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Concept of Operations for the Integrated Departure Route Planning (IDRP) Tool

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16. Abstract

A concept of operations for the Integrated Departure Route Planner (IDRP) tool is proposed to address issues in the area of departure route management. By combining information about weather and departure demand, IDRP can both identify potential demand/capacity imbalances and recommend a rerouting option, if appropriate. To effectively implement IDRP into the operational environment, a two-phase approach is suggested. The first phase appends IDRP functionality onto the CIWS/RAPT platform, combining departure demand information with the convective weather information, creating a live prototype. This initial phase allows a gradual introduction of functionality into an existing display and enables the gathering of operational data to appropriately evolve IDRP to phase 2. The second phase involves introducing airline route preferences, along with any operational improvements discovered during the initial phase.

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ABSTRACT

A concept of operations for the Integrated Departure Route Planner (IDRP) tool is proposed to address issues in the area of departure route management. By combining information about weather and departure demand, IDRP can both identify potential demand/capacity imbalances and recommend a rerouting option, if appropriate. To effectively implement IDRP into the operational environment, a two-phase approach is suggested. The first phase appends IDRP functionality onto the CIWS/RAPT platform, combining departure demand information with the convective weather information, creating a live prototype. This initial phase allows a gradual introduction of functionality into an existing display and enables the gathering of operational data to appropriately evolve IDRP to phase 2. The second phase involves introducing airline route preferences, along with any operational improvements discovered during the initial phase.

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1. SCOPE

This document provides a concept of operations for the Integrated Departure Route Planner (IDRP). The purpose of this document is to communicate the air traffic management need for IDRP, the benefits that the tool will provide to the system, and the expectations for the tool's operational use.

Departure management is a critical function in the air traffic control (ATC) system that requires knowledge of the current and projected state of the system and coordination among multiple ATC facilities and airlines. According to an early study of the Integrated Terminal Weather System (ITWS)[1], suggestions were made that even minor improvements in departure operations in the New York airspace could greatly improve efficiency and reduce delays. The initial prototype of the IDRP will be fielded to address the issues in the New York airspace; therefore, the following document describes operations from the perspective of facilities involved in air traffic management for the New York area and its particular information systems for the purposes of clarity. This New York area focus for discussion's purpose, however, is not intended to limit the tool's ability to be adapted to and deployed in other facilities.

In today's operations, knowledge about a flight's ability to use a route at a given departure time during convective weather is provided by the Route Availability Planning Tool (RAPT). However, Traffic Management Coordinators (TMCs) must assemble information from various sources to identify pending demand and potential congestion on these routes and potential reroutes. This process can be cumbersome and can lead to inefficient operations and increased controller workload. IDRP provides a means to present and project integrated information about both weather impacts and congestion on departure routes. In addition, IDRP recommends how to reroute to avoid weather/congestion constraints if the reroute option is chosen by the TMC.

In this document, the following sections address

1. *Current Operations and Needs:* Functional loop of departure management and the progressive decision-making required in departure management
2. *Justification for and Nature of Changes:* How IDRP is expected to address departure management problems
3. *Operational Expectations of Proposed System:* Two-phase implementation strategy for IDRP
4. *Operational Scenarios:* Description of how IDRP would function within two key scenarios
5. *Summary of Impacts:* Summary of anticipated organizational/procedural costs of IDRP implementation
6. *Analysis of Proposed System:* Summary of anticipated benefits of IDRP implementation
7. *Areas of Research and Development:* Issues that would bring value to the IDRP tool, but require further research

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[1]Allan, S., S.G. Gaddy, and J.E. Evans: "Delay Causality and Reduction at New York Airports Using Terminal Weather Information Systems," Project Report ATC-291, MIT Lincoln Laboratory, 2001.

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2. CURRENT OPERATIONS AND NEEDS

The current operations and needs are described in this section through two means. The first means is through a departure management functional loop in which the steps of identifying problems and solutions are described. The second means is through a concept of progressive decision-making in which the sources of information used and the actions available to TMCs are dependent on when the problem is solved.

2.1 DEPARTURE MANAGEMENT FUNCTIONAL LOOP

A functional loop describing the departure management process is depicted below. Each of the functions will be described and difficulties performing these functions in the current system will be highlighted.

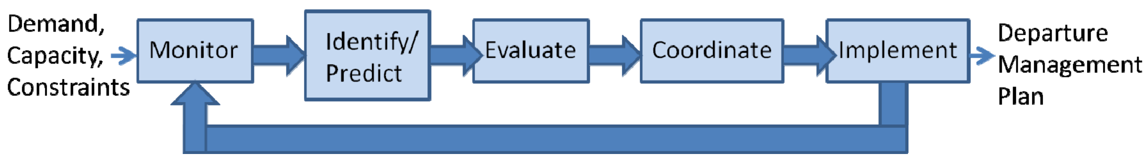


Figure 1. Departure management functional loop.

2.1.1 Monitoring

Monitoring the air traffic management/traffic flow management system is the beginning and end of the departure management process. In this stage, TMCs are assessing the departure delay status, arrival demand, operational capacity, the surface departure queue, the progress of airborne traffic on airways, traffic management initiatives (TMIs), and weather currently affecting the airspace of interest. Any of these elements could change such that a new plan may be required, and the departure management loop begins. After the departure management plan has been implemented, the TMCs are monitoring to ensure that their plan is working as expected, or else a new plan may be required.

Difficulties. The monitoring function is made more difficult in today's departure management environment due to the fact that there are separate displays and information presentations for the demand, capacity, and constraint information. Enhanced Traffic Management System (ETMS) (Figure 2), Departure Spacing Planner (DSP) (Figure 3), and the Airport Surface Detection Equipment (ASDE-X) data through the Sensis Aerobahn display (Figure 4) all provide demand information to the TMCs, but getting an overall picture of the demand is difficult. Not only do the TMCs have to mentally integrate information from the separate displays, but they also must interpret this information to address the problem at hand. DSP and the ASDE-X data both give the TMC an idea of what the departure order is likely to be, but the TMC then has to interpret what routes these departures will take and how this route demand will affect the Air Route Traffic Control Center's (ARTCC) individual sectors. If weather is involved, an additional information integration must occur combining demand information and weather information from CIWS and/or RAPT (Figure 5) over the period of time of interest. A similar issue confronts the TMC when integrating information to monitor operational capacity both within the facility and for the expected downstream capacity.

