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MITRE PRODUCT

Analysis of Fifth STAR Proposal for Runway Expansion at Minneapolis/St. Paul International Airport

March 2001

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MITRE
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McLean, Virginia

Abstract

The MITRE Corporation's Center for Advanced Aviation System Development (MITRE/CAASD) has investigated the effects of a new runway currently being constructed at Minneapolis/St. Paul International Airport (MSP). The principal focus of the analysis was to study the effects of adding a fifth Standard Terminal Arrival Route (STAR). The new STAR would accept approximately half the traffic approaching MSP from the east to relieve the existing TWINZ STAR. The results show the new STAR will not reduce delays at MSP and, because of the extra miles flown, is not justified under the conditions of this study.

KEYWORDS: Air Traffic Control, Federal Aviation Administration, Standard Terminal Arrival Route, Total Airspace and Airport Modeler

Acknowledgments

We would like to acknowledge the significant contributions of several study team members. Bruce Burns (M98) provided much of the initial simulation baseline and along with Chris Barth (M98) worked closely with us during the development and validation of the model. Scott Shelerud (ZMP) provided useful perspectives on Center operations. Cindy Greene (M98) and Ted Thomas (ZMP) provided direction and focus for the entire study. Finally, we appreciate the efforts of Angela Signore for her help in document preparation.

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Section 1

Introduction

1.1 Background

The Minneapolis-St. Paul International Airport (MSP) is currently constructing an additional runway with scheduled completion date of 2003. The new Runway 17/35 lies at the southwestern end of the airport as shown in Figure 1-1. Due to the geometry of the new runway, only southern operations will be allowed upon completion, i.e., arrivals to Runway 35 and departures from Runway 17.

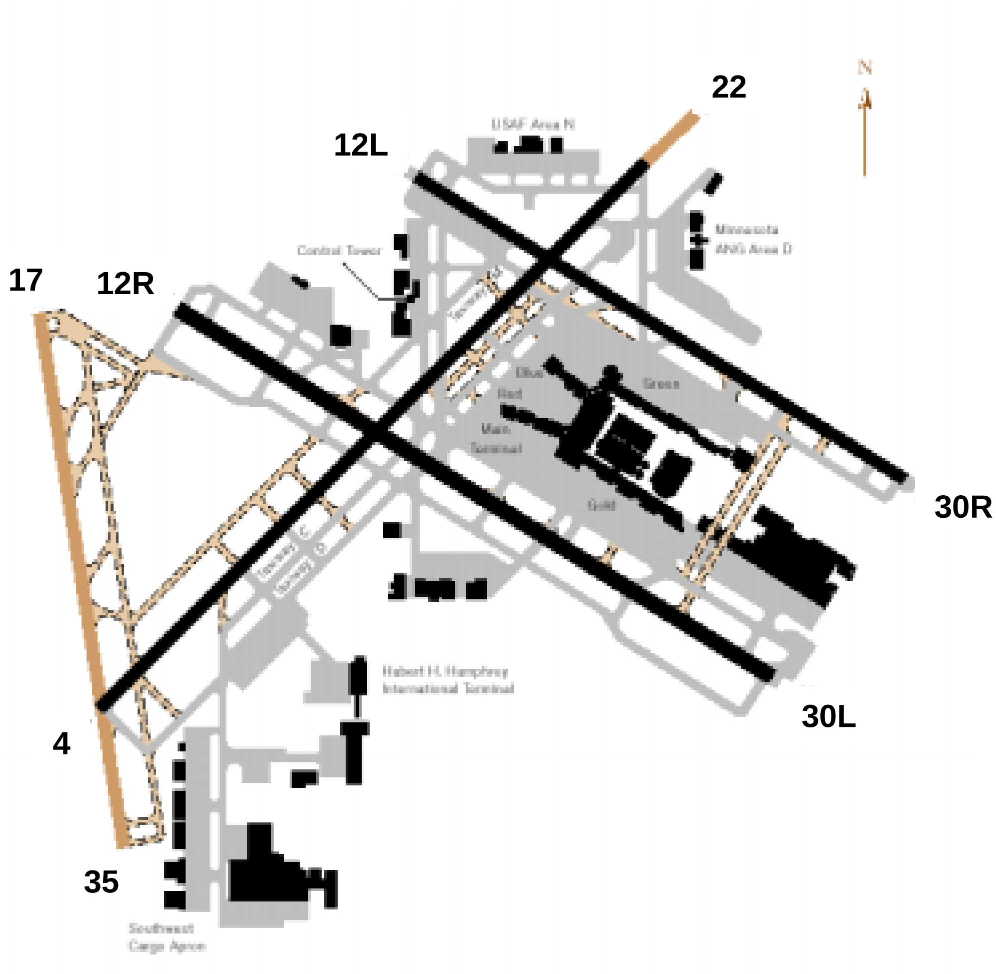

Figure 1-1. Minneapolis-St. Paul International Airport with New Runway 17/35

Representatives from MSP tower, M98 terminal radar approach control (TRACON), and Minneapolis Air Route Traffic Control Center (ZMP) have met periodically to discuss the best ways to integrate the new runway into local and center operations. M98 has a typical four-cornerpost operation with four associated Standard Terminal Arrival Routes (STARs). However, arrival and departure demands are predominantly to the south and east, and this, coupled with the restrictions on northern operations for the new runway would make airspace changes difficult. The M98/ZMP airspace study team proposed the addition of a fifth STAR to facilitate entry into the TRACON and to maximize runway utilization. The Federal Aviation Administration's (FAA) Office of Airspace Planning and Analysis (ATA-200) asked the MITRE Corporation's Center for Advanced Aviation System Development (MITRE/CAASD) to work with the Minneapolis team in order to model a new fifth STAR and assess its impact on operations. The CAASD modeling group chose the Total Airspace and Airport Modeller (TAAM) as the modeling platform for this study. TAAM was selected for this study because of its ability to model complex, dynamic operations and for its ability to generate delay and throughput information. Also TAAM's visual presentation of a simulation facilitates interaction with controllers and validation of the modeling effort.

1.2 Document Organization

Section 2 describes the project history and meetings held between the M98/ZMP study team and the CAASD analysis group. Section 3 describes the components necessary to model M98/ZMP airspace, including STARs, Standard Instrument Departure routes (SIDs), and the processes used to assure model fidelity. Also described in Section 3 is the rationale for opening and closing the new runway and a characterization of the traffic used. Section 4 describes the analysis of delay with and without the new STAR for three future traffic scenarios: 2003, 2008, and 2013. Section 4 also focuses on throughput and effective runway utilization. Results are summarized in Section 5, and, finally, the appendices list in detail supplemental data needed to drive the simulation.

Section 2
Project History

The CAASD analysis team first met with the M98/ZMP airspace study team in March 2000. This meeting helped to define the scope of the project, including the objectives, approach, metrics, alternatives, and roles and responsibilities. Materials related to MSP and a previous study were disseminated along with information on a proposed new STAR through either the BITLR or Redwing (RGK) fix. The original proposal with the two candidate STARs is shown in Figure 2-1. The original design objective was to evaluate these two candidate STARs with respect to their effect on delays. Also to be determined were estimates of airport throughput at peak arrival times. The M98/ZMP study team decided not to construct a ground model of MSP for this analysis.

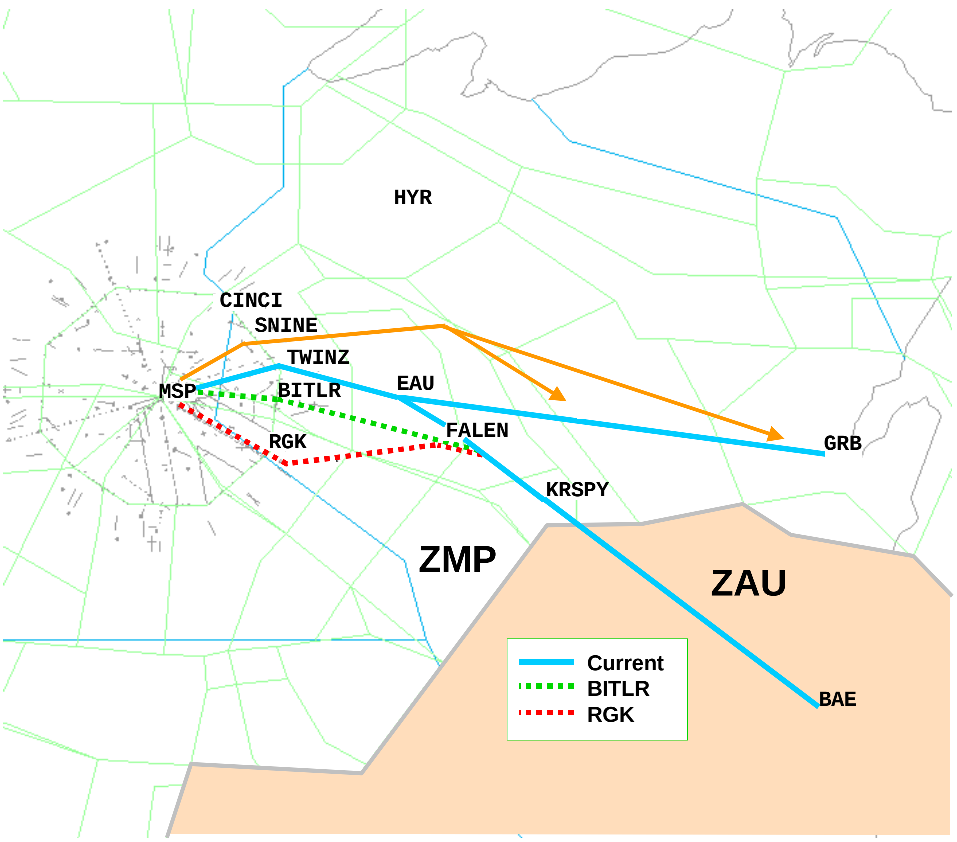

Figure 2-1. Original Proposal with Candidate BITLR and RGK STARs

In April 2000, the CAASD team met again with the M98/ZMP study team to review the data received previously and to start the formal process of data collection for current and future operations. Much new information on arrival and departure routes was provided at this meeting along with preferred usage of runways and the information on the type and amount of future traffic. New information was received on the proposed BITLR and RGK STARs.

In June 2000, the CAASD team returned to Minneapolis for a further refinement and verification of arrival and departure routes. Additional input on satellite arrival and departure routes and no-fix arrivals was also provided. Analysis assumptions for the 2003 traffic file were discussed. The CINCI STAR was first discussed at this meeting.

The M98/ZMP/CAASD meeting of July 2000 was pivotal in that the BITLR and RGK proposals were eliminated and the study team committed to the further study of the CINCI STAR, providing new information on this route. It was agreed that traffic through Green Bay (GRB) would proceed north to Hayward (HYR) and CINCI, as shown in Figure 2-2. Additional information on satellite arrival and departure routes and no-fix arrivals was provided in the process of continuing with the verification of existing arrival/departure

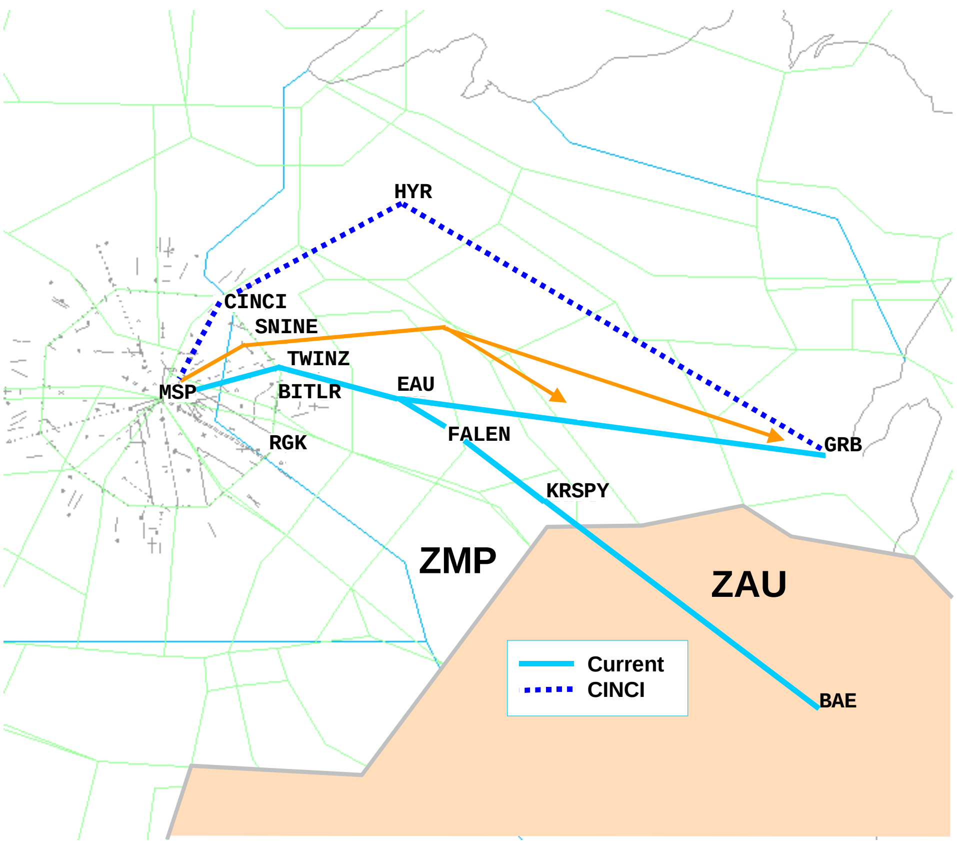

Figure 2-2. The Route of the CINCI STAR Proposal

routes. Southern arrival restrictions and related runway usage patterns were discussed. The study team approved the 2003 traffic file.

The last M98/ZMP/CAASD full study team meeting was held in Minneapolis in September 2000, where runway usage related to the CINCI STAR was refined. A significant agreement between ZMP and M98 relating to southern arrivals was achieved. The study team agreed that for the purposes of modeling, a new fix with an altitude restriction would be created north of the DELZY fix to facilitate landing on Runway 35. An additional requirement was made to build and analyze scenarios for traffic in 2008 and 2013.

In October 2000, representatives from ZMP came to Washington and completed validation of center airspace with CAASD. In December 2000, representatives from M98 came to Washington and completed validation of M98 airspace and operations with CAASD.

Preliminary results on the impact of the CINCI STAR were delivered in October and December. The results of Section 4 are the final results and support the major conclusions of the previous two reports.

Section 3

Modeling Technique

3.1 Overview and Rationale

The TAAM analysis of the M98 TRACON was performed in several stages. From the outset, the project was separated into northwest and southeast operations with arrivals and departures for Runway 17/35, resulting in four cases as shown in Figure 3-1. These cases served as the basis for analyzing the delay of the fifth STAR.

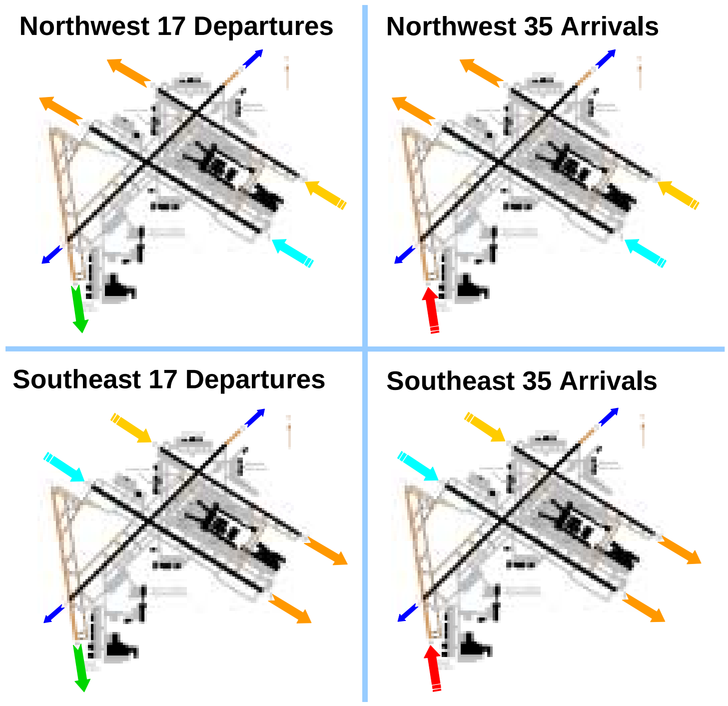

Figure 3-1. Northwest and Southeast Runway Configurations

For each runway configuration, detailed designs of the departure and arrival routes were constructed per the M98 Standard Operating Procedures, Letters of Agreement between ZMP and M98, and controller input from both M98 and ZMP. The TRACON vectoring patterns for arrivals and departures are known as SIDs and STARs in TAAM, not to be confused with the conventional use of STAR to refer to the enroute portion of an arrival route. The detailed TRACON SIDs and STARs as implemented in TAAM are shown in Sections 3.2 and 3.3. These templates consist of color graphic representations of MSP TRACON approach and departure routes with altitude/speed profiles according to runway usage. TAAM aircraft data blocks are color coded to match the SID/STAR template route color, thus simplifying the development and validation of the model its with controllers.

Traffic files were generated for 2003 operations (the year Runway 17/35 opens) and for future 2008 and 2013 levels. Section 3.4 details the procedure for generating MSP traffic files.

After the construction of the SID/STAR infrastructure and traffic files, the model was calibrated for departure ascent rates and runway arrival and departure rates. Since a ground model was not built for this project, the runway arrival and departure rates were determined from operational data. The TAAM model was tuned to these rates using departure and arrival separations. Further details for calibration procedures are found in Section 3.5.

Section 3.6 discusses model validation by the M98 controllers. The validation consisted of verifying departure/arrival routing, runway usage, runway balancing and other controller feedback.

3.2 Northwest Flow Throughput

Since Runways 17 and 35 are open at different times, separate departure and arrival routes were developed depending on which runway was in operation.

3.2.1 Runway 17 Operations Departure Routes

Departure routes as modeled in TAAM for northwest flow Runway 17 operations are shown in Figure 3-2 with indicated headings, altitude restrictions, and equipment restrictions. This configuration has departures and arrivals using Runways 30L and 30R and departures using Runway 17. DLL and ODI departures for B-727, DC-9 and DC-10 aircraft are turned wider than standard departure routes to allow these lower-performance aircraft enough time to gain sufficient altitude over the TWINZ arrival stream. For the ONL and FSD fixes, departures utilize all runways with the majority of departures using Runway 17. Additionally, the ODI departures from 30L/30R are routed north of the airport and then directed 130° to the TRACON border. Turboprops may depart using Runway 17 to ODI as needed and jets as per demand schedule. The schedule was determined during the controller model validation as discussed in Section 3.6.3. Also, turboprop routes that differ from jet routes are indicated as dotted lines. Altitude restriction color-coding may be applied to dotted turboprop routes, for example, a dotted blue route would indicate a turboprop departure restricted to 7000 ft. Note that international aircraft departing Runway 22 are routed to RST or ABR and Runway 04 departures are routed to RZN. These routes are not emphasized since they are used for only 17 flights per day.

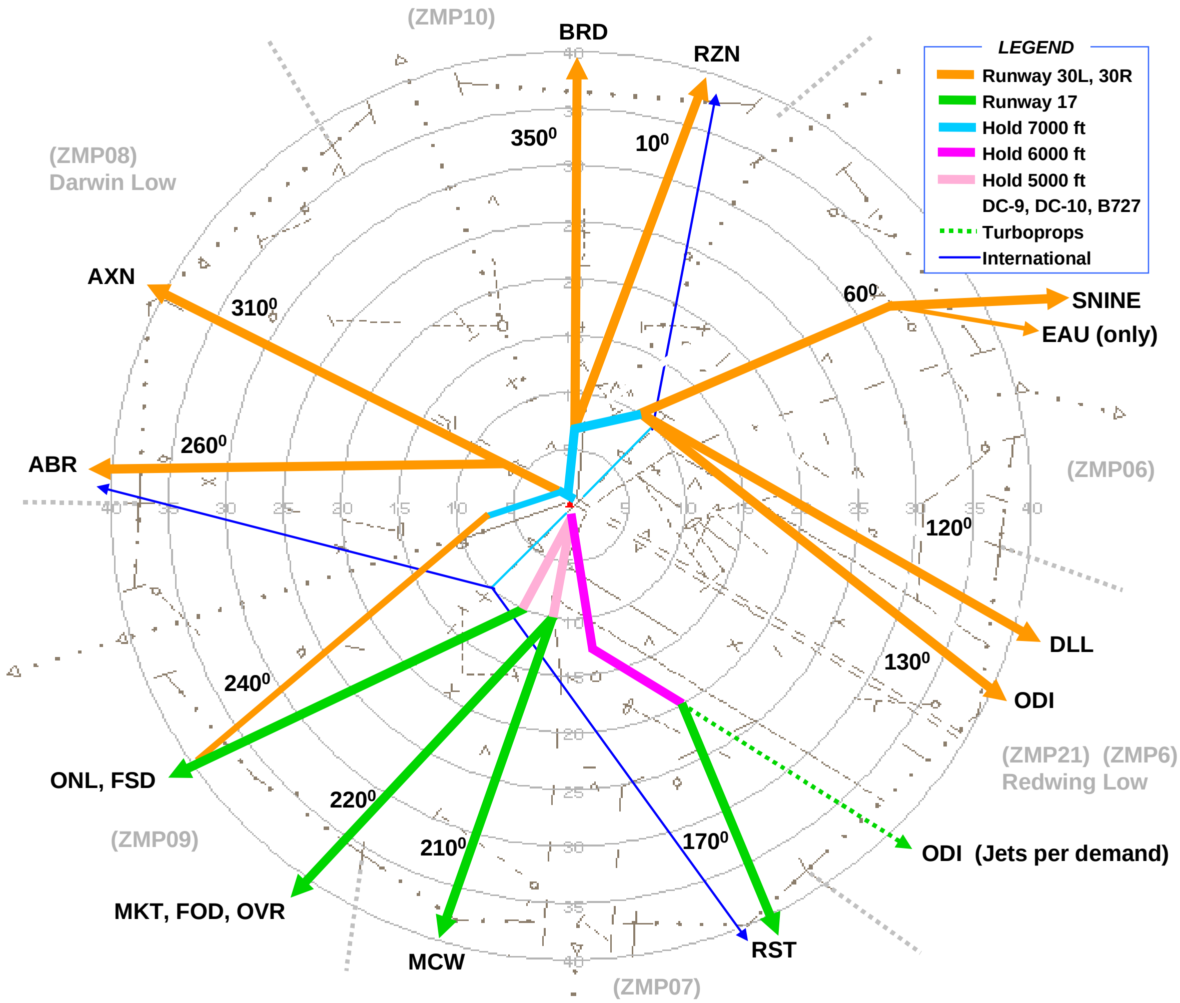

Figure 3-2. Departure Routes for Northwest Flow Runway 17 Operations

3.2.2 Runway 17 Operations Arrival Routes

M98 arrival routes as modeled in TAAM for northwest flow Runway 17 operations are shown in Figure 3-3, with indicated holding fixes and altitude and speed restrictions for jets and turboprops. This configuration has departures and arrivals using Runways 30L and 30R and departures using Runway 17. Current arrival gates to MSP are TWINZ from the east, DELZY from the south, SHONN from the west and OLLEE from the north. The proposed CINCI (fifth STAR) arrival route utilizes 30L and 30R for arrivals. ALEEN was selected as the holding fix for the CINCI star. Note that altitude-speed restrictions prefixed as "J" are for jets and "P" are for turboprops. Restrictions shown as " Jxxx" have no altitude restriction. For runway crossover arrival flow separation, jets from the north cross the runway centerlines at 10,000 ft and jets from the south cross the runway centerlines at 11,000 ft. Turboprops cross airport centerlines at 8000 ft from the north and 9000 ft from the south.

