The Route Availability Planning Tool (RAPT)

Evaluation of Departure Management Decision Support during the 2008 Convective Weather Season

Mike Robinson
Rich DeLaura
Ngaira Underhill

MIKER@LL.MIT.EDU
Motivation

2008 On-time Departure Rank of Major U.S. Airports (out of 32)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Airport</th>
<th>% On-Time Departures</th>
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<td>26</td>
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Need and Opportunity for Decision Support in Departure Management

- Arrival preference led to long departure delays, surface gridlock
- Departure queuing model suggested significant benefits for small improvements
- FAA began funding in FY2007
  - Component of NY Aviation Rulemaking Committee (ARC) ‘NY77’ initiatives under FAA administrator
  - ‘Flagship application’ for FAA Collaborative Air Traffic Management Technologies (CATM-T) initiative

Experience with New York Integrated Terminal Weather System (ITWS) prototype led to RAPT, Rev 1.0... funded by THE PORT AUTHORITY OF NYANJ
Outline

• Overview and Motivation

• RAPT Description

• 2008 RAPT Evaluation

• 2009 RAPT

• Summary
Basic RAPT Concept

Reduce the cognitive load needed to answer the question:

If at this time an aircraft is released on this route, will it encounter hazardous weather?

- Initial model was simple
  - Departure trajectory = fixed route from runway to jet route
  - Blockage = intersection with intense precipitation contour
  - Departure release decision assumed to be local (Towers, N90, ZNY)
- Refinement needed to capture complexities of real operations
RAPT Algorithm Overview

CIWS Echo Tops Forecast

Weather Avoidance Field (WAF) Generator

RAPT timelines: route status + blockage location + echo tops
ZBW, ZDC, ZOB: RAPT in TMU and Areas adjacent to ZNY

** COA EWR Ramp Tower and COA-Houston
Outline

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RAPT 2008 Field-Assessment

Facilities

Air Route Traffic Control Centers (ARTCC)
ZNY (TMU and Areas), ZBW, ZDC, ZOB

N90 TRACON

Traffic Management Coordinators (TMC)

Observers:
MIT Lincoln Lab
FAA Aviation Weather Office

Weather

Period 1, Day 1: 21 July
Period 1, Day 2: 22 July

Period 2: 15 August
Period 3: 09 September

11 Total Facilities
4 Convective Weather Days
39 hours of observations

COA RAMP
TOWER

LGA
JFK
EWR

TEB

ATCSCC

ZNY Supervisor Traffic Management Coordinator (STMC) Position
RAPT Observed Benefits
2008 Snapshot Examples

ZNY TMU: 21 Jul 2008 – 2015 UTC
- J95 pathfinder small deviation
  - Area concerned about running both J95 and J36
- RAPT used by TMU to convince Area to reopen J95

RAPT Benefits: RO, I/IC, EP, SA-1

ZNY Area B: 15 Aug 2008 – 2200 UTC
- Area B Sup, using TSD wx, thinks RBV will soon have to close
- Area Sup checks RAPT - predicts all RBV routes unimpacted in near-term
- Area Sup keeps RBV open, does not request MIT, and informs controllers of “no impacts expected” to ease tensions

RAPT Benefits: DOL, I/IC, EP, SA-2
**Estimated Annual RAPT Benefits Frequency**

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<th>2008</th>
<th>2007</th>
<th>&quot;Near-term&quot; potential</th>
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**Estimated Annual RAPT Benefits Occurrences**

**RO** Route Reopenings; Eased Restrictions  
**RRP** More Timely Reroute Planning/Implementation  
**DP** Directing Pathfinders  
**DOL** Departure Routes Open Longer  
**AHD** Proactively Resuming Arrival Flows  
**Decreased Airborne Holding**  
**PRSA** Proactive Runway Sequencing Assistance  
**EP** Enhanced Productivity; Reduced Workload  
**I/IC** Enhanced Inter/Intra-Facility Coordination  
**SA-1** Enhanced Common Situational Awareness  
**SA-2** Improved Awareness of Evolving Impacts  
**SA-3** Decision/Information Confirmation/Evaluation

### 2008

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<th>RAPT Benefit Category</th>
<th>Hours</th>
<th>Monetary Value ($)</th>
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<td><strong>RAPT Benefit Category</strong></td>
<td><strong>Primary</strong></td>
<td><strong>Downstream</strong></td>
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<td>2008 TOTAL</td>
<td>1,452</td>
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<td>2007 TOTAL</td>
<td>1,312</td>
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10 – 16% increased delay/cost savings from 2007

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<th>2008</th>
<th>Annual Jet Fuel Consumption Savings (Gal)</th>
<th>Annual Jet Fuel Cost Savings ($)</th>
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<td>TOTAL – freq/fuel</td>
<td>98,736</td>
<td>323,854</td>
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Decision-Making Environment: Context for RAPT Usage

