

um
2026

The use of Cardanit for railway operations simulation: evidence from PORTRAIT project

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Agenda

Introduction on railway capacity

Railway system of Friuli Venezia Giulia region

Integrated methodology

Results

Conclusions

Capacity of railway systems

- Maximum number of trains in a certain time interval
- Main influential factors:

- Track availability



- Train mix and timetable



- Signaling system

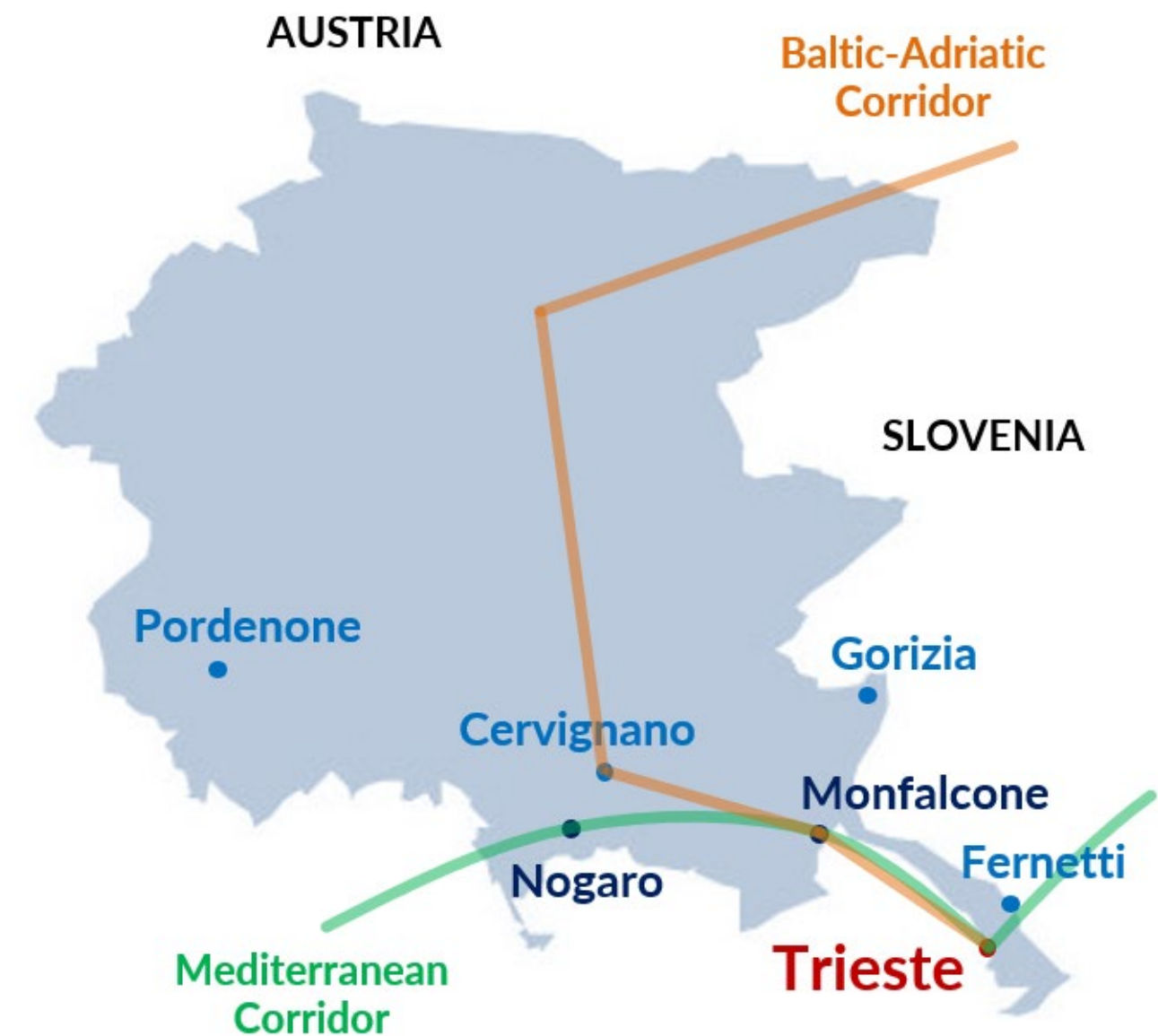


- Junctions



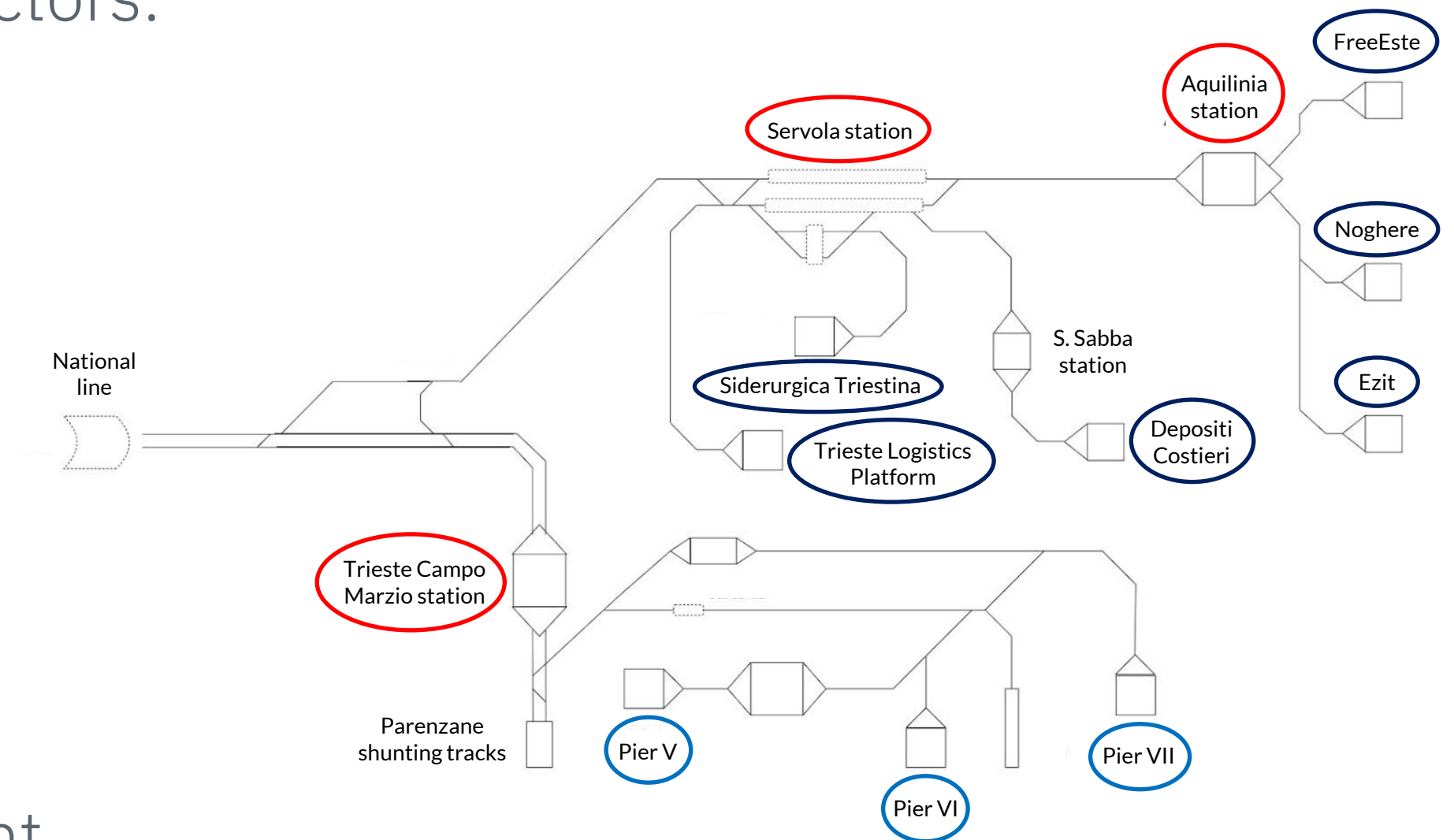
Railway system of Friuli Venezia Giulia region

