Enroute traffic overflows versus arrival management delays

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Network management

Ground delay applied to avoid traffic overflows

Regulated take-off time within [-5,10] min window
Arrival management, 100NM

Arrival management horizon around destination

Delay shift

Terminal area delay

En-route / ground delay
Arrival management, 200NM

Arrival management horizon around destination

Delay shift

Terminal area delay
En-route / ground delay
Arrival management, 300NM

Arrival management horizon around destination

Delay shift

Terminal area delay
En-route / ground delay
Arrival management, 400NM

Arrival management horizon around destination

Delay shift

Terminal area delay
En-route / ground delay
Network and arrival management: interactions?
State of the art

- Previous studies look at
  - Interactions between ground delay program and traffic management advisories [1, 2]
  - Distribution of delays between successive strategic and tactical process [4, 5]
  - Transfer of delay from terminal to en-route, extended arrival management horizon [3, 6, 7]
  - Terminal area delay for buffering uncertainties [7]

- Our contribution
  - Assess interactions of strategic and tactical management process created by the geographical arrival management extension

Conducted as part of SESAR2020 (PJ01-01)
Impact of arrival management delay on network (400NM)

Arrival management horizon around destination

Within regulated areas

Planned = 25

Arrival management delay

Actual = 26
How much traffic overflows?

Arrival management horizon around destination
Network management integration: reduced extension benefits?

Arrival management horizon around destination
Model: arrival management
Runway capacity

Arrival delay

Delay strategy
1- Terminal minimum pressure
2- Enroute upstream
3- Ground (within horizon)
4- Terminal

Model: arrival management

Arrival flight

50NM

400NM
Model: arrival management

Delay strategy

4- Terminal
3- Ground (within horizon)
2- Enroute upstream
1- Terminal minimum pressure
Model: integrate network management

Delay strategy
- 4- Terminal
- 3- Ground (within horizon)
- 2- Enroute upstream
- 1- Terminal minimum pressure

Runway capacity

Delay absorption capacity

Flight not crossing regulated area delay may apply until horizon

Arrival delay

Regulated areas

50NM

400NM
Model: integrate network management

Delay strategy

1. Terminal minimum pressure
2. Enroute upstream
3. Ground (within horizon)
4. Terminal

Flight not crossing regulated area delay may apply until horizon
Flight crossing regulated area delay may only apply downstream

Runway capacity
Arrival delay

Delay absorption capacity
Regulated areas

50NM
400NM
Experiment setup

- Top four European airports in 2017
- 50 days of traffic, 3 hours peak (individual)
- In total 25000 flights

- 10 experiments per traffic sample
  - 5 horizons: 0, 100, 200, 300, 400NM
  - Network management integration: Yes/No

- 50 days x 4 airports x 10 experiments
  = 2000 runs
Characteristics: regulations

Tracks and cumulated time in regulated areas (hour)

<table>
<thead>
<tr>
<th>EDDF</th>
<th>EGLL</th>
<th>EHAM</th>
<th>LFPG</th>
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Regulation duration (flight hour) 0 100
Characteristics: network management integration

Tracks and NM constraints

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NMconstraint – No – Yes
How much traffic overflows?

Arrival management horizon around destination
Overflows, 100NM

Without NM

Every 5 minutes, Number of flights planned and actual within regulated areas < 400NM
Overflows, 200NM

Without NM

Every 5 minutes,
Number of flights
planned and actual
within regulated areas
< 400NM
Overflows, 300NM

Without NM

Planned vs. actual flight counts

Every 5 minutes, Number of flights planned and actual within regulated areas < 400NM
Overflows, 400NM

Without NM

Every 5 minutes, Number of flights planned and actual within regulated areas < 400NM
Overflows

Without NM

Planned vs. actual flight counts

Actual - planned number of flights

Planned number of flights
Overflows

For each 5 minutes period, with planned flights > 20

Check if

- Planned = Actual,
- Planned > Actual,
- Planned < Actual

Report ratios

Actual vs. planned counts within all regulated areas

![Graph showing actual vs. planned count comparison for different regulated areas (EDDF, EGLL, EHAM, LFPG). The x-axis represents horizon (NM) ranging from 0 to 400, and the y-axis represents ratio ranging from 0% to 100%. The graph uses different colors to represent EQUAL, GREATER, and LOWER ratios.](image-url)
At 400NM, median overflow +5% to +7%

3rd quartile +9% to +11%

95th percentile +18% to +21%
Zoom on overflows

At 400NM, median overflow +5% to +7%

3rd quartile +9% to +11%

95th percentile +18% to +21%
Where are the overflows?

Overflow counts (horizon = 400NM)

Frankfurt Main
London Heathrow
Amsterdam Schiphol
Paris CDG

Sum of overflows per discretised areas (slices 50NM/20 degrees)

Total overflow per slice

0 65
Network management integration: reduced extension benefits?

Arrival management horizon around destination
Average delays, without and with integration, 400NM

Average delays and NM integration

Without

With

Tracks and NM constraints

Average delay (min)
Delay shift, without network management integration

Delays: average +/- standard deviation

3 minutes delay shift
Delay shift and network management integration

Delays: average +/- standard deviation

- Without:
  - 3 minutes delay shift

- With:
  - 1 minute delay shift
Delay shift and network management integration

Average terminal area delay, 400NM

Without integration: 1,8 minutes

With integration: 2,5 minutes

Without vs with: increase +42s, +40%
Conclusion

• Key results
  • Without network management integration, traffic overflows are observed
    • At 400NM, median traffic overflow about +5%, up to +21%
  • With network management integration, delay shift toward enroute and ground decreases
    • At 400NM, +42s average delay within terminal area (+40%)

• In perspective
  • Trade-off and level of performances expected in terms of capacity limits (tolerance) considering short term flow management measures may apply