- State of *arrival* streams can affect *departure* decisions
- TMU vs. Area route usage decisions
- Pathfinder procedures limit RAPT usage/benefits
- Airspace status uncertainty – unsure of NY airspace availability status ~950 times in 2008
- Lack Of Understanding (‘LOU’): coordinating facilities often unaware of the constraints and concerns of others

Full scope of ATM concerns guides development and provides context for RAPT deployment

RAPT provides critical information needed to increase understanding of SWAP constraints
RAPT “Post-Impact GREEN” (PIG) Missed Opportunities

- 4 – 8 RAPT missed opportunities per SWAP event
- Most common missed opportunity: more timely route reopenings based on RAPT “All Clear” forecasts
- Post – Impact GREEN ("PIG") = RAPT route ALL GREEN for >= 3 hours
- PIG Missed Opportunity if first departure on route is released >= 15 min after RAPT correctly predicts ALL GREEN
% PIG Missed Opportunities per “Route”
11 SWAP Case Days

1. COATE/GAYEL
   J36 / J95
   27%

2. ELIOT
   J60 / J64 / J80
   0%

3. J6 / J48 / J75
   13%

4. WAVEY
   43%

7 PIGs

15 Minute Departure Counts by RAPT Status

EWR
LGA
JFK

22 PIGs 20 PIGs 22 PIGs

75% 57% 63%

27% 0% 13% 43%
RAPT PIG Missed Opportunities Per Route Grouping

11 SWAP Case Days in 2008

- Total RAPT “PIG” Route Opening (RO) delay per SWAP day for all routes: 2.6 hours
- Estimated 2008 Early Departure Route Reopening (RO) delay savings: 225 hours
- Estimated 2008 RO delay savings, with additional PIG savings: 1534 hours (600% increase)
Potential Reasons of RAPT “PIG” Missed Opportunities

- Unaware of potential opportunity
- Routing workload / coordination
- Surface Complexity
- N90 volume
- Route status uncertainty
- Arrival traffic demand / deviations
- Decision pushback (risk management differences)

RAPT Can Assist In 2009
Outline

• Overview and Motivation
• RAPT Description
• 2008 RAPT Evaluation
• 2009 RAPT
• Summary
Refocused RAPT Concept of Operations

GREEN = GO
Open Route, Keep Open

YELLOW = JUDGEMENT
Reopen / Restrict Route
Under Guidance

RED = REROUTE
Route Blocked,
Plan / Maintain Reroute

Convective forecast

Route Status at Departure Time

OPEN

Monitor
Restrict / Reopen
Close

REROUTE

Route Planning
OPEN
2009 RAPT Display

Plane location along J95/J36 given a departure time of 05 min past the hour

RAPT Route Blockage Forecast Accuracy (by Departure Gate)

RAPT Route BlockageTREND

RAPT “Post-Impact Green (PIG)” Timer – minutes route has been ALL GREEN after route impact ended NEW NEW
## RAPT Evaluation Post-Event Analysis Tool

**High-Resolution Archives of:**
- CIWS Weather (Precip and Echo Tops)
- Traffic
- RAPT guidance

**NY Weather and Flight Track Movies**
(by 7AM next day)

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### Cumulative Daily Departures by Route Group vs. RAPT

**Compared with Fair-WX Traffic**

- **EWR J60, J64, J80 – 13 July 2008**

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<th>Date</th>
<th>Total PIG Events (All Rios)</th>
<th>Total PIG Period (Min)</th>
<th>Avg PIG Period (Min)</th>
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**Cumulative Daily Departures vs. RAPT**

**Compared with Fair-WX Traffic**

**EWR – 13 July 2008**

- **Cumulative fair-wx departures**
- **Cumulative departure count colored by avg RAPT blockage across all routes**

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**Departure performance summary by airport…**

- **No NY**
- **Swan**
- **P,** but strong weather elsewhere in East US
- **Clear or benign Weather**
  - **NY in SWA**
  - **Philadelphia**

---

**http://repeat.wx.ll.mit.edu**

**Account:** rapt
**Password:** rapture

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**RAPT vs. Departures**

**EWR-RELIOT**

**J60 – 13 July 2008**

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Summary

• RAPT combines CIWS weather forecasts with model for departure operations to provide decision support for departure management in New York

• Field evaluation in 2008 documented significant RAPT benefits and identified key operational issues

• RAPT in 2009 is using a refocused concept of operations to support training, increase user confidence, increase decision coordination, and address key missed opportunities

• RAPT post-analysis web tool supporting daily review and objective assessment of NY departure management performance