- FVG railway system composed by:
 - National network
 - Wet ports (Trieste, Monfalcone, Nogarò)
 - Dry ports (Cervignano, Ferneti, Gorizia, Pordenone)
 - Cross border stations (Villa Opicina, Tarvisio)
- Strategic role for European rail freight transport:
 - North-South axis (Mediterranean Corridor)
 - East-West axis (Baltic-Adriatic Corridor)



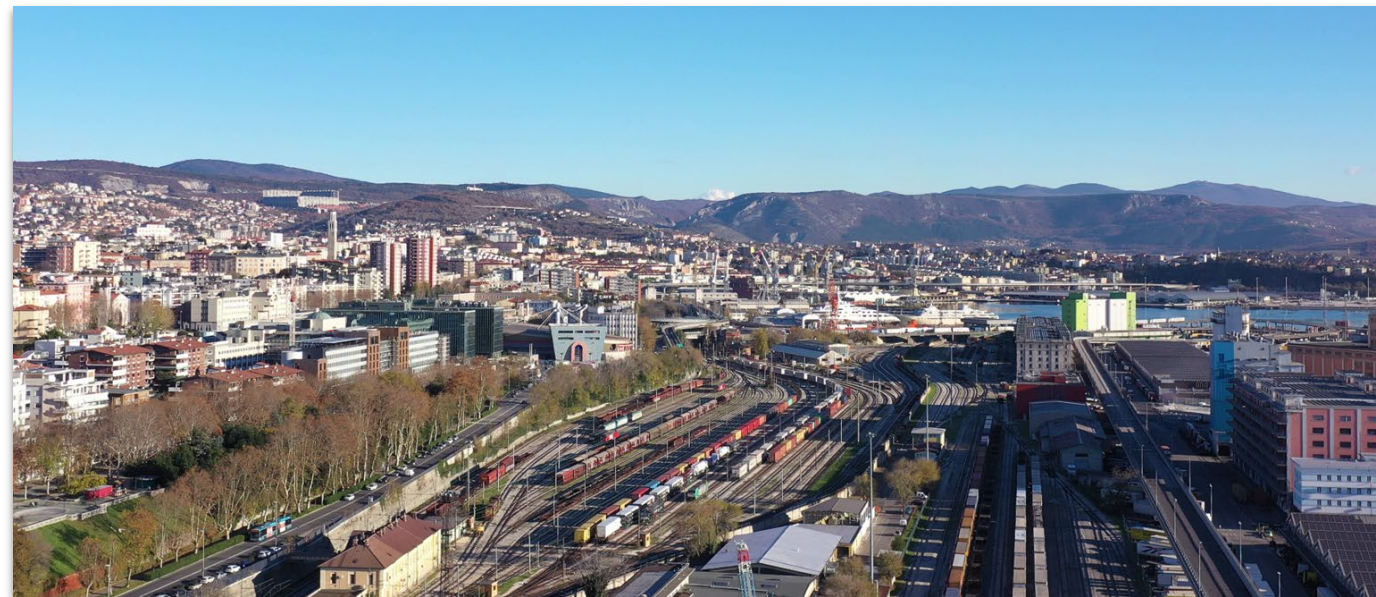
Focus on the Port of Trieste

- Infrastructural configuration and related actors:
 - 9 terminals (private operators)
 - 3 main railway stations (port authority)
 - Shunting tracks (port authority)
 - 1 line towards national network (infrastructure manager)
- Competition for infrastructural resources
- Fairness and efficiency in port management

