Project Report
ATC-381

Estimation of Potential IDRP Benefits during Convective Weather SWAP

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16. Abstract

This document presents a preliminary analysis of potential departure delay reduction benefits in New York as the result of the use of the Integrated Departure Route Planning (IDRP) tool during convective severe weather avoidance programs (SWAP). The analysis is based on weather impact and air traffic data from operations between May and September 2010 in the New York metroplex region. Two methodologies were employed in the analysis: ‘flight pool’ and ‘resource pool.’ In the flight pool methodology, individual flights with excessive taxi times were identified, and opportunities to find potential alternative reroutes using information that IDRP will provide were assessed. In the resource pool methodology, route impact minutes were tallied over several days, based on the judgment of a human analysis, and opportunities to recover capacity lost to route impacts via IDRP-identified reroutes were estimated. The flight pool methodology estimated that approximately 156 hours of delay could be saved through the use of IDRP over a full SWAP season. The resource pool methodology estimated that approximately 15% of capacity lost to convective weather impacts could be recovered via IDRP-based reroutes.

It should be noted that the potential benefits are based on several assumptions that are described in detail in the text of the report. The estimation of delay savings due to reroute is also speculative. It is very difficult to ascertain when the assignment of a reroute actually makes use of underutilized capacity and when the reroute simply shifts the problem from one congested resource to another. Further research is needed to develop reliable metrics that can guide the assessment of reroute impacts on overall traffic management performance.

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ABSTRACT

This document presents a preliminary analysis of potential departure delay reduction benefits in New York as the result of the use of the Integrated Departure Route Planning (IDRP) tool during convective severe weather avoidance programs (SWAP). The analysis is based on weather impact and air traffic data from operations between May and September 2010 in the New York metroplex region. Two methodologies were employed in the analysis: ‘flight pool’ and ‘resource pool.’ In the flight pool methodology, individual flights with excessive taxi times were identified, and opportunities to find potential alternative reroutes using information that IDRP will provide were assessed. In the resource pool methodology, route impact minutes were tallied over several days, based on the judgment of a human analysis, and opportunities to recover capacity lost to route impacts via IDRP-identified reroutes were estimated. The flight pool methodology estimated that approximately 156 hours of delay could be saved through the use of IDRP over a full SWAP season. The resource pool methodology estimated that approximately 15% of capacity lost to convective weather impacts could be recovered via IDRP-based reroutes.

It should be noted that the potential benefits are based on several assumptions that are described in detail in the text of the report. The estimation of delay savings due to reroute is also speculative. It is very difficult to ascertain when the assignment of a reroute actually makes use of underutilized capacity and when the reroute simply shifts the problem from one congested resource to another. Further research is needed to develop reliable metrics that can guide the assessment of reroute impacts on overall traffic management performance.

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1. OVERVIEW

This document provides an initial estimate of the potential benefits due to the use of the Integrated Departure Route Planning (IDRP) tool during convective weather SWAP. IDRP will provide decision support for departure management during Severe Weather Action Programs (SWAP) by providing several capabilities:

- Ability to identify flights whose filed flight plans/departure routes may be blocked by convective weather and/or volume congestion impacts
- Ability to aggregate weather and/or congestion impacted flights by route, fix, etc., to support rapid evaluation of the magnitude of impacts and need for mitigation
- Ability to identify viable impact mitigation options (e.g., reroutes, restrictions, and/or gate delay) for departure flights affected by convective weather or volume impacts

IDRP decision support will provide information to improve the effectiveness of the following key decisions in departure management during SWAP:

- When are reroutes necessary? If necessary, what feasible reroutes (i.e., routes with manageable weather and volume impacts) are available for flights whose filed plans are blocked by weather or volume congestion?
- When do departure routes/fixes in active use require demand adjustments? What type of demand restrictions (e.g., MIT) are applicable, and when can they be modified, given the forecast weather and/or volume impacts?
- Should a pending departure be held at the gate because no viable departure route is likely to be available by the time the flight is ready to roll?

Note that IDRP addresses primarily reroute planning—whether or not a reroute is the appropriate solution, and, if so, identifying and implementing the best reroute available, based on an analysis of en route constraints, starting from the departure fix. IDRP information may support traffic managers in applying other weather mitigation tactics—for instance, managing weather avoiding deviations by vectoring rather than rerouting—but estimating the value of IDRP in making such complex judgments, and the operational improvements that ensue, requires field evaluation. It also must be recognized that full realization of IDRP benefits may be dependent upon the efficient operation of other operational systems beyond its scope (e.g., surface management).

