Explore the Past to Improve the Future: How Airlines Can Benefit From Historical Data?

Cynthia Barnhart (MIT)
Virot Chiraphadhanakul (MIT)
Niklaus Eggenberg (EPFL, Switzerland)

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Agenda

- Airline operations: current state
- Robust Maintenance Routing Problem(MRP)
  - Definition of the problem
  - How robustness is defined
  - How to model/evaluate robustness
- Comparative results for robust MRP

Impact of disruptions (US)

- Total profit (07):...............$5.6 Billion
  - < 2% profit margin
- Total delay costs (08):......$41 Billion
  - 4.3 Billion hours delay
  - $19 Billion additional operating costs
  - $12 Billion passengers' value of time
  - $10 Billion spill out to other industries
- Pollution:.........................7.1 Mio tons of carbon diox.
  - 0.2% of total US emission in 2008, solely additional flight time due to delays

Robust Maintenance Routing Problem

- Modify existing maintenance routing by
  - Re-assigning aircraft to flights (rerouting only)
  - Retiming flights for same routes (retiming only)
  - First rerouting and then retiming
- Use different Objectives
  - Minimize total propagated delay
    - Requires historical data to estimate delays
  - Maximize total slack
  - Maximize minimum slack
- Limit total retiming by constant upper bound

Measuring Robustness

- Robustness of a solution depends on
  - Metric defining robustness
  - Model
    - Objective function
    - Way objective is modeled
    - Way the model is solved
  - Evaluation
    - A priori and/or a posteriori evaluation
    - Used performance metrics to evaluate
  - Data
    - Airline type (network structure, disruption management,…)
    - Historical data used in model

Evaluating a robust MRP

- According to initial a priori metric
  - Total slack
  - A priori estimations on delay propagation
  - Effects of retiming (lost connections/passengers
- Evaluate on a posteriori statistics
  - Aircraft statistics
    - Propagated delay
    - 15 or 60-minutes on-time performance
  - Passenger statistics
    - Number of disrupted passengers
    - Number of canceled passengers
    - Total passenger delay

