	14	0	458	12.21	14	0
ZJX074	17	382	10.26	12	0	382	10.32	11	0	382	10.24	11	0	378	10.29	12	0
ZJX075	16	410	9.53	11	0	333	9.38	10	0	333	9.38	10	0	379	9.27	10	0
ZJX076	21	497	8.49	13	0	388	8.37	11	0	388	8.37	11	0	539	9.02	14	0
ZJX077	16	311	11.41	10	0	324	11.47	10	0	324	11.43	9	0	310	11.46	10	0
ZJX078	16	614	10.98	15	0	666	11.07	19	6	666	11.07	18	5	509	11.02	14	0
ZJX079	20	232	13.93	11	0	233	11	10	0	233	11	10	0	273	11	10	0
ZJX084	20	81	8.25	5	0	76	8.62	5	0	76	8.62	5	0	82	8.25	5	0
ZMA001	18	258	24.37	18	0	213	21.51	14	0	213	21.26	14	0	266	21	12	0
ZMA002	21	498	21.01	20	0	495	20.81	19	0	495	20.32	16	0	512	21.01	16	0
ZMA003	15	84	11.93	5	0	84	11.94	5	0	84	11.94	4	0	83	11.86	5	0
ZMA004	15	155	12.47	6	0	137	12.88	7	0	137	12.88	7	0	158	12.45	7	0
ZMA005	15	276	8.24	9	0	276	8.23	9	0	276	8.23	9	0	272	8.27	10	0
ZMA006	15	162	13.13	9	0	162	13.24	10	0	162	13.14	10	0	172	13.12	10	0
ZMA007	13	265	10.67	9	0	239	8.28	10	0	239	8.28	10	0	264	10.6	9	0
ZMA021	15	315	8.14	12	0	278	8.59	11	0	278	8.53	11	0	312	8.2	11	0
ZMA022	15	369	12.07	11	0	377	11.05	11	0	377	11.02	11	0	373	12.09	10	0
ZMA024	15	371	11.06	13	0	413	10.31	13	0	413	10.31	12	0	412	11.14	9	0
ZMA025	15	404	11.52	11	0	398	10.86	14	0	398	10.86	14	0	411	11.41	11	0
ZMA026	20	286	14.34	11	0	286	14.45	13	0	286	14.32	13	0	307	14.35	13	0
ZMA031	20	184	7.45	6	0	184	7.46	6	0	184	7.46	8	0	182	7.46	6	0