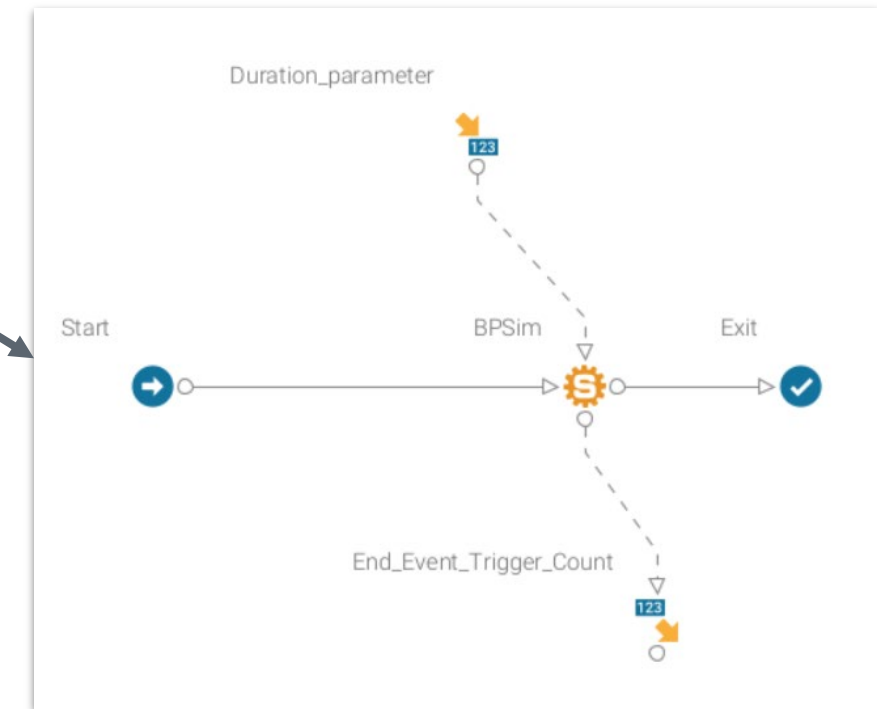
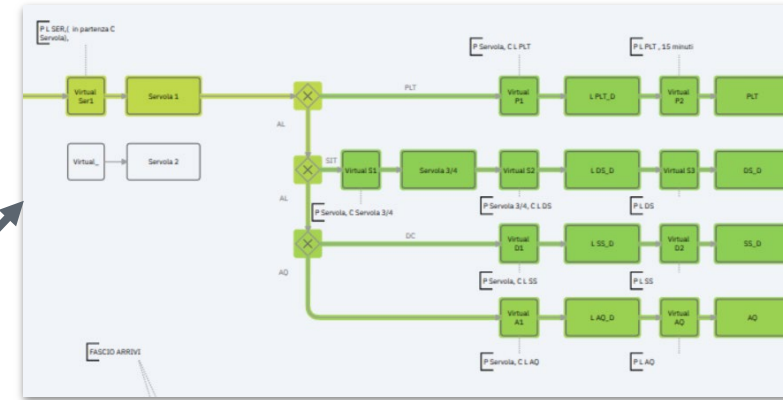
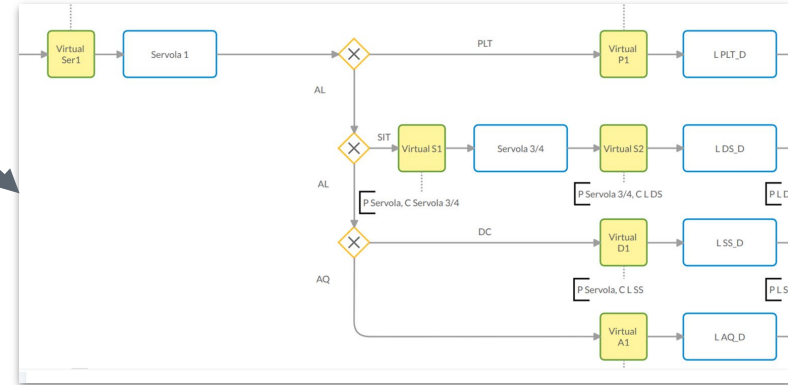


Optimizing rail freight transport in the FVG network

- Maximization of railway capacity
- Operational constraints:
 - Passenger services
 - Origin/destination matrix
 - Minimum terminal operability

