

# Energy Efficient Timetabling

Similarities & differences between aviation and railways – a high level overview

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20 February 2018 | Version 1.0 | Status Final



# Scope and contents

## Scope:

- High level, **simplified** comparison between “timetabling” and journey planning in aviation and railway sector.
- **Not** in depth presentation, all details are ignored.
- Purpose to show main aspects in relation to Energy Efficient Timetabling.

## Contents:

- Main principles of Flight Scheduling.
- Main principles of Flight Planning.
- Comparison aviation and railway, similarities and differences.
- Conclusions.



# Main principles Flight Scheduling

- Yields the published **timetable** and is based on average (generic) conditions and normal variations (for example due to headwind or tailwind, congestion at airports) such that the timetable is achievable. In the USA airlines are forced by law to publish a realistic timetable.
- Based on an average balance between minimum flying time and minimum fuel use (cost).
- Airport capacity (available departure and landing slots) and commercial needs of airline (time of flights and frequency) need to be brought in balance, especially in peak hours.
- Typical margins of 15 minutes or more in departure and arrival times are normal and accepted by passengers. Margins also applied to prevent cost of delays and missed connections under normal conditions.
- Is much similar to the **timetabling** process for railways, but with much bigger margins for uncertainties in the actual conditions when scheduled flight takes place.

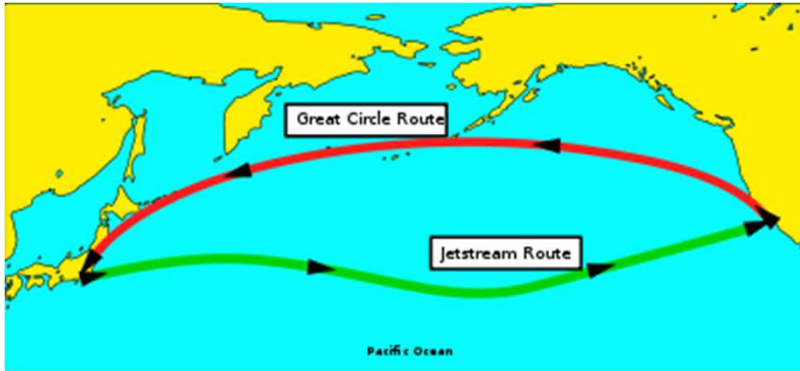


# Main principles Flight Planning

- Detailed planning or rescheduling of the actual flight short before and during flight by Operations Center to optimize operation, mainly cost driven (but takes all cost into account, not only fuel).
- Actual conditions taken into account, includes negotiation with ATC.
- Cost Index used to set priority (trade off) between (minimum) flying time and (minimum) fuel usage.
- Trade off includes possible cost of delays and missed connections A missed connection can cost up to 1000,= USD.
- Is similar to **dispatching**, **driving strategy** selection and **traffic management** processes for railways.
- Typical duration of flight > 1 hour, time for optimization during flight.
- Typical ride between 2 stops for train < ½ hour, limited time for optimization during ride.



# All to create best conditions and to avoid costly inefficiencies (congestion, strong headwind, delays, holding patterns, passengers missing connections)



Most (fuel) efficient route depends heavily on direction and speed of wind on cruising altitude.  
Great Circle is shortest, but heavy tailwind will compensate the longer distance of Jetstream Route.



Busy day over Europe...congested airspace.



In holding pattern to wait for landing slot:  
costly waste of time.



Irritated passengers who missed their  
connecting flight...

For an airline, good flight planning means the difference between making money or losing money on flights.



# Comparison aviation and railway, similarities and differences

## Aviation

### Flight Scheduling

- Margins of up to 1 hour
- Average (generic) conditions
- Published to the public

### Flight Planning

- Margins of up to 15 mins
- Specific conditions
- Flight Plan and Route Clearance

### Flight Optimization

- During flight
- Pilot or Ops center invoked
- Total cost optimization

#### Aviation:

- Primarily cost driven (trade-off between on time and fuel cost based on total cost).
- Cost Index in Flight Management System used to enforce best flight plan based on optimization of total cost.
- Typical flight > 1 hour, time for optimization during flight.

## Railways

### Timetabling

- Margins of up to 5 minutes
- Detailed route and rolling stock characteristics
- Published to the public on the minute

### Dispatching

- Margins of up to 1 minute
- Specific conditions
- Take into account connecting trains (more from service than from cost)

### Journey optimization

- TMS
- C-DAS
- Manual driving strategy
- On time main driver, energy secondary driver

#### Railways:

- Primarily on time (punctuality) and service driven, energy cost is secondary.
- Smooth traffic flow also taken into account, but not primarily from a cost optimization point of view as in aviation.
- Typical ride between 2 stops < ½ hour, limited time for optimization during ride.



# Conclusions

- Timetabling, Dispatching and Journey Optimization play an important role in both aviation and railway planning and operation.
- Flight Scheduling is more generic and with relative big margins, as actual conditions during flight may differ substantially from average conditions used in scheduling process.
- However, main optimization criteria are different:
  - Aviation: total cost is driving factor, with punctuality and service as secondary criteria, cost are mainly determined in Flight Planning (dispatching) phase and during flight .
  - Railways: punctuality and service are driving factors, cost are mainly determined in timetabling phase (seating capacity, available running time margin for ECO driving) and during ride (decisions of rail traffic control and driving strategy of train driver).
- It may be of interest to the railway sector to investigate the need and possibility to take total cost into account in all phases and decisions, especially in the (upcoming) era of C-DAS and ATO: wrong or incomplete optimization criteria can cause huge unnecessary cost.