Table I-3: Year 2010 Sector Attributes, Cont'd

	Baseline					Base + RNAV				Direct/Wind				Direct/Wind with RVSM			
Sector	MAP	Throughput	Transittime	MIAC	Exe_map	Throughput	Transittime	MIAC	Exe_map	Throughput	Transittime	MIAC	Exe_map	Throughput	Transittime	MIAC	Exe_map
ZMA036	20	11	6.82	1	0	11	7	1	0	11	7	1	0	11	6.82	1	0
ZMA032	20	11	5.82	2	0	11	5.83	2	0	11	5.73	2	0	11	5.82	2	0
ZMA033	20	84	33.7	13	0	84	33.75	12	0	84	33.73	11	0	84	32.75	11	0
ZMA034	20	27	8.44	2	0	27	8.41	3	0	27	8.41	3	0	26	8.37	3	0
ZMA039	20	159	19.82	9	0	159	19.83	9	0	159	19.43	7	0	162	19.84	9	0
ZMA038	20	22	11.41	2	0	22	11.32	2	0	22	11.32	2	0	22	11.36	2	0
ZMA040	15	242	10.42	12	0	242	10.43	11	0	242	10.43	11	0	241	10.46	9	0
ZMA041	15	214	9.62	8	0	214	9.67	7	0	214	9.32	7	0	216	9.7	9	0
ZMA042	15	222	12.18	8	0	222	12.21	8	0	222	12.21	8	0	208	12.21	8	0
ZMA043	20	84	21.07	6	0	84	21.23	6	0	84	21.23	6	0	84	21.18	6	0
ZMA045	10	73	13.18	5	0	73	13.16	5	0	73	13.32	5	0	71	13.1	5	0
ZMA046	9	519	9.83	11	3	423	6.94	11	3	423	6.94	11	2	512	9.79	11	2
ZMA047	10	665	9.39	12	31	667	10.27	12	28	665	10.27	11	22	618	9.3	12	22
ZMA059	20	154	12.06	11	0	154	12.15	11	0	154	12.06	11	0	151	11.87	11	0
ZMA060	20	256	24.54	14	0	256	23.94	14	0	265	23.29	14	0	262	23.12	14	0
ZMA061	15	269	19.91	15	14	269	19.89	14	0	269	19.89	13	0	266	19.2	15	3
ZMA062	21	208	35	14	0	208	33	14	0	208	33	14	0	204	32	14	0
ZMA063	21	73	30.47	6	0	73	29	6	0	73	29	6	0	73	28.12	6	0
ZMA067	15	543	9.86	15	0	531	10.68	17	4	531	10.58	16	3	535	9.83	16	4
ZMA066	15	77	12.7	5	0	74	12.99	5	0	74	12.92	5	0	74	12.7	5	0
ZMA064	14	425	8.34	10	0	423	7.95	12	0	423	7.95	12	0	447	8.36	10	0
ZMA065	15	333	13.35	13	0	352	11.74	13	0	352	11.74	13	0	368	11	13	0
ZMA090	20	447	8.19	13	0	440	8.3	13	0	440	8.2	12	0	453	8.17	12	0
ZMA095	20	1057	8.87	20	0	1057	8.82	19	0	1057	8.72	18	0	1065	8.9	18	0
ZMA096	38	2112	9.24	43	37	2113	8.78	39	35	2109	8.78	31	0	2109	9.19	29	0
ZMA097	20	335	7.58	9	0	325	7.57	10	0	325	7.23	10	0	338	7.57	10	0
ZTL070	99	3619	10.09	78	0	3561	9.14	71	0	3541	9.04	64	0	3601	10.12	61	0
ZTL071	20	445	8.57	12	0	447	8.53	12	0	451	8.53	12	0	465	8.58	12	0
ZTL072	20	181	10.38	10	0	181	10.4	10	0	181	10.4	10	0	192	10.39	10	0
ZTL075	20	315	9.18	12	0	322	9.15	11	0	322	9.06	11	0	312	9.17	13	0
ZTL076	20	425	11.78	12	0	408	11.95	13	0	408	11.96	10	0	423	11.37	12	0
ZTL077	20	146	12.56	7	0	148	12.41	8	0	148	12.41	8	0	142	12.55	7	0
ZTL078	20	136	10.84	6	0	141	10.86	6	0	141	10.86	5	0	135	10.37	6	0
ZTL079	20	271	9.83	7	0	280	9.69	7	0	267	9.69	7	0	272	9.86	7	0
ZTL080	20	141	15.68	9	0	141	15.91	9	0	141	15.35	9	0	154	15.7	10	0
ZTL082	20	120	11.92	6	0	124	11.57	6	0	124	11.57	6	0	128	11.93	5	0
ZTL089	20	168	8.77	7	0	178	8.68	6	0	178	8.59	6	0	163	8.72	6	0