Two benefits methodologies were applied: ‘flight pool’ and ‘resource pool.’ The flight pool methodology determines the benefits pool by identifying flights with excessive delay, relative to other flights on the case study day, whose delay could have been reduced by assigning a reroute. The resource pool methodology identifies reroute opportunities by finding periods of time during the case days when reroute opportunities could be determined based on RAPT status and traffic. The resource pool considers all flights aggregated and expressed as typical fair weather route demand, not just those with excessive delay, in its estimation of delay reduction. Unlike the flight pool methodology, it does not include explicit identification of those flights; rather it considers the impacts on and availability of specific departure routes (the resource). The results from the two analyses should be interpreted as two independent estimates of potential benefits from IDRP that provide insight into the potential value of different IDRP capabilities.

Finally, a description of expected ‘process’ benefits is presented. Process benefits are defined as improvements in the departure management environment (for instance, improved situational awareness) that may lead to improvements in departure metrics and quantifiable benefits, but whose impacts on departure metrics (e.g., departure throughput) cannot be directly quantified. Validation of these potential benefits will require direct observation and evaluation in the field.

1.1 ASSUMPTIONS

The following assumptions are common to both methodologies:

1. Operational IDRP demand estimates are sufficiently accurate that flights identified as ‘pending departures’ in the post-event benefits analysis would appear in the predicted IDRP demand list within an operationally insignificant time window.
2. Errors in the IDRP aggregate demand predictions for departure fixes and routes are operationally insignificant.
3. Airline operations and surface management are capable of delivering demand to the end of the departure runway at the time when IDRP expects wheels off, within an operationally insignificant time window.
4. Overall airport and Terminal Radar Control (TRACON) capacity is sufficient to absorb rerouted flights at the times identified by IDRP in the analysis—in other words, rerouted flights that can depart earlier because of an IDRP departure opportunity are not simply taking someone else’s slot, resulting in a system-wide reshuffling of delay, rather than a system-side reduction.
5. IDRP-identified reroutes will be acceptable to airlines. The effects of this assumption are mitigated by considering, in this analysis, only reroutes options through nearby fixes (same departure gate, or nearest neighbor). In some instances, airlines may be willing to accept more drastic reroutes just to get off the ground, but we assume this is the exception rather than the rule, and, therefore do not build it into the overall set of assumptions.

Other assumptions that are made in specific benefit analyses are described in the methodology section as part of those analyses.

1.2 FLIGHT POOL METHODOLOGY

The flight pool methodology was applied to departures from LaGuardia, Newark International, and JFK airports on eighteen different SWAP days during the summer of 2010. The analysis steps are as follows:

1. Calculate the taxi time for each flight f (t_f = wheels-off – pushback) from ASPM data.
2. For each flight f, calculate the median time of all flights departing from the same airport on potential reroutes that also pushed back within 30 minutes of the pushback time of the flight (μ_p). If ($t_f - \mu_p \geq t_d$, where t_d = 30 minutes), f is added to the potential reroute benefits pool (P_r)—in other words, flight f had significantly greater delay than flights departing on potential reroute alternatives for flight f.
3. P_r includes all flights with excessive delays that could possibly be mitigated by rerouting to available reroutes with significantly lower delays. For each flight in the benefits pool, check the NTML to determine if there is evidence that the delay was associated with some event other than weather or traffic volume impacts (e.g., medical emergency). Flights with evidence of other delay causality are removed from P_r.
4. Retain only those flights in P_r for which there was IDRP forecast information that could have identified the flight as one in potential need of reroute: either RAPT RED status for at least 15 of the first 30 minutes of taxi time, or a very low departure volume on the filed route in the 30 minutes prior to and immediately after pushback, or a significant demand for the filed route already pushed back and waiting on the ground at the time of pushback.
5. Calculate the departure delay reduction, T_r, achievable by rerouting all flights remaining in P_r, by summing up the delay reduction [$t_r = (t_f - \mu_p)$] for each flight f: $T_r = \Sigma t_r$. For flights in P_r that have been assigned EDCTs, t_r = min[($t_f - \mu_p$), (wheel-off – EDCT)]; EDCT flights with $t_r < 30$ minutes are removed from P_r. In this analysis, departure delay savings are not calculated using a departure queuing model, since the capacity added via reroute is not applied to departures already in queue.