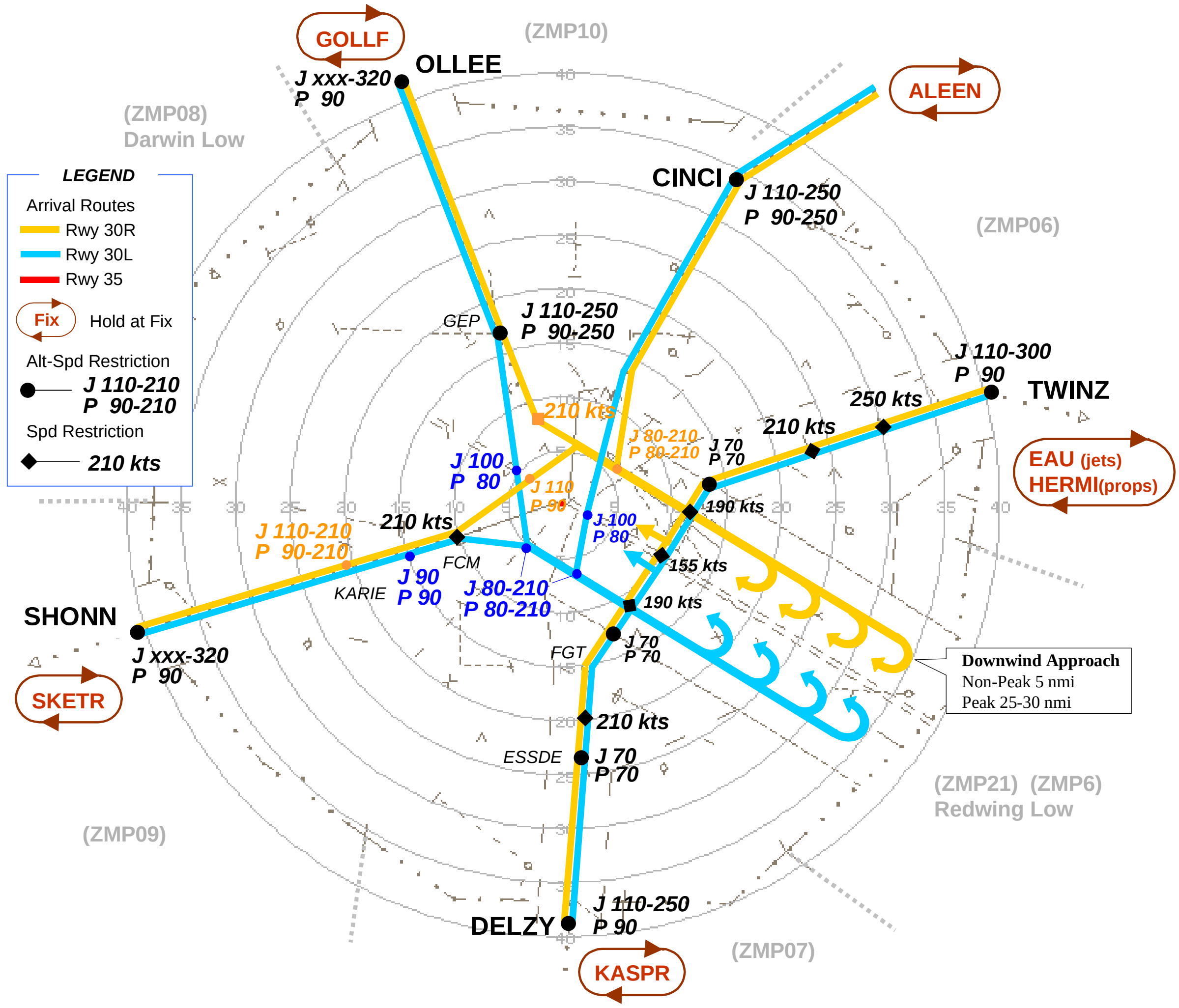

Figure 3-3. Arrival Routes for Northwest Flow Runway 17 Operations

3.2.3 Runway 35 Operations Departure Routes

Departure routes as modeled in TAAM for northwest flow Runway 35 operations are shown in Figure 3-4. This configuration has departures and arrivals using Runways 30L and 30R and arrivals using Runway 35. The departure routes reflect current operations (2001) with the exception of adding the RST turboprop departure route to “tunnel” under the Runway 35 arrivals. As before, the B-727, DC-9 and DC-10 departures are modeled with wider turns to climb above the TWINZ and DELZY arrival streams.

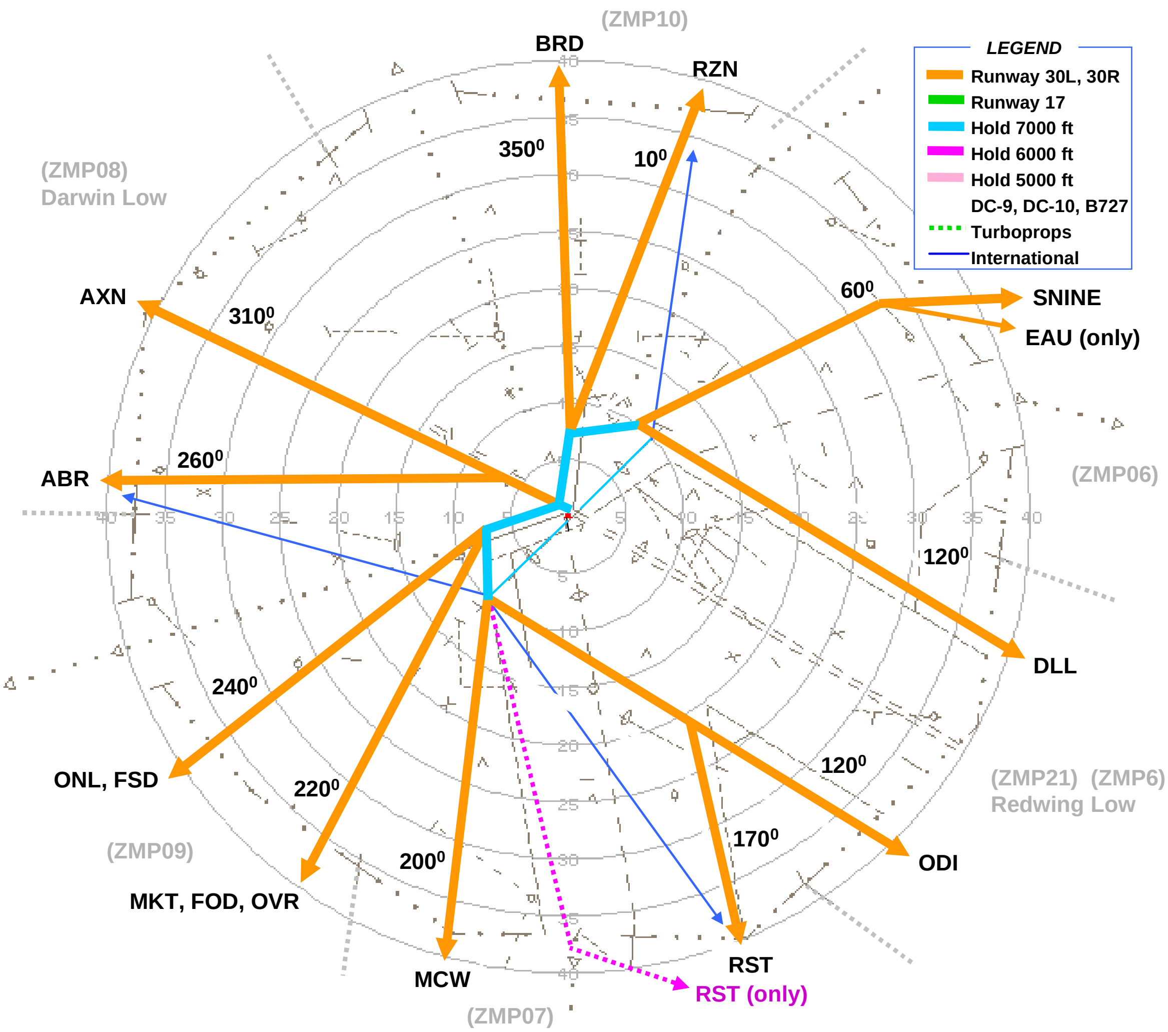

Figure 3-4. Departure Routes for Northwest Flow Runway 35 Operations

3.2.4 Runway 35 Operations Arrival Routes

Arrival routes as modeled in TAAM for northwest flow Runway 35 operations are shown in Figure 3-5. This configuration has departures and arrivals using Runways 30L and 30R and arrivals using Runway 35. The new arrival routes for Runway 35 are SHONN from the west and DELZY from the south. Per agreement from M98 and ZMP, NEWFIX was added to the DELZY arrival route to facilitate landing on Runway 35 from the south. Altitude restrictions at NEWFIX for jets and turboprops are 9000 ft and 7000 ft respectively, along with a speed restriction of 210 kts. Note that the altitude and speed profiles when Runway 35 is in operation are different from when Runway 17 is in operation (refer to Figure 3-3).

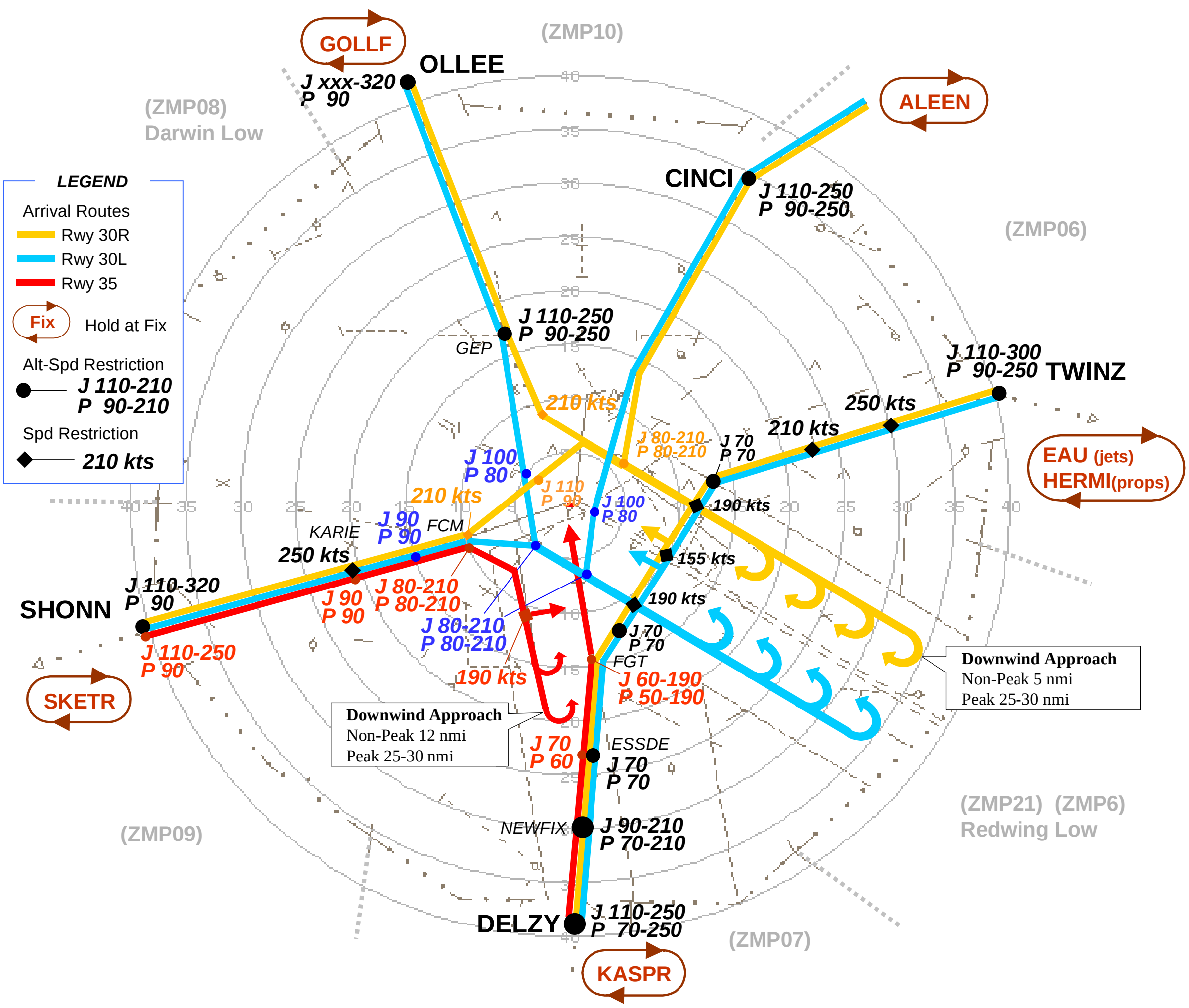

Figure 3-5. Arrival Routes for Northwest Flow Runway 35 Operations

3.2.5 Turboprop Altitude Restrictions

Figure 3-6 shows altitude restrictions for turboprop aircraft for northwest and southeast flows. M98 turboprop departures to ZMP sectors 08 and 09 are restricted to 12,000 ft and below at the TRACON boundary (40 nmi), while departures to ZMP sectors 10, 06, 21 and 07 are restricted to 11,000 ft and below at the TRACON boundary.

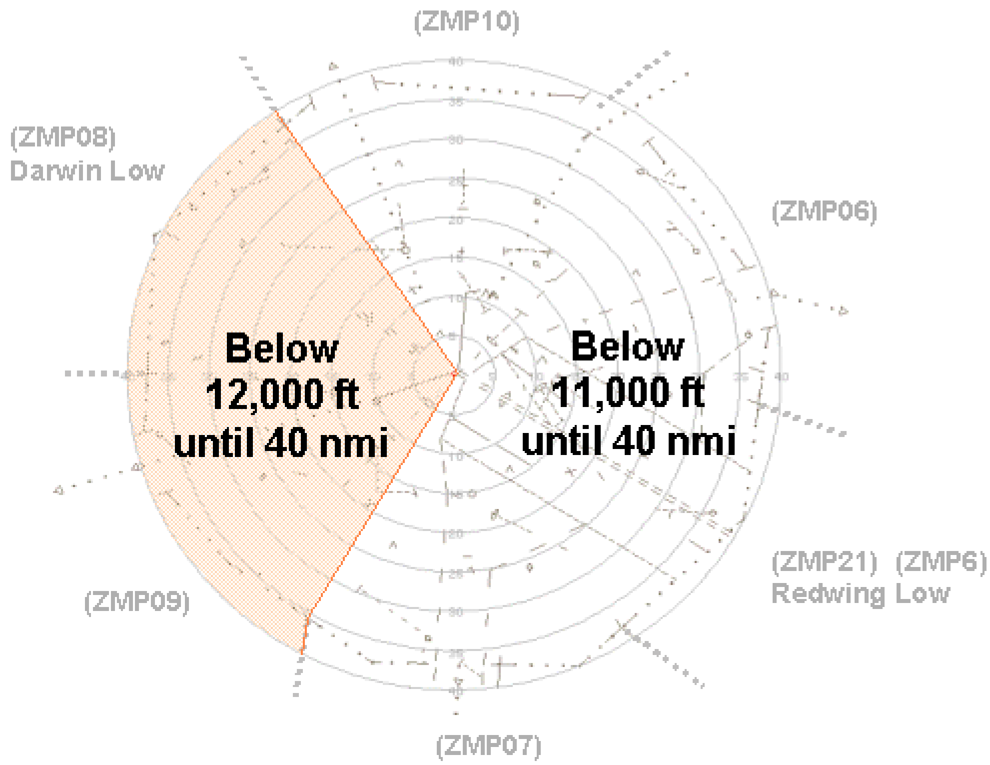

Figure 3-6. Altitude Restrictions for Turboprop Aircraft for NW and SE Flows

3.3 Southeast Flow Throughput

3.3.1 Runway 17 Operations Departure Routes

Departure routes as modeled in TAAM for southeast flow Runway 17 operations are shown in Figure 3-7. This configuration has departures and arrivals using Runways 12R and 12L and departures using Runway 17. Of special interest are the west departure routes from Runway 17, which are held to 5000 feet until 10 DME MSP and then directed 310° west to ABR, ATY or AXN. The ABR and AXN routes are available for both jets and turboprops while ATY is reserved exclusively for turboprops. All routes are scheduled per west departure demand peaks. Note that RST turboprops and jets are split at Runway 17 departure and recombined near the TRACON boundary to allow for adequate departure separation of the aircraft. Also, forty percent of jets and turboprops departing through the ODI fix are allowed to depart from Runway 17.

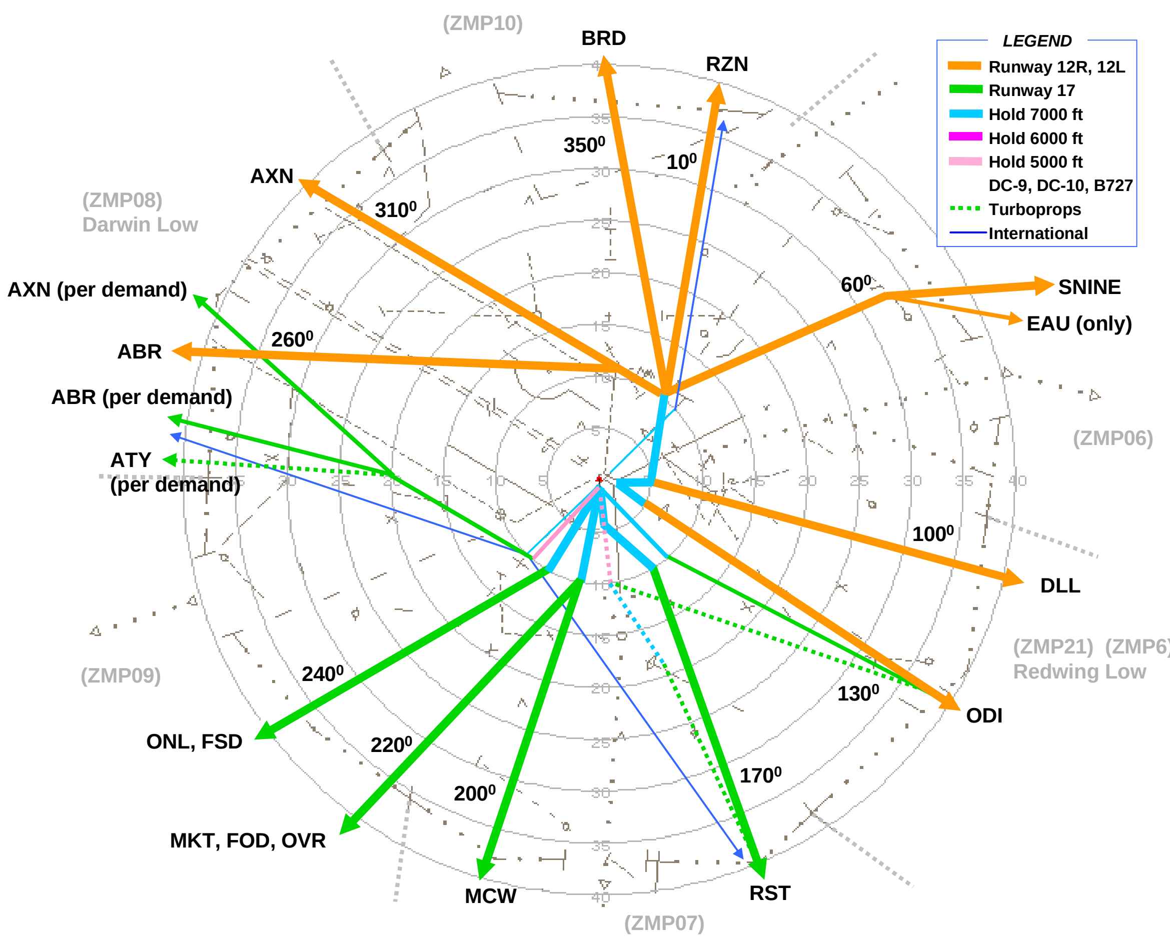

Figure 3-7. Departure Routes for Southeast Flow Runway 17 Operations

3.3.2 Runway 17 Operations Arrival Routes

Arrival routes as modeled in TAAM for southeast flow Runway 17 operations are shown in Figure 3-8. This configuration has departures and arrivals using Runways 12R and 12L and departures using Runway 17. The fifth STAR arrival flow is split at the CINCI fix with 12L arrivals tracking direct to GEP and the 12R arrival flow tracking near MSP and then directed to the downwind approach flow.

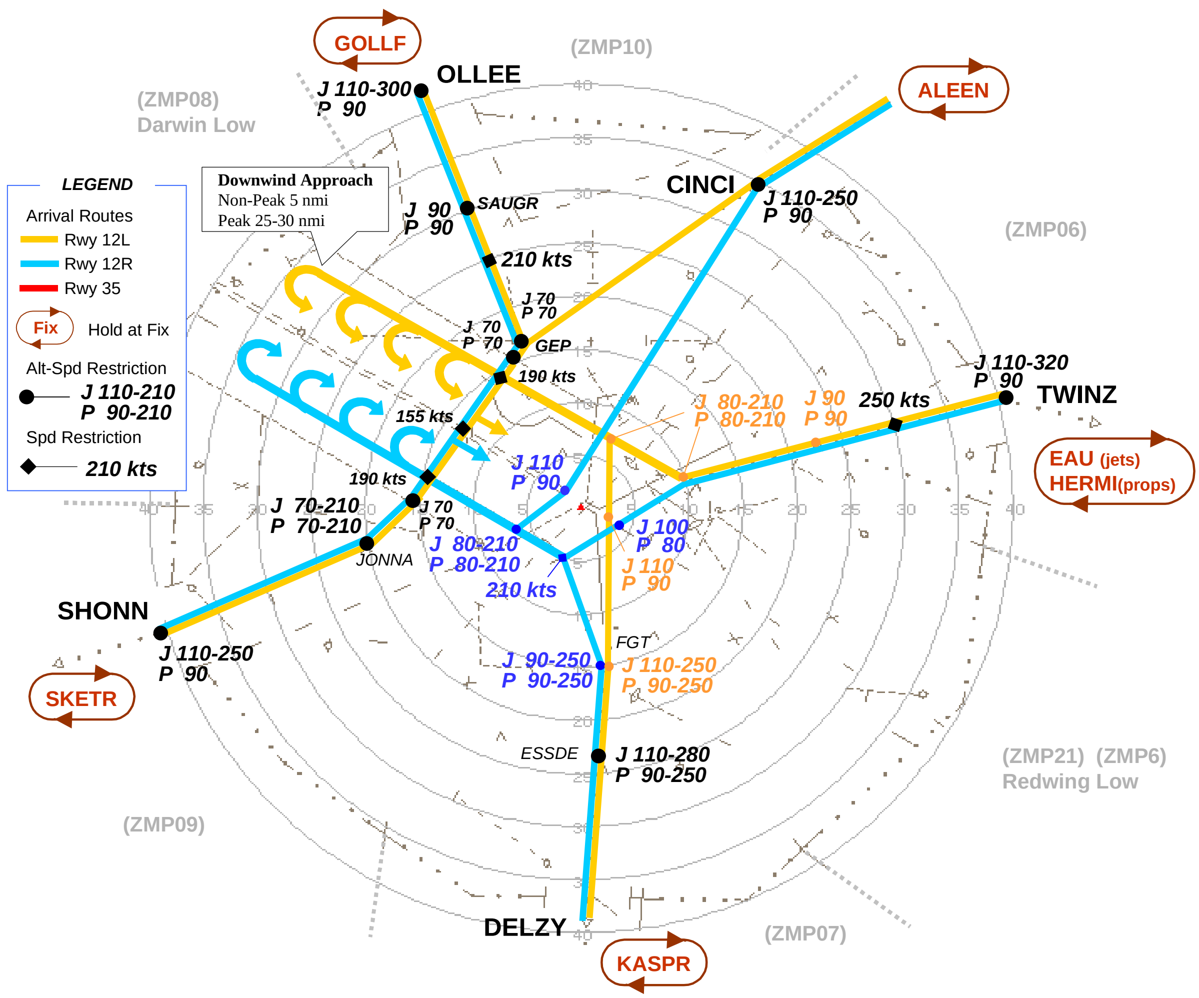

Figure 3-8. Arrival Routes for Southeast Flow Runway 17 Operations

3.3.3 Runway 35 Operations Departure Routes

Departure routes as modeled in TAAM for southeast flow Runway 35 operations are shown in Figure 3-9. This configuration has departures and arrivals using Runways 12R and 12L and arrivals using Runway 35. The ONL, FSD and MCW departures initially track 130° to 5 DME MSP, then track 170° to 15 DME MSP and are finally vectored towards their respective departure fixes. This allows aircraft to gain sufficient altitude to top the Runway 35 arrivals. Note that turboprops are vectored to departure fixes at 25 DME MSP and then tunneled (at 6000 ft) under the Runway 35 arrival stream.