Table I-3: Year 2010 Sector Attributes, Cont'd

	Baseline					Base + RNAV				Direct/Wind				Direct/Wind with RVSM			
Sector	MAP	Throughput	Transittime	MIAC	Exe_map	Throughput	Transittime	MIAC	Exe_map	Throughput	Transittime	MIAC	Exe_map	Throughput	Transittime	MIAC	Exe_map
ZTL001	18	149	13.38	9	0	149	13.4	9	0	149	13.4	9	0	145	12.45	9	0
ZTL002	17	630	10.54	18	22	684	9.52	16	0	684	9.52	16	0	687	10.49	17	0
ZTL003	15	710	11.5	18	14	694	10.84	18	12	694	10.84	17	11	671	11.56	16	9
ZTL004	13	513	8.09	12	0	506	8.31	11	0	501	8.31	11	0	510	8.12	11	0
ZTL005	18	522	6.15	11	0	550	5.93	12	0	550	5.93	12	0	520	6.11	11	0
ZTL006	13	601	8.75	14	41	615	8.45	13	39	615	8.43	13	32	634	8.5	15	34
ZTL008	18	345	13.46	13	0	315	12.21	11	0	315	11.56	11	0	374	11	13	0
ZTL009	38	740	14.78	20	0	730	13.47	18	0	730	13.47	15	0	743	13.21	17	0
ZTL010	13	434	9.96	12	0	380	9.47	10	0	376	9.07	10	0	423	9.77	11	0
ZTL011	17	354	10.92	11	0	334	10.43	13	0	334	10.27	12	0	344	10.93	13	0
ZTL012	12	282	8.53	12	12	274	8.22	10	0	274	8.22	10	0	281	8.5	11	0
ZTL013	18	343	10.87	12	0	361	10.76	12	0	361	10.76	12	0	336	9.48	11	0
ZTL014	18	291	13.22	11	0	303	13.16	10	0	303	13.43	10	0	282	13.23	10	0
ZTL015	18	456	16.14	21	4	471	15.3	19	4	471	15.3	19	3	473	15.27	18	3
ZTL016	15	675	8.95	17	15	677	8.78	17	15	677	8.78	17	14	689	8.32	17	13
ZTL017	18	117	14.55	7	0	117	14.57	7	0	117	14.57	7	0	112	13.89	7	0
ZTL018	18	113	15.66	7	0	116	15.41	7	0	116	15.41	7	0	114	14.72	7	0
ZTL019	18	244	9.4	9	0	338	7.34	10	0	338	7.21	10	0	235	9.34	9	0
ZTL020	15	546	10.24	13	0	537	9.76	15	0	537	9.53	14	0	483	10	12	0
ZTL021	13	651	9.47	14	5	572	10.22	15	4	537	10.22	15	4	667	9.01	15	4
ZTL022	18	667	11.64	18	6	629	11.7	16	0	629	11.7	14	0	663	10.23	15	0
ZTL023	18	537	12.75	21	2	522	12.98	20	2	522	12.86	18	2	567	12.63	20	3
ZTL024	17	293	11.39	9	0	282	10.53	8	0	282	10.26	8	0	295	10.25	10	0
ZTL025	20	51	11.08	4	0	56	10.36	4	0	56	10.36	4	0	51	10.23	4	0
ZTL028	18	384	15.55	24	10	388	15.56	22	9	388	15.11	21	8	387	15	20	8
ZTL029	10	395	6.59	9	0	378	6.87	9	0	378	6.7	7	0	378	6.23	10	0
ZTL030	11	598	7	12	5	586	6.83	13	6	586	6.34	12	4	601	7.01	13	5
ZTL033	17	604	9.92	20	18	601	9.89	18	14	601	9.63	17	12	587	9.96	18	13
ZTL034	13	298	6.17	13	0	312	5.89	12	0	323	5.34	12	0	334	5.83	12	0
ZTL036	13	272	8.53	13	0	321	7.84	12	0	310	7.84	12	0	276	7.23	10	0
ZTL037	13	530	9.93	15	5	603	9.2	14	5	613	9.2	14	5	510	9	14	5
ZTL038	13	562	7.64	13	31	544	7.86	12	0	544	7.29	12	0	557	7.64	12	0
ZTL039	15	653	10.61	17	0	686	10.31	17	0	686	9.83	17	0	654	9	16	0
ZTL040	18	618	10.51	19	38	607	10.21	20	39	607	10.21	19	31	665	10.03	20	33
ZTL041	18	262	11.99	10	0	272	12.28	10	0	272	12.28	9	0	298	11.97	9	0
ZTL042	15	198	11.2	9	0	192	10.28	8	0	192	10.19	8	0	167	10.03	6	0
ZTL043	13	672	11.68	16	31	648	11.11	16	31	675	11.09	15	26	665	11.01	14	18
ZTL044	15	452	9.87	11	0	450	10.3	14	0	450	10.3	14	0	409	9.87	11	0
ZTL045	17	372	11.46	14	0	361	11.32	11	0	361	11.32	11	0	386	11.44	11	0
ZTL046	18	336	10.73	10	0	327	10.21	9	0	327	10.21	9	0	336	10.13	9	0
ZTL047	15	452	9.79	12	0	428	9.19	13	0	445	9.19	12	0	448	8.43	14	0
ZTL048	18	189	13.8	11	0	189	13.79	11	0	189	13.73	11	0	198	12.4	11	0
ZTL049	38	690	11.74	18	0	673	9.23	14	0	701	9.23	13	0	605	9.23	12	0
ZTL050	15	765	8.9	17	13	788	8.52	15	12	788	8.52	15	11	720	8.74	17	12