The most significant caveat to this methodology is that this information is available only in a post-event analysis. During operations, traffic managers will not have advance warning about which pending departures are likely to have excessive taxi times. The benefits pool adjustment test applied in step (4) is intended to address this caveat. The threshold for ‘very low departure volume’ was defined as 0 or 1 per half-hour, in keeping with the observed departure rates on RED RAPT routes (90% of RED routes in 2009 and 2010 had departure rates <2 flights per half-hour). The threshold for ‘significant demand’ was set to five per half-hour, one-half of the estimate for fair weather departure fix capacity provided by subject matter experts (since this analysis applies to SWAP, not fair weather, it was considered appropriate to reduce the ‘warning’ level of demand). In order to capture these potential benefits, IDRP functionality may need to be extended to present information that helps traffic managers to identify and address flights that have a high likelihood of incurring excessive delay, and whose delay may be mitigated through rerouting.

1.3 RESOURCE POOL METHODOLOGY

The resource pool analysis was limited to departures through the following 12 departure routes and/or fixes: J95, J36 (north gate); J60, J80, J6, J48 (west gate), J75, J230 (via RBV fix out of JFK), J209 (WHITE), J179 (WAVEY), GREKI, MERIT (east gates). These routes all have at least 20 minutes of flight time in the CIWS domain, ensuring that a reasonable RAPT route status forecast can be made. The analysis steps are as follows:

1. Using NTML, RAPT status, and traffic data, identify time periods and departure routes with significant weather impacts, as defined by one or more of the following conditions: RAPT RED or YELLOW impacts and either an NTML route closure message, observed traffic stoppage, observed capacity reduction relative to fair weather, or observed weather avoiding deviations on the route prior to route closure.
2. For each route identified in (1), identify other routes in the same departure gate with low weather impacts (GREEN and or YELLOW) and departure rates that are lower than fair weather rates during some time window of the period of weather impacts (the time window must be ≥30 minutes; available time windows less than 30 minutes are assumed to be too uncertain to be considered as a reliable reroute target). If several adjacent impacted routes are identified in (1) (for instance, all departures in a single departure gate are impacted), the search for an available route may be extended to nearby departure routes in neighboring gates. Routes available for potential reroute are referred to as 'reroute targets.' If an NTML message shows that a reroute target was reopened for use prior to the start time of the window identified using the weather impact criteria, the start of the reroute target window is extended to the time of the NTML message.
3. If capacity is restricted on the reroute target identified in (2) due to factors beyond the scope of IDRP (e.g., weather impacts in downstream Air Route Traffic Control Centers (ARTCCs)), the reroute opportunity is removed from the potential benefits pool.
4. Calculate the number of route impact minutes from (1): (number of routes impacted × minutes of impact). Calculate the number of reroute target minutes from the potential benefits pool: (number of reroute targets × minutes available). The ratio (route impact minutes/reroute target minutes) suggests the percentage of convective weather and volume congestion impacts during SWAP that may be addressable through the use of IDRP.

The three caveats, in addition to the global assumptions listed above, are as follows:

1. While RAPT guidance is all that is necessary to identify alternative potential reroutes that are free of weather impacts, IDRP demand predictions will provide demand information needed to ensure efficient use of the additional capacity identified by RAPT on the reroute target. For purposes of this analysis, the potential benefits, which should be shared with RAPT, are wholly assigned to IDRP.

2. The implicit assumption that potential reroute targets with some weather impacts (RAPT YELLOW) will have capacities near fair weather capacity has not been validated.
3. The existence of unserved demand that could have made use of identified reroute capacity was not validated.

1.4 FLIGHT POOL RESULTS

Eighteen case days were analyzed from the 2010 SWAP season; potential benefits were identified on 16 of those 18 days. The total benefits pool included 91 flights and potential delay savings of 4293 minutes (approximately five flights and 238 minutes of delay savings per SWAP day). Over the course of a typical SWAP season (63 SWAP days), the expected benefits total 319 flights, with a delay savings of 15,741 minutes (approximately 250 hours).

After adjusting for the difference between post-event analysis and information available during operations, the benefits pool was reduced to 62 flights (68% of total), with a resulting delay savings of 2680 minutes (62% of total). Over the course of a SWAP season, this translates to a total of 185 flights with an expected delay savings of 9380 minutes (approximately 156 hours). Table 1 summarizes the results. Appendix A provides detailed illustrations of the analysis.