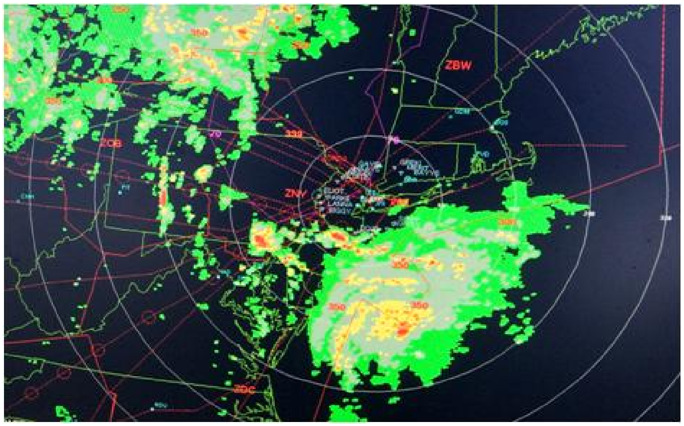


Figure 2. Enhanced Traffic Management System.

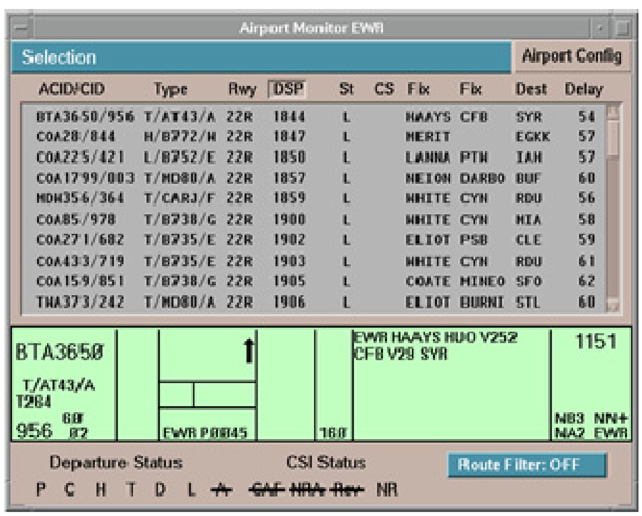


Figure 3. Departure Spacing Planner.

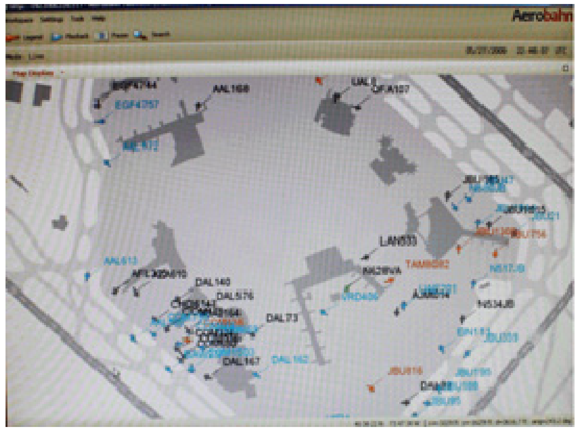


Figure 4. Sensis Aerobahn Display of ASDE-X Data.

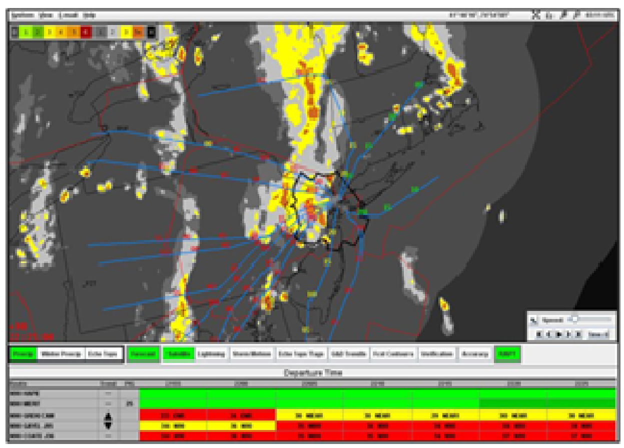


Figure 5. Corridor Integrated Weather System (CIWS) and the Route Availability Planning Tool (RAPT).

An additional issue with monitoring is the difficulty acquiring objective, real-time evaluation of TMIs. TMI restrictions are often put in place based upon “feel” or habit, without complete awareness of pending demand, because of the difficulty in accessing focused demand information at the time and place in which the decision is being made. As a result, TMI restrictions can be out of synch with demand, and departure throughput suffers. For example, a TMC may place an unnecessarily high MIT restriction on a route because that is the restriction normally applied. In another case, when a TMI passback is handed to the ARTCC from a neighboring facility, the TMC must determine how that affects what the facility does with the expected demand. A simple means of evaluation is counting the number of flights affected by the TMI. In some cases, the number is so low (e.g., one or two flights) that the TMI is not actually warranted. But determining the number of flights to count can be a tedious process of information integration.

Costs of System Failure. There is an increased TMC workload associated with initially acquiring the information and subsequently integrating these different sources of information. In addition, the more time spent on information integration, the less time the TMCs can spend on proactive traffic flow management decision making. If the monitoring function is poorly or incompletely managed, the TMCs may fail to recognize problems, and they are therefore not addressed.

2.1.2 Identifying and Predicting

Identifying and predicting demand, capacity, and constraints is the next function in the departure management functional loop. Recognizing the traffic demand that intends to fly from an airport along specific routes or through specific fixes of interest is critical to the TMC's system understanding. Similarly, recognizing the capacity of these resources is inherent to the process. Dynamic constraints such as weather, traffic management initiatives, and special use airspace usage may affect capacity such that the identification and prediction of these constraints is also important.

