

Air-rail multimodal disruption management

Rail network supporting air disruptions

Michał Weiszer¹, Luis Delgado¹, Lucía Menéndez-Pidal²

¹University of Westminster

²Nommon Solutions and Technologies

SIDs 2025

Introduction – Managing disruptions

- Reallocating passengers to mitigate delays and stranded
- Consider door-to-door itineraries
 - ▶ maintain route with alternative service
 - ▶ using different routes
 - ▶ consider different start/end infrastructure nodes
 - ▶ using different transport mode

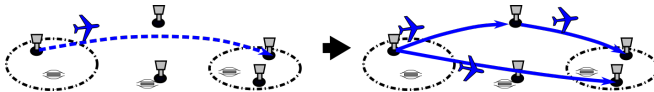


Figure. Reallocation of passengers in case of disruption

Introduction – Managing disruptions

- Rail could help mitigate air-network disruptions
 - ▶ Substitution
 - ▶ Multimodal



Figure. Substitution of fly by rail alternative

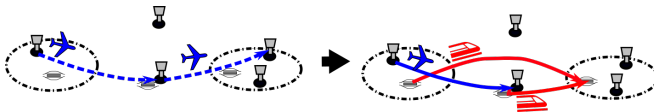


Figure. Potential miss connection substituted by rail or multimodal journey

Introduction – Managing disruptions

- Disruptions with enough anticipation
 - ▶ industrial actions
 - ▶ reduced capacity
 - ▶ airport closures
- Flexibility on rebooking passengers
 - ▶ from keeping operator and route
 - ▶ to full flexibility

This work is part of MultiModX project: Integrated passenger-centric planning of multimodal networks

- Aim:
 - ▶ Performance Framework: strategic and tactical evaluators
 - ▶ Schedule Designer: Future Air-Rail Schedule Design
 - ▶ Disruption Manager: Future Air-Rail Disruption Management
- <https://multimodx.eu/>
- Open code on GitHub



Co-funded by
the European Union

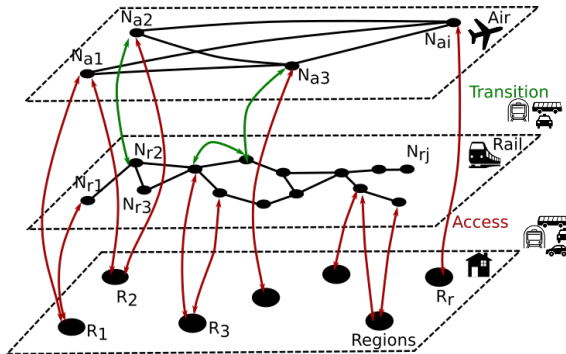


Replanning of passenger itineraries

1. Network modification (replanning of operations, delays and cancellations),
2. Identification of the status of passengers impacted by the replanned operations,
3. Estimation of available capacity on remaining services,
4. Computation of possible alternatives in the replanned network
5. Reassigning passengers to the possible itineraries.

Possible alternatives in the replanned network

- Origin/Destination Regions;
- Nodes (stations, airports) with access/egress;
- Transitions (minimum connecting time , passenger processes);
- Services with remaining capacity.



Passenger assignment flexibility

Keeping mode



Figure. PA01 – Maintain operator and path

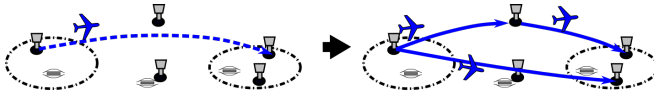


Figure. PA02 – Allow different path

Passenger assignment flexibility

With mode swap

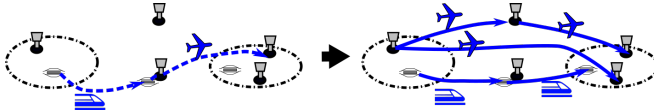


Figure. PA03 – Allow mode swap (with the same operator)

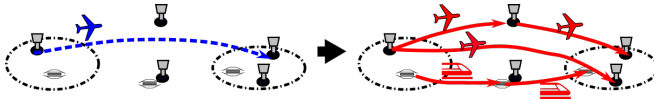


Figure. PA04 – Allow operator change

Passenger assignment flexibility

Alternative	Description
PA01	Close to planned (same operator and path)
PA02	Allow different path
PA03	Allow different path and mode swap
PA04	Allow different path, mode swap and different operators
PA05	Allow different path, mode swap, different operators, and to leave origin earlier than initially planned

Spain case study



Figure. Spanish NUTS-3 regions.