Table 1
Summary of Flight Pool Benefits Analysis Results

Day	Flights w/ Excessive Delay	EDCT	Other (from NTML)	Potential Benefit Pool (flights)	Potential Delay Reduction (minutes)	Adjusted Benefit Pool (flights)	Adjusted Delay Reduction (minutes)
Total	121	28	2	91	4293	62	2680
5/12/2010	15	2	1	12	505	7	266
5/14/2010	4	0	0	4	196	4	196
5/23/2010	2	0	0	2	528	0	0
5/27/2010	10	1	0	9	362	8	320
5/28/2010	3	1	0	3	114	3	114
6/01/2010	13	4	0	9	352	5	209
6/03/2010	9	0	0	9	355	4	155
6/06/2010	12	1	0	11	457	9	383
6/12/2010	1	0	0	1	34	1	34
6/19/2010	2	1	0	1	36	1	36
6/27/2010	6	1	0	5	232	4	200
7/09/2010	3	0	0	3	144	2	109
7/13/2010	3	0	0	3	150	3	150
7/19/2010	0	-	-	-	-	-	-
7/20/2010	0	-	-	-	-	-	-
7/21/2010	15	2	1	12	525	7	302
8/04/2010	19	12	0	6	227	3	130
8/05/2010	3	3	0	1	76	1	76

It must be noted that extrapolation of this analysis to estimate the number of flights with excessive delay, median taxi times, and potential delay savings in future years is very difficult. These estimates of delay savings should be considered very approximate.

1.5 RESOURCE POOL RESULTS

Route impact minutes and reroute target minutes were calculated for eight SWAP days in New York in 2010.

Total route impact minutes for the eight days were 11,118 (1390 per day). Reroute target minutes were 1887 (236 per day), suggesting that, on average, approximately 17% of the capacity lost to weather and related volume congestion impacts could be recovered by more efficient rerouting. The results are summarized in Table 2, and detailed examples of the analysis are provided in Appendix B.

Table 2
Summary of Resource Pool Benefits Analysis Results

Day	Route Impact Minutes	Target Reroute Minutes	% Capacity Loss Recovered
Total	11,118	1887	17
5/12/2010	798	277	35
5/14/2010	1020	90	9
5/27/2010	2070	330	16
6/03/2010	1320	270	20
6/06/2010	1935	180	9
7/09/2010	1410	150	11
7/23/2010	1080	270	25
8/12/2010	1485	320	22

2. POTENTIAL PROCESS BENEFITS

IDRP will integrate and present key information about TRACON and en route constraints from several disparate systems in a single system that will be accessible by all participants in the departure management process. IDRP will also provide operationally relevant information processing and display filters that will reduce the workload needed to identify potential problems and coordinate responses to them. Departure management process improvements anticipated as a result of IDRP use include

1. Reduction in the time and effort needed to monitor the evolving state of the National Airspace System (NAS) and weather impacts by integrating weather, weather impact, and demand forecast information into a single display.
2. Common situational awareness resulting from the dissemination of information about weather, weather impacts, departure route status, congestion, and reroute suggestions to all key participants in departure management decisions provides a common base from which to negotiate and coordinate decisions.
3. More rapid identification of problems and potential solutions.
4. Reduced time to implement reroutes, using automated reroute option identification.
5. Distribution of rerouting workload among facilities (ARTCC, TRACONs, Towers) who require this action for a flight within their airspace.

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3. SUMMARY

The efficient use of departure routes during convective weather SWAP is challenging, requiring the identification, assessment of the severity, and clear communication of constraints, and the coordination of effective responses to mitigate the effects of those constraints. The process is complicated further by enormous uncertainty, due to the unpredictability of convective weather and the significant disruptions of scheduled demand due to weather impacts. Objective estimation of achievable capacity is also difficult, due to the many factors that affect operations during convective weather SWAP that are difficult to quantify and are poorly understood. As a result, there will be limits to what is achievable through automation in IDRP, and the realized benefits will be highly dependent on factors that are difficult to model and quantify.

This level of complexity and uncertainty makes it difficult to estimate the amount of unavoidable delay due to weather impacts, which is so critical to the estimation of potential benefits. Furthermore, the period of time analyzed (2010), for which the most complete data are available, is a period in which departure demand has been approximately 10–15% below recent peak levels (2005–2007), and benefits estimates must be scaled up to anticipated future demand levels, a process that is likely to be somewhat unreliable given the uncertainties in existing models of departure operations. A more complete benefits analysis can mitigate some of these shortcomings by augmenting modeled estimates with field observations that provide direct evidence of improvements that may be achieved through the use of IDRP capabilities.