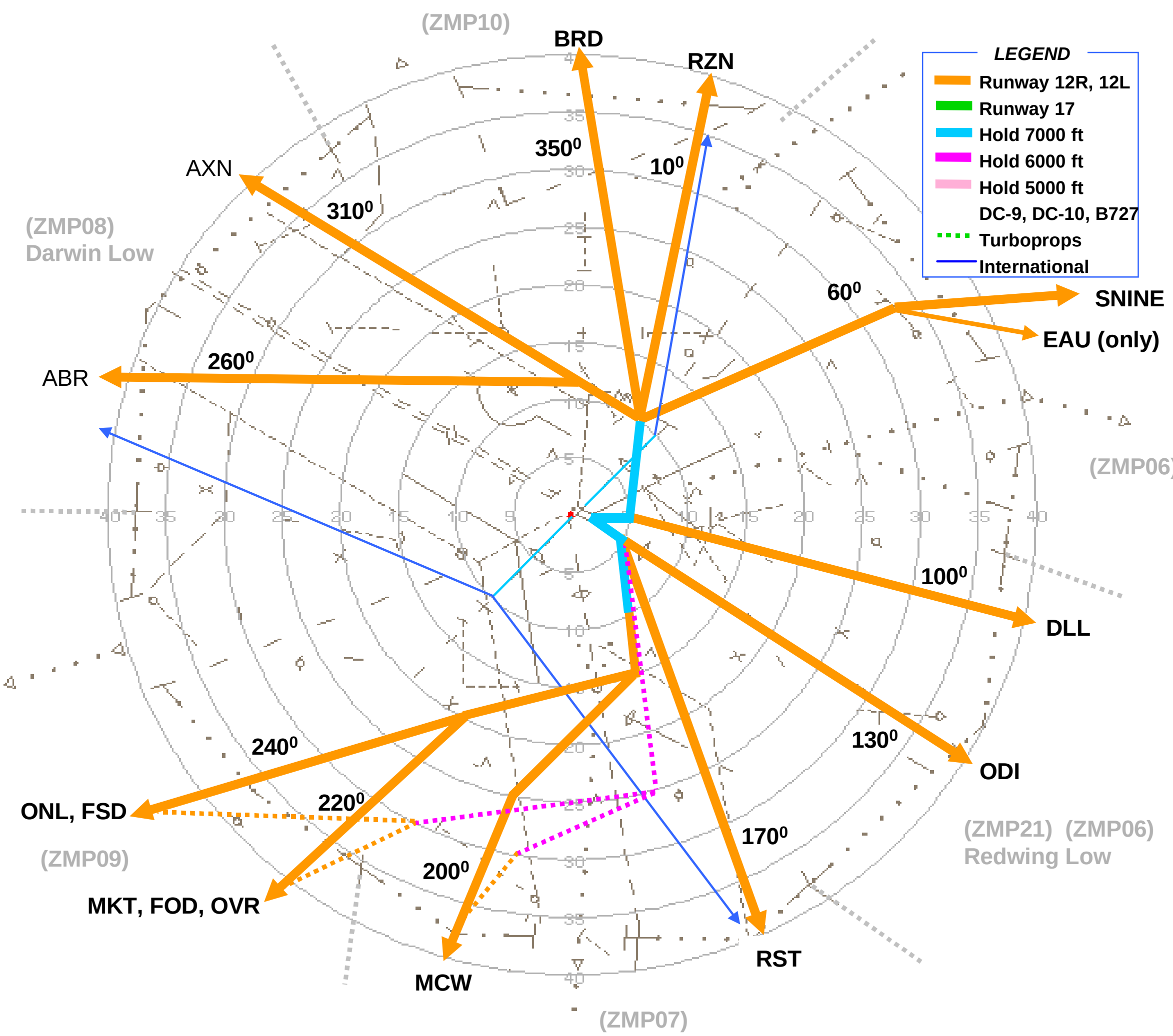

Figure 3-9. Departure Routes for Southeast Flow Runway 35 Operations

3.3.4 Runway 35 Operations Arrival Routes

Arrival routes as modeled in TAAM for southeast flow Runway 35 operations are shown in Figure 3-10. This configuration has departures and arrivals using Runways 12R and 12L and arrivals using Runway 35. Note that NEWFIX restrictions apply only to the DELZY Runway 35 arrivals. The arrival altitude and speed restrictions for the SHONN and DELZY arrivals to Runways 12R and 12L differ from those that apply to Runway 17 operations (see Figure 3-8).

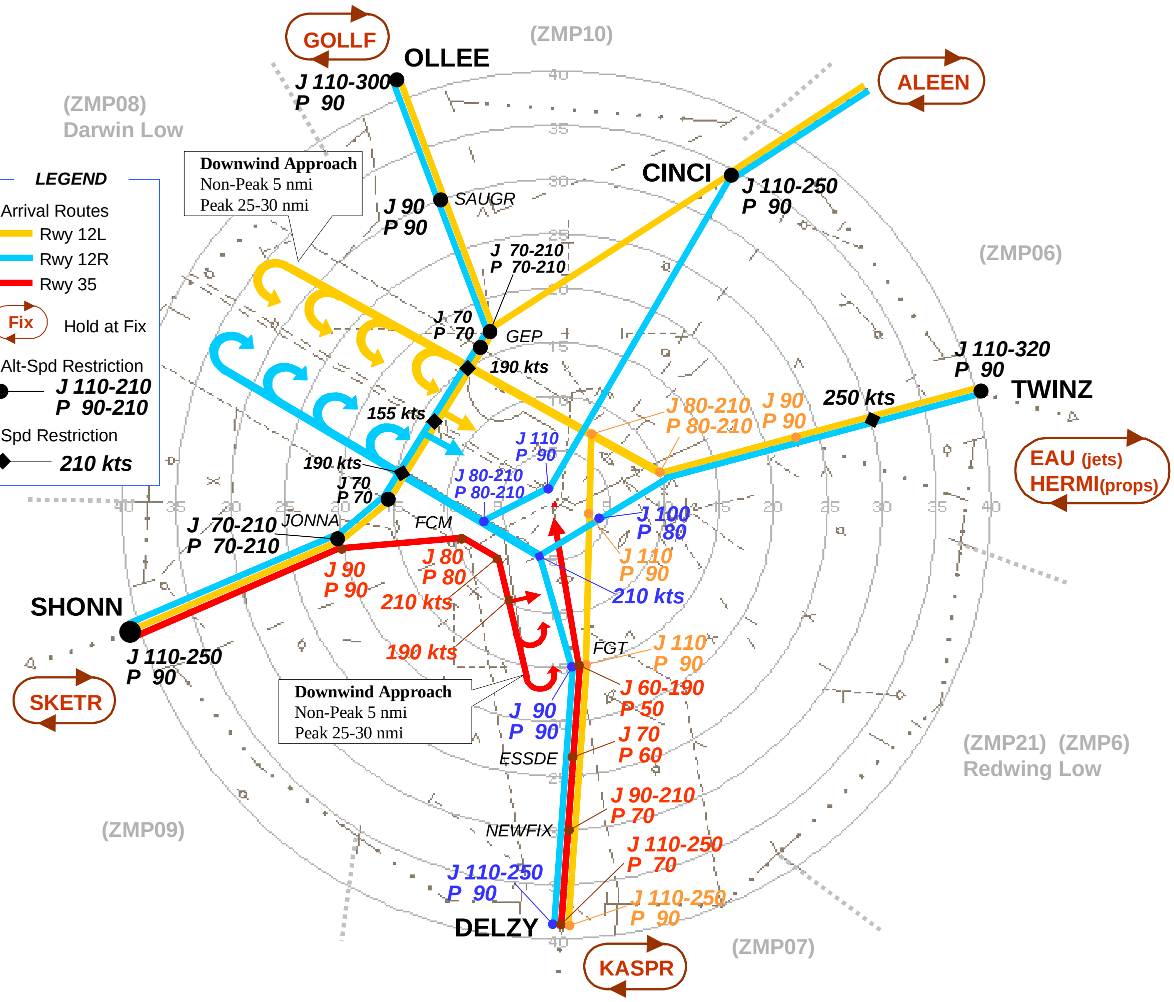

Figure 3-10. Arrival Routes for Southeast Flow Runway 35 Operations

3.4 Characterization of Traffic

The 2003 MSP traffic file was created using several sources: the MSP Part 150 Update, the MSP Departure Destination Gate Analysis, Enhanced Traffic Management System (ETMS) data, and Official Airlines Guide (OAG) data. The M98/ZMP team provided the MSP Part 150 Update and the Departure Destination Gate Analysis. The Part 150 includes characterization of a 2005 MSP traffic file. Since recent traffic growth has exceeded expectations, the number of operations and the distribution of aircraft types in the Part 150 were used as targets for the 2003 MSP traffic file. The Departure Destination Gate Analysis is based on 6629 air carrier jet departures in February 2000. This formed the basis for the distribution of city pairs in the 2003 traffic file. One Thursday's worth (3/30/2000) of ETMS data was converted into a TAAM traffic file as the foundation for 2003 traffic. Additional flights were added in a manner consistent with OAG arrival and departure peaks.

3.4.1 2003 Traffic

There were 1573 operations in the 2005 MSP traffic file in the Part 150 Update; there are 1575 operations in the 2003 traffic file created for this study. A little over ninety percent of the flights can be classified as passenger, regional, or cargo. The remaining flights are GA or military. About two thirds of the flights are associated with Northwest Airlines (NWA) or Mesaba Airlines (MES). This is consistent with what was found in the Part 150 and in the sample of ETMS data. The 2003 TAAM traffic file's flight category distribution can be seen in Figure 3-11.

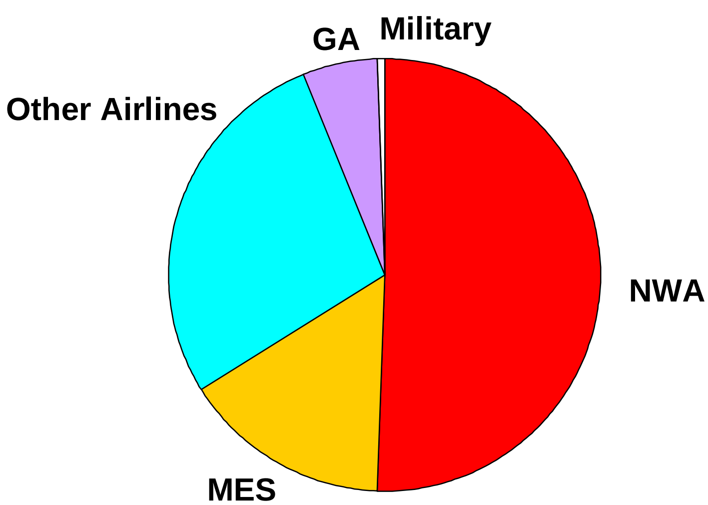

Figure 3-11. 2003 Traffic Flight Category Distribution

Table 3-1 compares the number and percentage of aircraft types in the 2003 traffic file to the 2005 traffic file in the Part 150. All aircraft types with at least one percent of operations are shown.

Table 3-1. Aircraft Types in 2003 Traffic File versus 2005 Traffic File in the Part 150

Aircraft Type 2003 MSP TAAM Traffic File	Number	Percentage	Aircraft Type -- PT 150	Number	Percentage
A320	421	26.7%	A320	421	26.8%
DC9Q	228	14.5%	DC9Q	231	14.7%
SF34	149	9.5%	SF34	151	9.6%
CRJ1	133	8.4%	CRJ1	135	8.6%
B752	111	7.0%	B752	108	6.9%
BA46	73	4.6%	BA46 plus RJ70(2)	75	4.8%
B733	36	2.3%	B733	36	2.3%
F100	36	2.3%	F100 (plus MU30s)	36	2.3%
B72Q	33	2.1%	B72Q	30	1.9%
BE80	29	1.8%	BE80 (GA twin plus IA1125)	29	1.8%
DC10	28	1.8%	C208 (plus GA TP)	28	1.8%
C208	27	1.7%	LR35	28	1.8%
B73Q	25	1.6%	DC10	26	1.7%
LJ31/35/55/60	25	1.6%	B73Q	25	1.6%
MD80	25	1.6%	MD80	25	1.6%
C310	20	1.3%	C310	24	1.5%
B735	17	1.1%	CL60 (CL600)	18	1.1%
C650	15	1.0%	B735	17	1.1%

The Departure Destination Gate Analysis was used as a foundation for refining the distribution of city pairs in the 2003 TAAM traffic file. Because the Gate Analysis is based solely on air carrier jet departures, the M98/ZMP team directed CAASD to supplement the 2003 departures with regional destinations that may not use gates. The regional destinations were obtained from ETMS data. There are also destinations in the Gate Analysis that were not in the sample of ETMS data. They are seasonal flights and largely charter operations. None of these destinations made up more than one half of one percent of the departures. The M98/ZMP team directed CAASD not to focus on these specific flights, but to translate the departure gate percentages to the SID distribution. Figure 3-12 compares the SID distribution in the 2003 TAAM traffic file to the gate distribution in the Gate Analysis. Of the 787 departures in the TAAM traffic file, 711 of them (90%) are associated with named SIDs. The denominator used when calculating the percentages for the TAAM departures is 711.

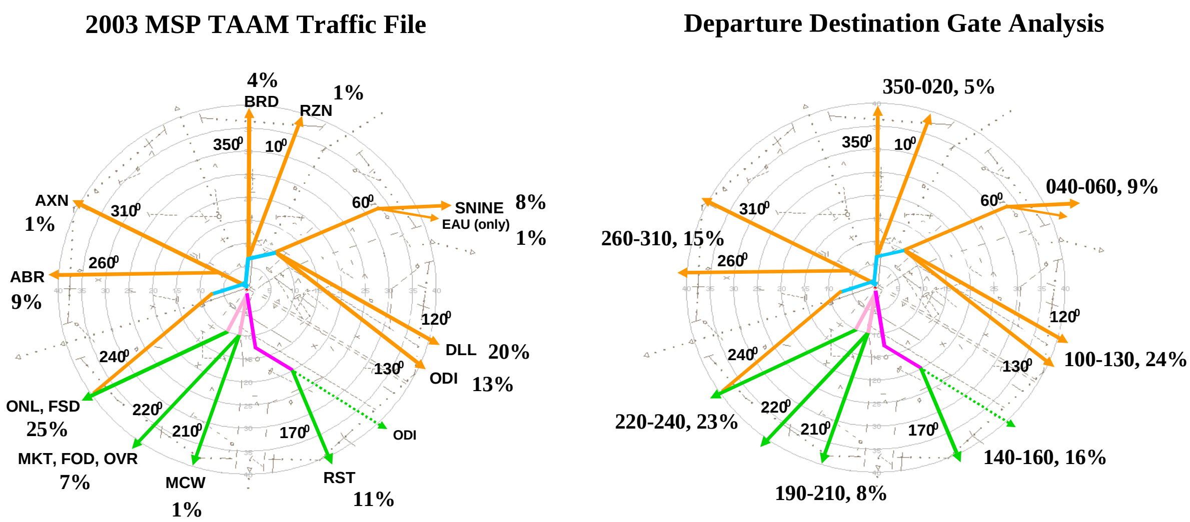

Figure 3-12. 2003 Traffic and Gate Analysis SID Distribution

Figure 3-13 shows the STAR distribution of arrivals in the 2003 TAAM traffic file. The two percentages shown for CINCI and TWINZ correspond to the cases where the CINCI STAR was used and not used.

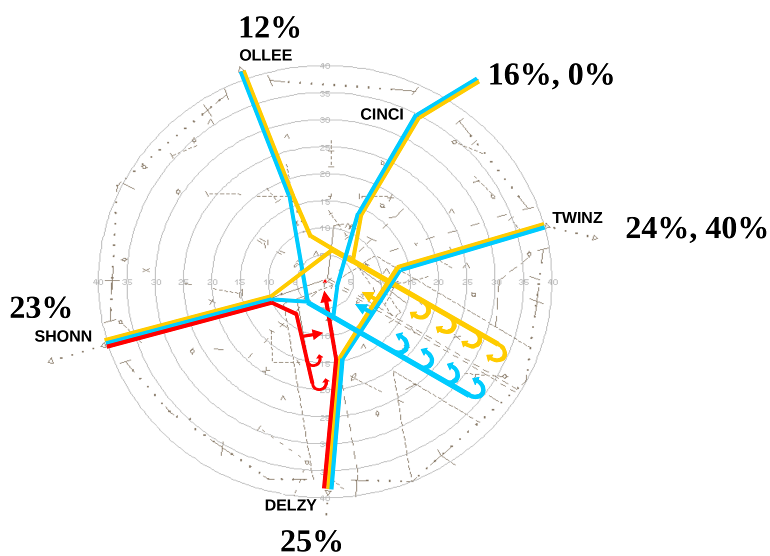

Figure 3-13. 2003 Traffic STAR Distribution of Arrivals

In addition to the domestic departures, there are 17 international ones (destinations: Mexico, the Netherlands, Japan, and England) in the 2003 TAAM traffic file. The traffic file also includes eight military flights (C130s) distributed evenly over Rochester (RST), Duluth (DLH), and Brainerd (BRD). Table 3-2 shows the top 30 departure destinations for the 2003 MSP TAAM traffic file and the Gate Analysis.

Table 3-2. Departure Destinations and Gate Analysis for 2003 Traffic File

Destination Airport -- 2003 MSP TAAM Traffic File	Number	Percentage	Destination Airport -- Departure Destination Gate Analysis	Number	Percentage
KORD	28	3.6%	KORD	279	4.3%
KDFW	24	3.0%	KDFW	232	3.6%
KPHX	23	2.9%	KPHX	214	3.3%
KDTW	21	2.7%	KDTW	202	3.1%
KCLE	20	2.5%	KMCI	193	3.0%
KMDW	17	2.2%	KCLE	176	2.7%
KEWR	15	1.9%	KDEN	160	2.5%
KLAS	15	1.9%	KSTL	152	2.4%
CYYZ	14	1.8%	KATL	134	2.1%
KDEN	14	1.8%	KLAX	133	2.1%
KLAX	14	1.8%	KMDW	133	2.1%
KMCI	14	1.8%	KEWR	131	2.0%
KATL	13	1.7%	KLAS	123	1.9%
KPHL	13	1.7%	KIAH	122	1.9%
CYWG	12	1.5%	KSFO	115	1.8%
KBOS	12	1.5%	KSLC	113	1.8%
KSEA	12	1.5%	KOMA	110	1.7%
KIAH	11	1.4%	CYYZ	109	1.7%
KMKE	11	1.4%	KBOS	106	1.6%
KOMA	11	1.4%	KSEA	106	1.6%
KRST	11	1.4%	KFSD	103	1.6%
KSAN	11	1.4%	KPIT	102	1.6%
KSFO	11	1.4%	CYWG	101	1.6%
KSLC	11	1.4%	KMEM	100	1.6%
KSTL	11	1.4%	KMKE	99	1.5%
KDSM	10	1.3%	KPHL	98	1.5%
KLGA	10	1.3%	KLGA	92	1.4%
KPIT	10	1.3%	KSAN	92	1.4%
KARR	9	1.1%	KMCO	78	1.2%
KFAR	9	1.1%	KCVG	76	1.2%

As mentioned earlier, additional flights were added to the 3/30/2000 ETMS day to represent the traffic counts expected in 2003. The M98/ZMP team directed CAASD to build on the peaks found in 2000 OAG data, particularly for the arrivals, where rates are expected to exceed ninety per hour. Figures 3-14 and 3-15 display hourly departure and arrival demand from 3/30/2000 OAG data and from the 2003 MSP TAAM traffic file.

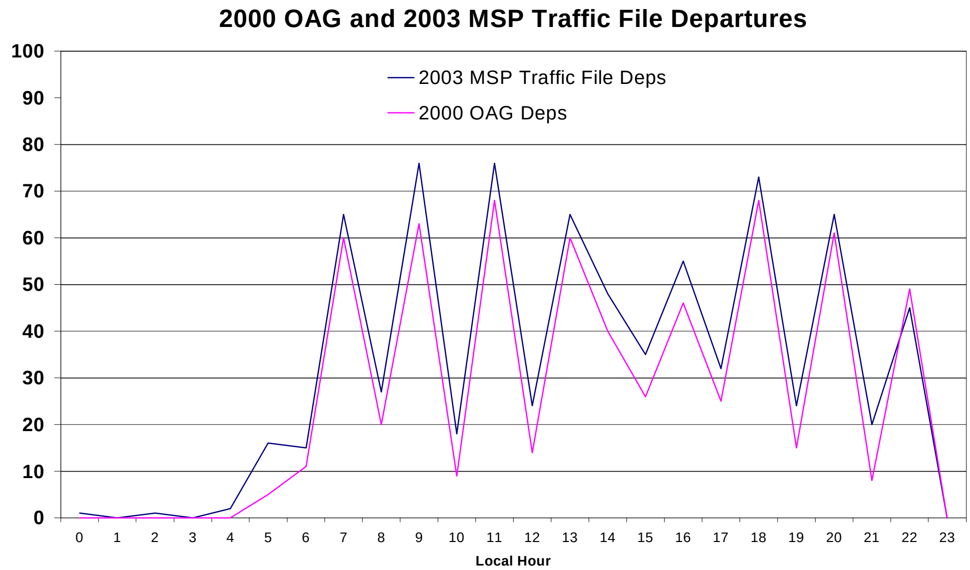

Figure 3-14. Hourly Departure Demand, 3/30/2000 OAG and 2003 MSP TAAM Traffic

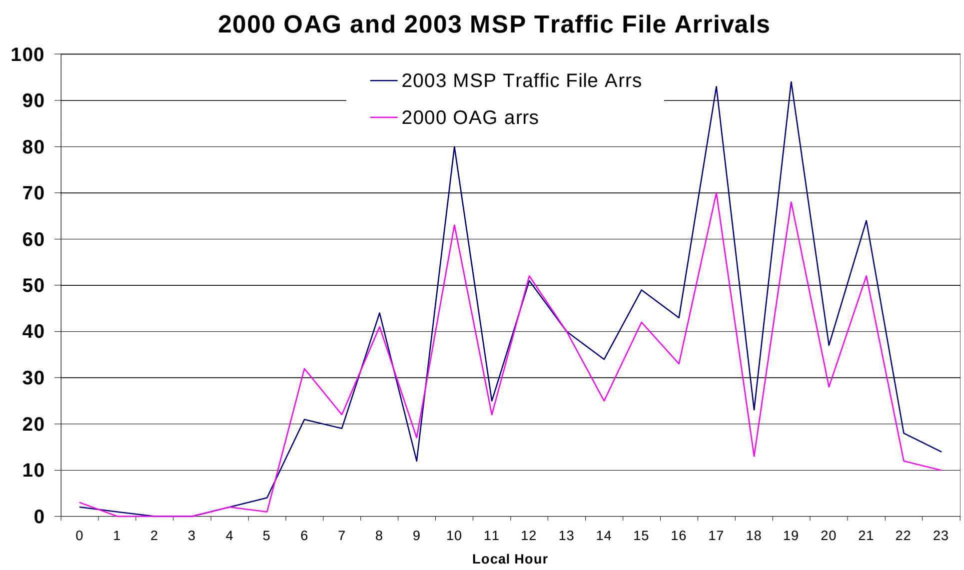

Figure 3-15. Hourly Arrival Demand, 3/30/2000 OAG and 2003 MSP TAAM Traffic

3.4.2 2008 and 2013 Traffic

The M98/ZMP study team required an evaluation of the impact of traffic for the year the new runway opens (2003) and for two additional future years, 2008 and 2013. The team recommended creating the future traffic files by uniformly increasing the 2003 TAAM traffic file at a rate of 3.7% a year. The 2003 traffic file contains 1575 operations. The rate of increase results in about 20% more traffic every 5 years, resulting in 1913 operations for the 2008 traffic file and 2319 operations for the 2013 traffic file. The uniform increase in operations resulted in a proportionate increase of traffic throughout the day. The uniform distribution also kept the proportion of aircraft types and city pairs similar to the 2003 traffic file. Figures 3-16 and 3-17 display hourly departure and arrival counts for an OAG Thursday (3/30/2000) and the three MSP TAAM traffic files.