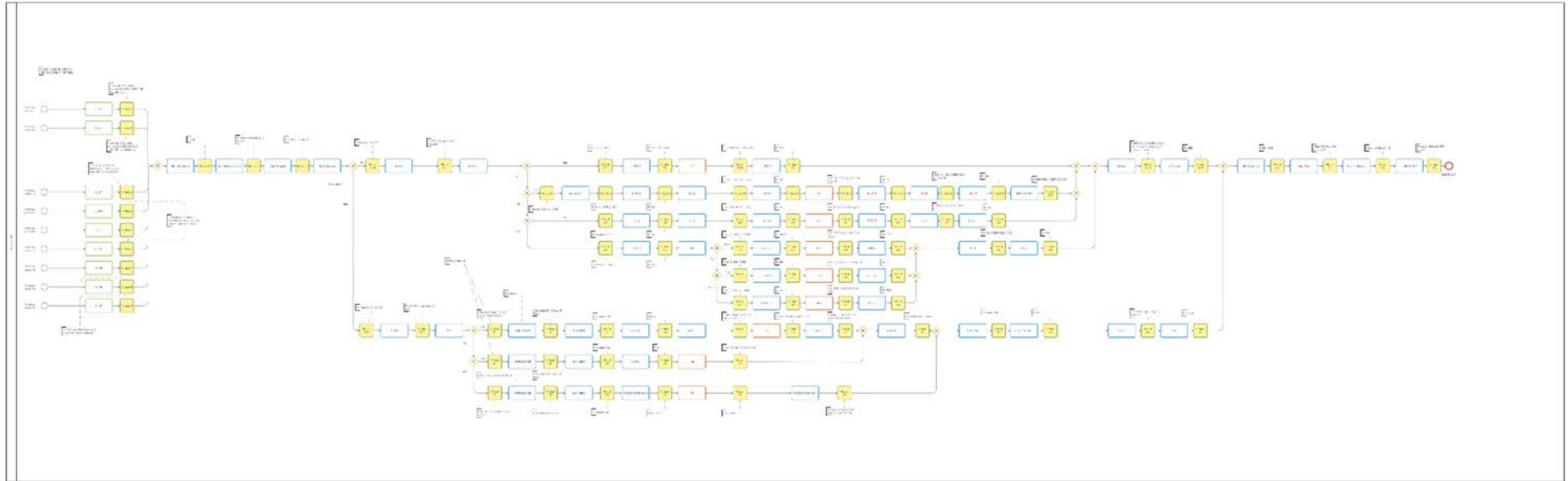


From modeling to simulation to optimization



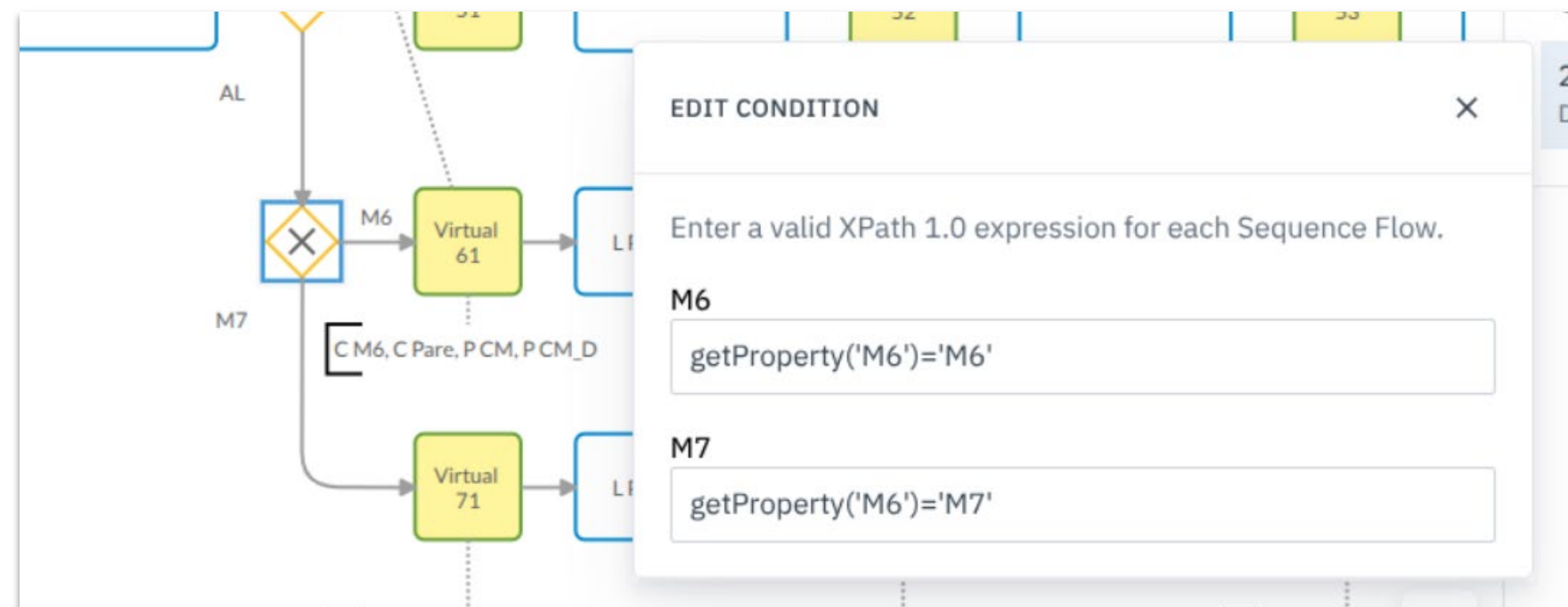


The Servola BPMN model



Preparing for simulation, BPSim-compliant