- Demand flows between the 49 largest cities (MND)
- and flows from international flights to/from Spain (AviationWeek).
- for single day in September 2019.
- Access and egress time based on population centroids.
- The accessibility of nodes from the NUTS from MND.
- Trains from UIC/flights OAG.

Disruptions at LEMD

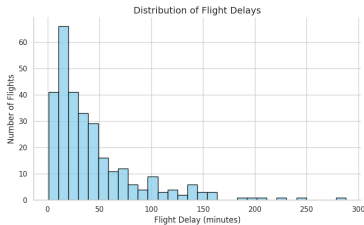
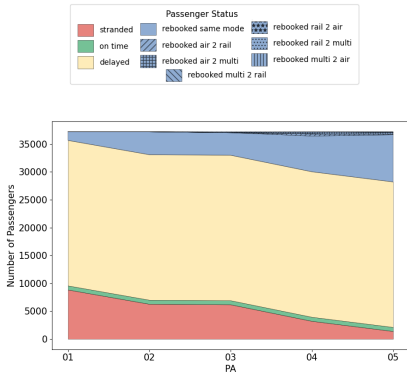


Figure. Distribution of delay for delayed flights due to ATFM in Industrial Action (IA)

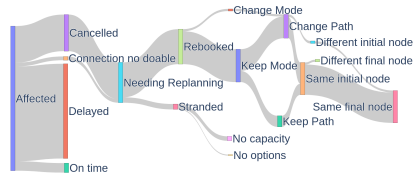
- The disruptions at LEMD consider:
 - ▶ Industrial action: flight delays and 7.5% cancellations,
 - ▶ Significant cancellations:
 - ▶ 25%
 - ▶ 50%
 - ▶ 75 %
 - ▶ 100 % (closure)

Industrial action at LEMD

Industrial action at LEMD



- Increased flexibility reduces stranded passengers
- With maximum flexibility (PA05), only 0.2% of passengers are stranded



Industrial action at LEMD

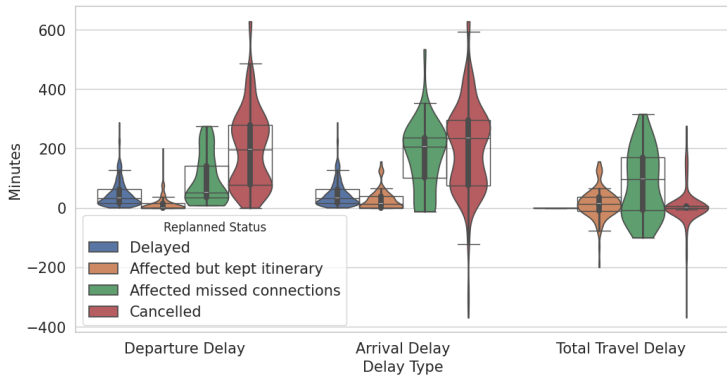


Figure. Passenger delay for PA02

Industrial action at LEMD

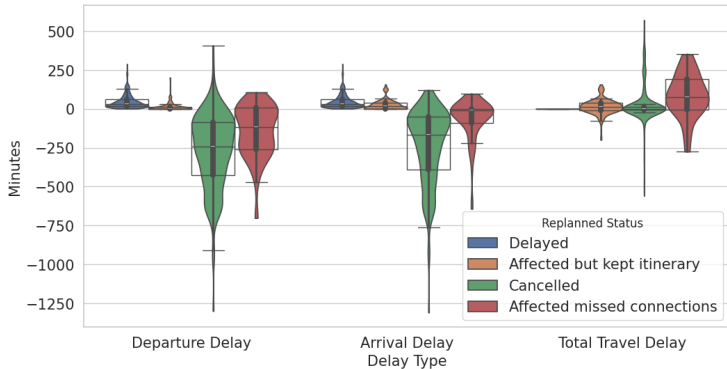
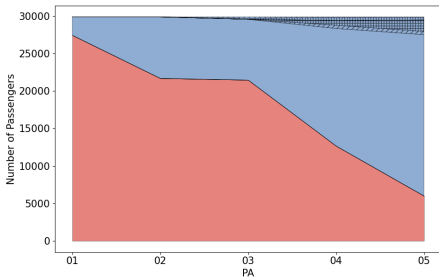
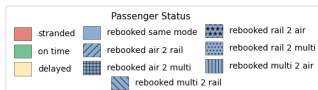