The goals of this benefits analysis were twofold: to gain insight into measurable inefficiencies in current departure management that may be addressed by the current or revised IDRP concept of operations, and to provide a rough order of magnitude estimate of potential benefits achievable through the use of IDRP. The analysis examined two distinct benefits pools: the set of departures whose taxi times significantly exceeded those of other flights filed on the same or nearby routes (departures with ‘excessive delays’), and the set of routes with weather impacts whose reroute targets had capacity that was underutilized. Assumptions and caveats were explicitly stated; the most critical were related to the uncertainty inherent in estimating underutilized capacities and dependencies on other systems beyond the scope of IDRP (for instance, the ability of airport surface management to deliver flights reliably within the timeframe needed to take advantage of available capacity). Potential benefits were expressed as the percentage of impacted capacity that could be recovered due to IDRP use, above and beyond what is currently being achieved. For the relatively small benefits pool of flights with excessive delays, IDRP use may address up to approximately 50% of current impacts. For the larger pool of potential capacity on reroute targets, the estimate of recoverable capacity is in the range of 15–20%. Subsequent field evaluations coupled with additional data analysis will enable us to refine and validate these estimates.

APPENDIX A
DETAILED ILLUSTRATIONS OF THE FLIGHT POOL METHODOLOGY

This appendix presents the detailed flight pool analysis from June 6, 2010. On this day, 12 flights with excessive delay were identified. One of these flights was assigned an EDCT; it was removed from the potential benefits pool because it departed one minute earlier than the assigned departure time. Of the remaining 11 flights, two were removed because they did not pass the predictability criteria; the filed route carried departure traffic, and pending demand did not exceed the SWAP fix congestion capacity (shaded in gray on the table). There were 383 minutes of excess delay for the nine flights that remained in the benefits pool; of those nine flights, only three had RAPT red status in the first 60 minutes after pushback. The remainder of those nine flights were filed on routes that showed very little departure activity in the 30 minutes prior to, and immediately after, pushback (columns 7 and 8 in Table A-1 below), indicating that traffic managers may have had some information at the time of pushback that the filed route may be highly constrained. Table A-1 summarizes the results of the individual flight analyses from June 6.

Table A-1
Summary of Flight Pool for June 6, 2010

Flight ID	Push Back	Wheels Off	Taxi Time (min)	Median (min)	Excess (min)	Departure Counts (Previous 30 min)	Departure Counts (Following 30 min)	Demand on Ground at Push Back	RAPT RED in First 60 min	Reject ?	Potential Benefit (min)
COA881	2151	2302	71	39	32	1	0	1	Y	-	32
COA107	1910	2017	67	36	31	1	0	0	N	-	31
BTA2925	1827	2002	95	44	51	1	1	3	Y	-	51
JBU35	2330	0056	86	51	35	4	1	7	N	-	35
JBU155	2308	0038	90	52	38	4	2	3	N	Route active	0
DAL99	2304	0032	88	52	36	5	3	2	N	Route active	0
DAL1409	2317	2441	84	52	32	1	1	0	N	-	32
PDT4149	1802	1915	73	57	16	1	0	0	Y	EDCT	0
COM375	2025	2145	80	50	30	1	1	0	N	-	30
COM447	1830	2023	113	51	62	1	0	0	N	-	62
BTA5765	1856	2105	129	56	73	1	2	2	N	-	73
ACA713	1757	2022	145	108	37	1	1	0	Y	-	37

APPENDIX B
DETAILED ILLUSTRATIONS OF THE RESOURCE POOL METHODOLOGY

This appendix presents the analysis of operations on May 27, 2010, used to estimate route impact and target reroute minutes. On this day, there were widespread convective impacts that affected operations on north, west, and south gate departure routes, beginning around 1800Z and continuing through 0200Z on the 28th. Table B-1 summarizes the specific route impacts and potential reroute opportunities, with Figures B-2 through B-6 providing additional detail. Figure B-1 illustrates a summary of route impacts and departure and arrival counts by gate. RAPT status for each route is shown at the left for every five minute RAPT forecast update from 11Z until 03Z the following day. Routes are, in order from left to right, J95, J36 (North gates), J60, J64, J80. J6 (West gates), J48, J75, WHITE-J209, and WAVEY-J174 (South gates). Thrity-minute departure (pink bars) and arrival (gray bars) counts, partitioned by gate, are shown at the right.