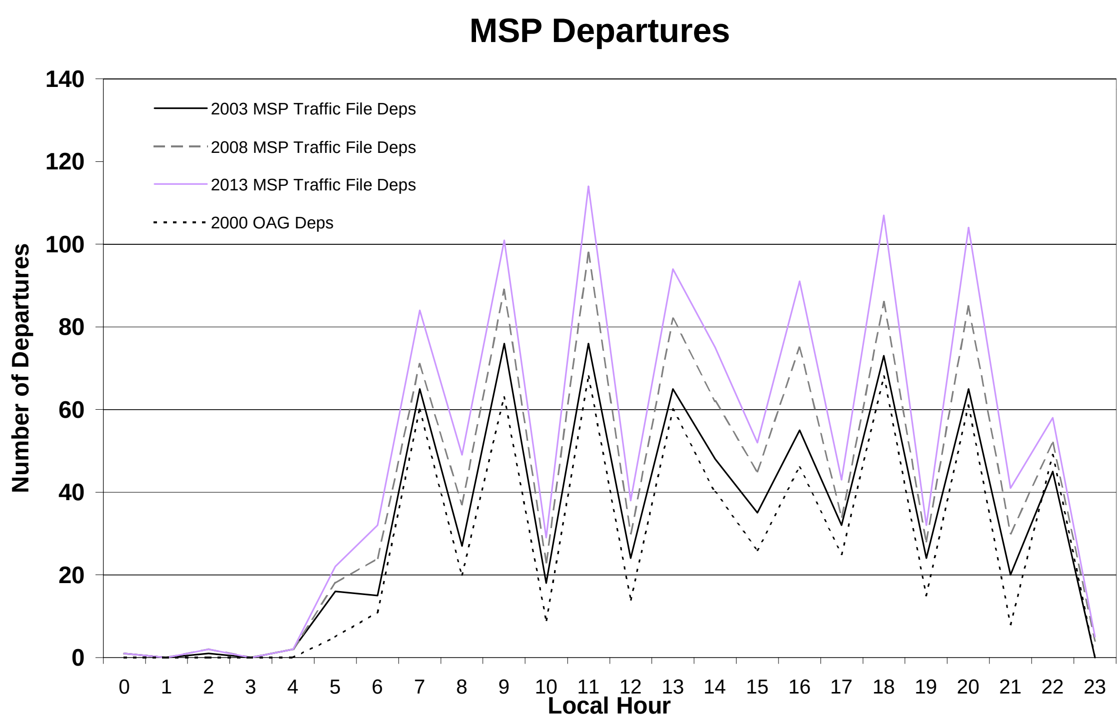

Figure 3-16. Hourly Departure Counts for OAG, 2003, 2008 and 2013 Traffic

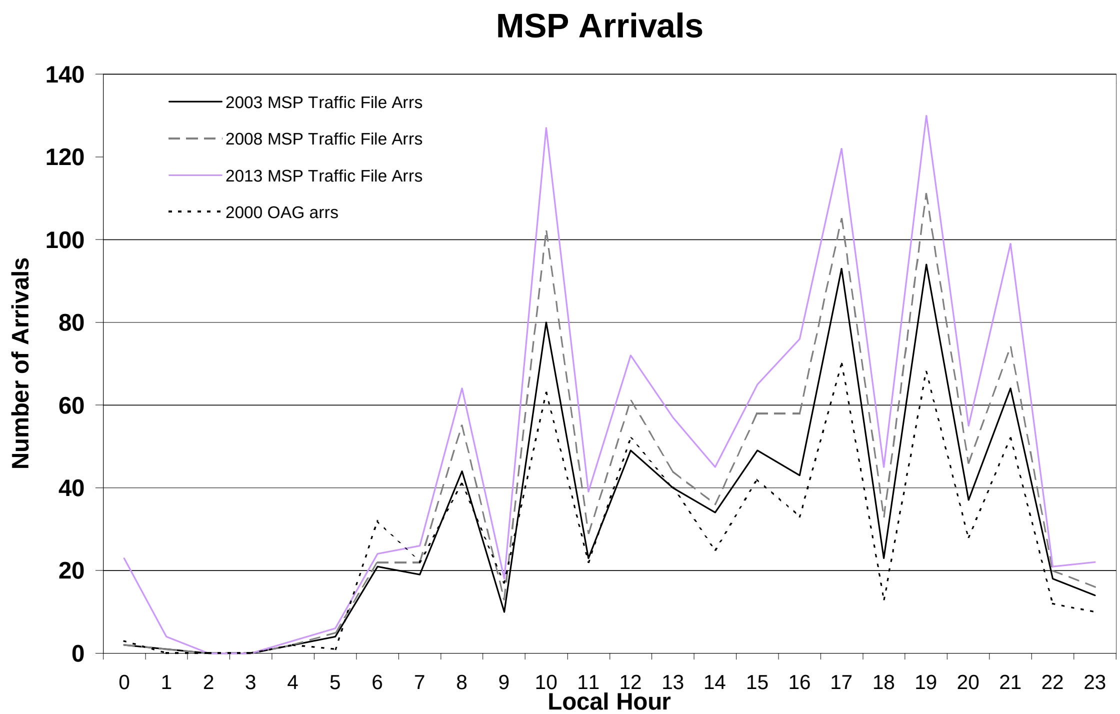

Figure 3-17. Hourly Arrival Counts for OAG, 2003, 2008 and 2013 Traffic

3.5 Calibration

3.5.1 Departure Ascent Rates

During validation of the TAAM simulation, both M98 and ZMP controllers observed that aircraft departing the airport showed ascent rates that were much to steep. The ascent rates in TAAM were adjusted to correspond to known altitudes as observed in SAR track data using graphics obtained from the Sector Design Analysis Tool (SDAT).

The first step in the process was to obtain from SDAT color coded-altitude bands for 0-7000 ft, 7100-17,000 ft, 17,100-23,000 ft and 23,100-33,000 ft. The corresponding color-coded altitude bands are shown below in Figure 3-18. Next, "proximity zones" were created in TAAM to match the SDAT altitude bands. Finally, the aircraft data blocks in TAAM were color-coded to match the SDAT altitude bands. Aircraft higher than 33000 feet were color coded green. Visual inspection of the TAAM simulation initially showed aircraft data block colors were not matching the proximity zone colors. Since the aircraft were climbing too fast, the global performance in TAAM was adjusted until the majority of aircraft data blocks fell within the appropriate proximity zone. Figures 3-19 and 3-20 show snapshots of the departure ascent calibration for northwest flow at 13:23:50 and 13:31:22 respectively.

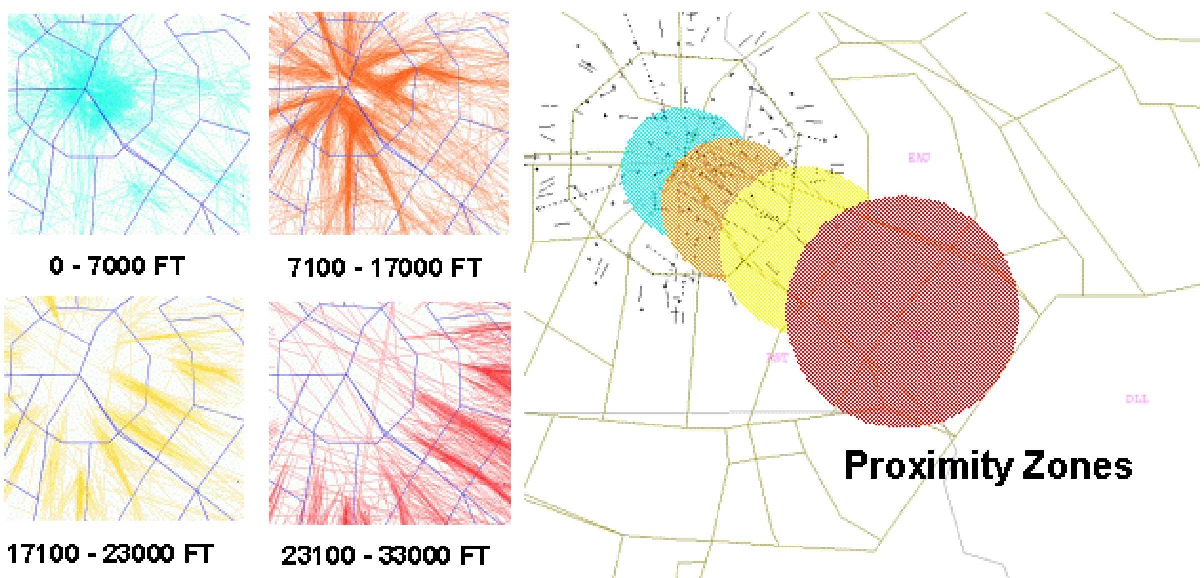

Figure 3-18. SDAT Data Color Banded by Altitudes for TAAM Calibration

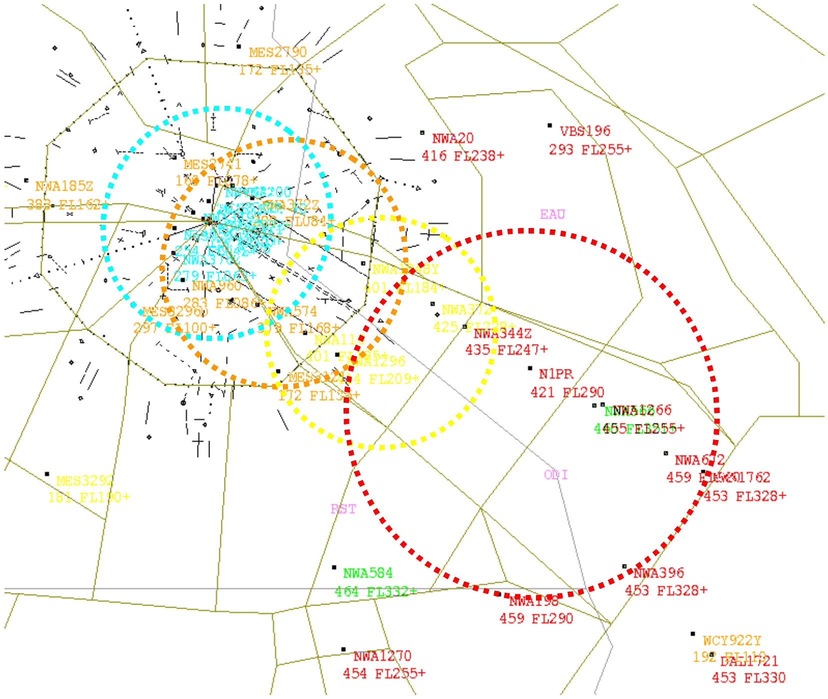

Figure 3-19. Departure Ascent Calibration at 13:23:50 Local Time

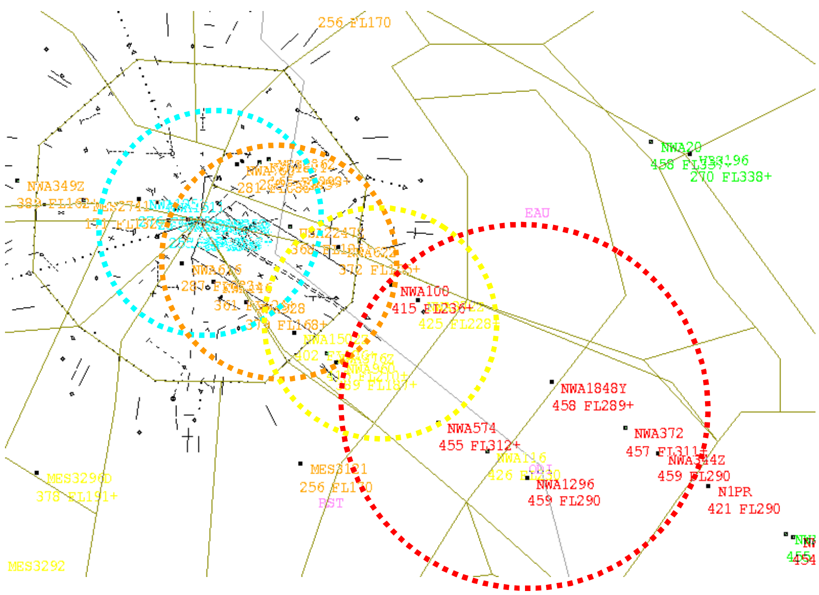

Figure 3-20. Departure Ascent Calibration at 13:31:22 Local Time

3.5.2 Runway Departure and Arrival Rates

Runway departure and arrival rates were calibrated in two steps: (1) extracting observed peak departure/arrival rates from operational data and (2) tuning separations in the TAAM simulation to achieve the observed peaks. Figures 3-21 and 3-22 show the observed peak departure and arrival rates per 15 minutes as reported by the FAA's Aviation System Performance Measurement system (ASPM) for October 5, 2000. Observed peaks for both departures and arrivals are overlaid on these figures. Since operations vary day-to-day, a sample of eight days was taken spanning the months of October and November 2000.

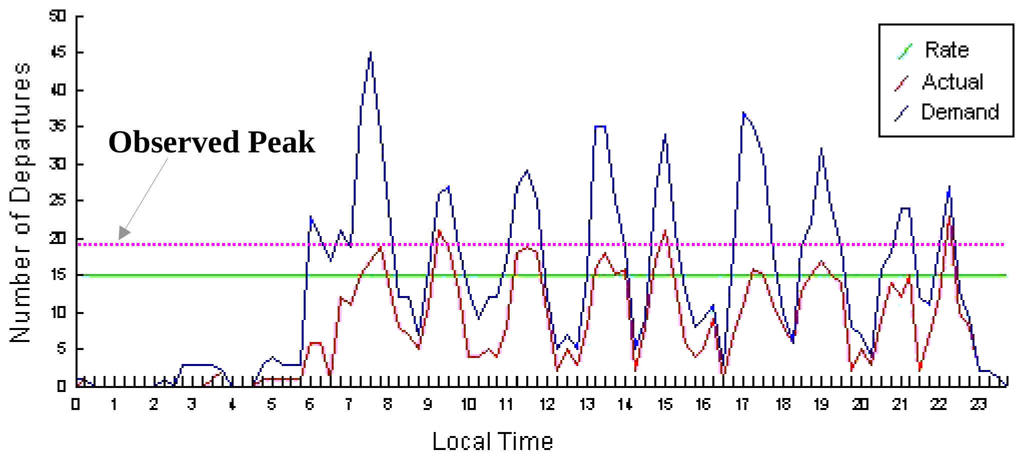

Figure 3-21. Observed Peak Departure Rate per 15 Minutes for October 5, 2000

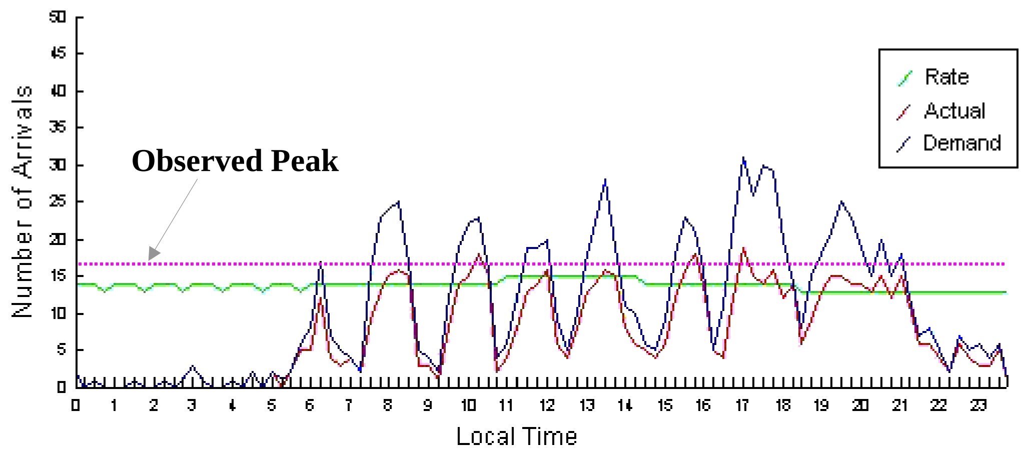

Figure 3-22. Observed Peak Arrival Rate per 15 Minutes for October 5, 2000

ASPM dates and observed peaks are tabulated in Table 3-3, showing that the consistent 15-minute observed peak for departures is 19 and for arrivals is 17. These rates were adjusted to account for the fact that ASPM does not report all operations. Total operations from the FAA OPSNET system, which counts all aircraft, was obtained for the dates in Table 3-3. A comparison of ASPM and OPSNET data shows 5% more aircraft for OPSNET. The observed peak values were increased by 5% resulting in final values of 20 departures and 18 arrivals per 15-minute period.

Table 3-3. Determination of MSP Observed Peak Throughput Calibration (15-Minute Rate)

Date	Dep	Arr
5-Oct-2000	19	16
12-Oct-2000	18	20
19-Oct-2000	19	16
26-Oct-2000	18	17
2-Nov-2000	16	17
9-Nov-2000	18	15
15-Nov-2000	16	16
22-Nov-2000	19	15
Consistent Observed Peak	19	17
OPSNET Adjusted	20	18
Calibration Rate	**20**	**18**

A current operations model of MSP (2003 traffic without Runway 17/35) was developed to calibrate runway throughput in TAAM. Arrival and departure separations were adjusted to achieve the desired throughput. The calibrated separation values for the parallel runways are shown in Figure 3-23. The departure separation on Runway 17 was set to the wake turbulence values as determined by the MSP SIMMOD study. The arrival separation for Runway 35 was set to 2.5 miles, as directed by the M98 team.

The results of the TAAM throughput calibration for northwest and southeast flows are shown in Figures 3-24 and 3-25 for departures and arrivals respectively. Note that both models are calibrated to peak rates of 20 departures per 15 minutes and 18 arrivals per 15 minutes.

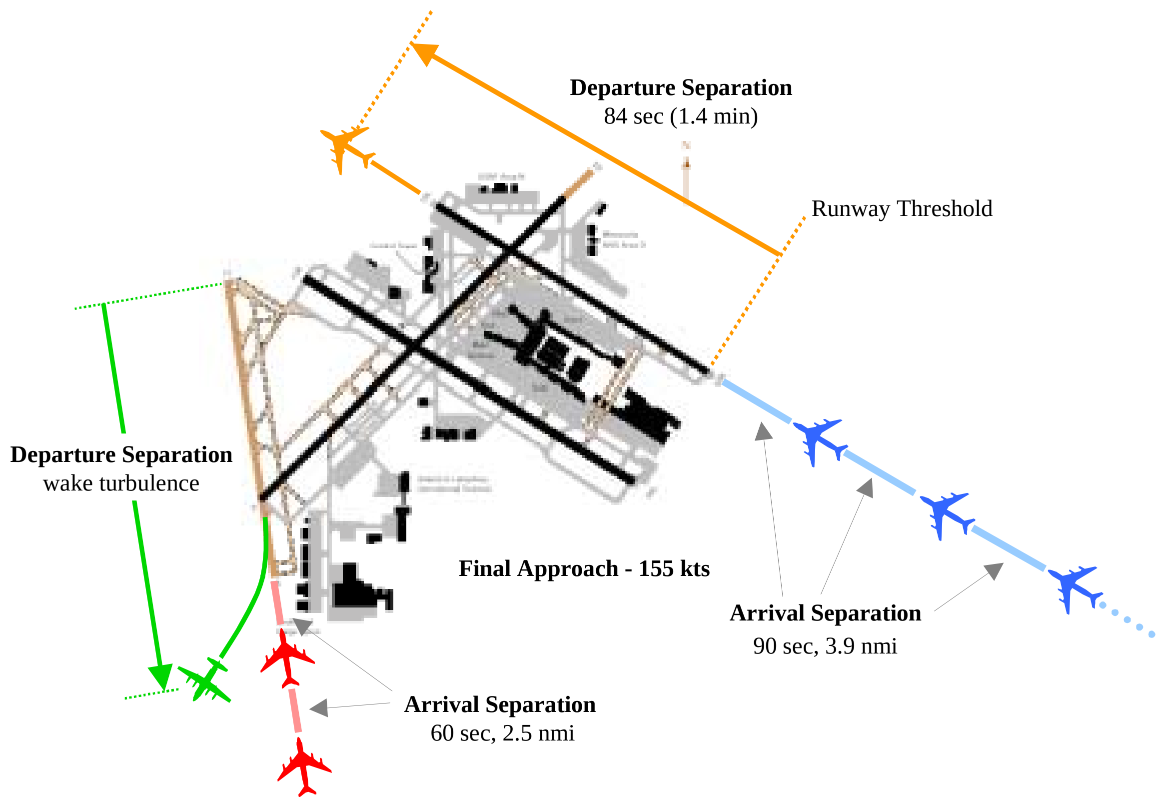

Figure 3-23. Departure and Arrival Separation

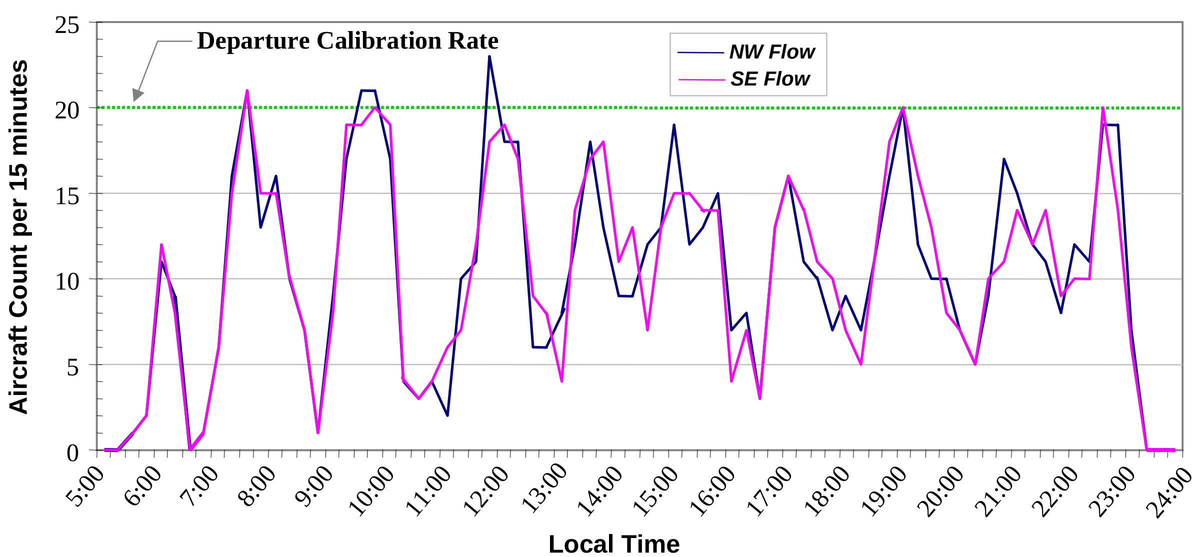

Figure 3-24. Departure Throughput without New Runway

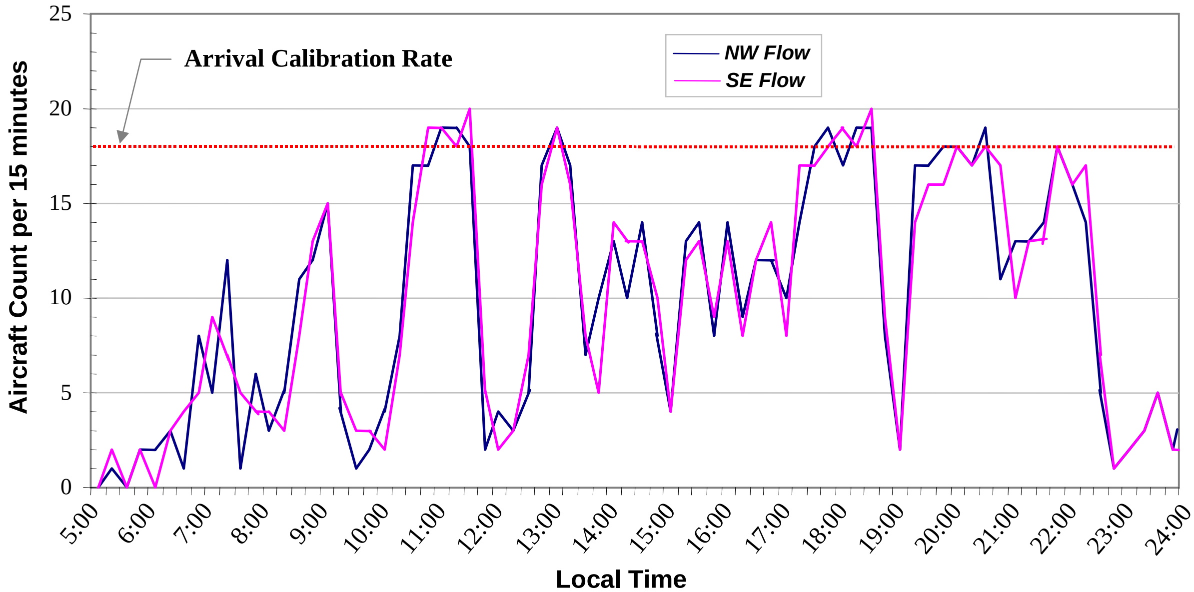

Figure 3-25. Arrival Throughput without New Runway

3.6 Validation

3.6.1 Runway Usage

The first Runway 17/35 usage schedule was developed by plotting total throughput over the course of the day and then selecting the runway operations per demand. While this method produced a reasonable schedule for the use of Runway 17/35, further research revealed that using delay as a runway schedule selection criterion was better in minimizing the total delay over the course of the day. Figure 3-26 shows delay for two different TAAM runs: (1) with Runway 17 open all day, resulting in maximum arrival delays; and (2) with Runway 35 open all day resulting in maximum departure delays. This figure also shows the delay-based schedule selection that resulted from observation of the timing of peak delays.