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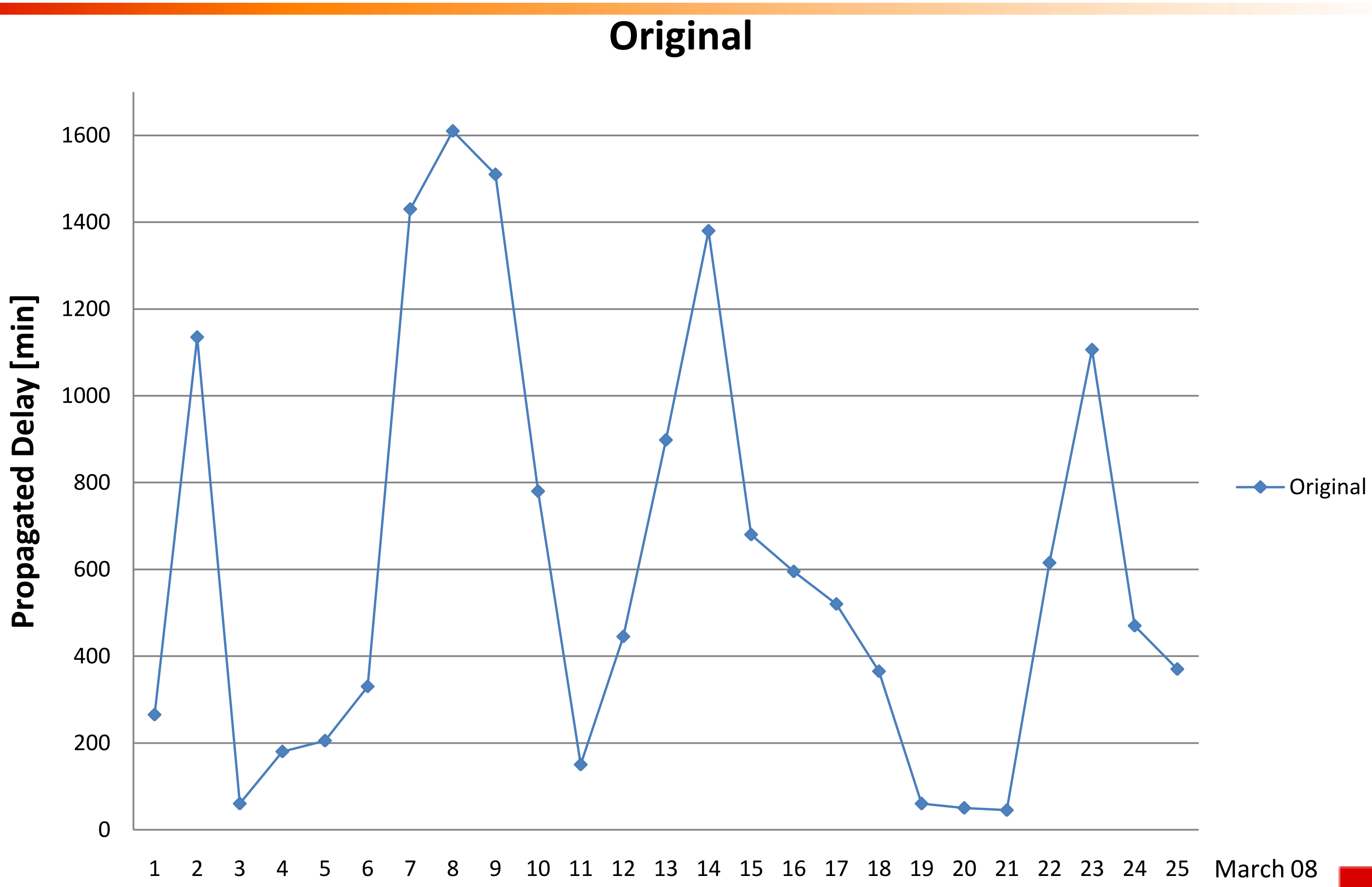
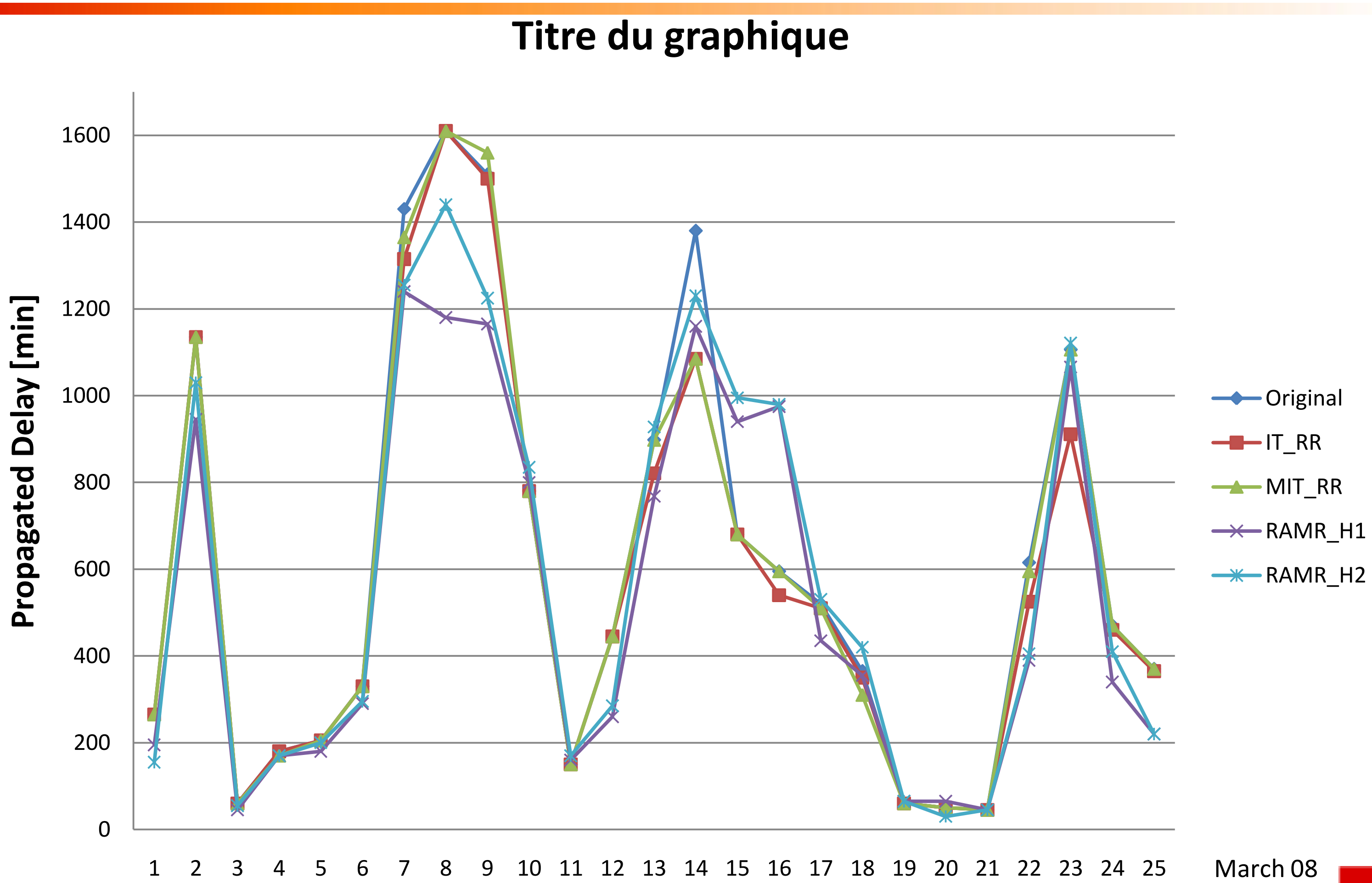
Used models