Table I-4: Year 2015 Sector Attributes

Base						Base + RNAV				Base + RNAV + Direct/Wind Op				RVSM			
Sector	MAP	Throughput	Transittime	MIAC	DurPastMAP	Throughput	Transittime	MIAC	DurPastMAP	Throughput	Transittime	MIAC	DurPastMAP	Throughput	Transittime	MIAC	DurPastMAP
ZJX001	20	271	12.22	9	0	262	12.43	8	0	262	12.44	8	0	258	12.55	8	0
ZJX002	20	206	9.27	7	0	182	9.71	9	0	182	9.71	9	0	186	9.63	9	0
ZJX003	20	141	8.44	8	0	137	8.1	9	0	137	8.09	8	3	137	8.15	8	0
ZJX004	20	285	7.84	9	0	265	7.9	8	0	265	7.9	8	0	268	7.88	8	0
ZJX005	20	106	11.51	6	0	112	10.98	6	0	112	10.98	6	0	112	10.97	6	0
ZJX006	20	85	9.12	4	0	82	9.22	5	0	82	9.23	6	0	82	9.29	5	0
ZJX007	20	102	16.42	10	0	98	14.56	5	0	98	11.92	6	0	98	12.3	5	0
ZJX008	20	319	20.32	22	2	333	19.34	22	3	333	18.31	23	39	330	20.16	22	0
ZJX009	20	209	15.45	12	0	220	14.56	9	0	220	12.94	9	0	217	14.36	11	0
ZJX011	20	508	16.44	20	4	512	15.36	19	0	497	15.09	20	19	517	14.88	17	0
ZJX012	16	742	17.86	27	94	698	16.45	23	38	691	15.92	22	20	681	17.14	24	41
ZJX013	20	79	15.36	8	0	67	11.79	4	0	67	10.4	4	0	59	14.58	4	0
ZJX014	18	754	12.36	20	25	796	12.33	17	0	790	12.14	20	0	752	12.16	20	14
ZJX015	18	727	11.32	19	33	948	11.66	23	17	921	11.34	22	0	885	11.09	22	3
ZJX016	18	707	9.27	16	0	807	12.28	22	5	831	10.86	22	22	772	10.3	20	0
ZJX021	20	84	10.54	6	0	89	10.3	6	0	89	10.36	6	0	88	10.4	6	0
ZJX022	20	1863	8.54	24	119	1820	9.21	24	66	1827	8.93	24	24	1843	9.11	24	23
ZJX023	20	113	13.32	8	0	114	13.08	7	0	117	13.03	6	0	128	13.45	9	0
ZJX024	20	592	11.96	19	0	633	11.33	19	0	636	11.32	21	18	625	11.46	18	0
ZJX025	20	101	21.34	10	0	97	18.93	8	0	97	16.13	7	0	97	18.93	8	0
ZJX026	20	167	16.36	11	0	202	15.24	10	0	201	15.06	10	0	202	15.39	10	0
ZJX027	20	33	14.56	4	0	33	14.23	3	0	33	14.76	4	0	33	14.67	3	0
ZJX030	21	371	25.76	20	0	448	25.36	24	0	448	24.77	22	0	483	24.37	24	0
ZJX047	21	435	16.22	16	0	491	13.68	21	2	491	13.68	20	0	375	12.51	17	0
ZJX048	21	346	16.01	15	0	582	15.06	20	0	582	15.08	21	10	614	13.49	19	0
ZJX050	18	449	13.94	16	0	537	12.18	22	7	509	11.06	16	0	419	10.94	13	0
ZJX051	21	458	15.67	19	0	228	17.56	11	0	228	16.82	11	0	314	16.97	17	0
ZJX052	21	310	16.51	13	0	283	11.87	9	0	283	11.77	10	0	385	11.36	13	0
ZJX053	18	100	10.78	6	0	268	10.2	9	0	268	9.97	9	0	447	9.88	14	0
ZJX055	20	22	12.68	2	0	223	14.49	12	0	223	14.5	13	0	396	15.02	20	21
ZJX056	20	6	23.45	1	0	13	22.46	2	0	13	20.15	2	0	13	21.38	2	0
ZJX060	20	8	8.38	1	0	8	8.75	1	0	8	8.62	2	0	8	8.75	1	0
ZJX070	20	15	15.8	3	0	15	15.8	3	0	15	15.8	3	0	15	15.87	3	0
ZJX088	20	63	8.83	4	0	48	8.92	3	0	48	12.33	5	0	48	10.92	4	0
ZJX010	18	391	27.04	25	16	349	26.47	25	14	349	24.56	26	0	349	23.45	24	0
ZJX017	20	649	12.04	20	22	661	11.27	17	38	634	11.23	18	0	504	11.08	14	0
ZJX028	18	362	21.56	25	0	318	19.73	14	0	321	19.58	16	0	309	23.58	17	0
ZJX029	18	91	23.01	9	0	96	22.24	8	0	96	19.15	8	0	97	19.57	8	0

