RAIL TRAFFIC FLOW OPTIMISATION BY KRONECKER ALGEBRA FOR IRISH RAIL

DESTination Rail: Decision Support Tool for Rail Infrastructure Managers

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DESTination RAIL
Decision Support Tool for Rail Infrastructure
EU Project No. 636285

DESTination RAIL facts:

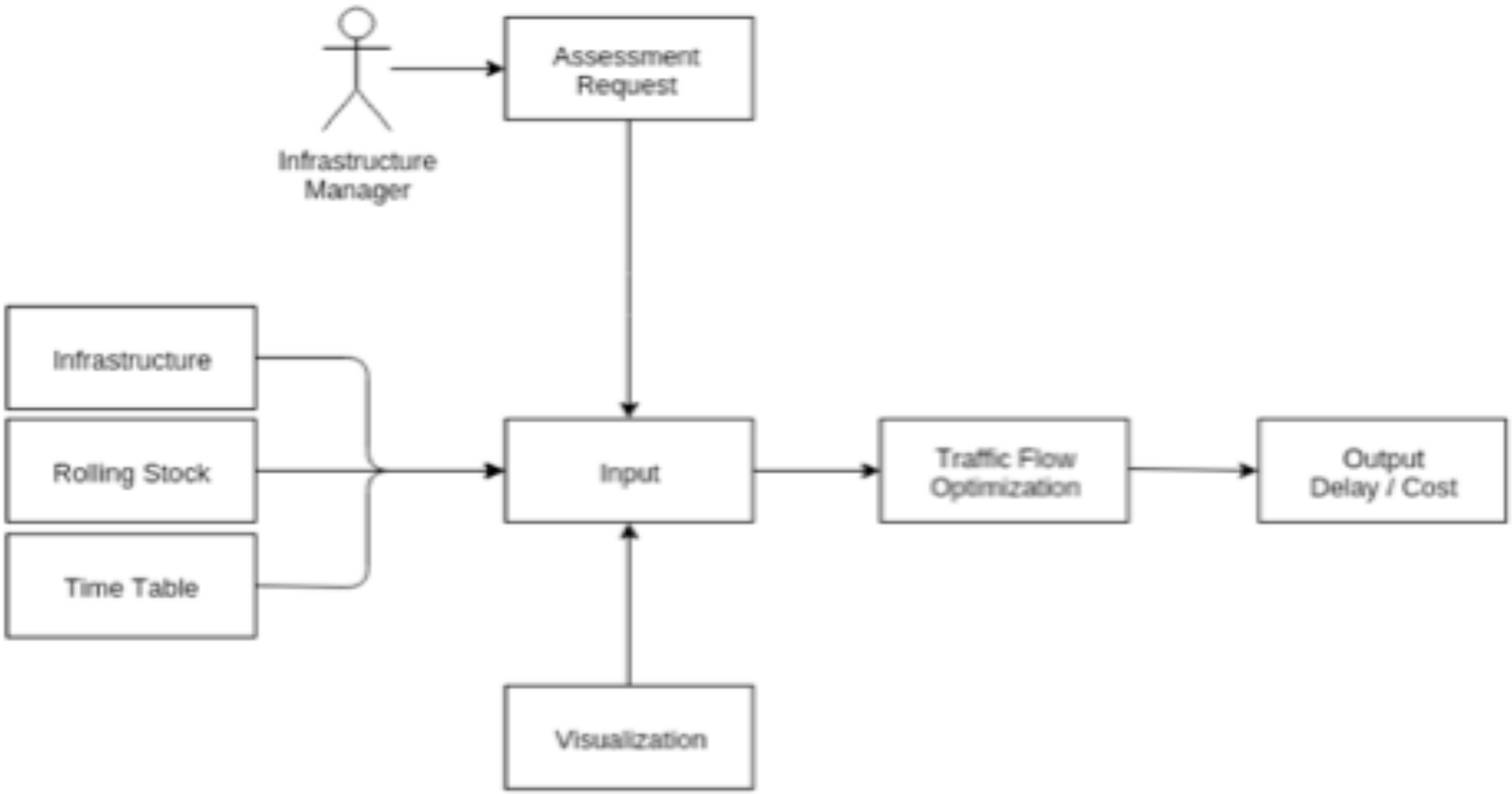
- Horizon 2020 funded
- Runs for 3 years from May 2015 to April 2018
- Consortium: 15 partners from 9 countries
- Develop Decision Support Tool, which relies on reliable data, for rational decision making of infrastructure managers to offer safer, reliable and efficient rail infrastructure.
  - ➢ Looking at reducing Infrastructure Costs
  - ➢ Delivers practical solutions