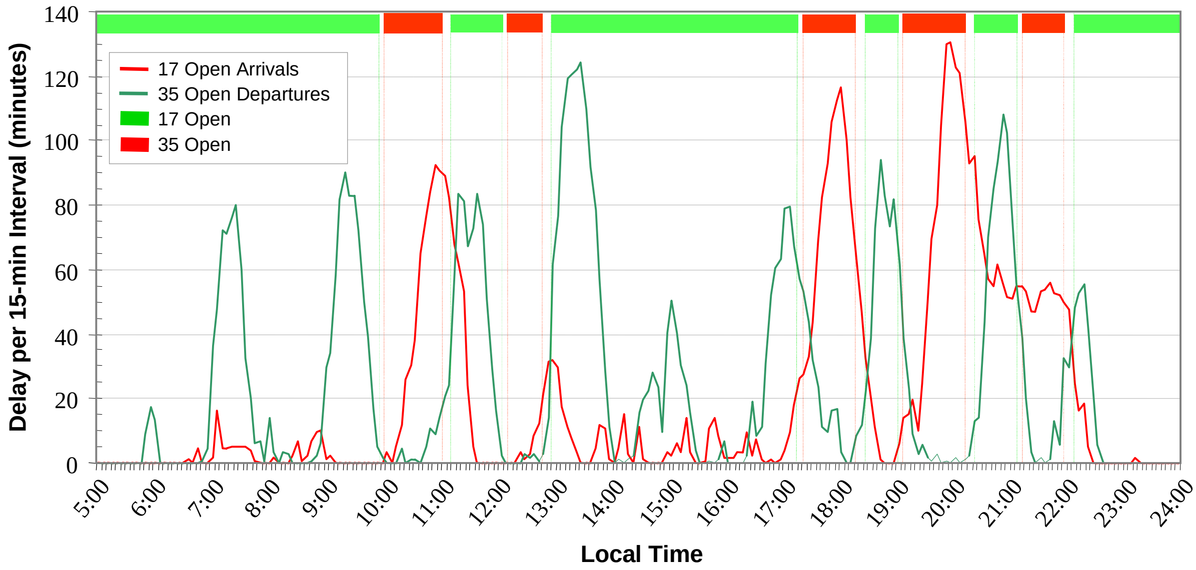

Figure 3-26. Delay-Based Runway 17/35 Schedule Determination for 2003 Operations

Table 3-4 shows the runway schedule used in TAAM to minimize overall delay. M98 initially suggested that Runway 17/35 be closed for five minutes during transition between operating modes. After further TAAM analysis, it was determined that the arrival-to-departure transition gap should be increased to ten minutes to allow time for aircraft in hold during heavy arrival pushes to land on Runway 35 without interfering with Runway 17 departures.

Table 3-4. Delay-Based Runway 17/35 Schedule for 2003 Operations

Local Time	Runway 17	Runway 35
00:00 - 10:00	open	closed
10:05 - 11:05	closed	open
11:15 - 12:10	open	closed
12:15 - 12:50	closed	open
13:00 - 17:20	open	closed
17:25 - 18:20	closed	open
18:30 - 19:05	open	closed
19:10 - 20:15	closed	open
20:25 - 21:10	open	closed
21:15 - 22:00	closed	open
22:10 - 24:00	open	closed

Figure 3-27 shows the result of applying the schedule in Table 3-4 to a northwest flow configuration with 2003 traffic using the same scale shown in Figure 3-26. Note that the maximum arrival peak around 11:30 shows 75 minutes of delay in a 15-minute interval, whereas the maximum peak from Figure 3-26 shows 130 minutes at 13:30, a reduction of almost 40%. Additional analysis using variations on the schedule in Table 3-4 did not result in reductions in overall delay.

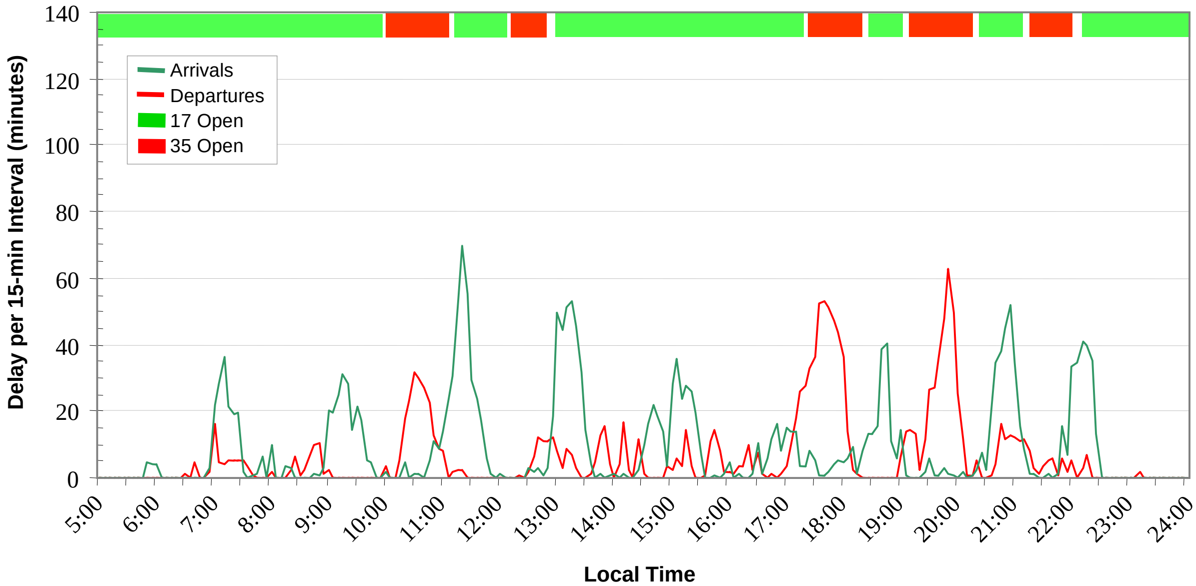

Figure 3-27. Delay Reduction with Delay-Based Runway 17/35 Schedule

3.6.2 Runway Balancing

TAAM balances runway use with runway selection rules. The guidelines for achieving balance as directed by M98 personnel was to utilize 17 departures and 35 arrivals as much as possible to "unload" the parallel runways. Figures 3-28 and 3-29 show the results of these rules for northwest and southeast flows, respectively, as applied in the TAAM simulation. Included in the figures are the fix usage in percent for Runway 17 and 35. Note that arrivals for the parallel runways are closely balanced for both northwest and southeast flows. Runway 12R/30L has lower throughput than 12L/30R due to off loading of southern departure fix aircraft to Runway 17 and TAAMs preference use Runway 12L/30R for north and northeast departures. Overall, Runway 17 accounts for 35-40% of the daily departures and Runway 35 accounts for 15-16% of the total daily arrivals. For both northwest and southeast flows, the results indicate the new runway is primarily used as a departure runway, except during heavy arrival pushes to relieve the parallel runways.

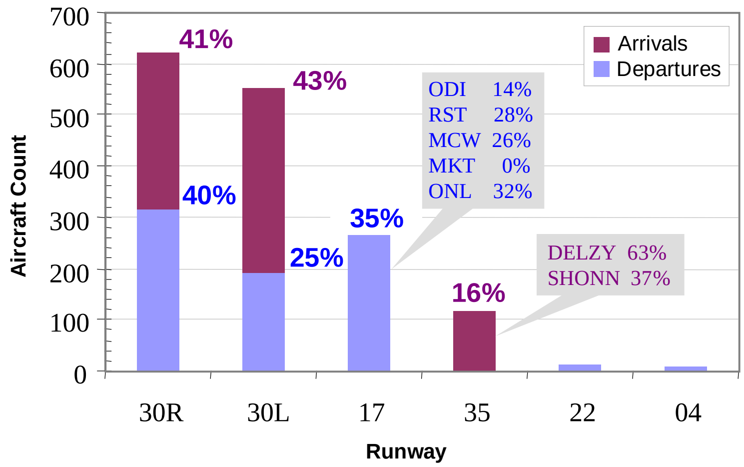

Figure 3-28. Northwest Flow TAAM Runway Throughput for 2003 Operations

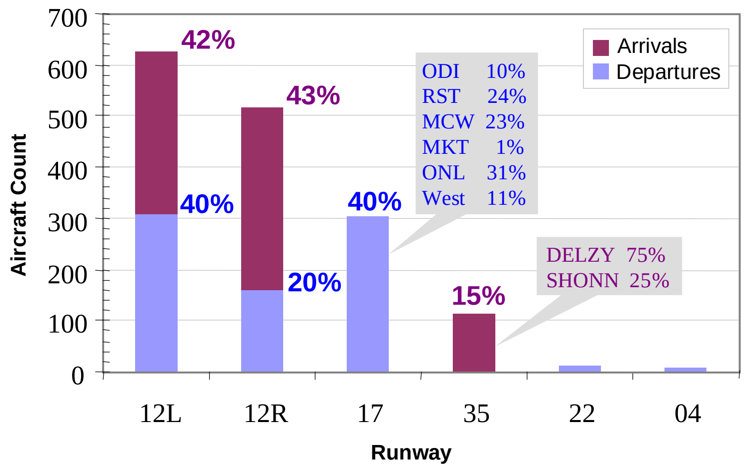

Figure 3-29. Southeast Flow TAAM Runway Throughput for 2003 Operations

3.6.3 Controller Validation

Final validation sessions were held in October 2000 with ZMP controllers and in December 2000 with M98 controllers. The validation consisted of working with the controllers on both northwest and southeast flow TAAM simulations and updating the model. Prior to the validation, infrastructure checklists were created to assist CAASD and the controllers with the validation process. Figure 3-30 shows a sample checklist for the northwest flow SIDs and STARs used during the validation.

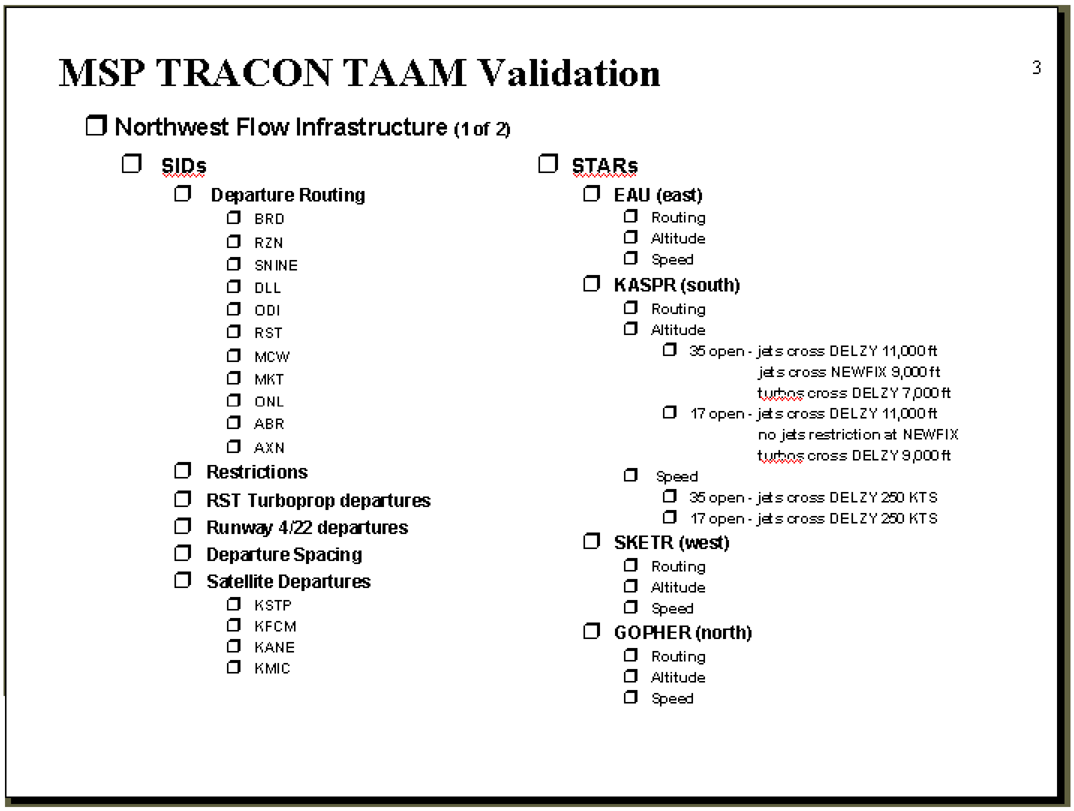

Figure 3-30. Sample Checklist from M98 TRACON Validation

After making some changes, the controllers verified all SID/STAR usage, altitude restrictions, speed restrictions, departure ascent calibration, arrival separation, and runway usage.

For the northwest flow, additional SIDs where added to Runway 17 to allow jet departures to utilize the ODI fix during peak departure periods to relieve workload in the airspace north of the airport. Peak departure periods where selected from TAAM departure demand as shown in Figure 3-31 and implemented as rules in TAAM to allow these departures at the specified times. Turboprops are allowed to use 17 ODI departures as long as 17 is open (refer to Table 3-4). Table 3-5 summarizes the implemented departure times.

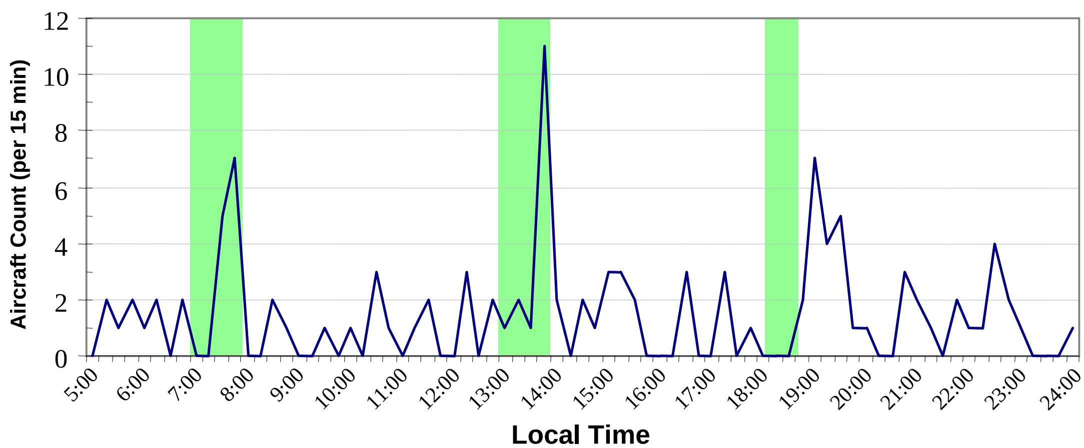

Figure 3-31. Peak Departure Times through ODI Fix, Northwest Flow, 2003 Traffic

Table 3-5. Northwest Flow Runway 17 ODI Jets Schedule

Local Time	Runway 17 ODI Jets
00:00 - 07:00	closed
07:00 - 08:00	open
08:00 - 13:00	closed
13:00 - 14:00	open
14:00 - 18:10	closed
18:10 - 18:40	open
18:40 - 24:00	closed

For the southeast flow, SIDs and rules were constructed to allow Runway 17 west departures for jets and turboprops. As before, the schedules were determined according to peak demand for west departure fixes as shown in Figure 3-32 and summarized in Table 3-6. The west departure fixes used to determine demand were ATY, ABR and AXN (refer to Figure 3-7).

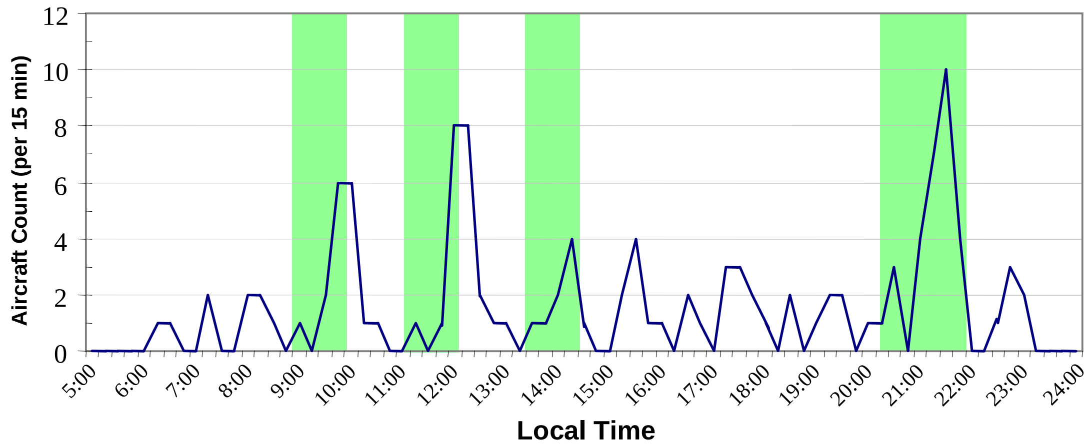

Figure 3-32. Peak Departure Times through West Fixes, Southeast Flow, 2003 Traffic

Table 3-6. Southeast Flow Runway 17 West Departures Schedule

Local Time	Runway 17 West Depart
00:00 - 09:00	closed
09:00 - 10:00	open
10:00 - 11:10	closed
11:10 - 12:10	open
12:10 - 13:30	closed
13:30 - 14:30	open
14:30 - 20:20	closed
20:20 - 22:00	open
22:00 - 24:00	closed

Section 4

Analysis

4.1 Delay Analysis from Validated Model

The model as validated by the M98 and ZMP teams has been used to generate arrival and departure delays for future levels of traffic. The delay analysis results are presented by airport configuration – Northwest and Southeast. Figure 4-1 summarizes the results by showing the average arrival and departure delays per aircraft for all three traffic scenarios and configurations with and without the CINCI STAR. Figures 4-2, 4-3, and 4-4 show the arrival and departure delays using the Northwest configuration for 2003, 2008, and 2013 traffic levels, respectively. Figures 4-5, 4-6, and 4-7 show the arrival and departure delays using the Southeast configuration for 2003, 2008, and 2013 traffic levels, respectively. Depicted on these charts are total delay amounts for all aircraft in five minute time intervals. The normalized change superimposed at the top of the charts is the percentage change in delay caused by the CINCI STAR (relative to the maximum delay in that chart without the CINCI STAR).