Difficulties. Certain information key to predicting demand is simply not available. Mechanical issues with the aircraft, crew availability issues, status of passenger boarding are all examples of areas that have major impact on a flight's readiness to depart, but the ability to capture and share this critical information is lacking. Effects of upstream weather on the ARTCC's demand and capacity are also difficult to identify and predict. In addition, when the air traffic control system becomes delayed, it affects future flight schedules and the flights' proposed departure times, changing the demand in unpredictable ways.

Another issue in identifying capacity is determining even whether a departure route is currently open or closed, and if open, whether a TMI has been issued for that route. One electronic source of information on the current state of departure routes is a Google Docs spreadsheet that is manually updated by ARTCC TMCs, and this source is used less by ATC facilities and more by airlines for information. The purpose of NTML is to electronically share restrictions, but this system is only sporadically updated because the information inputted does not provide the TMC inputting information any added benefit. The ARTCC TMCs use teleconferences to verbally pass information along to the other ATC facilities, who then verbally pass the TMIs on to controllers and/or input the information into the Information Display System (IDS). Thus, during busy periods, facilities may miss an announcement, and there are regularly facilities asking the status of departure routes on teleconferences.

Identifying and predicting constraints is also a difficult task. It is innately difficult to forecast dynamic weather. Weather impacts also vary with geography and traffic load, making these difficult to predict. For example, there may be situations in which arrivals deviating around weather utilize airspace normally reserved for departures. In today's environment there is also a lack of models to identify and predict volume congestion, particularly when there are significant weather impacts.

Costs of System Failure. The inability to adequately identify and predict demand, capacity and constraints can severely handicap the system. Poor demand estimates result in unused slots if the demand is estimated too high, and congestion if the demand estimate is too low. Not receiving the information that a departure route has reopened unnecessarily reduces system capacity. In addition, excess time spent assessing the state of departure routes means that the TMC spends less time pursuing proactive traffic management tasks. Poor information on constraints results in unanticipated deviations and route closures, late reopening of cleared routes (lost capacity), congestion leading to unanticipated, disruptive volume stops, reduced surface management efficiency, unnecessary reroutes, and excessive TMIs.

2.1.3 Evaluation

Evaluation of the potentially constraint-impacted capacity in relation to demand on the ATC resources is a key step in the process. Once the demand/capacity imbalance on these resources has been identified, the TMC develops a plan to address this imbalance. In a situation in which demand exceeds capacity, the plan can consist of rerouting a flight or set of flights, implementing a traffic management initiative, managing the excess demand within the sector through vectoring, departure metering and sequencing, or suggesting some other means of controlling demand to the particular resource. Alternatively, if the demand-controlling initiatives are no longer needed, the plan may be to rescind the traffic management initiatives and/or alternative routing strategy.

Often, the situation may not be resolved with a single action, but multiple subsequent actions may be required to balance demand and capacity across the airspace of interest. For example, if it is determined that a reroute is required off of a particular departure route due to weather, rerouting all flights onto a different departure route clear of weather may result in exceeding that departure route's capacity. A subsequent action is required to then balance demand/capacity on the second departure route.

Difficulties. Manually evaluating the demand/capacity imbalance can be incredibly time consuming. The TMC must identify the airspace and time of interest and interpret all of the information pertaining to it. Decisions about which traffic management strategies to employ are often heuristic-based, and they may not necessarily be the optimal means to manage demand in certain situations. When rerouting is recognized as the appropriate strategy to employ, identifying available route options can be difficult and time consuming due to the need to evaluate the feasibility of each alternative. Multiple, layered traffic management solutions may require a significant amount of time to solve and coordinate. It is also difficult for the TMC to generate plans to be robust to the situation evolution into the near future.

Costs of System Failure. Manual evaluation can result in missed opportunities due to lack of awareness of feasible alternatives. So many Coded Departure Route (CDR) alternatives exist that often TMCs default to two to three commonly used ones, which may or may not be the best reroute choices. Often, evaluation difficulties result in poor, reactive solutions that increase workload and confusion in the Traffic Management Unit (TMU), in other facilities, and in Flight Operations Centers (FOCs). Poor choices for reroutes can introduce congestion that spread problems to other routes, or they may be unacceptable to airlines, thereby requiring additional work to identify and coordinate other alternatives. Alternatively, if a plan takes too long to coordinate or no plan is implemented at all, a reactive "run to failure" stance may exist that closes routes unexpectedly. These last-minute closures result in increased delay due to disruption of current traffic patterns, No Route Available (NRA) flights in the queue on the airport surface, poor quality reroutes, and reroute assignment errors.

2.1.4 Coordination

Coordination may be required before the TMC's departure management plan can be implemented. He or she may be required to coordinate with floor controllers, other ATC facilities, or FOCs to determine the feasibility of the plan and/or whether the plan fully addresses the imbalance issue.

Difficulties. Coordinating reroutes can be cumbersome due to lack of good, shared information about demand and constraints between facilities. The TMCs also lack any good information (and occasionally any information at all) on preferences of the other ATC facilities and FOCs for different reroute alternatives. In many instances, it may be difficult even to communicate clearly the plan of action to all affected facilities.

Costs of System Failure. The lack of information and common situation awareness results in slowly executed reroutes or lower quality reroutes that have been coordinated on previous occasions. Long coordination time leads to excessive delay, NRA flights, stalled departure queues, and a general contribution to surface gridlock. Short notice reroutes create customer, Tower, TRACON, and ARTCC problems, including reduced trust and increased frustration in the Traffic Flow Management (TFM) system and resistance or inability to accept plans by TFM.

2.1.5 Implementation

Implementation of the plan can occur once the plan has been determined to be feasible. The plan must be executed using the traffic management actions available to the TMC (e.g., CDRs). Implementation may also include further coordination with floor controllers and other ATC facilities and/or electronic implementation of the plan.