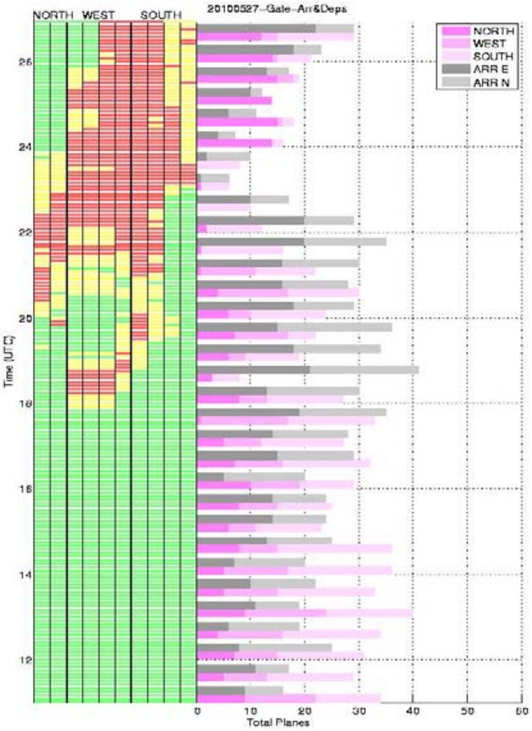


Figure B-1. Daily summary of weather impacts by route (left), and departure and arrival counts by gate (right).

Table B-1
Summary of Weather Impacts and Reroute Opportunities from May 27, 2010

Route	Impact Times (Z)	Impact Minutes	Reroute Opportunity Used	Reroute Opportunity Missed	Reroute Target Minutes	Comments
J95	2030–2230	120	-	GREKI 2000–2200	120	GREKI offloads began shortly before 2200; see Fig. B-2.
J36	2130–2300	90	-	GREKI 2000–2200	-	
J60	1800–1900	60	J36 1900–2030	J36 1830–1900	30	Storm grew quickly and left little planning time, even with forecast; difficult opportunity to capture; see Fig. B-3.
	2130–0030	180	J36 0000–0300	-	-	Very heavy use of north gate offloads; north gate offloads to GREKI for volume (‘double switch’); see Fig. B-4.
J80	1800–1900	60	-	-	-	
	2130–0300	330	J36 0000–0300	J60 0100–0300	120	Late route reopening (missed RAPT opportunity); see Fig. B-5.
J6	2130–0300	330	-	-	-	
J48	1900–2000	60	-	J6 1900–2000	30	Traffic managed very aggressively after 2000; difficult opportunity; see Fig. B-6.
	2100–0300	360	WHITE 2030–2330	-	-	
J75	2100–0300	360	WHITE 2030–2330	-	-	
WHITE	2300–0030	90	-	-	-	
WAVEY	2300–2330	30	-	-	-	
Totals		2070			330	

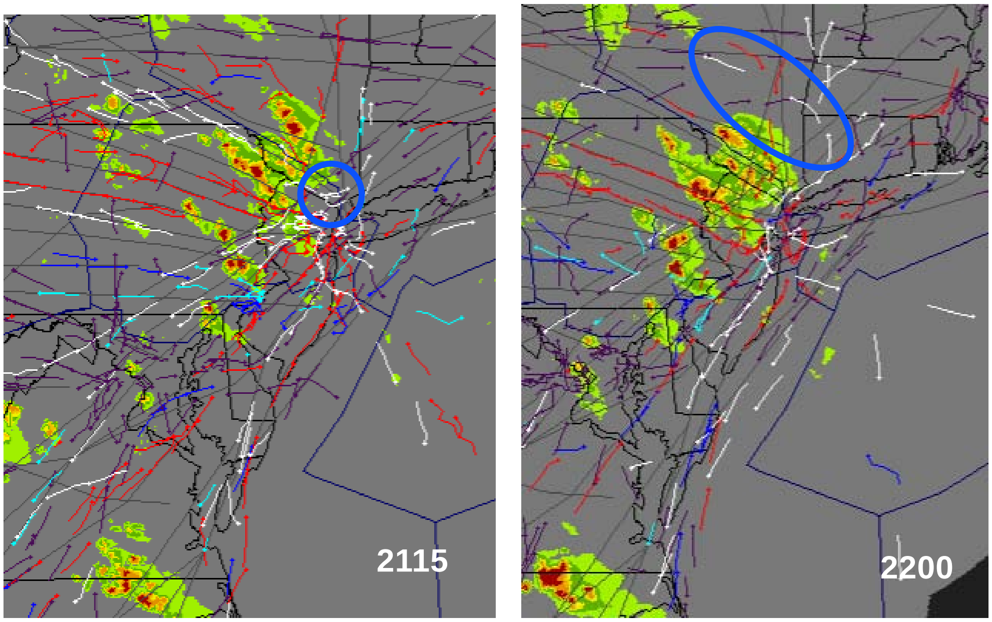


Figure B-2. Potential reroute opportunity to mitigate north gate impacts. Deviations force closure of north gate routes J36/J95 at 2115Z (blue circle in figure at left). North gate offloads onto GREKI begin shortly before 2200Z (blue oval at right). Traffic volumes on the north gate routes were very high in the preceeding hour, during moderate (RAPT YELLOW) impacts, suggesting that volume offload relief to GREKI in the hour preceeding closure (2000–2100) may have been beneficial.