Processes within DESTinationRail

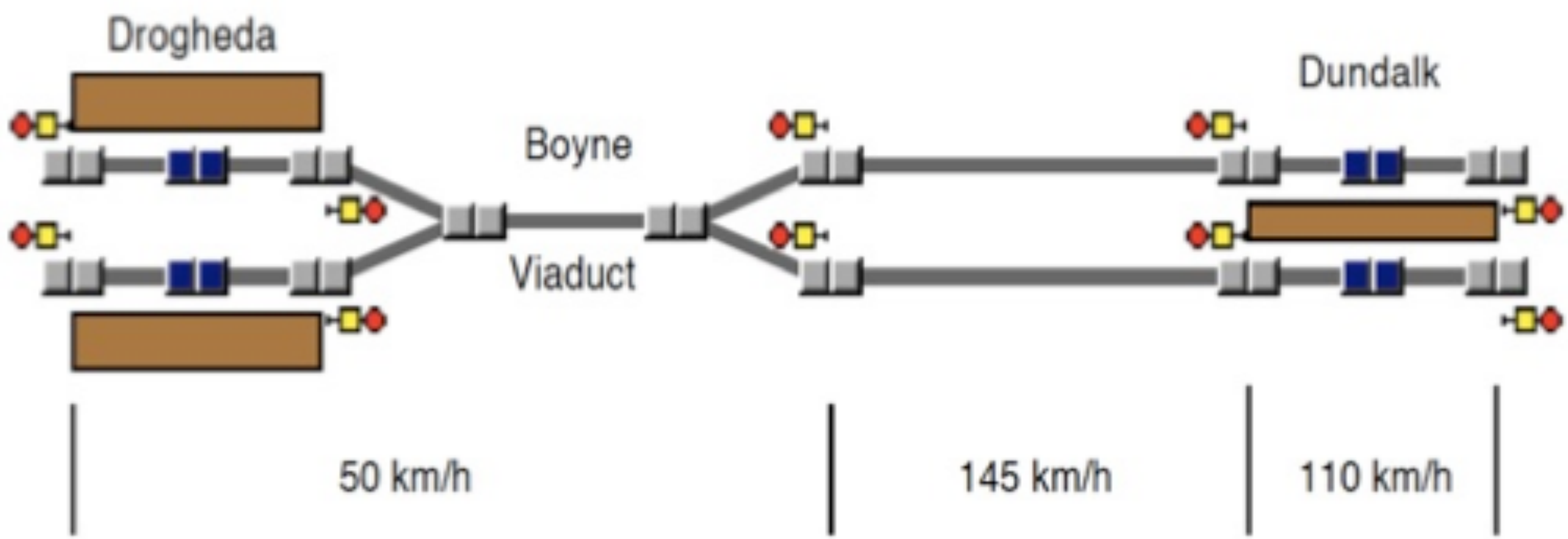
- four-step process that infrastructure managers face in the decision-making process
  - location and identification of risky assets before they fail
  - real-time safety assessment of existing infrastructure
  - evaluation of safety and assignment of scarce resources
  - **choosing the optimal rehabilitation techniques** (focus of this paper=WP4)

Irish Rail

Dataflow Model



Use Case of Irish Network



Infrastructure: Boyne Viaduct

Source: www.destinationrail.eu

IM Assessment Request

1. consequences of **restricted availability of infrastructure assets**

maintenance work on a given track section->reduced speed limit for that section or on the neighbouring track, as a protection measure for the staff

2. consequences of **operational incident**

interruption event can be a result of the broken down train or unavailability of the track section due to external factors, for example, flooding of a bridge

*For both cases **data needed**:

- affected track or track section (reference: infrastructure & timetable input)
- speed change [km/h]
- time period (begin [hh:mm:ss] – end [hh:mm:ss])
- thresholds for delays of affected trains [hh:mm:ss]
- costs of delay per minute for different train categories (regional, intercity, freight) and for the passenger transport information about differences in costs depending on the day of the week

IM Assessment Request

3. benefits from **infrastructure enhancement**

construction of an additional cross over on a highly frequented line or construction of an additional bridge