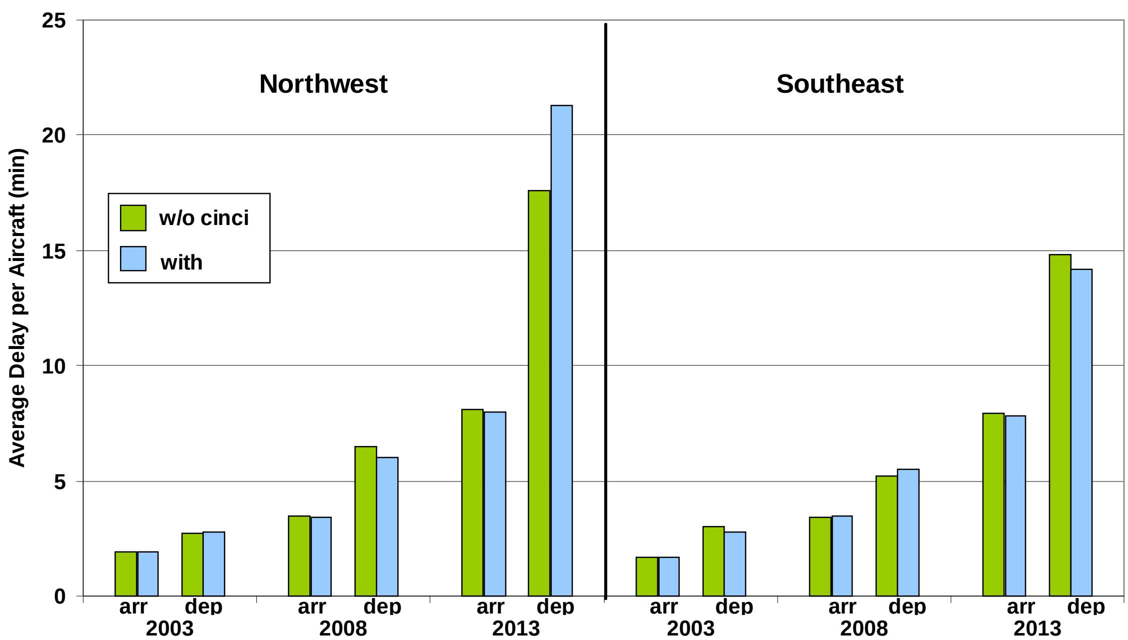

Figure 4-1. Average Arrival and Departure Delays with and without CINCI STAR

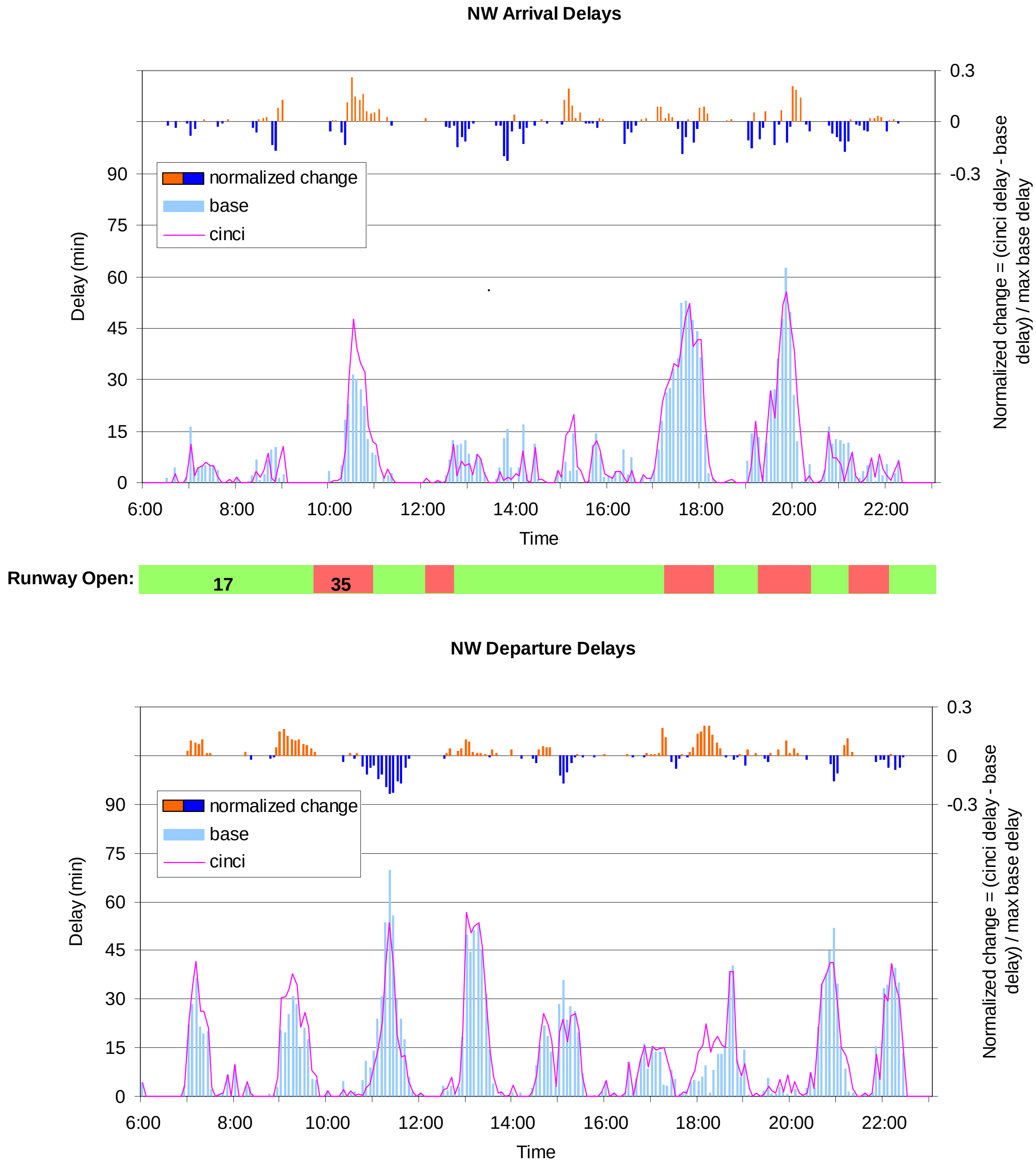

Figure 4-2. Northwest Arrival/Departure Delays with and without CINCI STAR (2003 Traffic)

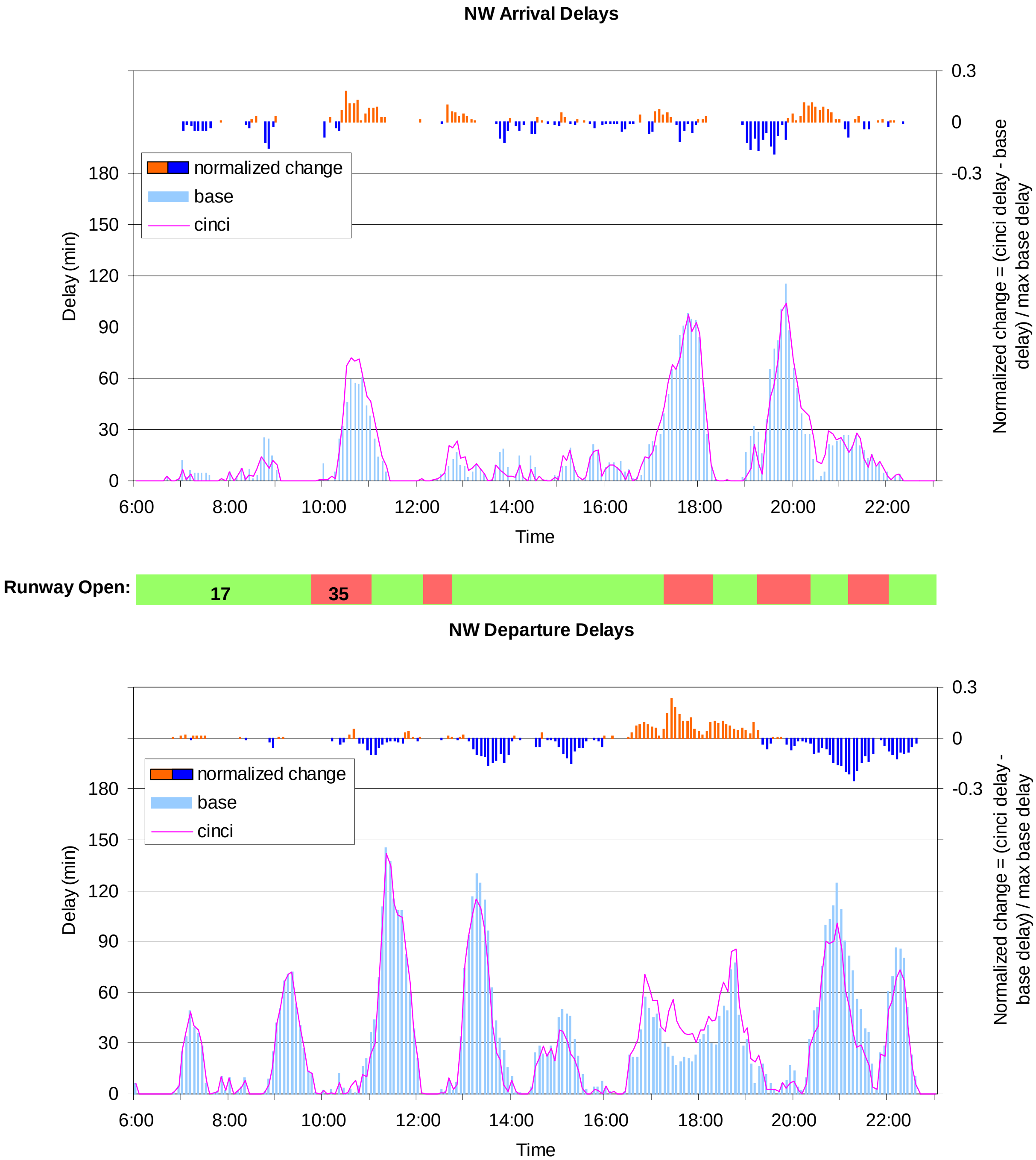

Figure 4-3. Northwest Arrival/Departure Delays with and without CINCI STAR (2008 Traffic)

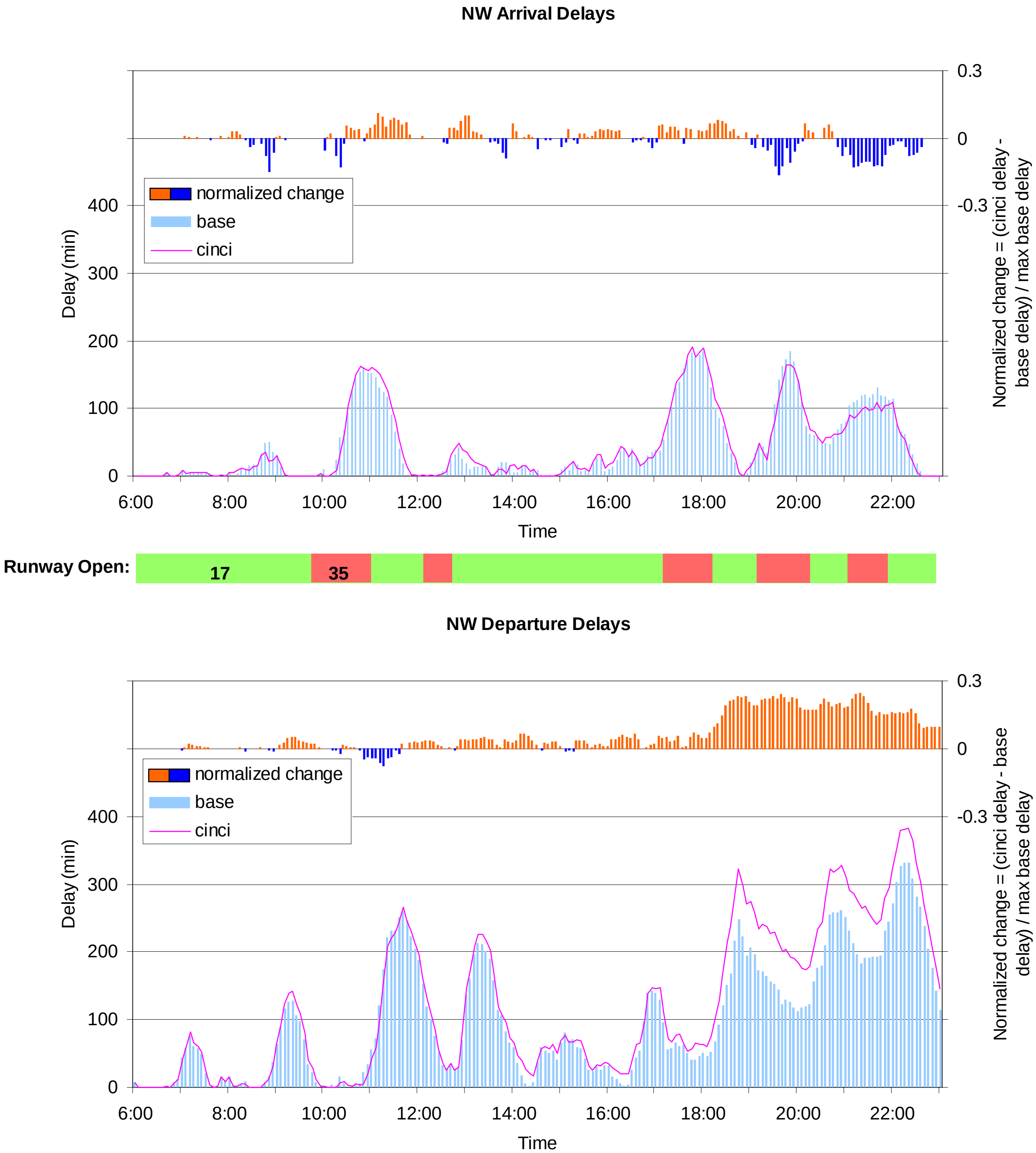

Figure 4-4. Northwest Arrival/Departure Delays with and without CINCI STAR (2013 Traffic)

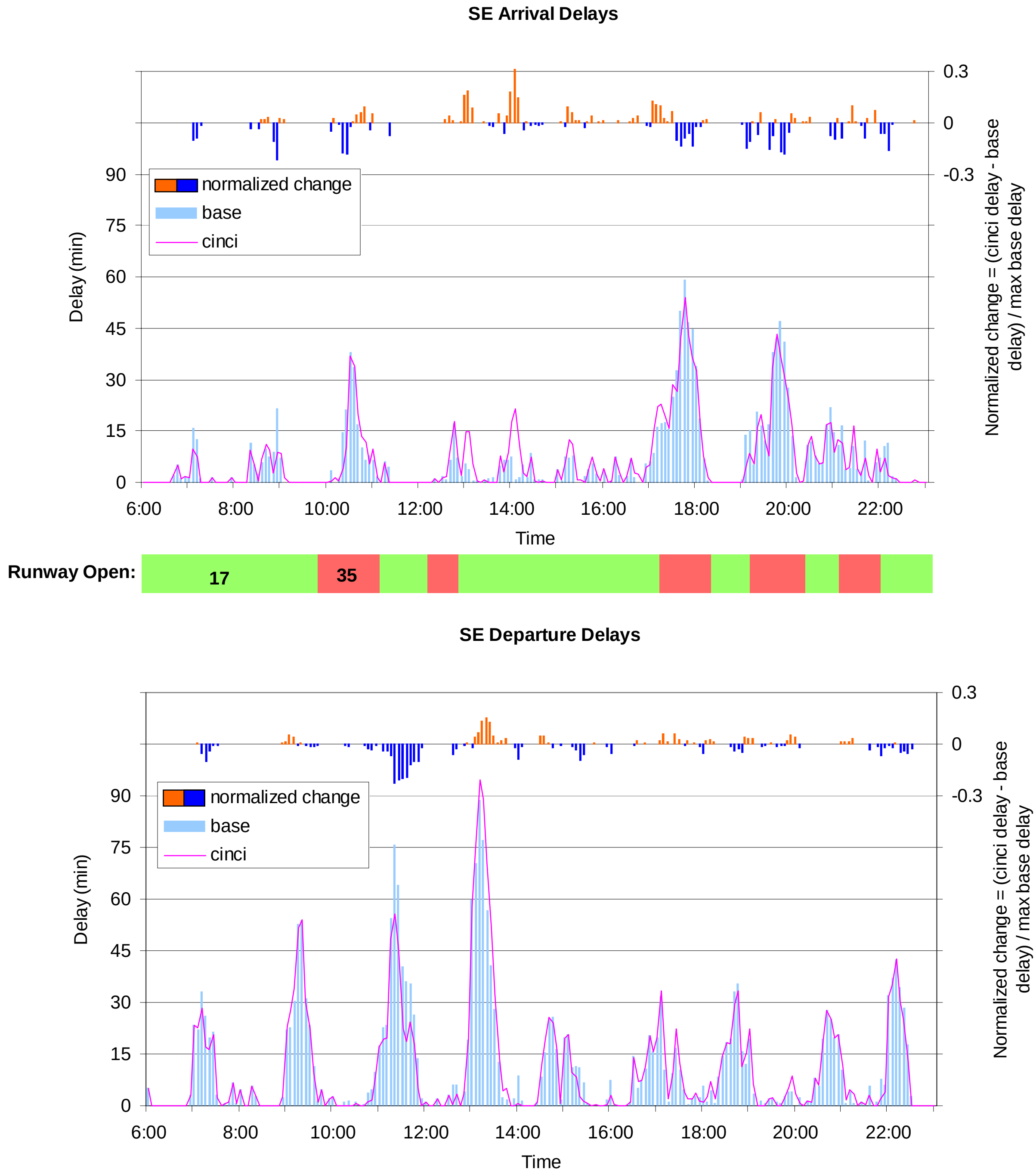

Figure 4-5. Southeast Arrival/Departure Delays with and without CINCI STAR (2003 Traffic)

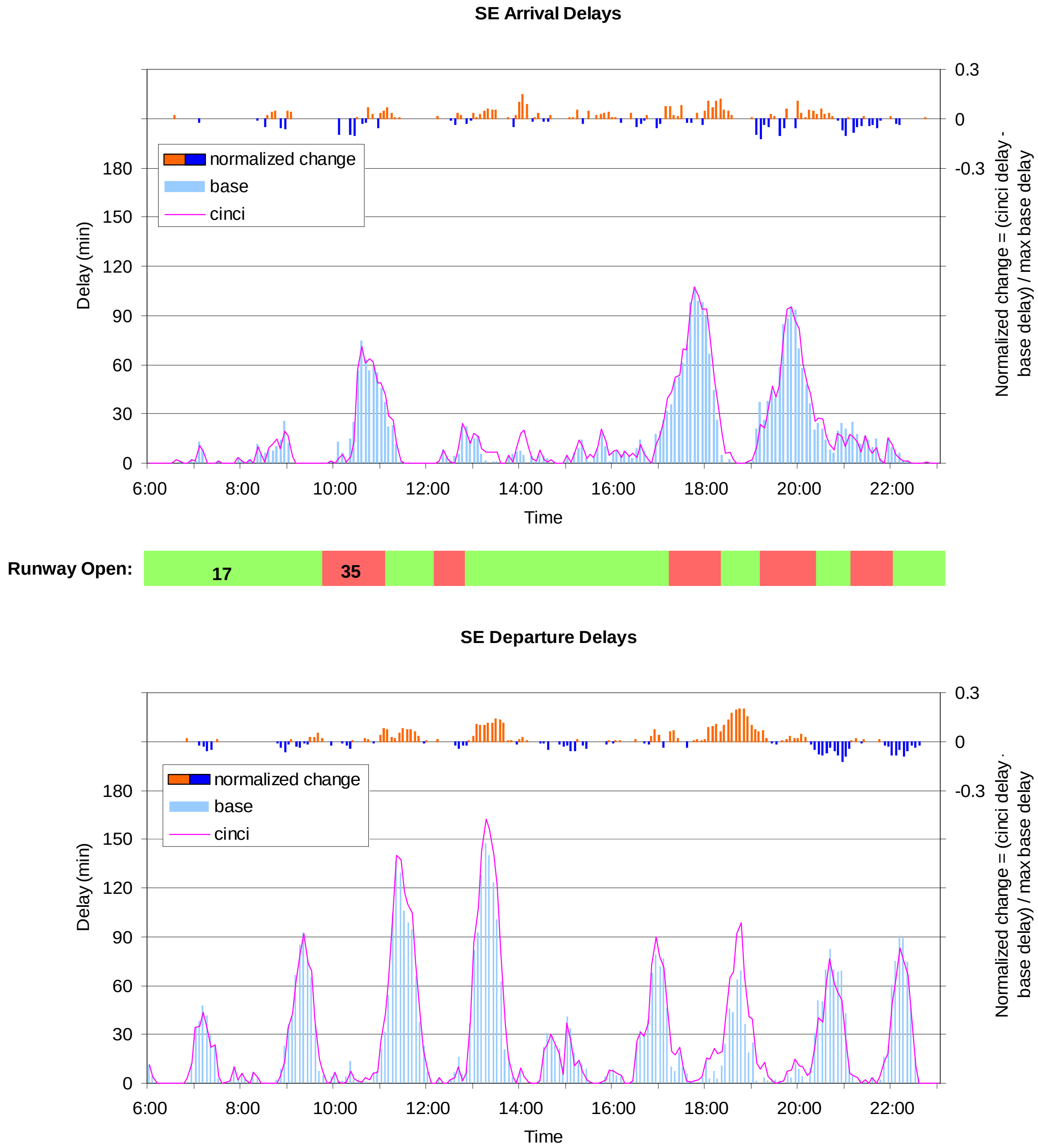

Figure 4-6. Southeast Arrival/Departure Delays with and without CINCI STAR (2008 Traffic)

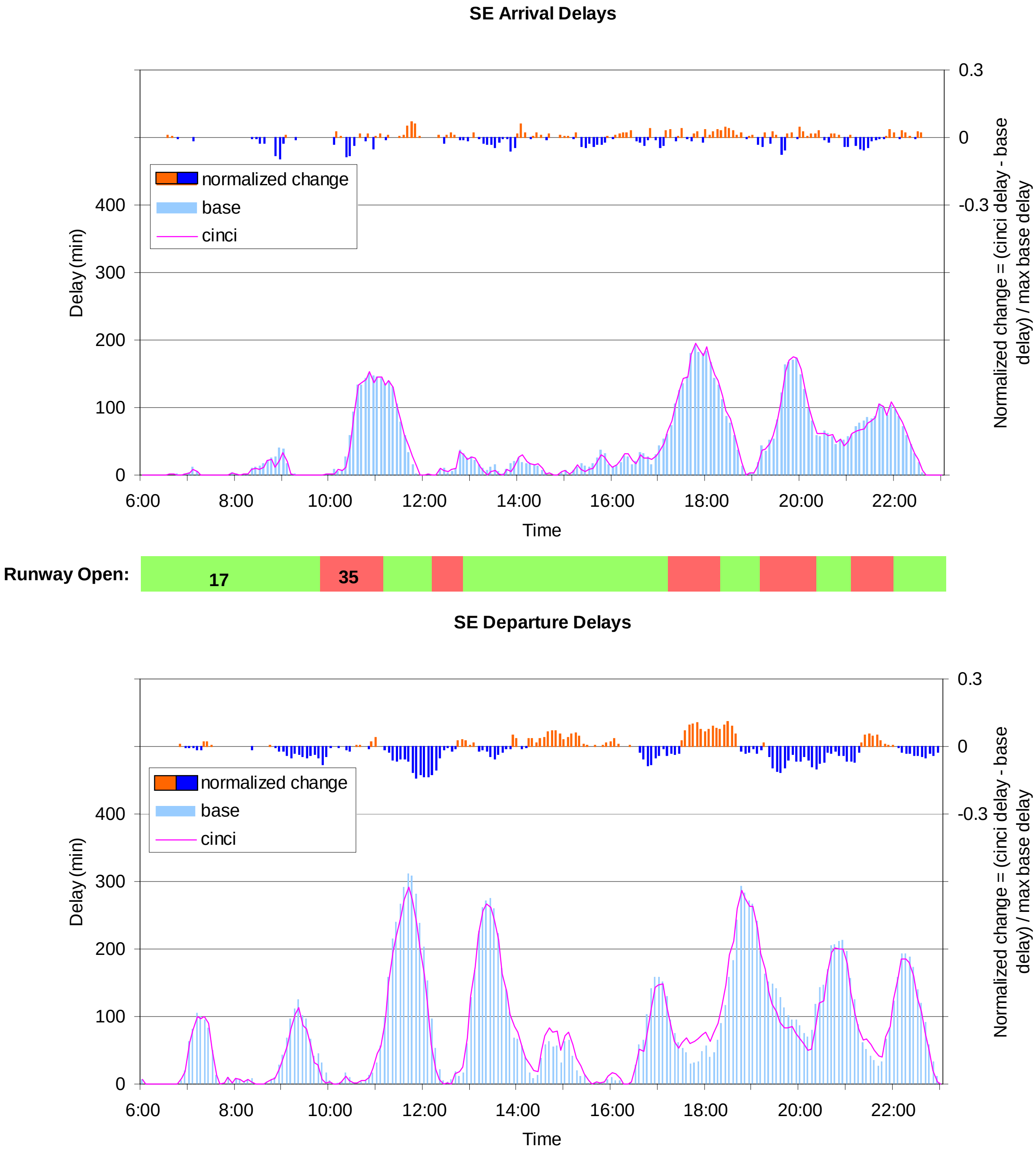

Figure 4-7. Southeast Arrival/Departure Delays with and without CINCI STAR (2013 Traffic)

4.2 Throughput

Previous analysis indicated that an arrival rate of approximately 96 aircraft per hour could be achieved with the new runway. Figure 4-8 shows the TAAM 15-minute arrival rates for M98 with 2003 traffic. It is clear that M98 can meet or exceed the projected arrival rate of 96 per hour but only when Runway 35 is open for arrivals.