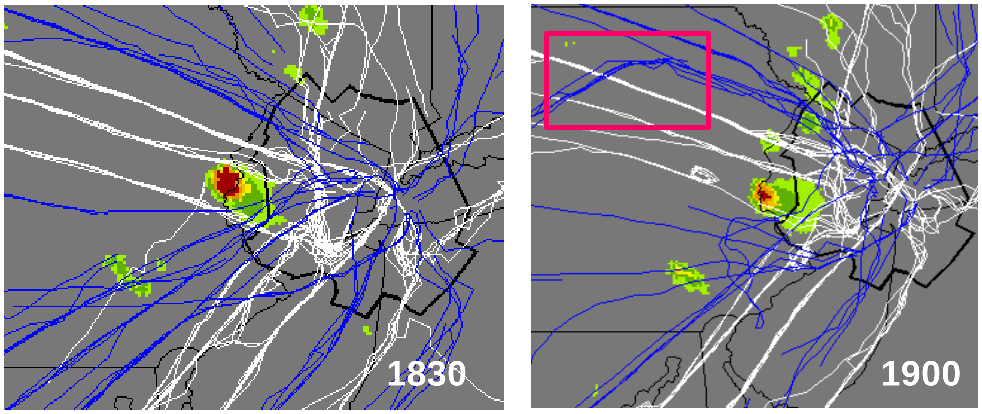


Figure B-3. Potential opportunity to mitigate impacts on ELIOT departure fix. Fast-growing storm closes ELIOT prior to 1830Z (left); DUCT reroutes (via NEION departure fix) begin approximately 1845Z (figure at right). Plots show 30 minute cumulative departures (blue) and arrivals (white), centered on the labeled time.

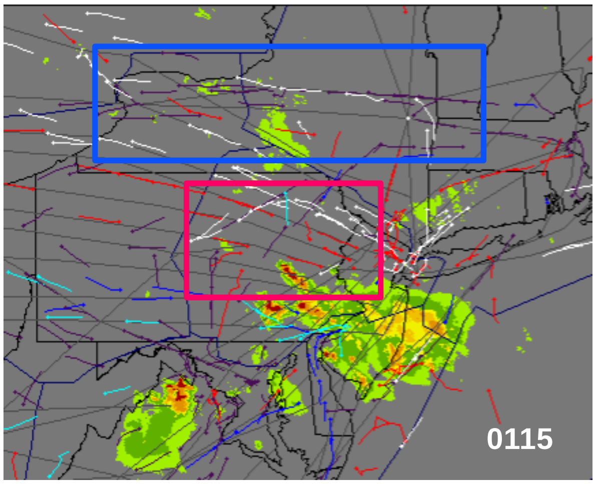
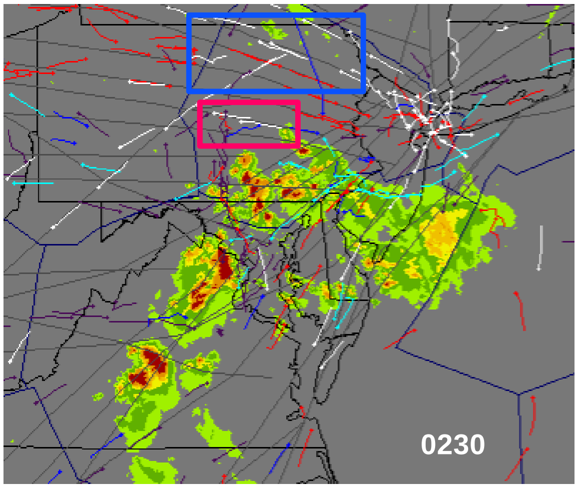
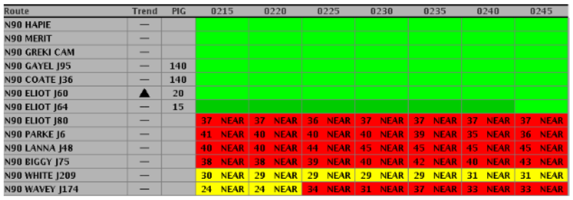


Figure B-4. Example of efficient use of a complex reroute opportunity. Westbound traffic is rerouted from ELIOT to the DUCT routes (pink box), while north gate traffic is rerouted onto the GREKI offload (blue box) to relieve congestion.