- Myopic methods (no historical data)
  - IT: maximize total slack (RR or RT)
  - MIT: maximize minimum slack (RR or RT)
- Models using historical data
  - RAMR: minimize propagated delay then maximize slack by rerouting only (H1 or H2)
  - RFSR: minimize propagated delay and total deviation from initial schedule (H1 or H2)
- Ways to use historical data
  - H1: min average propagated delay on historical data
  - H2: min propagation of average delays

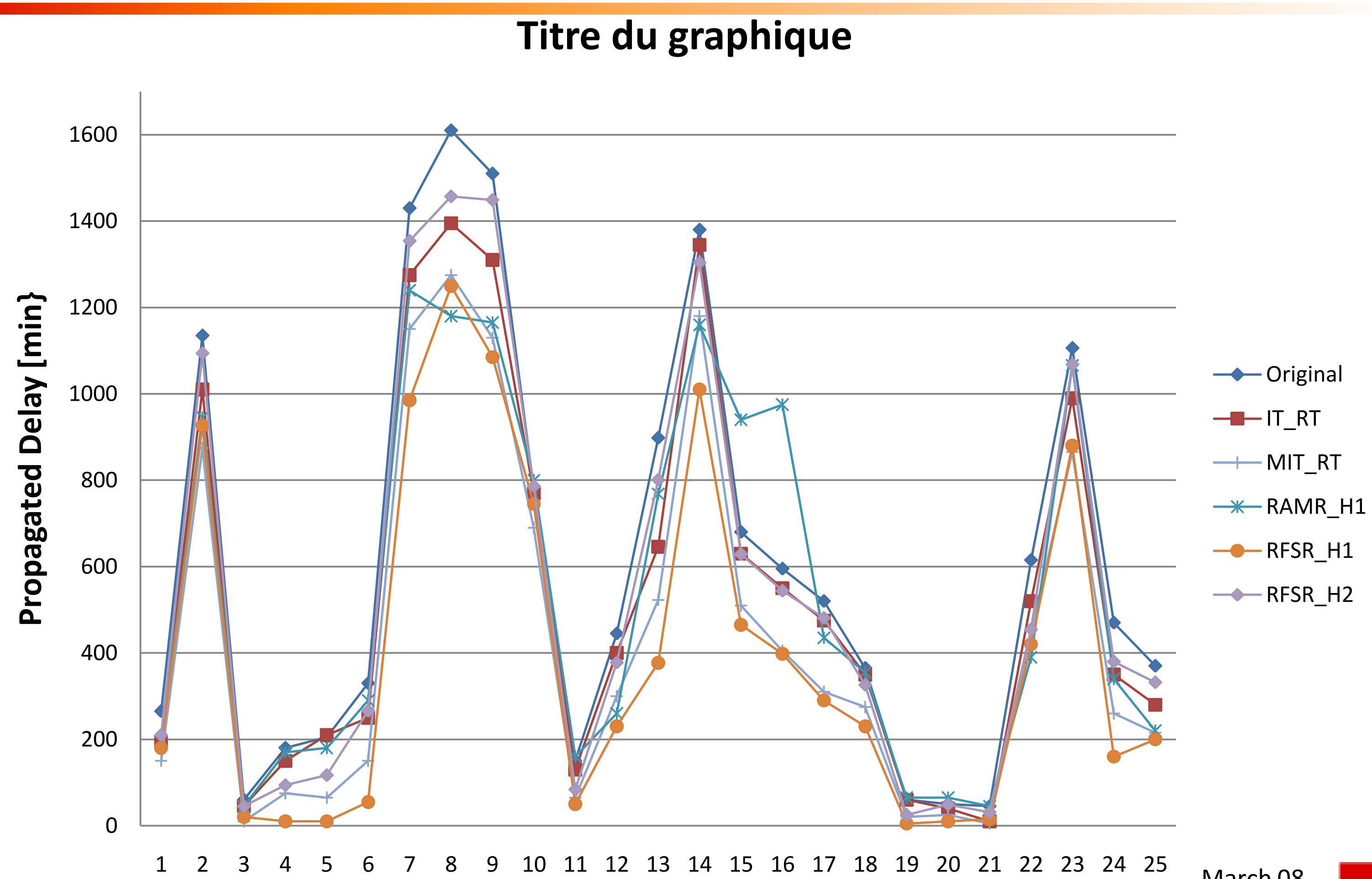