Table I-4: Year 2015 Sector Attributes, Cont'd

	Base					Base + RNAV				Base + RNAV + Direct/Wind Op				RVSM			
Sector	MAP	Throughput	Transittime	MIAC	DurPastMAP	Throughput	Transittime	MIAC	DurPastMAP	Throughput	Transittime	MIAC	DurPastMAP	Throughput	Transittime	MIAC	DurPastMAP
ZJX033	18	427	10.25	12	0	387	10.09	15	0	416	10.7	15	0	393	11.19	12	0
ZJX034	21	619	13.24	19	0	546	12.89	17	0	472	12.49	13	0	374	12.3	14	0
ZJX036	20	170	16.67	10	0	149	10.64	8	0	149	10.62	6	0	250	9.97	9	0
ZJX049	18	508	14.4	19	17	619	14.35	20	33	739	12.46	22	12	829	12.84	17	0
ZJX054	18	335	12.18	12	0	429	12.17	14	0	421	12.36	14	0	417	12.34	15	0
ZJX057	15	910	8.64	18	0	664	8.08	13	0	717	7.64	14	0	701	7.72	15	23
ZJX058	16	710	12.96	19	26	529	12.44	19	47	543	11.96	18	31	644	11.57	19	0
ZJX065	21	291	15.4	14	0	283	14.36	11	0	283	13.45	10	0	283	13.25	9	0
ZJX066	21	502	14.34	23	38	405	13.54	16	0	405	12.6	15	0	364	12.5	12	0
ZJX067	18	394	16.27	18	6	545	13.31	16	0	545	13.33	18	0	485	13.32	15	0
ZJX068	21	490	16.5	24	0	489	12.72	21	35	489	12.7	13	0	341	12.01	14	0
ZJX071	16	652	10.07	14	0	635	9.69	18	9	635	9.68	19	0	734	9.86	20	21
ZJX072	16	541	11.2	19	0	549	11.23	17	11	549	10.72	14	0	559	11.24	17	6
ZJX073	17	493	12.5	15	0	506	12.35	16	0	506	12.34	14	0	512	12.59	14	0
ZJX074	17	437	10.34	15	0	422	10.64	17	12	422	10.63	15	0	423	10.65	16	0
ZJX075	16	430	9.09	12	0	557	9.69	16	20	507	9.36	14	0	440	8.43	14	0
ZJX076	21	668	9.34	17	0	601	12.12	20	0	580	11.5	17	0	623	11.37	17	6
ZJX077	16	332	13.52	13	0	391	11.05	16	15	371	11.28	13	0	351	11.92	13	0
ZJX078	16	554	11.02	13	0	744	8.49	15	0	873	9.62	18	8	873	9.75	18	13
ZJX079	20	247	16.23	10	0	265	15.34	10	0	244	14.63	9	0	230	14.97	9	0
ZJX084	20	83	8.2	4	0	82	8.3	4	0	82	8.39	4	0	88	7.98	4	0
ZMA001	18	271	18.34	19	13	128	16.38	7	0	128	12.28	7	0	122	11.44	7	0
ZMA002	21	491	20.98	21	11	418	17.12	18	0	420	16.86	17	0	536	16.23	20	0
ZMA003	15	90	12.29	4	0	90	12.33	4	0	90	12.33	4	0	90	12.4	4	0
ZMA004	15	186	12.44	6	0	172	12.38	7	0	154	12.49	7	0	152	12.97	7	0
ZMA005	15	321	8.21	8	0	306	8.11	9	0	303	8.13	9	0	296	8.11	9	0
ZMA006	15	173	12.78	10	0	186	12.81	10	0	184	12.89	10	0	177	12.86	10	0
ZMA007	13	357	10.72	9	0	339	9.85	10	0	308	7.73	9	0	285	7.68	8	0
ZMA008	15	456	18.75	15	0	445	19.5	18	0	429	19.78	18	20	426	19.4	17	3
ZMA020	15	375	8.25	8	0	357	9.07	10	0	296	9.26	8	0	408	8.31	10	0
ZMA021	15	324	8.03	13	0	159	11.35	8	0	159	11.31	8	0	156	11.42	8	0
ZMA022	15	408	12.27	12	0	413	12.13	10	0	462	11.1	15	2	473	11.69	12	0
ZMA024	15	415	11.07	13	0	662	11.03	15	3	512	9.91	11	0	462	9.83	11	0
ZMA025	15	459	11.45	13	0	366	11.43	9	0	342	10.11	10	0	313	9.61	9	0
ZMA026	20	308	14.61	14	0	308	15.14	14	0	308	15.1	14	0	307	15.15	14	0
ZMA031	20	184	7.41	6	0	184	7.41	7	0	184	7.47	6	0	184	7.45	6	0
ZMA036	20	11	6.91	1	0	11	6.73	1	0	11	7	1	0	11	6.91	1	0
ZMA032	20	11	5.82	2	0	11	6	2	0	11	5.82	2	0	11	5.91	2	0
ZMA033	20	84	33.75	12	0	81	33.69	11	0	81	33.64	10	0	81	33.63	11	0
ZMA034	20	27	8.41	3	0	28	8.43	2	0	28	8.43	2	0	28	8.32	2	0