Route	Trend	PIG	0215	0220	0225	0230	0235	0240	0245
N90 HAPIE	—		🟩	🟩	🟩	🟩	🟩	🟩	🟩
N90 MERIT	—		🟩	🟩	🟩	🟩	🟩	🟩	🟩
N90 GREKI CAM	—		🟩	🟩	🟩	🟩	🟩	🟩	🟩
N90 GAYEL J95	—	140	🟩	🟩	🟩	🟩	🟩	🟩	🟩
N90 COATE J36	—	140	🟩	🟩	🟩	🟩	🟩	🟩	🟩
N90 ELIOT J60	▲	20	🟩	🟩	🟩	🟩	🟩	🟩	🟩
N90 ELIOT J64	—	15	🟩	🟩	🟩	🟩	🟩	🟩	🟩
N90 ELIOT J80	—		37 NEAR	37 NEAR	36 NEAR	37 NEAR	37 NEAR	37 NEAR	37 NEAR
N90 PARKE J6	—		41 NEAR	40 NEAR	40 NEAR	40 NEAR	39 NEAR	35 NEAR	36 NEAR
N90 LANNA J48	—		40 NEAR	40 NEAR	44 NEAR	45 NEAR	45 NEAR	45 NEAR	45 NEAR
N90 BIGGY J75	—		38 NEAR	38 NEAR	39 NEAR	40 NEAR	42 NEAR	40 NEAR	43 NEAR
N90 WHITE J209	—		30 NEAR	29 NEAR	29 NEAR	29 NEAR	29 NEAR	31 NEAR	31 NEAR
N90 WAVEY J174	—		24 NEAR	24 NEAR	34 NEAR	31 NEAR	37 NEAR	33 NEAR	33 NEAR

Figure B-5. Potential missed RAPT/reroute opportunity. Westbound traffic is rerouted over DUCT routes (blue box). ELIOT J60 is reopened late (pink box, around only two departures) and with light traffic. Note the 20 minute Post-Impact GREEN (PIG) shown in the RAPT timeline at 0215.

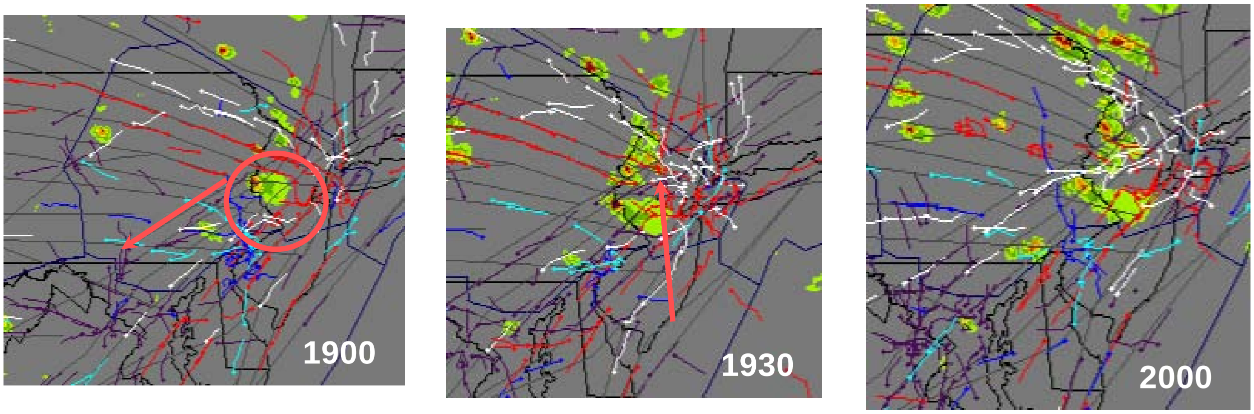


Figure B-6. Potential opportunity to mitigate impacts on LANNA departure fix. Thunderstorm anvil shuts LANNA/J48 as pilots deviate to avoid it (left, pink circle). Reroute onto J6 is available (RAPT YELLOW), with room to deviate to the north. First departure is released onto PARKE/J6 at 1930 (center, pink arrow). Traffic plan is fully in place by 2000 (right). Given the rapid evolution of the storm, the large arrival push into NY airports (traffic in red), this would be a difficult opportunity to realize.

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GLOSSARY

ARTCC	Air Route Traffic Control Center
IDRP	Integrated Departure Route Planning
NAS	National Airspace System
SWAP	Severe Weather Action Program
TRACON	Terminal Radar Control