Propagated Delay – Original Schedule



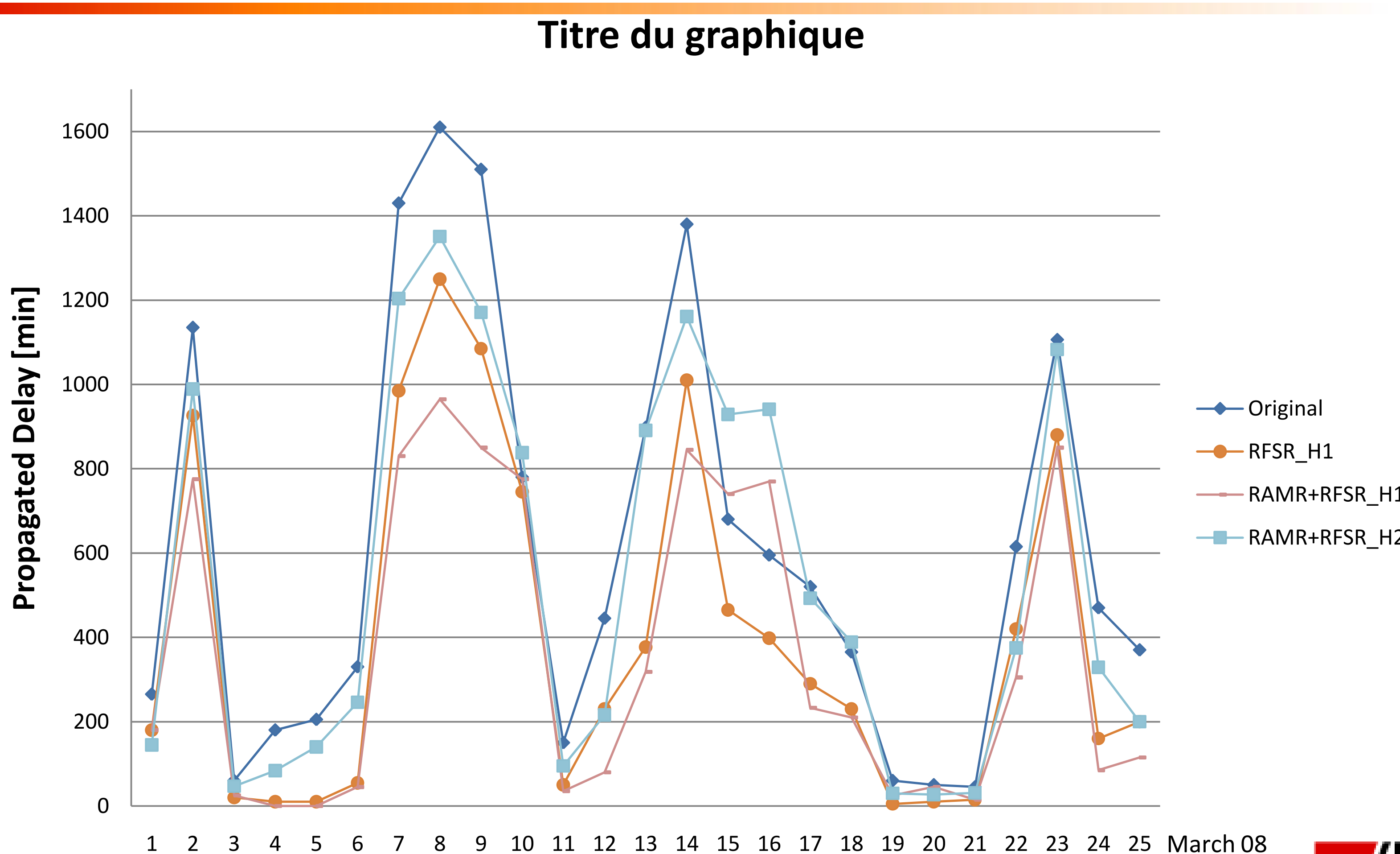
Propagated Delay – Rerouting only



Propagated Delay – Retiming only



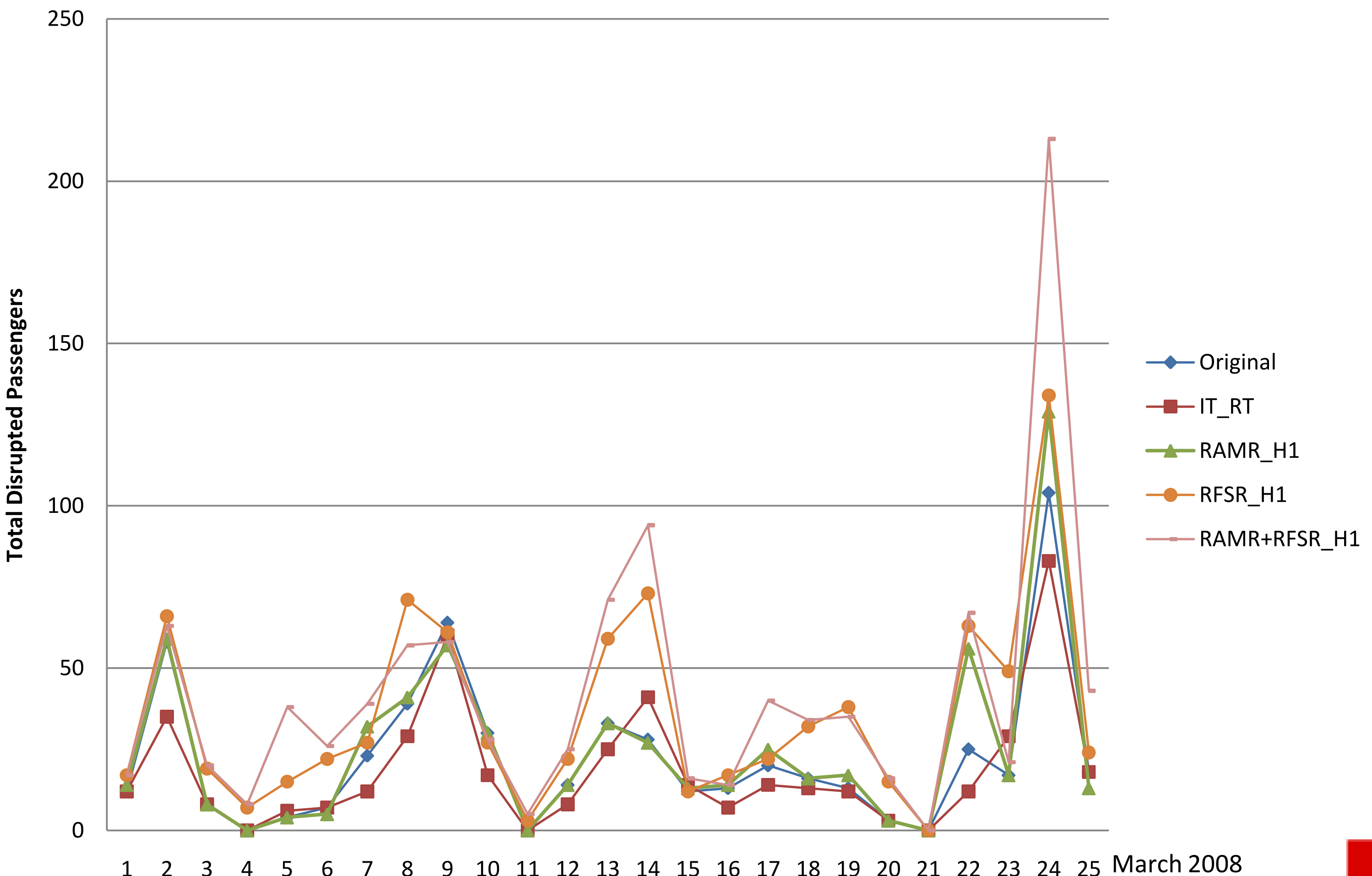
Propagated Delay – Rerouting and retiming



Observations so far

- Retiming allows for higher propagated delay reduction
- H1 lead to better results than H2
- Myopic rerouting barley improve the original schedule
- Myopic retiming models are not reducing propagated delay as much as other models
  - Knowing where to place the slack allows for further reducing slack

Number of disrupted passengers



Conclusions (1)

- More robustness is useful, but has to be well defined
- Using historical data helps
  - BUT: most intuitive way is not most efficient
- Myopic solutions are not as efficient w.r.t. delay propagation
  - BUT: way better in terms of disrupted passengers

Conclusions (2)

- Q: Which model is most appropriate?
- A: It depends what metric(s) the airline wants to improve!

Thank you for your attention!

Any questions?