Energy-efficient timetabling at NS

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UIC Energy-efficient timetable planning, Brussels, Belgium
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- Introduction
- Project DINT
- Project running times
- RailwayLAB
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Introduction

- Current timetable is not always conflict-free and realizable for train driver
- There is a need to improve our current way of timetable design:
  - Improve on-time running
  - Increase capacity
  - Decrease energy consumption
- Different projects to improve our timetable design methodology:
  - Project DINT
  - Project running times
  - RailwayLAB research
  - PhD research on EETC & EETT
Project DINT (1/5)

- Current timetable is developed and delivered in full minutes
- For improving on-time running, timetable fractions for train drivers (arrival) and train conductors (departure) should be separated and on smaller intervals
- Develop timetable in 1/10 min (6 s) accuracy
- Better for executing the timetable by train drivers and train conductors & provides more realistic slack time distribution

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Project DINT (2/5)

- By-pass in timetable design process (only 2-monthly amendments) since 2016 (Viriato/DONS)
- Pilot with Smart Watch for train conductor to departure exactly on time, counter starts at 35 s and disappears at 15 s
- Current research: project PINT (planning in Donna in 1/10 min)
- Energy savings only DINT: 2% in 2016
- More energy savings achieved combined with DAS RolTijd App at least 4% extra (up to 6%)
Project DINT (3/5)

Example

Current timetable in full minutes

<table>
<thead>
<tr>
<th>Soort</th>
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<th>Tot</th>
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<tr>
<td>Ut</td>
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Improved timetable with 1/10 minutes

Difference with current timetable

1. Planned times in s
2. Short stops divided into arrival and departure
3. Some arrivals are earlier
4. Extra information (dwell time, running time, supplements, speed advice, etc.)

Energy-efficient timetabling at NS
Project DINT (4/5)
Process with “by-pass” to generate 1/10 min timetable

Planning

BUP in whole minutes (Donna)

*24h

BD in whole minutes (Donna)

*365 days

SD in whole minutes (Donna)

Traffic control

Execution of the timetable in 1/10 minutes

BUP in 1/10 minutes (DONS)
Project DINT (5/5)

Results

Full minutes

1/10 minutes
Project running times

- Investigate how to compute running times and slack time
- Computation of running times:
  - Minimal
  - Total with slack time
- Computation of slack time:
  - Amount
  - Distribution
- Current results:
  - Use smaller time fractions for timetable (1/10 min)
  - Minimal running times: MA, CR (speed limit), MB (0.5 m/s²)
  - Apply 8% slack time without rounding to full minutes
  - Distribute slack time equally over trajectory
RailwayLAB (1/2)

- RailwayLAB: ProRail + NS innovation departments
- Focus: serious gaming, simulation and planning
- Planning in seconds instead of full minutes
- Timetable performance indicators (start with feasibility)
- Checking both scientific research + market consultation + European infrastructure managers & train operating companies
- Result: focus on microscopic timetable design & simulation
- Pilot with RailSys:
  - Aim: gain insight into microscopic timetable design and simulation and compare this with current timetable design process
  - Active participation of timetable planners NS on case Oude Lijn
  - Comparing conflict detection based on norms vs. block overlap
  - Analysing effect conflicts with deterministic simulation
Intermezzo: conflict detection (macro vs. micro)

Macroscopic: detection at timetable points based on norms (headway times) by Donna

<table>
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<th>Opvolgtijd in minuten</th>
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<tr>
<th>Tabel 2</th>
<th>Overkruistijd in dezelfde richting in minuten</th>
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<table>
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<th>Tabel 3</th>
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<td>6</td>
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Microscopic: detection based on block occupation
RailwayLAB (2/2)

- Direct feedback with RailSys whether timetable is feasible by checking conflicts and speed profile
- Insight in effect distribution running time supplements for train driver
- Possibility for planners to apply deterministic simulation to see effect of possible conflict
- Potential: compute energy consumption of developed timetable
- Improvement DONS: including block occupation + conflict detection
PhD research on EETC and EETT

- PhD research about energy-efficient train control (EETC) and energy-efficient train timetabling (EETT)
- PhD research commissioned by NS & conducted with TU Delft
- Aim thesis: develop design principles for energy-efficient timetables by considering total running time + robustness timetable
- Current research results mainly for EETC:
  - Literature review and optimal control theory
  - Comparing different (eco-)driving strategies
- Research on EETT still in progress

Invited Review

Review of energy-efficient train control and timetabling

Gerben M. Scheepmaker\textsuperscript{a,b,a}, Rob M. P. Goverde\textsuperscript{a}, Leo G. Kroon\textsuperscript{c,d}
Conclusions

■ Project DINT:
  • Improving timetable by smaller time fractions
  • Currently by-pass, in future in timetable model

■ Project running times:
  • Focus: computation of running times for timetable design
  • Smaller time fractions
  • 8% slack time and equal distribution

■ RailwayLAB:
  • Collaboration between NS and ProRail Innovation
  • Research microscopic timetable design and simulation

■ PhD research:
  • Developing design principles for energy-efficient timetabling
Questions?

Thank you for your attention!

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