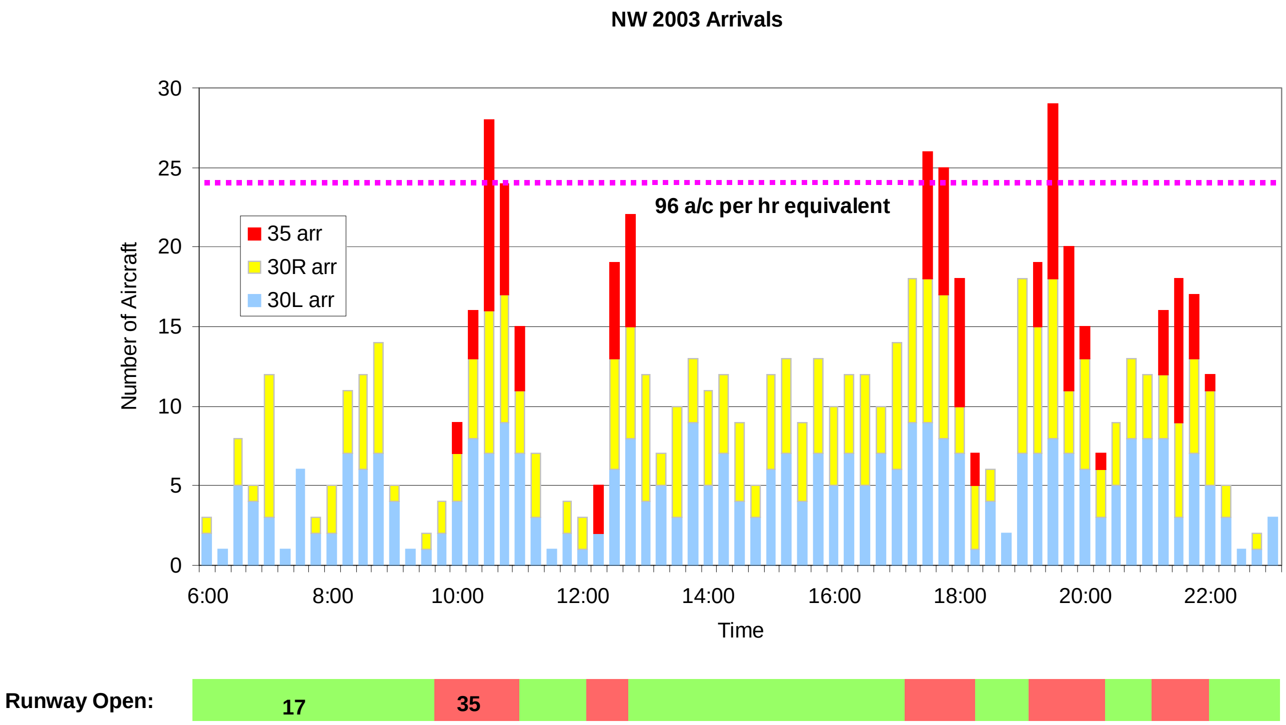

Figure 4-8. M98 15 Minute Arrival Rates with Runway 17/35 Schedule (2003 Traffic)

Figure 4-9 shows the 15-minute departure rates for M98 with 2003 traffic. From this chart, it can be seen that M98 can sustain a departure rate of approximately 104 aircraft per hour or more when Runway 17 is open. The arrival and departure rates shown here are derived based on the schedule for opening and closing Runways 35 and 17. As described in Section 3, the decisions as to when to open and close these runways were made based on projected arrival and departure delays for 2003 traffic. The rule was that Runway 17 was the default runway unless a justification for opening 35 could be given. Excessive arrival delay was that justification. These decisions were, of course, subjective judgements based on 2003 traffic. For this analysis, the same schedules were used for the future traffic years of 2008 and 2013. There may be other circumstances that might shift or otherwise change the Runway 17/35 schedule in future traffic years.

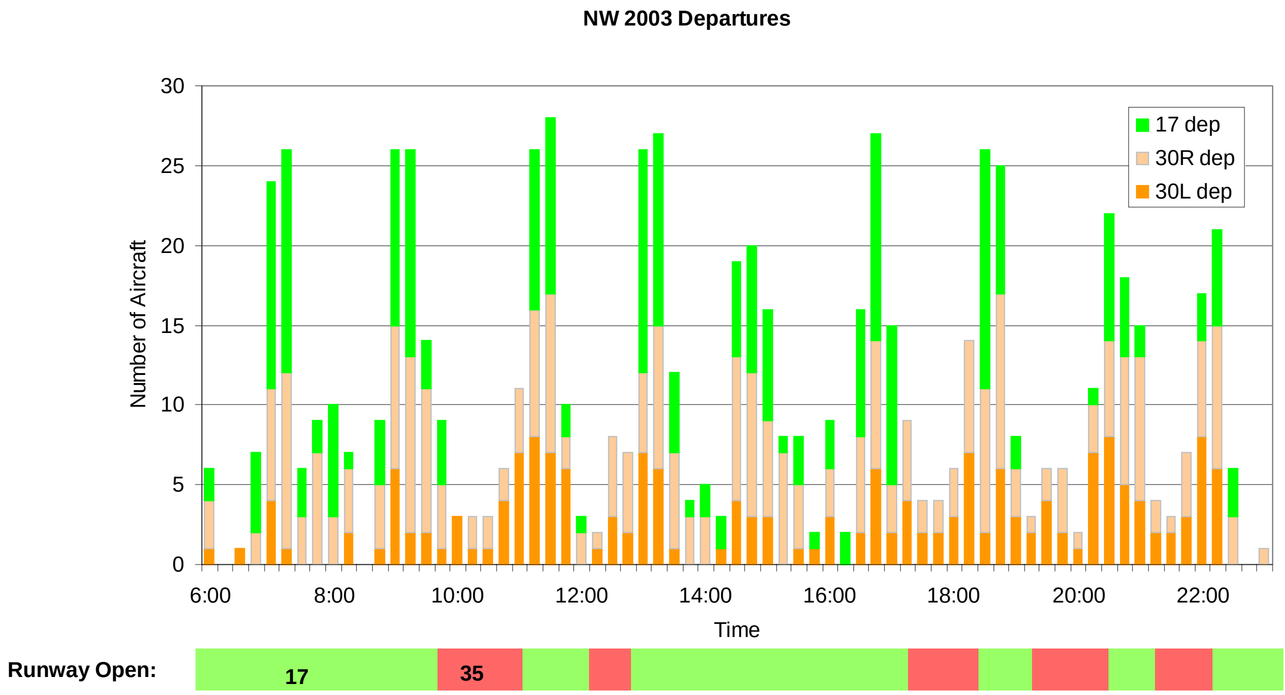

Figure 4-9. M98 15 Minute Departure Rates with Runway 17/35 Schedule (2003 Traffic)

4.3 Runway Utilization

Utilizing the new runways efficiently involves more than a well-chosen runway schedule. M98 has indicated that they intend to maintain a three mile separation between arrivals on final approach to the parallel runways, but a 2.5 mile separation for arrivals to Runway 35. This decreased separation alone will allow a higher arrival rate on Runway 35. Even more important is the loading of the new runways. Runways dedicated to arrivals only or departures only offer the best chance of improved efficiencies, assuming that there is sufficient, sustained demand. Runway preferences can be an important factor in ensuring maximum utilization of Runways 35 and 17 when open.

Figures 4-4 and 4-7 show noticeably larger departure delays in 2013 from 21:00 to 23:00 in the Northwest configuration as compared to the Southeast configuration. In the Northwest configuration, the model allows jet departures to ODI to use Runway 17 during the time periods 7:00-8:00, 13:00-14:00, and 18:10-18:40 (only 10 minutes of this last period are actually used since Runway 17 does not reopen until 18:30). Turboprops can use ODI throughout the day. These time periods were chosen because significant demand for the ODI fix exists at these times. However, there is also a reasonably sustained departure demand for the ODI fix during the latter part of the day (after 18:30). Runway 17 may then become relatively underutilized.

A test was run to determine if relaxing the restrictions on departing 17 for ODI for the Northwest configuration would increase utilization of Runway 17 enough to reduce delay during the latter part of the day. Figure 4-10 shows the cumulative percent runway utilization of Runway 17 through the second half of the day using the future traffic expected in 2013. Cumulative percent utilization is the total number of Runway 17 departures during the day up to that point divided by the total number of departures while Runway 17 was opened up to that point. Three cases are shown here: (1) Runway 17 during Southeast operations, (2) Northwest operations allowing unrestricted departures to ODI from Runway 17, and (3) Northwest operations with restricted departures to ODI from the validated model. Removing this restriction dramatically improves utilization of Runway 17. As can be seen in Figure 4-11, the improved utilization leads to a significant reduction in departure delay after 20:30. The increased utilization of Runway 17 resulted in 56 more flights departing Runway 17 during the day with an associated reduction of departure delay of 9.6%.

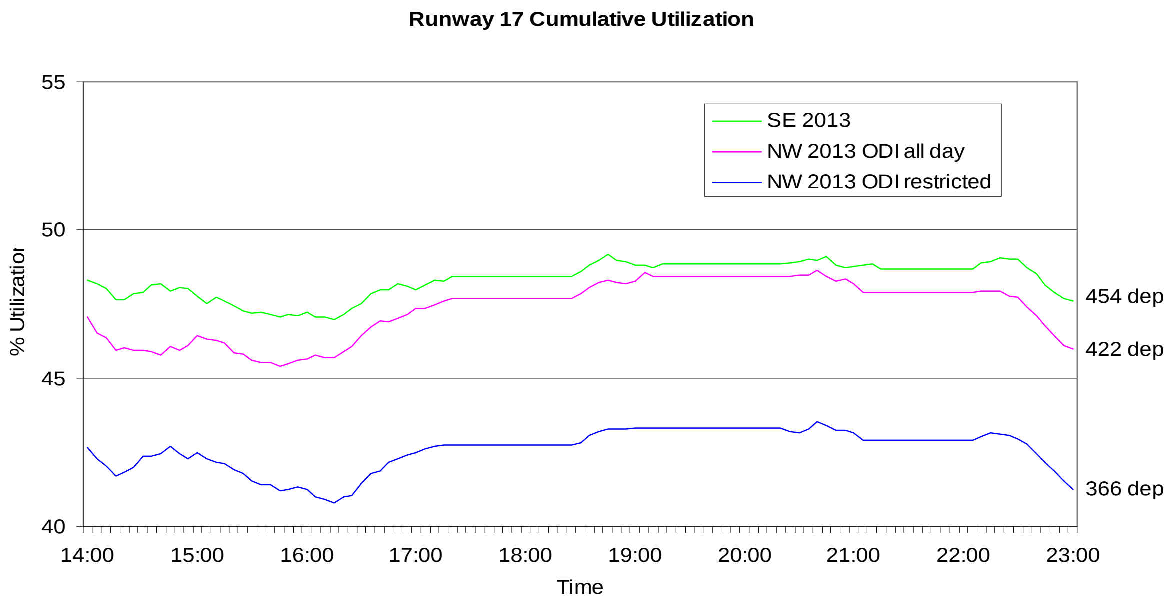

Figure 4-10. Runway 17 Cumulative Utilization

(with Total Runway 17 Departures from 6:00 through 23:00)

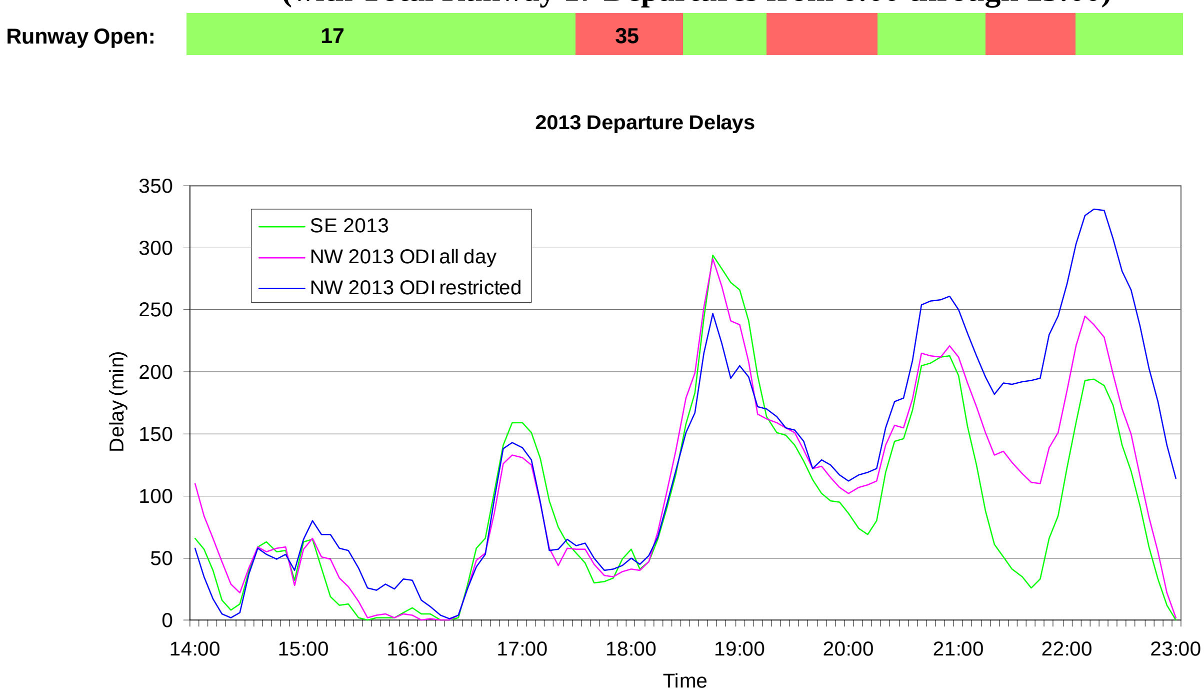

Figure 4-11. Effects of Runway 17 Utilization on Departure Delays

Section 5

Summary

Arrival and departure delays with and without the proposed CINCI STAR are not significantly different for any of the three future traffic scenarios or for either flow. The route of the CINCI STAR is approximately 50 nmi longer than the TWINZ STAR. Table 5-1 shows the number of flights taking the CINCI STAR and the resulting total extra miles flown per day for all aircraft.

Table 5-1. Extra Miles Flown with CINCI STAR

Year	CINCI Flights	Extra Distance Flown
2003	115	5750 nmi
2008	135	6750 nmi
2013	173	8650 nmi

Considering the extra miles to be flown, employing this new route does not appear to be justified since there are no significant benefits. The arrival and departure delay charts in Section 4 do not support the proposition that the CINCI STAR would reduce delays. In most cases, delay reductions during part of the day are mitigated by delay increases at other times.

There is a significant increase in throughput with the new runway. Simulation shows that the stated goal of an arrival rate of 96 aircraft per hour can be met or exceeded (at least for brief periods of time) when Runway 35 is open.

M98 should consider ways to make certain that the new runway is heavily utilized whenever open, since the single use runway offers one of the best chances for maintaining efficient operations. Finally, it should be noted that certain procedural methods of operation may have hidden flaws that will not manifest themselves in increasingly inefficient operations until the airport is faced with very large amounts of traffic.

Appendix A

Supplemental Data

A.1 Northwest Flow No-Fix STARs

No-Fix approach routes for MSP northwest flow are shown below in Figure A-1. The main constraint for these STARs was restricting altitudes at the TRACON boundary to 5000 ft for entry points from ZMP sectors 08 and 09 and 4000 ft from ZMP sectors 06, 07, 10 and 21.

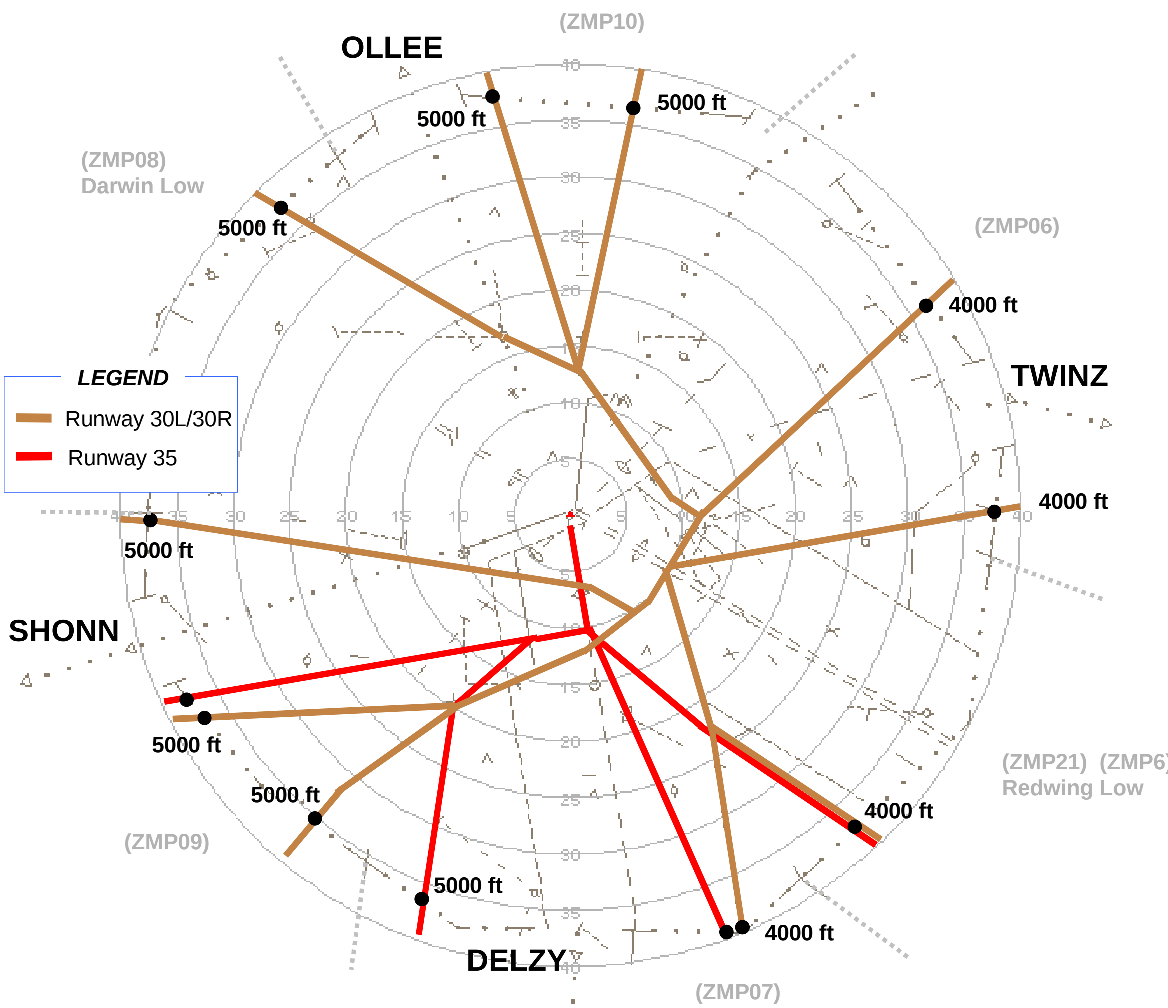

Figure A-1. MSP Northwest Flow No-Fix STARs

A.2 Southeast Flow No-Fix STARs

No-Fix approach routes for MSP southeast flow are shown below in Figure A-2. In the same manner as the northwest flow, the altitude restrictions at TRACON entry are set according to ZMP sector entry points.

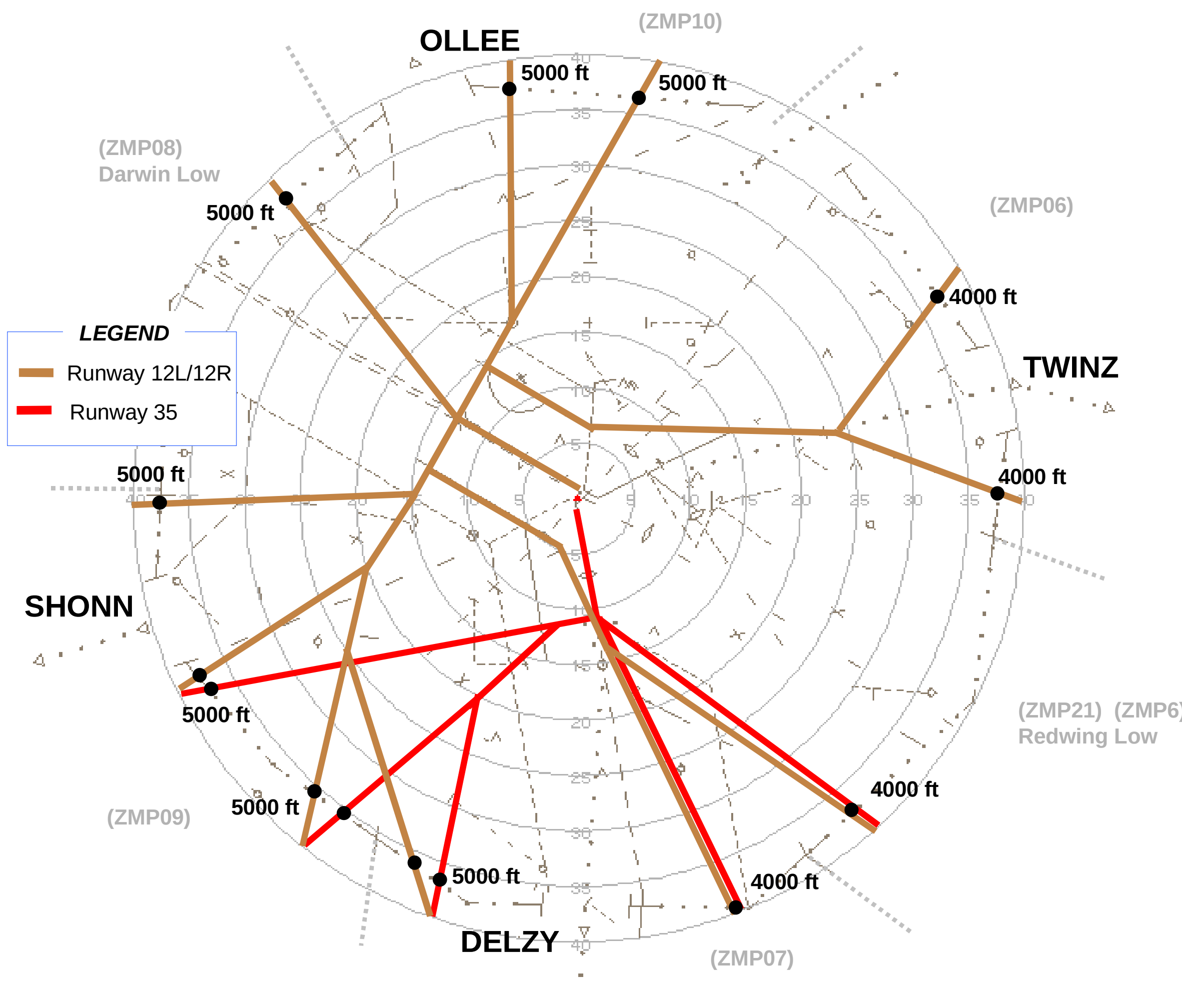

Figure A-2. MSP Southeast Flow No-Fix STARs

A.3 MSP Satellite Airport STARs

For the MSP project, STARs where built for downtown St. Paul airport (KSTP) and Flying Cloud Municipal (KFCM) as illustrated in Figure A-3. Several TAAM runs with satellite traffic integrated into the MSP flow where analyzed and showed no significant change to the MSP results. In light of this result and to save significant TAAM execution time, the final runs and results do not contain satellite traffic.