Table I-4: Year 2015 Sector Attributes, Cont'd

	Base					Base + RNAV				Base + RNAV + Direct/Wind Op				RVSM			
Sector	MAP	Throughput	Transittime	MIAC	DurPastMAP	Throughput	Transittime	MIAC	DurPastMAP	Throughput	Transittime	MIAC	DurPastMAP	Throughput	Transittime	MIAC	DurPastMAP
ZMA039	20	159	19.86	9	0	160	20.13	9	0	160	20.08	8	0	160	20.14	9	0
ZMA038	20	22	11.41	2	0	22	11.18	2	0	22	11.23	2	0	22	11.14	2	0
ZMA040	15	242	10.44	12	0	253	10.38	12	0	248	10.49	13	0	247	10.47	12	0
ZMA041	15	214	9.67	7	0	221	9.91	9	0	221	9.81	9	0	221	9.83	9	0
ZMA042	15	221	12.26	10	0	217	12.13	9	0	217	12.2	10	0	217	12.17	11	0
ZMA043	20	84	20.12	6	0	82	20.39	6	0	82	20.37	6	0	82	20.35	6	0
ZMA045	10	74	13.62	6	0	90	12	7	0	85	12.39	6	0	85	12.38	8	0
ZMA046	9	569	9.88	11	14	655	8.36	11	21	762	8.77	11	16	761	8.78	11	15
ZMA047	10	565	9.27	12	5	555	10.67	12	0	592	10.84	12	27	552	10.82	12	9
ZMA059	20	156	11.91	11	0	153	12.34	11	0	153	11.7	11	8	153	11.7	11	0
ZMA060	20	256	24.52	14	0	251	24.61	14	0	251	24.62	15	0	251	24.21	13	0
ZMA061	15	269	19.96	14	0	268	20	14	0	268	20.01	15	8	268	19	16	0
ZMA062	21	208	35	14	0	211	34.8	16	0	211	34.78	16	0	211	34.76	16	0
ZMA063	21	73	29.45	6	0	75	29.44	5	0	75	29.53	5	0	75	29.49	6	0
ZMA067	15	533	10.08	14	0	566	10.29	15	7	574	10.66	16	12	562	10.7	17	0
ZMA066	15	80	12.75	6	0	90	12.18	6	0	79	13.35	6	0	79	13.37	6	0
ZMA064	14	374	8.44	10	0	371	9.36	11	0	392	9.91	13	0	366	9.59	10	0
ZMA065	15	487	13.5	12	0	475	13.28	15	9	545	13.19	16	0	515	13.01	16	24
ZMA080	20	471	8.2	13	0	477	8.57	12	0	479	8.64	13	0	490	8.62	14	0
ZMA095	20	1147	9	19	0	1127	9.34	21	31	1129	8.64	20	14	1137	8.75	19	0
ZMA096	38	2265	9.19	41	84	2250	9.4	42	30	2256	8.58	40	6	2256	8.46	40	12
ZMA097	20	371	7.68	12	8	438	7.16	10	0	407	7.39	10	0	391	7.46	12	0
ZTL071	20	464	8.38	12	0	443	8.4	11	5	443	8.45	11	0	447	8.45	12	0
ZTL072	20	190	10.39	10	0	191	10.36	10	0	191	10.39	10	0	189	10.26	10	0
ZTL073	20	1566	6.63	24	24	1489	6.9	24	12	1489	6.9	24	32	1497	6.92	24	37
ZTL074	20	138	13.67	12	0	133	13.87	6	0	133	12.31	5	0	132	12.2	6	0
ZTL075	20	328	9.06	11	0	320	8.98	12	0	320	8.98	11	0	323	9.15	10	0
ZTL076	20	449	11.8	13	0	511	11.07	13	0	511	11.08	13	0	516	11.06	13	0
ZTL077	20	142	12.52	7	0	141	12.62	7	0	141	12.63	8	0	143	12.54	7	0
ZTL078	20	135	10.92	6	0	141	10.57	6	0	141	10.57	6	0	141	10.59	6	0
ZTL079	20	277	9.71	8	0	271	9.7	8	0	271	9.7	8	4	271	9.78	8	0
ZTL080	20	141	15.65	8	0	146	15.82	11	0	144	15.8	10	0	143	16.2	10	0
ZTL082	20	125	11.82	6	0	126	11.79	6	0	126	11.77	6	0	138	11.18	6	0
ZTL089	20	172	8.66	6	0	175	8.7	6	0	175	8.7	7	8	175	8.72	6	0
ZTL001	18	152	15.11	11	0	162	13.04	9	0	162	13.04	9	0	170	12.51	9	0
ZTL002	17	762	10.79	19	65	507	11.28	13	0	507	11.26	12	0	715	10.01	17	11
ZTL003	15	729	11.39	18	5	772	11.71	18	4	772	11.7	18	21	756	10.35	12	0
ZTL004	13	665	9.7	16	28	645	9.17	16	5	645	9.2	17	20	694	8.76	16	0
ZTL005	18	588	7.77	17	0	640	7.59	14	0	640	7.58	14	0	618	7.28	13	0
ZTL006	13	651	8.32	12	0	608	8.78	12	0	608	8.77	12	0	558	8.45	11	0