Difficulties. The reroute execution process itself can be time-intensive. For example, when the TMCs receive a closure from the Departure Director position, they must identify the flights that were filed on the closed route (using DSP or pulling a flight list from the Traffic Situation Display) and then identify the reroute CDR for the city-pair. Or if no CDR is feasible, they must create an ad-hoc route in which high-altitude maps may need to be consulted to identify unfamiliar downstream fixes, compounding the time spent executing the reroute. Multiple parties are also required to confirm the reroute or at least be informed of it. In addition, the "paperwork" associated with reroutes can be repetitive and tedious.

Costs of System Failure. Cumbersome clerical procedures in the TMU and other facilities increase the time to implement a flight plan reroute. Extended amount of time to complete the reroute execution process leads to increased delays, more NRAs, and increased chance of surface gridlock.

2.2 PROGRESSIVE DECISION-MAKING IN DEPARTURE MANAGEMENT

The departure management functional loop described above is written from a tactical traffic management perspective. It is important to note that in departure management, the information used and the actions available to TMCs changes depending on how far in the future the demand/capacity imbalance is expected to occur. The table below gives an indication of how the information/actions available change as the expected demand/capacity imbalance approaches.

Table 1. Departure Management Decision Timeline

Time before expected demand/capacity imbalance	4 hrs	1 hr	30 min	In air
Demand data used	ETMS (scheduled)	ETMS (traffic in air now)	DSP/ASDE-X	ARTS/DSR/TSD
TM Actions (normal)	• AAR, GDP, AFP (SCC) • Runway configuration (Tower/ TRACON) • Staffing plan (All) • Schedule adjustments (Airline)	• GDP, AFP (SCC) • APREQ, DSP, TMA (ARTCC/ TRACON)	• Reroutes, MIT, TMA, APREQ, plan to vector (ARTCC/ TRACON) • Departure sequencing (Tower)	• Reroutes, MIT, TMA (ARTCC/ TRACON)
TM Actions (problem recovery)	Cancellations (Airline)	• GS (SCC) • Plan for diversions (ARTCC)	• GS (SCC) • Gate/taxiway holding (Tower/ airline)	Vectoring, holding, diverting (ARTCC/ TRACON)

Large cuts in demand are often made hours before the aircraft even depart. Scheduled ETMS data provides TMCs estimates of the expected demand. If large imbalances are predicted, the System Command Center (SCC) will get involved in issuing Ground Delay Programs (GDPs) and Airspace Flow Programs (AFPs). At other facilities, plans for staffing can be made, and the airlines may even make schedule adjustments, including cancellations.

At 1 hour ahead, much of the traffic is already in the air, so the ETMS predictions of demand for en route sector issues can be much more accurate. Even though it is much more accurate for en route traffic, ETMS data for departure routes is still questionable because the flights that will provide congestion for the departure routes in an hour's time have not yet departed. Anticipating demand/capacity imbalances, TMCs can continue to pursue GDPs for nearby airports, establish Approval Request (APREQ) restrictions, or establish DSP restrictions. If arrivals interact with the departure routes, Traffic Management Advisor parameters may be adjusted as well. With lesser imbalances, TMCs may decide, alongside the sectors, to handle the traffic without restriction.

Once the timeframe becomes tactical (15–30 minutes ahead of the expected imbalance), the expected departure route traffic is either taxiing to the runway or has just become airborne. It is in this tactical time period that ETMS demand data become less useful to TMCs, who begin to favor ASDE-X for surface traffic (if available) or DSP. As discussed in the functional loop section, TMCs have a variety of demand management techniques to use in this timeframe, including reroutes, MIT, APREQs, vectoring or even management through effective sequencing of departures.

When the demand/capacity imbalance is imminent, all flights are in the air at this point, and demand is best seen on the DSR, ARTS, and TSD, depending on the location of the imbalance. Actions that can be taken at this point may include rerouting and TMA adjustments, but also MIT.

At any point during the progressive decision-making process, TMCs could have misestimated the demand/capacity imbalance and/or a constraint changes the way it affects capacity (e.g., a thunderstorm has more impact than expected). At each timeframe, TMCs may use problem recovery actions to immediately halt demand and preserve safety. Cancellations, Ground Stops, and airborne holding are almost exclusively used to respond to demand/capacity imbalances that are larger than expected.

Thus, departure management progressive decision-making allows the TMCs to gradually become surgical in their demand honing to match the capacity of the system at the time. This process allows spreading of the impact and workload around the facilities, minimizing coordination required, and minimizing impact on the airlines. In addition, this progressive decision-making is a rolling process that is occurring for all timeframes constantly to effectively manage departures from now into the future.

From this discussion, it becomes evident that the primacy of data falls into different facilities as well. The most accurate expected departure demand lies first with the airlines, but once pushed back, with the Tower. The constraint information (weather situation, sector capacity) and the overall plan for the NY metroplex, on the other hand, lie with the ARTCC and the TRACON. Therefore, since IDRP is intended to address the impacts of en route constraints in the 30-minute (or when information quality supports it, 60 minute) timeframe, the tool must recognize this primacy of data issue in its function.

3. JUSTIFICATION FOR IDRP

The overall goal of IDRP is to aid the TMC in assigning the best available route to a flight at the right time, with limited impact on the overall departure airspace system. If it is determined that no acceptable route will become available in IDRP's predictive time frame, IDRP should provide information that enables traffic managers to manage the unavoidable delay as effectively as possible. To aid in the accomplishment of this goal, IDRP integrates the traffic, weather, and airspace resource information and projects the information into the future. In addition, IDRP identifies reroutes that are free of both traffic congestion and weather, in a form that can be implemented by the TMC. This allows the TMC to maintain common situation awareness, quickly identify problems that can be solved with high confidence, suggest feasible solutions and provide tools to reduce reroute coordination and implementation. The following section describes how IDRP will aid the TMC in the difficulties identified at each stage of the departure management functional loop in Section 2.1.