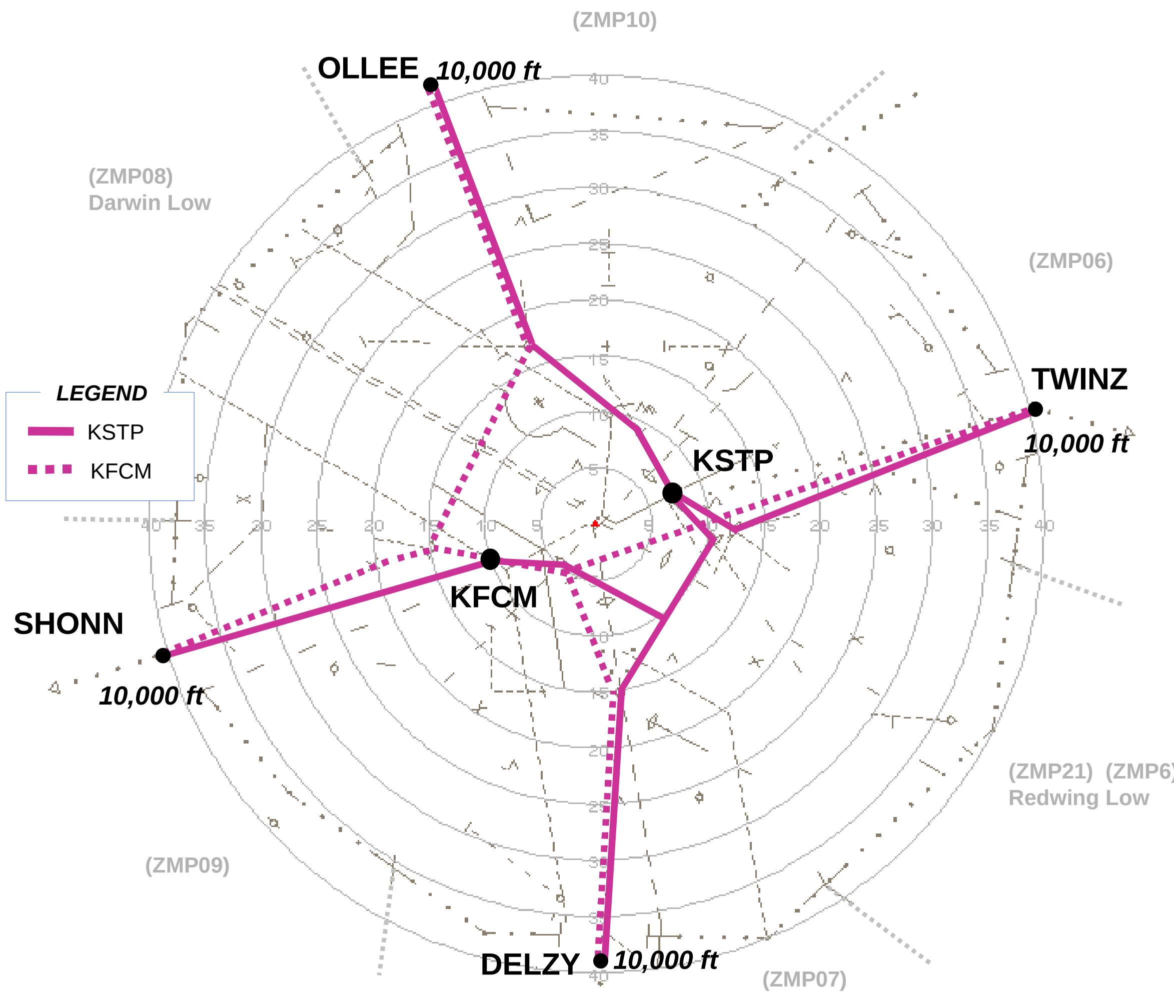

Figure A-3. MSP Satellite Airport STARs

Appendix B

Northwest Flow TAAM Model Parameters

Runway 04 : 70.0 meters wide

Open for: **Departures only**
Arrival queue is **dependent** on parallel runways.
Departure queue is **dependent** on all ops on parallel runways.

All market segments permitted to use this runway.
All weight classes permitted to use this runway.

Max Taxi	Capture Distance (m)	Touchdown Distance from threshold (m)	Capture distance for crossing vs. arrivals	Trombone inwards (nmi)	Trombone outwards (nmi)	base leg minimum (nmi)	base leg maximum (nmi)
unl.	1800	300	1800	0.00	0.00	3.00	13.01

Runway Dependencies

Runway	Departure waiting for Arrival	Departure/Departure Separation	Arrival/Arrival Separation	Departure/Arrival Separation
12L	Independent	Independent	Independent	Become airborne before other aircraft reaches capture distance.
12R	Independent	Independent	Independent	Become airborne before other aircraft reaches capture distance.
17	Independent	Independent	Independent	Independent
22	Commence after landing aircraft passes crossing point.	Commence after departing aircraft passes crossing point.	Independent	Become airborne before other aircraft reaches capture distance.
30L	Independent	Independent	Independent	Independent
30R	Independent	Independent	Independent	Independent
35	Independent	Independent	Independent	Independent

Pairwise Runway Capture Distances (m)

	Turbojet	Turboprop	Piston
Turbojet	1800	0	0
TurboProp	0	0	0
Piston	0	0	0

Runway 12L : CLOSED

Runway 12R : CLOSED

Runway 17 : 70.0 meters wide

Open for: **Departures only**
Arrival queue is **dependent** on parallel runways.
Departure queue is **dependent** on all ops on parallel runways.

All market segments permitted to use this runway.
All weight classes permitted to use this runway.

Max Taxi	Capture Distance (m)	Touchdown Distance from threshold (m)	Capture distance for crossing vs. arrivals	Trombone inwards (nmi)	Trombone outwards (nmi)	base leg minimum (nmi)	base leg maximum (nmi)
unl.	1800	300	1800	3.00	15.01	3.00	10.01

Runway Dependencies

Runway	Departure waiting for Arrival	Departure/Departure Separation	Arrival/Arrival Separation	Departure/Arrival Separation
04	Independent	Independent	Independent	Independent
12L	Independent	Independent	Independent	Independent
12R	Independent	Independent	Independent	Independent
22	Independent	Independent	Independent	Independent
30L	Independent	Independent	Independent	Independent
30R	Independent	Independent	Independent	Independent
35	Independent	Independent	Independent	Independent

Pairwise Runway Capture Distances (m)

	Turbojet	Turboprop	Piston
Turbojet	1800	0	0
TurboProp	0	0	0
Piston	0	0	0

Runway 22 : 70.0 meters wide

Open for: **Departures only**
Arrival queue is **dependent** on parallel runways.
Departure queue is **dependent** on all ops on parallel runways.

All market segments permitted to use this runway.
All weight classes permitted to use this runway.

Max Taxi	Capture Distance (m)	Touchdown Distance from threshold (m)	Capture distance for crossing vs. arrivals	Trombone inwards (nmi)	Trombone outwards (nmi)	base leg minimum (nmi)	base leg maximum (nmi)
unl.	1800	300	1800	0.00	0.00	3.00	13.01

Runway Dependencies

Runway	Departure waiting for Arrival	Departure/Departure Separation	Arrival/Arrival Separation	Departure/Arrival Separation
04	Commence after landing aircraft passes crossing point.	Commence after departing aircraft passes crossing point.	Independent	Become airborne before other aircraft reaches capture distance.
12L	Independent	Independent	Independent	Become airborne before other aircraft reaches capture distance.
12R	Independent	Independent	Independent	Become airborne before other aircraft reaches capture distance.
17	Independent	Independent	Independent	Independent
30L	Independent	Independent	Independent	Independent
30R	Independent	Independent	Independent	Independent
35	Independent	Independent	Independent	Independent

Pairwise Runway Capture Distances (m)

	Turbojet	Turboprop	Piston
Turbojet	1800	0	0
TurboProp	0	0	0
Piston	0	0	0

Runway 30L : 70.0 meters wide

Open for: **All**
Arrival queue is **dependent** on parallel runways.
Departure queue is **dependent** on all ops on parallel runways.

All market segments permitted to use this runway.
All weight classes permitted to use this runway.

Max Taxi	Capture Distance (m)	Touchdown Distance from threshold (m)	Capture distance for crossing vs. arrivals	Trombone inwards (nmi)	Trombone outwards (nmi)	base leg minimum (nmi)	base leg maximum (nmi)
unl.	1800	300	1800	5.00	25.02	1.00	30.02

Runway Dependencies

Run way	Departure waiting for Arrival	Departure/Departure Separation	Arrival/Arrival Separation	Departure/Arrival Separation
04	Independent	Independent	Independent	Independent
12L	Independent	Independent	Independent	Independent
12R	Independent	Independent	Independent	Independent
17	Independent	Independent	Independent	Independent
22	Independent	Independent	Independent	Independent
30R	Independent	Independent	Independent	Independent
35	Independent	Independent	Independent	Independent

Pairwise Runway Capture Distances (m)

	Turbojet	Turboprop	Piston
Turbojet	900	900	900
TurboProp	450	450	450
Piston	450	450	450

Runway 30R : 70.0 meters wide

Open for: **All**
Arrival queue is **dependent** on parallel runways.
Departure queue is **dependent** on all ops on parallel runways.

All market segments permitted to use this runway.
All weight classes permitted to use this runway.

Max Taxi	Capture Distance (m)	Touchdown Distance from threshold (m)	Capture distance for crossing vs. arrivals	Trombone inwards (nmi)	Trombone outwards (nmi)	base leg minimum (nmi)	base leg maximum (nmi)
unl.	1800	300	1800	5.00	25.02	1.00	30.02

Runway Dependencies

Runway	Departure waiting for Arrival	Departure/Departure Separation	Arrival/Arrival Separation	Departure/Arrival Separation
04	Independent	Independent	Independent	Independent
12L	Independent	Independent	Independent	Independent
12R	Independent	Independent	Independent	Independent
17	Independent	Independent	Independent	Independent
22	Independent	Independent	Independent	Independent
30L	Independent	Independent	Independent	Independent
35	Independent	Independent	Independent	Independent

Pairwise Runway Capture Distances (m)

	Turbojet	Turboprop	Piston
Turbojet	900	900	900
TurboProp	450	450	450
Piston	450	450	450

Runway 35 : 70.0 meters wide

Open for: **Arrivals only**
Arrival queue is **dependent** on parallel runways.
Departure queue is **dependent** on all ops on parallel runways.

All market segments permitted to use this runway.
All weight classes permitted to use this runway.

Max Taxi	Capture Distance (m)	Touchdown Distance from threshold (m)	Capture distance for crossing vs. arrivals	Trombone inwards (nmi)	Trombone outwards (nmi)	base leg minimum (nmi)	base leg maximum (nmi)
unl.	1800	300	1800	3.00	15.01	3.00	10.01

Runway Dependencies

Runway	Departure waiting for Arrival	Departure/Departure Separation	Arrival/Arrival Separation	Departure/Arrival Separation
04	Independent	Independent	Independent	Independent
12L	Independent	Independent	Independent	Independent
12R	Independent	Independent	Independent	Independent
17	Independent	Independent	Independent	Independent
22	Independent	Independent	Independent	Independent
30L	Independent	Independent	Independent	Independent
30R	Independent	Independent	Independent	Independent

Pairwise Runway Capture Distances (m)

	Turbojet	Turboprop	Piston
Turbojet	1800	0	0
TurboProp	0	0	0
Piston	0	0	0

Sequencing Intervals

Default Interval(s)	RWY Capture Dist (m)	Crossing Clearance (m)	Seq Distance for Parallels (m)	Ground Delay Threshold (s)	Runway Holding Preference	Airborne Separation Check (nmi)
60	1853	1853	3706	0	0%	0.0

Arrival Sequencing & Landing Queue Thresholds

Queues & Sequencing on the basis of **distance:**

Enter landing queue **125** nmi from airport.
Begin sequencing actions **125** nmi from airport.
Sequence fixed **45** nmi from airport.

Departure sequencing

The sequencing strategy is in order of **Flow ETA**
No departure sequence optimization
Departures **are not** radar separated.
Conflict look-ahead time is **0** seconds.

Max crosswind/tailwind, dry runway: 5 / 25 kts.
Max crosswind/tailwind, wet runway: 0 / 20 kts.

Flights **may** overtake on STARS.

Simultaneous operations **are** permitted on crossing runways.

Link flights by **callsign, flight number, or carrier**.

Delay flights at gate to **minimize overall delay**.

Miles In Trail and Flow Management

Do not use intrail separation with overflights.
Do not use intrail separation past top of descent.
No limit on flow into airport.
Reassess flow every **0** minutes.
No speed control on cruise.

Use ground delay instead of airborne if the departure airport is within **0** nmi.
The desired IAS on final approach is **155** kts.
If the ground delay is greater than **3** hours, let the flight depart.

Line up departures **early.**

Miscellaneous Parameters

Select a sid or star if the route is within **60** miles and **50** degrees of the arrival fix (measured from airport).
Airborne conflict checking is **off**.
Safe taxi mode is **off**.
Calculate runway length needed from **acceleration of aircraft**
Gates are **not** used.
Taxipath changing is **not permitted**
Taxipath changing is **permitted** after a waitof **0.0** minutes at an intersection.
Doglegs for short air delays **will not** be used.

Miscellaneous Parameters

Select a sid or star if the route is within **60** miles and **50** degrees of the arrival fix (measured from airport).
Airborne conflict checking is **off**.
Safe taxi mode is **off**.
Calculate runway length needed from **acceleration of aircraft**
Gates are **not** used.
Taxipath changing is **not permitted**
Taxipath changing is **permitted** after a waitof **0.0** minutes at an intersection.
Doglegs for short air delays **will not** be used.

Runway Selection Strategies

Departures

If no suitable runway is found, **use the runway closest to suitable.**
Override the default selection if the difference in

queue length is greater than **6**,
crosswind (kt) is greater than **20**,
tailwind (kt) is greater than **5**,

gate/runway distance (m) is greater than **5000**,

Arrivals

If no suitable runway is found, **use the runway closest to suitable.**
Override the default selection if the difference in

queue length is greater than **2**,
crosswind (kt) is greater than **20**,
tailwind (kt) is greater than **5**,
gate/runway distance (m) is greater than **5000**,

Appendix C

Southeast Flow TAAM Model Parameters

Runway 04 : 70.0 meters wide

Open for: **Departures only**
Arrival queue is **dependent** on parallel runways.
Departure queue is **dependent** on all ops on parallel runways.
All market segments permitted to use this runway.
All weight classes permitted to use this runway.

Max Taxi	Capture Distance (m)	Touchdown Distance from threshold (m)	Capture distance for crossing vs. arrivals	Trombone inwards (nmi)	Trombone outwards (nmi)	base leg minimum (nmi)	base leg maximum (nmi)
unl.	1800	300	1800	0.00	0.00	3.00	13.01

Runway Dependencies

Runway	Departure waiting for Arrival	Departure/Departure Separation	Arrival/Arrival Separation	Departure/Arrival Separation
12L	Independent	Independent	Independent	Independent
12R	Independent	Independent	Independent	Independent
17	Independent	Independent	Independent	Independent
22	Commence after landing aircraft passes crossing point.	Commence after departing aircraft passes crossing point.	Independent	Become airborne before other aircraft reaches capture distance.
30L	Commence after landing aircraft passes crossing point.	Commence after departing aircraft passes crossing point.	Touch down before other aircraft reaches clearance gap.	Become airborne before other aircraft reaches capture distance.
30R	Commence after landing aircraft passes crossing point.	Commence after departing aircraft passes crossing point.	Touch down before other aircraft reaches clearance gap.	Become airborne before other aircraft reaches capture distance.
35	Independent	Independent	Independent	Independent

Pairwise Runway Capture Distances (m)

	Turbojet	Turboprop	Piston
Turbojet	1800	0	0
TurboProp	0	0	0
Piston	0	0	0

Runway 12L : 70.0 meters wide

Open for: **All**
Arrival queue is **dependent** on parallel runways.
Departure queue is **dependent** on all ops on parallel runways.

All market segments permitted to use this runway.
All weight classes permitted to use this runway.

Max Taxi	Capture Distance (m)	Touchdown Distance from threshold (m)	Capture distance for crossing vs. arrivals	Trombone inwards (nmi)	Trombone outwards (nmi)	base leg minimum (nmi)	base leg maximum (nmi)
unl.	1800	300	1800	5.00	25.02	1.00	30.02

Runway Dependencies

Run way	Departure waiting for Arrival	Departure/Departure Separation	Arrival/Arrival Separation	Departure/Arrival Separation
04	Independent	Independent	Independent	Independent
12R	Independent	Independent	Independent	Independent
17	Independent	Independent	Independent	Independent
22	Independent	Independent	Independent	Independent
30L	Independent	Independent	Independent	Independent
30R	Independent	Independent	Independent	Independent
35	Independent	Independent	Independent	Independent

Pairwise Runway Capture Distances (m)

	Turbojet	Turboprop	Piston
Turbojet	900	900	900
TurboProp	450	450	450
Piston	450	450	450

Runway 12R : 70.0 meters wide

Open for: **All**
Arrival queue is **dependent** on parallel runways.
Departure queue is **dependent** on all ops on parallel runways.

All market segments permitted to use this runway.
All weight classes permitted to use this runway.

Max Taxi	Capture Distance (m)	Touchdown Distance from threshold (m)	Capture distance for crossing vs. arrivals	Trombone inwards (nmi)	Trombone outwards (nmi)	base leg minimum (nmi)	base leg maximum (nmi)
unl.	1800	300	1800	5.00	25.02	1.00	30.02

Runway Dependencies

Runway	Departure waiting for Arrival	Departure/Departure Separation	Arrival/Arrival Separation	Departure/Arrival Separation
04	Independent	Independent	Independent	Independent
12L	Independent	Independent	Independent	Independent
17	Independent	Independent	Independent	Independent
22	Independent	Independent	Touch down before other aircraft reaches clearance gap.	Independent
30L	Independent	Independent	Independent	Become airborne before other aircraft reaches capture distance.
30R	Independent	Independent	Independent	Become airborne before other aircraft reaches capture distance.
35	Independent	Independent	Independent	Independent

Pairwise Runway Capture Distances (m)

	Turbojet	Turboprop	Piston
Turbojet	900	900	900
TurboProp	450	450	450
Piston	450	450	450

Runway 17 : 70.0 meters wide

Open for: **Departures only**
Arrival queue is **dependent** on parallel runways.
Departure queue is **dependent** on all ops on parallel runways.

All market segments permitted to use this runway.
All weight classes permitted to use this runway.

Max Taxi	Capture Distance (m)	Touchdown Distance from threshold (m)	Capture distance for crossing vs. arrivals	Trombone inwards (nmi)	Trombone outwards (nmi)	base leg minimum (nmi)	base leg maximum (nmi)
unl.	1800	300	1800	3.00	15.01	3.00	10.01

Runway Dependencies

Runway	Departure waiting for Arrival	Departure/Departure Separation	Arrival/Arrival Separation	Departure/Arrival Separation
04	Independent	Independent	Independent	Independent
12L	Independent	Independent	Independent	Independent
12R	Independent	Independent	Independent	Independent
22	Independent	Independent	Independent	Independent
30L	Independent	Independent	Independent	Independent
30R	Independent	Independent	Independent	Independent
35	Independent	Independent	Independent	Independent

Pairwise Runway Capture Distances (m)

	Turbojet	Turboprop	Piston
Turbojet	1800	0	0
TurboProp	0	0	0
Piston	0	0	0

Runway 22 : 70.0 meters wide

Open for: **Departures only**
Arrival queue is **dependent** on parallel runways.
Departure queue is **dependent** on all ops on parallel runways.

All market segments permitted to use this runway.
All weight classes permitted to use this runway.

Max Taxi	Capture Distance (m)	Touchdown Distance from threshold (m)	Capture distance for crossing vs. arrivals	Trombone inwards (nmi)	Trombone outwards (nmi)	base leg minimum (nmi)	base leg maximum (nmi)
unl.	1800	300	1800	0.00	0.00	3.00	13.01

Runway Dependencies

Runway	Departure waiting for Arrival	Departure/Departure Separation	Arrival/Arrival Separation	Departure/Arrival Separation
04	Commence after landing aircraft passes crossing point.	Commence after departing aircraft passes crossing point.	Independent	Become airborne before other aircraft reaches capture distance.
12L	Independent	Independent	Independent	Independent
12R	Independent	Independent	Independent	Independent
17	Independent	Independent	Independent	Independent
30L	Commence after landing aircraft passes crossing point.	Commence after departing aircraft passes crossing point.	Touch down before other aircraft reaches clearance gap.	Become airborne before other aircraft reaches capture distance.
30R	Commence after landing aircraft passes crossing point.	Commence after departing aircraft passes crossing point.	Touch down before other aircraft reaches clearance gap.	Become airborne before other aircraft reaches capture distance.
35	Independent	Independent	Independent	Independent

Pairwise Runway Capture Distances (m)

	Turbojet	Turboprop	Piston
Turbojet	1800	0	0
TurboProp	0	0	0
Piston	0	0	0

Runway 30L : CLOSED

Runway 30R : CLOSED

Runway 35 : 70.0 meters wide

Open for: **Arrivals only**
Arrival queue is **dependent** on parallel runways.
Departure queue is **dependent** on all ops on parallel runways.

All market segments permitted to use this runway.
All weight classes permitted to use this runway.

Max Taxi	Capture Distance (m)	Touchdown Distance from threshold (m)	Capture distance for crossing vs. arrivals	Trombone inwards (nmi)	Trombone outwards (nmi)	base leg minimum (nmi)	base leg maximum (nmi)
unl.	1800	300	1800	5.00	25.02	3.00	10.01

Runway Dependencies

Runway	Departure waiting for Arrival	Departure/Departure Separation	Arrival/Arrival Separation	Departure/Arrival Separation
04	Independent	Independent	Independent	Independent
12L	Independent	Independent	Independent	Independent
12R	Independent	Independent	Independent	Independent
17	Commence after landing aircraft is clear of runway.	Independent	Independent	Independent
22	Independent	Independent	Independent	Independent
30L	Independent	Independent	Independent	Independent
30R	Independent	Independent	Independent	Independent

Pairwise Runway Capture Distances (m)

	Turbojet	Turboprop	Piston
Turbojet	1800	0	0
TurboProp	0	0	0
Piston	0	0	0

Sequencing Intervals

Default Interval(s)	RWY Capture Dist (m)	Crossing Clearance (m)	Seq Distance for Parallels (m)	Ground Delay Threshold (s)	Runway Holding Preference	Airborne Separation Check (nmi)
60	1853	1853	3706	0	0%	0.0

Arrival Sequencing & Landing Queue Thresholds

Queues & Sequencing on the basis of **distance:**

Enter landing queue **125** nmi from airport.
Begin sequencing actions **125** nmi from airport.
Sequence fixed **45** nmi from airport.

Departure sequencing

The sequencing strategy is in order of **Flow ETA**
No departure sequence optimization
Departures **are** radar separated, beginning **20** nmi from airport.
Conflict look-ahead time is **0** seconds.

Max crosswind/tailwind, dry runway: 5 / 25 kts.
Max crosswind/tailwind, wet runway: 0 / 20 kts.

Flights **may** overtake on STARS.

Simultaneous operations **are** permitted on crossing runways.

Link flights by **callsign, flight number, or carrier**.

Delay flights at gate to **minimize overall delay**.

Miles In Trail and Flow Management

Do not use intrail separation with overflights.
Do not use intrail separation past top of descent.
No limit on flow into airport.
Reassess flow every **0** minutes.
No speed control on cruise.
Use ground delay instead of airborne if the departure airport is within **0** nmi.
The desired IAS on final approach is **155** kts.

If the ground delay is greater than **3** hours, let the flight depart.

Line up departures **early.**

Miscellaneous Parameters

Select a sid or star if the route is within **60** miles and **50** degrees of the arrival fix (measured from airport).
Airborne conflict checking is **off**.
Safe taxi mode is **off**.
Calculate runway length needed from **acceleration of aircraft**
Gates are **not** used.
Taxipath changing is **not permitted**
Taxipath changing is **permitted** after a waitof **0.0** minutes at an intersection.
Doglegs for short air delays **will not** be used.

Runway Selection Strategies

Departures

If no suitable runway is found, **use the runway closest to suitable.**
Override the default selection if the difference in

queue length is greater than **4**,
crosswind (kt) is greater than **20**,
tailwind (kt) is greater than **5**,
gate/runway distance (m) is greater than **5000**,

Arrivals

If no suitable runway is found, **use the runway closest to suitable.**
Override the default selection if the difference in

queue length is greater than **2**,
crosswind (kt) is greater than **20**,
tailwind (kt) is greater than **5**,
gate/runway distance (m) is greater than **5000**,

Glossary

ASPM	Aviation System Performance Measurement
CAASD	Center for Advanced Aviation System Development
ETMS	Enhanced Traffic Management System
M98	Minneapolis/St. Paul Approach Control
nmi	Nautical Mile
OAG	Official Airlines Guide
OPSNET	Operations Network
SID	Standard Instrument Departure
SDAT	Sector Design Analysis Tool
STAR	Standard Terminal Arrival Route
TAAM	Total Airspace and Airport Modeler
TRACON	Terminal Radar Approach Control
ZMP	Minneapolis Enroute Control