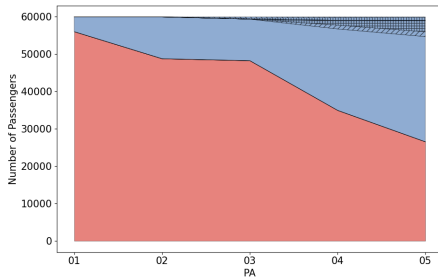
Figure. Passenger delay for PA05

Cancellations of flights

Cancellations of flights

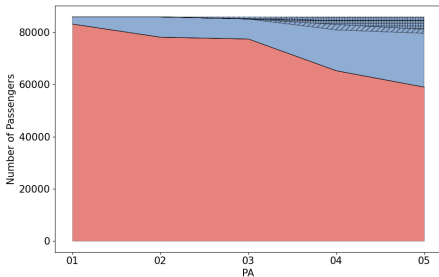
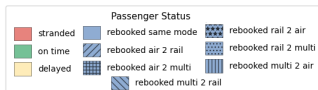


(a) C25

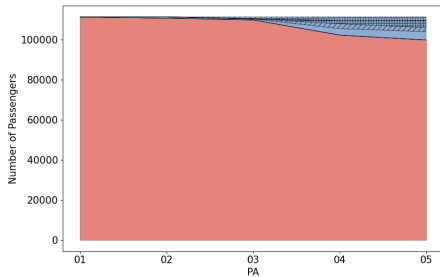


(b) C50

Cancellations of flights



(c) C75



(d) C100

Cancellations of flights

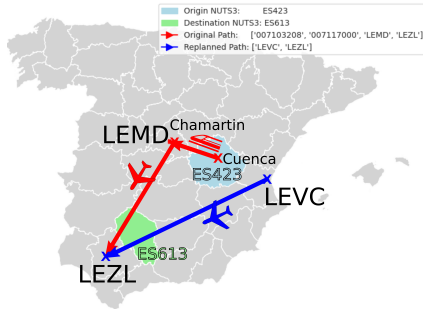


Figure. Example itinerary replanned in C100 (PA05).

- Lack of options due to lack of rail capacity.

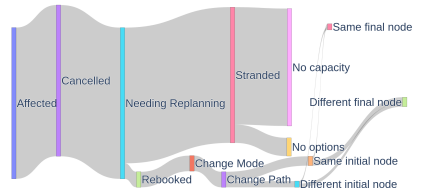


Figure. Distribution of itineraries status for C100 (PA05).

Increasing capacity of trains for closure of LEMD
(100 % cancellation)

Increasing capacity of trains

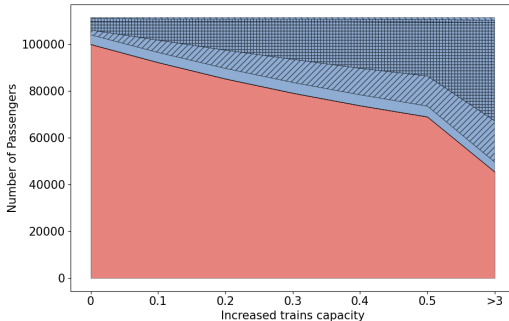
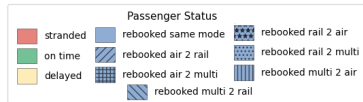


Figure. Sensitivity analysis of providing extra train capacity in C100.

- Increasing rail capacity improves reaccommodation rates.
- Demonstrates strategic value of maintaining reserved extra rail capacity.

Conclusions and future directions

- Evaluated replanned multimodal mobility networks
- disruptions at LEMD: industrial action, cancellations
- **Model Capabilities:**
 - ▶ Finds alternative itineraries for affected passengers.
 - ▶ Computes PIs considering door-to-door journeys.
- **Key Findings:**
 - ▶ Increased flexibility reduces stranded passengers:
 - ▶ Majority reaccommodated within the same mode.
 - ▶ 7–8% consistently shifted to rail across all scenarios.
 - ▶ Constraints due to:
 - ▶ Lack of alternatives for international flights.
 - ▶ Limited rail capacity for increased intra-Spain demand.

Conclusions and future directions

- **Sensitivity Analysis:**

- ▶ Increasing rail capacity improves reaccommodation rates.
- ▶ Demonstrates strategic value of maintaining reserved extra rail capacity.

- **Future work:**

- ▶ optimisation of replanned services,
- ▶ the importance of the access/egress of airports reviewed.
- ▶ alternative paths via complementary international hubs explored,
- ▶ the criticality of links identified,

Thank you!