Table I-4: Year 2015 Sector Attributes, Cont'd

	Base					Base + RNAV				Base + RNAV + Direct/Wind Op				RVSM			
Sector	MAP	Throughput	Transittime	MIAC	DurPastMAP	Throughput	Transittime	MIAC	DurPastMAP	Throughput	Transittime	MIAC	DurPastMAP	Throughput	Transittime	MIAC	DurPastMAP
ZTL008	18	382	13.21	15	0	250	12.19	8	0	245	12.38	8	0	298	12.32	11	0
ZTL009	38	651	15.26	39	81	670	14.87	26	0	636	14.26	27	0	564	15.43	23	0
ZTL010	13	451	9.57	15	19	432	9.78	10	0	398	10.04	10	0	265	9.62	8	0
ZTL011	17	319	12.29	11	0	438	12.31	14	0	438	12.36	14	0	306	11.92	10	0
ZTL012	12	336	9.98	11	0	320	9.07	13	0	320	9.03	13	20	315	9.22	13	0
ZTL013	18	366	14.67	14	0	349	11.1	12	0	349	11.22	13	0	363	11.86	13	0
ZTL014	18	314	13.56	13	0	334	13.4	13	0	334	13.39	14	0	331	13.38	13	0
ZTL015	18	569	14.58	23	0	542	14.36	19	17	542	14.38	19	4	690	14.06	19	2
ZTL016	15	777	10.36	18	0	721	10.35	18	0	721	10.39	18	9	762	10.01	18	18
ZTL017	18	117	14.85	7	0	118	14.43	8	0	118	14.43	8	0	117	14.49	7	0
ZTL018	18	114	16.27	9	0	115	15.63	7	0	115	15.63	7	0	114	15.7	7	0
ZTL019	18	259	10.52	10	0	407	10.06	12	0	289	10.39	10	0	262	10.54	10	0
ZTL020	15	562	9.96	14	0	551	10.06	15	19	452	10.67	13	0	406	10.65	13	0
ZTL021	13	569	10.58	18	0	457	10.84	15	13	614	8.91	14	21	616	9.12	13	16
ZTL022	18	704	11.42	19	15	705	12.34	17	0	872	9.92	19	19	709	9.18	16	0
ZTL023	18	687	12.97	21	3	554	13.85	16	0	634	11.6	17	0	734	12.34	19	12
ZTL024	17	412	11.45	12	0	397	10.43	14	0	397	10.44	14	0	380	9.97	11	0
ZTL025	20	52	11.08	3	0	56	10.5	3	0	56	10.52	3	0	58	10.26	3	0
ZTL028	18	468	15.34	20	27	337	14.38	12	0	337	13	13	0	366	12.19	13	0
ZTL029	10	421	6.72	10	0	442	7.26	8	0	373	7.2	8	0	365	7.28	9	0
ZTL030	11	558	7.22	13	0	510	7.32	13	0	510	6.95	13	13	514	6.97	12	0
ZTL031	13	513	8.48	12	0	511	8.63	14	30	511	8.58	14	0	510	8.58	14	0
ZTL032	13	744	8.82	16	37	587	9.01	15	5	587	9.02	15	19	487	7.82	12	0
ZTL033	17	631	9.83	16	0	695	9.62	17	0	696	9.66	18	10	585	9.14	17	34
ZTL034	13	328	5.44	7	0	382	7.84	10	0	382	7.85	10	12	356	6.82	9	0
ZTL036	13	398	8.49	10	0	372	7.34	9	0	372	7.35	9	0	509	7.42	11	0
ZTL037	13	636	9.86	14	1	637	10.33	16	20	637	10.32	16	0	609	9.36	16	17
ZTL038	13	658	8.93	16	22	608	8.9	16	29	608	8.93	12	0	645	8.84	16	8
ZTL039	15	671	10.6	17	13	779	11.56	18	5	779	11.13	18	5	727	10.28	17	21
ZTL040	18	756	10.72	24	1	543	10.76	11	5	463	10.76	13	0	627	10.04	15	0
ZTL041	18	283	12.14	9	0	308	12.34	9	0	308	11.94	9	0	322	11.36	9	0
ZTL042	15	200	10.4	7	0	465	10.47	15	21	465	10.52	14	0	487	10.03	14	0
ZTL043	13	701	11.39	16	21	682	10.47	15	48	682	10.41	15	6	597	9.98	14	15
ZTL044	15	523	9.94	15	7	511	9.48	15	8	511	9.49	14	0	511	9.56	15	19
ZTL045	17	402	11.7	10	0	406	11.77	10	0	406	11.77	11	0	395	11.34	12	0
ZTL046	18	379	10.72	12	0	330	10.62	11	0	330	10.62	10	0	344	9.58	9	0
ZTL047	15	509	9.87	15	0	450	9.48	12	0	450	9.45	12	0	459	9.41	12	0
ZTL048	18	192	13.96	12	0	206	13.3	13	0	206	13.3	12	2	217	12.74	13	0
ZTL049	38	765	14.36	31	0	773	14.32	23	0	773	13.08	22	5	753	12.12	27	53
ZTL050	15	881	8.44	18	41	875	8.84	18	21	875	8.85	17	56	882	8.58	18	6