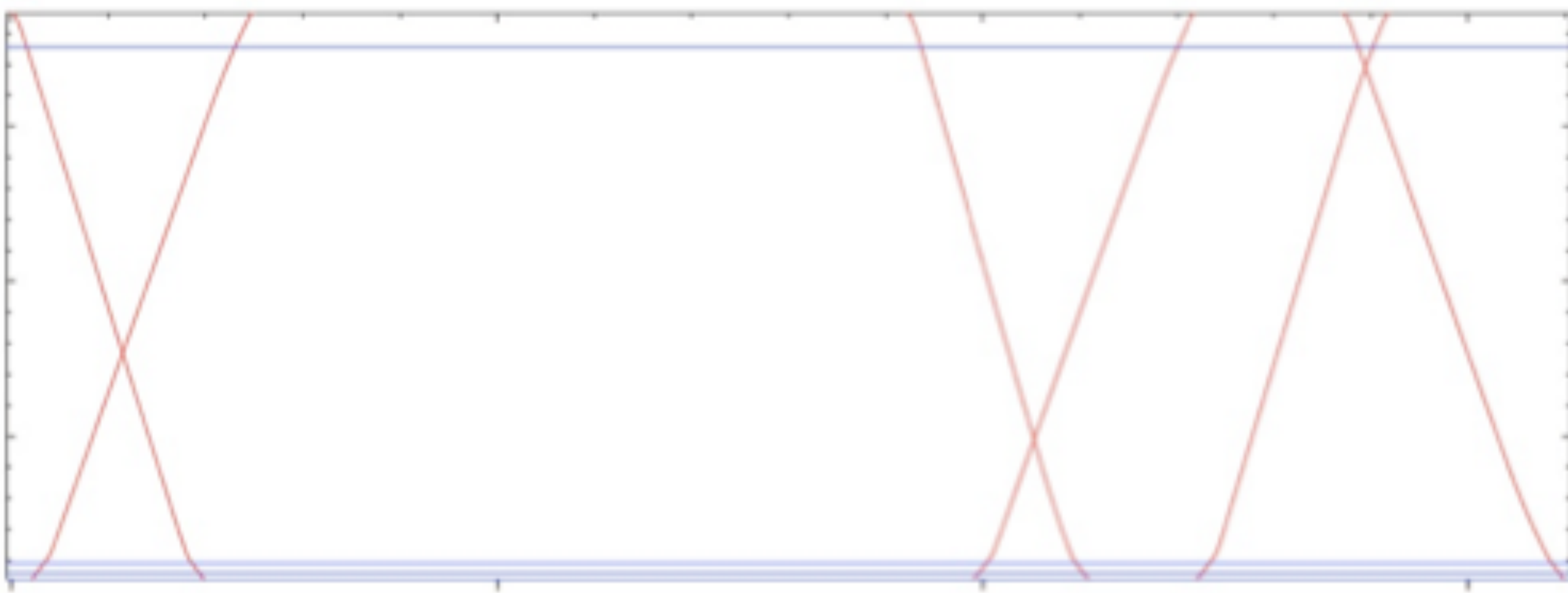
Data needed:

- location of the planned section and connections to existing tracks (reference: infrastructure input [track::id] and position on the track [meters])
- length of the planned section [meters]
- speed restriction on the selected section [km/h]
- gradient on the selected section (if changed) [‰]
- set of affected trains (reference: timetable)
- costs of delay per minute for different train categories (regional, intercity, freight) and for the passenger transport information about differences in costs depending on the day of the week.