3.1 MONITORING

IDRP provides an integrated display of demand, weather and weather impacts, and airspace to aid the TMC in the monitoring task. The tool presents this information such that, at a glance, the TMC can immediately identify whether there is a problem with weather or congestion on the routes most commonly used. IDRP provides several views into departure demand forecast information: (1) the number of flights expected over a period of time on each of the commonly used routes and departure fixes, and (2) lists of pending departure flights that may be sorted, aggregated, and examined in several ways to provide demand information in a form against which to evaluate the TMIs.

3.2 IDENTIFYING AND PREDICTING

IDRP automatically identifies the resources and flights that are blocked due to severe weather constraints (when the RAPT displays red on its timeline) or due to traffic congestion. It also provides a means to identify departure routes that are closed/restricted. By identifying potential blockages in the future, IDRP reduces the chance that the system will "run to failure." IDRP also provides information that the TMC may use to determine when a reroute is a preferred alternative and routes that are clear, feasible reroute alternatives from a restriction, severe weather, and congestion perspective (e.g., when the RAPT display is green on its timeline, the route still has available capacity, and is "open"). In addition, IDRP automatically incorporates known capacity reductions into the route availability assessment. Known capacity reductions include identification of routes and flights in which human evaluation may be needed due to uncertainty about weather impacts (e.g., when the RAPT displays yellow in its timeline) and weather blockages in downstream facilities (i.e., outside of RAPT coverage area), which currently manifest in terms of TMI passbacks. This allows for a rational TFM solution for cases in which the automated route blockage detection does not capture the operational situation.

3.3 EVALUATING

IDRP automatically alerts users to situations of demand/capacity imbalance that require attention. The tool also immediately identifies reroute alternatives of high confidence and high quality for those routes affected by either severe weather or congestion. These "high quality" reroutes are ensured to be clear of closure, severe weather, and congestion, and they are also ordered based on customer preference and other optimization criteria (e.g., time of flight, statistically preferred). Decision support is also provided to open a closed departure route once the route clears of weather/congestion, through the use of the RAPT departure status timeline. If the IDRP best reroute alternatives are either not available or rejected, alternative reroutes are provided with additional information, allowing the TMC to investigate further. Evaluation and reroute recommendations for not only the present time, but also for a period of time into the future enable robust reroutes to be used, reducing the likelihood that multiple reroutes will be required. For the situations in which it is less clear whether a reroute is required (e.g., RAPT displays the route as yellow), further information (such as echo tops and trend information) is provided to aid the TMC in making a decision.

3.4 COORDINATING

IDRP aims to reduce coordination by preferring precoordinated reroutes during reroute suggestion. This reduces the amount of discussion required within or between facilities during reroute planning. By providing a means to log opening/closures/restrictions on departure routes, coordination about the state of departure routes can be significantly reduced. IDRP also provides a single, integrated source of information by which coordination and effective decision-making can be made.

3.5 IMPLEMENTING

IDRP enables an expedient reroute implementation process by automatically distributing feasible reroutes to all interested parties. It also provides tools to reduce the "clerical" tasks of rerouting. For example, IDRP's database would automatically identify an appropriate CDR for a city-pair, reducing the need to create reroutes by consulting high-altitude sector maps for appropriate waypoints. As IDRP evolves, it is expected that there will also be automatic implementation of reroutes at the ARTCC and any other facility as needed. An expanded set of reroute alternatives in later IDRP evolutions will also increase the likelihood of finding an acceptable automated reroute solution.

4. OPERATIONAL EXPECTATIONS OF IDRP

IDRP seeks to ensure that departures can be cleared for takeoff when they reach the head of the departure queue on the airport surface, without any operationally significant delays due to a lack of an available route. The tool provides value to the TMCs both in times of Severe Weather Action Program (SWAP) during which there are blockages due to weather, and in times of fair weather when route capacity may be exceeded by the demand for the routes.

IDRP will be fielded in a multi-phase process. The live prototype is being fielded as an extension to the existing RAPT platform. Phased updates, as knowledge is gained in the field, will allow IDRP to evolve to the full capabilities system. Evolution provides IDRP with several advantages. It initially allows IDRP to leverage RAPT's capability to automatically identify weather constraints, impacted routes, and routes clear of weather. A phased implementation of IDRP into RAPT reduces the training requirements for TMCs as compared to implementation of a separate, fully functional IDRP system. This initial phased implementation also allows all key facilities involved in NY departure management decision-making that are each already provided with RAPT displays (e.g., Towers, TRACON, ARTCC) to assess the prototype IDRP capabilities. To implement some of the full capabilities functionality of IDRP, significant procedural changes are required. For example, procedural changes are required to allow automatic implementation of reroutes from facilities other than the ARTCC. Phasing the IDRP into RAPT allows some benefits to TMCs to be realized immediately while the enabling procedures are given an opportunity to catch up to the IDRP additional functionality. Using RAPT as a live prototype gives IDRP access to RAPT's post-event analysis tools to evaluate IDRP usage and its performance. Operational benefits can be immediately assessed from the RAPT platform, and modification of the IDRP Concept of Operations can evolve based on TMC feedback and usage patterns.

4.1 PHASE 1: LIVE PROTOTYPE

A limited IDRP functionality was fielded in the 2010 summer using RAPT as a platform. The scope for this initial implementation was limited based on what functions were deemed implementable in the narrow 6–9 month window. Figure 6 illustrates the user interface fielded in the initial prototype, and highlights the IDRP functionality that was available.

IDRP functions were presented as an extension to the existing RAPT interface. The predicted 30 minute departure demand for each route was presented, partitioned by the RAPT status. The total predicted demand through the departure fix was also presented. Where fix demand exceeded the fix capacity limit (in the prototype, this was a site-adaptable parameter), the fix demand was flagged as excessive. This straightforward presentation of predicted demand, weather, and volume constraints enabled traffic managers to quickly assess the scale of the reroute problem and the readily available reroute capacity. It also provided information to allow the TMCs to quickly evaluate the TMI imposed and provided information with which to negotiate a reduced TMI (e.g., in the cases in which a 30 MIT restriction is implemented on a route, but the demand for that route is low, suggesting reduced [or no] restrictions may be more appropriate).