Glossary

Adaptation Controlled Environment System (ACES) — 3
Advanced Concepts Branch (ACT-540) — ES-i
Air Route Traffic Control Centers (ARTCCs) — 1
Air Traffic Control (ATC) — 6
Air Traffic Control Systems Command Center (ATCSCC) — 10
Aircraft Owners and Pilots Association (AOPA) — ES-i
Airline Service Quality Performance (ASQP) — 10
area navigation (RNAV) — ES-i
Atlanta Center (ZTL) — 1
Atlanta Hartsfield International Airport (ATL) — 4
Automated Observation System (AOS) — 10
Controller-Pilot Data Link Communications (CPDLC) — ES-i
Daytona Beach International Airport (DAB) — 4
Department of Transportation (DOT) — 10
Enhanced Traffic Management System (ETMS) — 8
Federal Aviation Administration W.J. Hughes Technical Center (FAATC) — ES-i
Flight Management System (FMS) — 2
Ft. Lauderdale-Hollywood International Airport (FLL) — 4
Future Demand Generator (FDG) — 8
General Aviation (GA) — 12
Global Navigation Satellite System (GNSS) — 2
Ground Delay Program (GDP) — 10
International Civil Aviation Organization (ICAO) — 7
Investment Analysis and Operations Research Analysis Division (ASD-400) — ES-i
Jacksonville Center (ZJX) — 1
Jacksonville International Airport (JAX) — 4
Long Range Navigation System (LORAN) — 19
Miami Center (ZMA) — 1
Miami International Airport (MIA) — 4
NAS Performance Analysis Capability (NASPAC) — 6
National Airspace Redesign (NAR) — 13
National Airspace System (NAS) — ES-i
National Climatic Data Center (NCDC) — 4
National Oceanic and Atmospheric Administration (NOAA) — 9
nautical miles (nmi) — ES-i
Navigational Aid (NAVAID) — 9
Next Generation Weather Radar (NEXRAD) — 4
National Route Program (NRP) — ES-ii
North Atlantic Systems Implementation Group Cost Effectiveness (NICE) — 7
Official Airline Guide (OAG) — 8
Operational Evolution Plan (OEP) — ES-i
Operations Research and Analysis Branch (ASD-400) — ES-i
Optimized Trajectory Generator (OPGEN) — 5

References

1) Report of the NICE Task Force, October 1999

2) Design of the NASPAC Simulation Modeling System, Millner, June 1993

3) NAS Operational Evolution (2001-2010), April 2001

4) Operational Evolution Plan Briefing, Version 3.0, June 2001

5) User Request Evaluation Tool (URET) Conflict Probe Performance and Benefits Assessment, Brudnicki and McFarland, October 1996

6) National Airspace Resource Investment Model (NARIM) Run Manager, November 1998

7) Technical and Economic Evaluation of Air Transportation Management Issues Related to Free Flight, Logistics Management Institute, October 1996

8) Multi-Center GPS Direct Routes Analysis, ASD-430, July 1997

9) RAMS User Manual, Version 2.3, August 1998

10) The Impact of National Airspace Modernization on Aircraft Emissions, August 1998

11) FAA Administrators Fact Handbooks, January 1996 - August 2000

12) Airport Capacity Benchmark Report, FAA

13) Base of Aircraft Data (BADA), October 1999

14) United States DRVSM, Users Meeting Briefing, May 31, 2001

15) Initial Impacts of Reducing the Number of ATC-Preferred Routes, MITRE/CAASD, 1998

16) Satellite Navigation Investment Analysis Report, September 1999

17) Post Operational Evaluation Tool (POET)