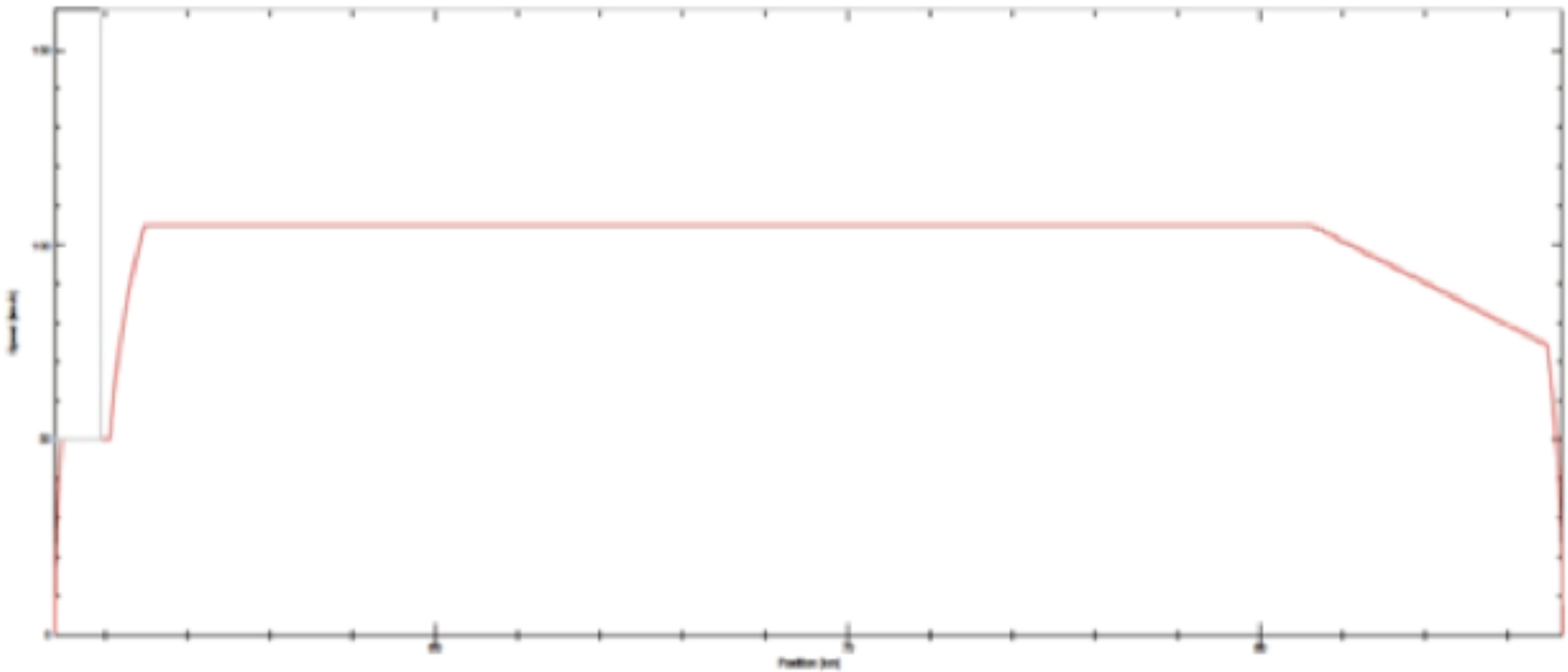
Rail Traffic Flow Optimisation Tool using Kronecker Algebra

- From informatics
- Kronecker product and Kronecker sum form Kronecker algebra.
- The Kronecker product can be used to model synchronization while Kronecker sum calculates all possible interleavings.
- Deadlock avoidance (NOT deadlock prevention and deadlock detection)
- This approach works better if more constraints are added
- The application of Kronecker Algebra enables a deadlock free railway operation

Output from Kronecker Algebra: Train Graph



Output from Kronecker Algebra: Optimised Train Run



Output from Kronecker Algebra: Optimised Train Run

- T1 Train1 108000 400000 213 8 210 160 0.85 50786 87318
- T2 Train2 108000 400000 213 8 210 160 0.85 50786 87318
- T3 Train3 108000 400000 213 8 210 160 0.85 50786 87318
- T4 Train4 108000 400000 213 8 210 160 0.85 87318 50786
- T5 Train5 108000 400000 213 8 210 160 0.85 87318 50786
- Structure of output: ID / TrainID / Engine mass / Trailer mass / Train length / No. of wagons / Used engine / max. speed recuperation rate / start time / stop time

- Train 1 Result 1 of 1 Energy demand: 256.6 Demand complete: 256.6 kWh
- Train 2 Result 1 of 1 Energy demand: 230.1 Demand complete: 486.7 kWh
- Train 3 Result 1 of 1 Energy demand: 256.6 Demand complete: 743.3 kWh
- Train 4 Result 1 of 1 Energy demand: 254.8 Demand complete: 998.1 kWh
- Train 5 Result 1 of 1 Energy demand: 254.8 Demand complete: 1252.9 kWh

- New minimum found: 1252.9

Conclusion

- This project produces practical ways for reducing costs for major infrastructure maintenance
- Provide support to Infrastructure Managers in maximising capacity through the use of the Decision Support Tool
- Kronecker Algebra proved early during the project to be the most effective tool for optimization of traffic flow

Thank You for you attention

www.destinationrail.eu