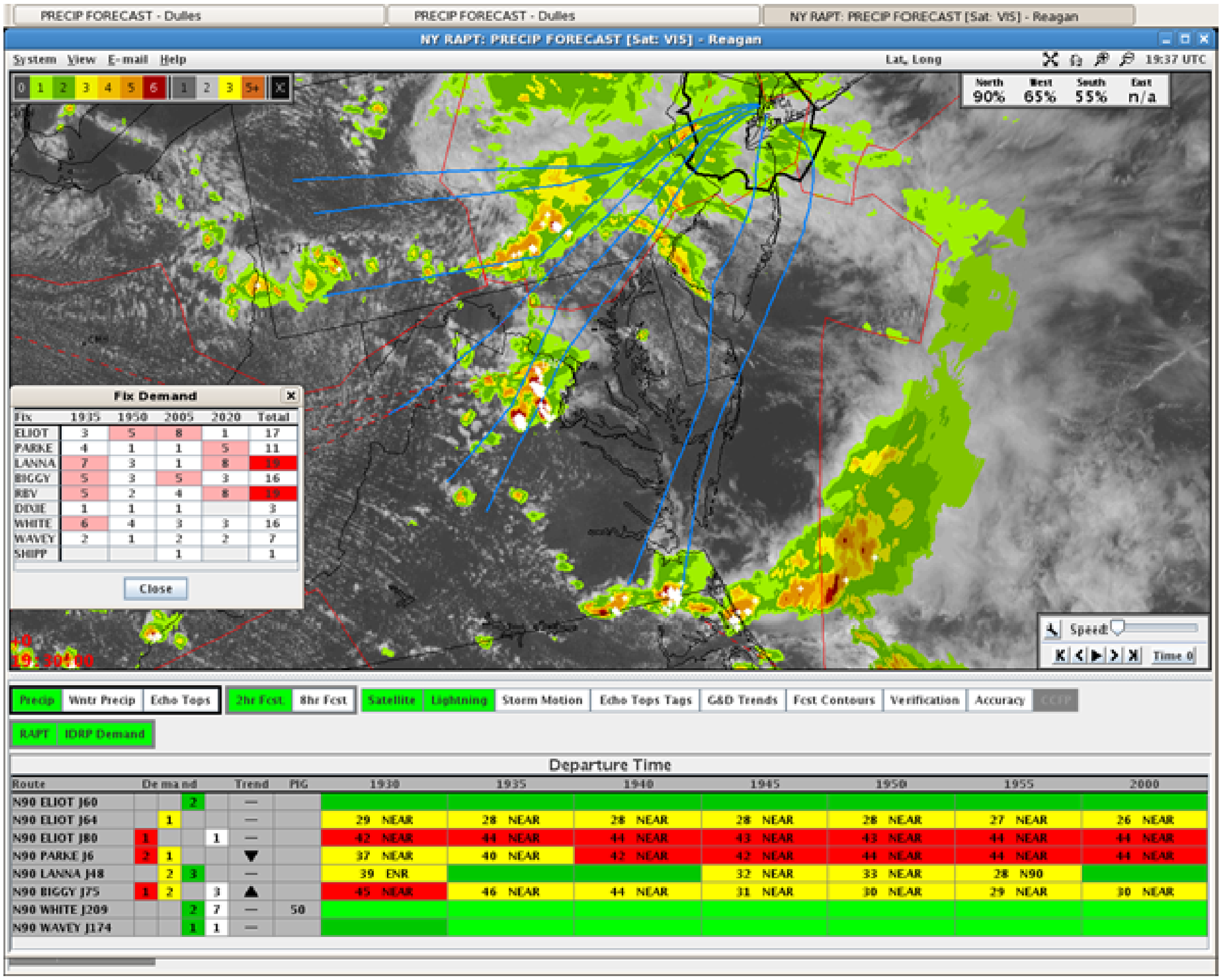


Figure 6. 2010 prototype IDRP interface.

Two additional means by which IDRP limited its scope in the prototype was through timeframe and route/reroute set. The initial prototype limited the prediction of demand and weather impacts to departure times up to 30 minutes into the future. This ensured that the demand estimates used by IDRP were reasonably accurate. This timeframe followed the lead of the ZNY TMCs, who reduce unnecessary disruption to flights by applying weather avoidance reroutes only to flights taxiing or in the departure queue. The limited timeframe also reduced the weather, demand, and congestion forecast errors that become unstable and operationally ineffective projecting beyond a certain timeframe. The congestion and weather impact evaluations probed to 45 minutes of flight time. This allowed the flight to clear the most highly congested regions surrounding the New York airports (ZNY and northern ZDC), and it also reduced uncertainty inherent in longer flight times.

The other means by which IDRP was scoped is by limiting the route/reroute set used to make recommendations on route alternatives. Weather impact evaluations were limited to only the current RAPT-eligible routes—those flights with greater than 1 hour of flight time and cruising above 25,000 ft.

The weather impacts were limited to convective weather only. However, traffic volume evaluation was performed on all routes. The CDRs that were provided as recommended alternatives were limited to the most commonly used routes, evaluated based on historical flight path analysis. The benefit to limiting CDRs to those most commonly used was that the rationale for using these was transparent to TMCs, they could be implemented without extended coordination, and these routes were generally acceptable to the customer.

During the summer 2010 field trial, it was discovered that the major issue with the initial IDRP prototype was the demand information used to provide the congestion estimates. The prototype used ETMS scheduled data to make estimates of route demand, which, as discussed in section 2.2, proved to be too inaccurate for the tactical time period in which reroutes would be made. Thus, the disparity between the IDRP estimates and DSP was so great that trust in the prototype could not be instilled. It quickly became clear that a source of surface data was required to provide IDRP adequate demand estimates for rerouting purposes.