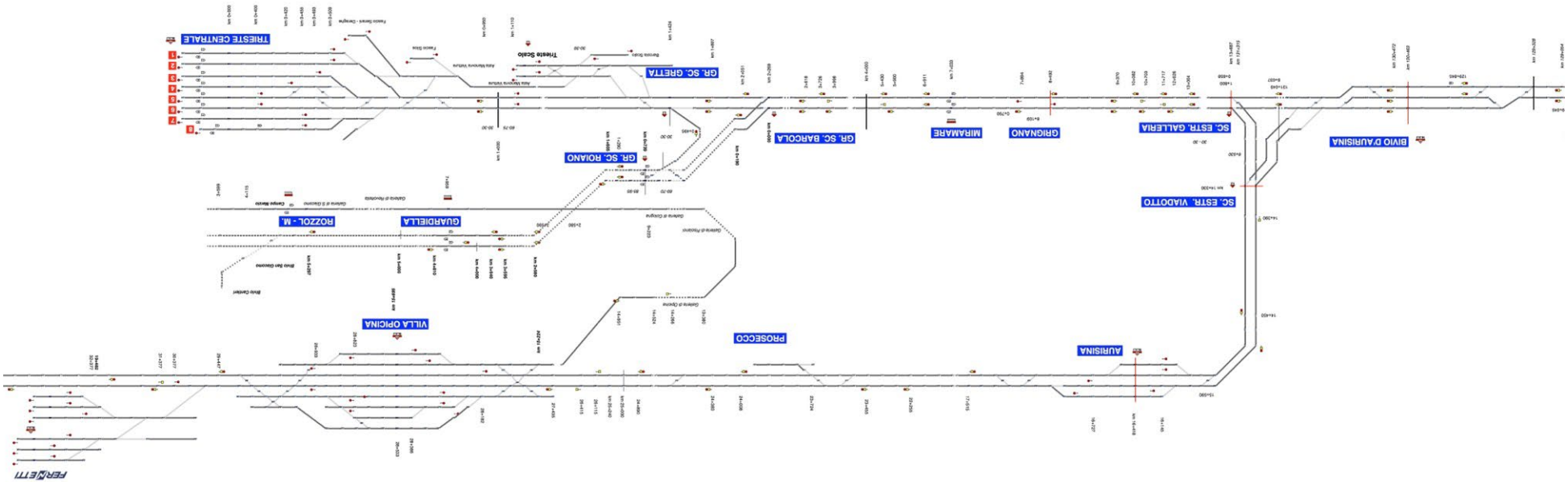
- # of departures per destination, in a specific time range
 - Calendars, Inter trigger Timer
- Train routing
 - Token attributes (Properties)
- Railway track occupancy
 - Resource Producer/Consumer