Another issue observed during the field trial (and also during previous RAPT field evaluations in 2007–2009) was the confusion caused by lack of knowledge of the state of a departure route (open, closed, or restricted). Not knowing this information, facilities kept routes closed and restricted longer than they should, reducing departure efficiency. Since there is currently no adequate means of electronically sharing departure route state information, IDRP has the opportunity to allow input this information directly into the tool. Departure route state information could inform both RAPT (whether a route is a true Post Impact Green) and IDRP (whether a route is an open, viable option for reroute).

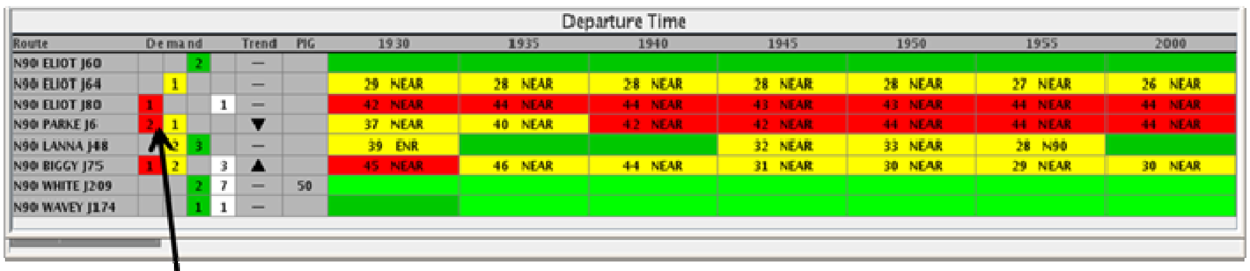
4.2 PHASE 2: FULL CAPABILITIES IDRP

IDRP will evolve primarily based on feedback, benefits, usage, and performance in the field. There are expected scope extensions to both the timeframe and route/reroute set as research is completed and better understanding of the field usage of IDRP is gained.

One of the initial IDRP functionality extensions is the ability to input departure route status into the tool. Besides achieving the recommendation benefits that reading the departure route status into IDRP would provide, by requiring TMCs to procedurally interact with IDRP on a regular basis, the tool will become more integrated into their decision processes faster than if this capability were not provided. This capability can be further extended to enable IDRP to forward status information to other NAS systems (e.g., NTML) to ensure the dissemination of resource status information from a single source to all parties and systems that require it.

Another potential opportunity for IDRP is to provide information to TMCs when a reroute should be considered, as opposed to, for example, an MIT restriction. Rerouting is a natural strategy when the original route is affected by a weather constraint. However, when the constraint is congestion-based, TMCs often prefer to use MIT restrictions rather than a reroute to reduce demand. According to fair weather benefit analyses performed, some missed opportunities to reroute from COATE J36 departure route to ELIOT J60 were discovered. Identifying the circumstances in which reroutes could be the optimal strategy when TMCs would naturally opt for a different strategy would be beneficial.

Another aspect of initial functionality will likely be an evaluation of routing for weather and congestion on a flight-by-flight basis once accurate demand information is utilized. A TMC could click on a route that RAPT has determined is “RED” and be presented with a list of the individual flights that have filed that route with suggested alternative routes. The flight evaluation functionality is consistent with the method TMCs address weather-based rerouting, in that they only reroute individual flights as they are taxiing or in the departure lineup rather than as a group when the route becomes unavailable. This averts the problem of possibly having to reroute a single flight multiple times. It also allows the TMC to reroute a group of flights onto multiple routes if desired to minimize congestion.



ACID	DEP	ARR	ETD	Suggested	Assigned
COA568	EWR	LAS	1943		EWRLAS64
AAL731	LGA	DFW	1952	COATE J26	

Figure 7. IDRP flight list allowing rerouting on a flight-by-flight basis.

There are inherent limitations to the timeframe of prediction due to forecast errors. However, it is possible that probabilistic demand estimates could be used. In the end state IDRP, the customer will have a much more active role in the reroute process. There will be preliminary notification of the FOCs about expected impacts and the set of reroutes potentially in play. Reroute alternatives will explicitly include customer preferences and ad hoc reroutes can be suggested and evaluated.

The route set extensions in the end state IDRP will include the evaluation of short-haul flights with less than 1 hour of flight time and the flights with low cruise altitudes. Evaluation and suggestion of tunneling routes through severe weather could be included in the end state tool, if the weather forecasts needed to support such assessments become available. However, these additions are conditional on the results of the benefits analysis of such extensions.

5. OPERATIONAL SCENARIOS

Two scenarios are presented below to describe how IDRP would function in two key situations. The first scenario is a convective weather situation in which RAPT would provide the impetus for a rerouting decision. The second is a situation in which congestion is the major factor and IDRP has suggested that rerouting is the optimal solution.

5.1 WEATHER SCENARIO

The ZNY TMC is monitoring the situation and IDRP alerts the TMC that PARKE J6 has gone RED in RAPT. The IDRP demand shows that several flights will be affected by the weather. Since the airspace is affected by weather for at least 45 minutes into the future, the TMC determines that rerouting would be the best traffic management option in this situation. But because the weather is only affecting a few flights, the TMC determines that he will keep the route open (thus minimizing inter-facility coordination). By selecting these red flights, reroutes are automatically suggested for these flights onto open, FOC-preferred routes, free of both weather and congestion. (FOCs were also warned by IDRP that reroutes could be possible and could prepare for the possibility of IDRP reroutes.) The TMC evaluates these reroute suggestions and accepts them, sending the new CDRs to the PIT through IDRP.

5.2 CONGESTION SCENARIO

The ZNY TMC is monitoring the situation and IDRP alerts the TMC that demand on ELIOT J60 is predicted to exceed the indicated capacity for that departure route. IDRP suggests that the best traffic management option in this situation is to reroute some of the traffic from ELIOT J60 to COATE J36. By selecting these flights, reroutes are automatically suggested for these flights onto open, FOC-preferred routes, free of both weather and congestion. Surveying the individual flight reroute suggestions, the TMC is able to change the reroute manually if he chooses, but decides to accept IDRP's suggested reroutes. The TMC sends the new CDRs to the PIT through IDRP.

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6. SUMMARY OF IMPACTS (COSTS)

IDRP tool is expected to have minimal negative impact on the operational environment. There is no additional monitor to be added to the Traffic Management Unit in the facilities—IDRP will function on the CIWS/RAPT monitor. The tool is not expected to add workload to the TMC. In fact, the tool is expected to lessen unproductive workload added by clerical tasks and information integration tasks. The primary impact occurs during development in which field observations of how the tool is used are conducted. Additional personnel are in attendance to perform the observations to aid in improving the system evolution.

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7. ANALYSIS OF SYSTEM (BENEFITS)

The system benefits expected by IDRP can be summarized as follows:

- IDRP reduces the monitoring loop time by integrating weather, weather impact, demand, and departure route status forecast information together.
- IDRP identifies problems earlier than a TMC could (upon the receipt of new weather, traffic, or departure route status information).
- The end state IDRP could identify situations in which a reroute is a better option than alternative traffic management initiatives, such as miles-in-trail.
- IDRP can identify a complex, multilayered reroute solution in time to coordinate the solution to implementation.
- IDRP reroutes incorporate more customer preferences than standard reroutes.
- IDRP reduces coordination by incorporating an interface to provide departure route status (closed, open, restricted).
- IDRP provides shared information about weather, departure route status, congestion, and reroute suggestions as a common base of information from which to negotiate, and this common set of information amongst facilities reduces coordination during this negotiation.
- IDRP reduces the time to implement a reroute with automatic reroute distribution capability and by automatically (rather than manually) identifying CDRs from its extensive database.
- IDRP could distribute the workload of rerouting amongst facilities (ARTCC, TRACONs, Towers) who require this action for a flight within their airspace.

IDRP may also have a limited set of disadvantages or limitations, including

- There will be limitations on the accuracy of timing, location, and severity of weather impact forecasts from RAPT due to the inherent uncertainty in forecasting weather and pilot decision making.
- IDRP automation cannot take into account impacts on NY operations due to downstream restrictions, congestion, or weather because this information is outside of the scope of RAPT/IDRP.
- IDRP cannot take into account the impacts on NY operations beyond the timeframe of 45–60 minutes because this is outside of the scope of the congestion/weather forecasting capabilities of IDRP.
- IDRP's departure route status information is limited by the participation of the TMCs, who are required to manually input the status into IDRP.
- IDRP's complex, multilayered reroute solution has the potential not to be transparent to the TMC such that it is may be difficult to trust that IDRP has found the correct reroute solution.

Functional alternatives considered in IDRP include whether or not to automatically alert the TMC to problems and/or suggest potential solutions. The correct decision on whether or not to automate must lie with the rate of correct detections and false alarms provided by the system.

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8. AREAS FOR RESEARCH AND DEVELOPMENT

IDRP's potential end state functionality reveals the need for substantial additional research before implementation in the prototype is suitable. The areas for research and development include weather, congestion, operational issues, and benefits identification.

8.1 WEATHER

Additional weather research is required to expand the severe weather evaluation from that of RAPT. Convective weather impacts and blockage models for low altitude, descending flights is a substantial research task, but would provide the ability to evaluate weather impacts for short-haul flights. Non-convective weather impacts would require study to extend weather evaluation beyond convective models currently in RAPT. The refinement of RAPT's blockage algorithms is ongoing.

8.2 CONGESTION

Automated congestion prediction exists, but requires evaluation and refinement based on field usage. Fair weather prediction and congestion prediction taking downstream weather into account is required for the prototype; however, the evaluation of congestion in severe weather will likely require extended study.

8.3 OPERATIONAL ISSUES

Better understanding of the airspace is required to develop a useful set of potential reroutes. Identifying the operational limitations to rerouting and how the set can be expanded within the current operational paradigm needs to be explored, even for the prototype implementation. Extensive study into how TMCs create ad hoc reroutes and in what situations this solution is appropriate also requires research for the end state system. Determining the procedural changes required to enable the full functionality of IDRP is another issue for exploration. The Concept of Operations, procedures, and decision support needed for higher uncertainty scenarios will likely require continued research as well. Further research is needed to identify the roles of the airline operations center in the concept of operations.

8.4 INTEGRATION WITH OTHER SYSTEMS

The conceptual and digital interfaces between IDRP and other systems related to departure management need to be explored and defined. These systems include the Collaborative Trajectory Option Program (CTOP, formerly SEVEN), eXecution of Flow Strategies (XFS), the Tower Flight Data Manager (TFDM), and others.

8.5 BENEFITS IDENTIFICATION

Objective metrics for evaluation of IDRP and the estimation of operational benefits is required even in the prototype and will likely be iterated as experience is gained in the field.

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GLOSSARY

AFPs	Airspace Flow Programs
APREQ	Approval Request
ARTCC	Air Route Traffic Control Centers
ASDE-X	Airport Surface Detection Equipment
ATC	air traffic control
CDR	Coded Departure Route
CIWS	Corridor Integrated Weather System
CTOP	Collaborative Trajectory Option Program (formerly SEVEN)
DSP	Departure Spacing Planner
ETMS	Enhanced Traffic Management System
FOCs	Flight Operations Centers
GDPs	Ground Delay Programs
IDRP	Integrated Departure Route Planner
IDS	Information Display System
ITWS	Integrated Terminal Weather System
NRA	No Route Available
RAPT	Route Availability Planning Tool
SCC	System Command Center
SWAP	Severe Weather Action Program
TFDM	Tower Flight Data Manager
TFM	Traffic Flow Management
TMCs	Traffic Management Coordinators
TMIs	traffic management initiatives
TMU	Traffic Management Unit
XFS	eXecution of Flow Strategies

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