Preparing for simulation, BPSim-compliant

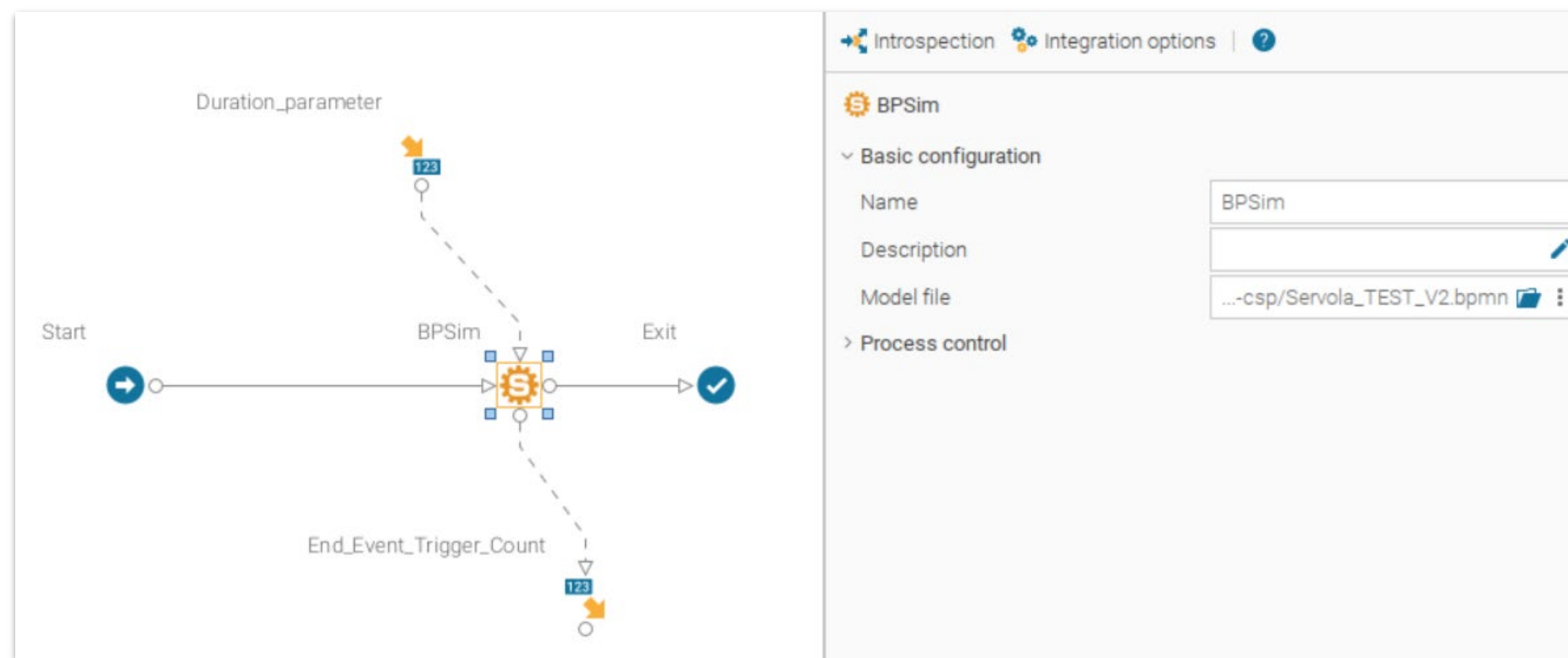
- Infrastructural resources:
 - Technical meetings with port authority
- Duration of tasks:
 - Real data from shunting operator
 - Simulated data from railway traffic microsimulation (OpenTrack software)
- Technical times for train blocks
- Warm-up time

Num.	Prog. Km	Station	Sched A Trk	Real A Trk	Sched A	Real A	Del A	Cause A	Sched D Trk	Real D Trk	Sched D	Real D	Del D	Cause D
1	—	Station A	1	1	08:00	08:05	5	X	D1	D1	09:00	09:10	10	X
2	—	Station B	2	3	08:15	08:20	5	—	D2	D2	09:15	09:18	3	—
1	—	Station C	3	3	08:30	08:32	2	—	D3	D3	09:30	09:35	5	—
2	—	Station D	4	5	08:45	08:50	5	—	D4	D4	09:45	09:55	10	—
1	—	Station E	5	5	09:00	09:03	3	—	D5	D5	10:00	10:05	5	—
2	—	Station F	1	1	09:15	09:20	5	Y	D6	D6	10:15	10:25	10	Y
1	—	Station G	2	3	09:30	09:28	-2	—	D7	D7	10:30	10:28	-2	—
2	—	Station H	3	3	09:45	09:50	5	—	D8	D8	10:45	10:50	5	—
1	—	Station I	4	4	10:00	10:03	3	—	D9	D9	11:00	11:05	5	—
2	—	Station J	1	5	10:15	10:18	3	—	D10	D10	11:15	11:20	5	—



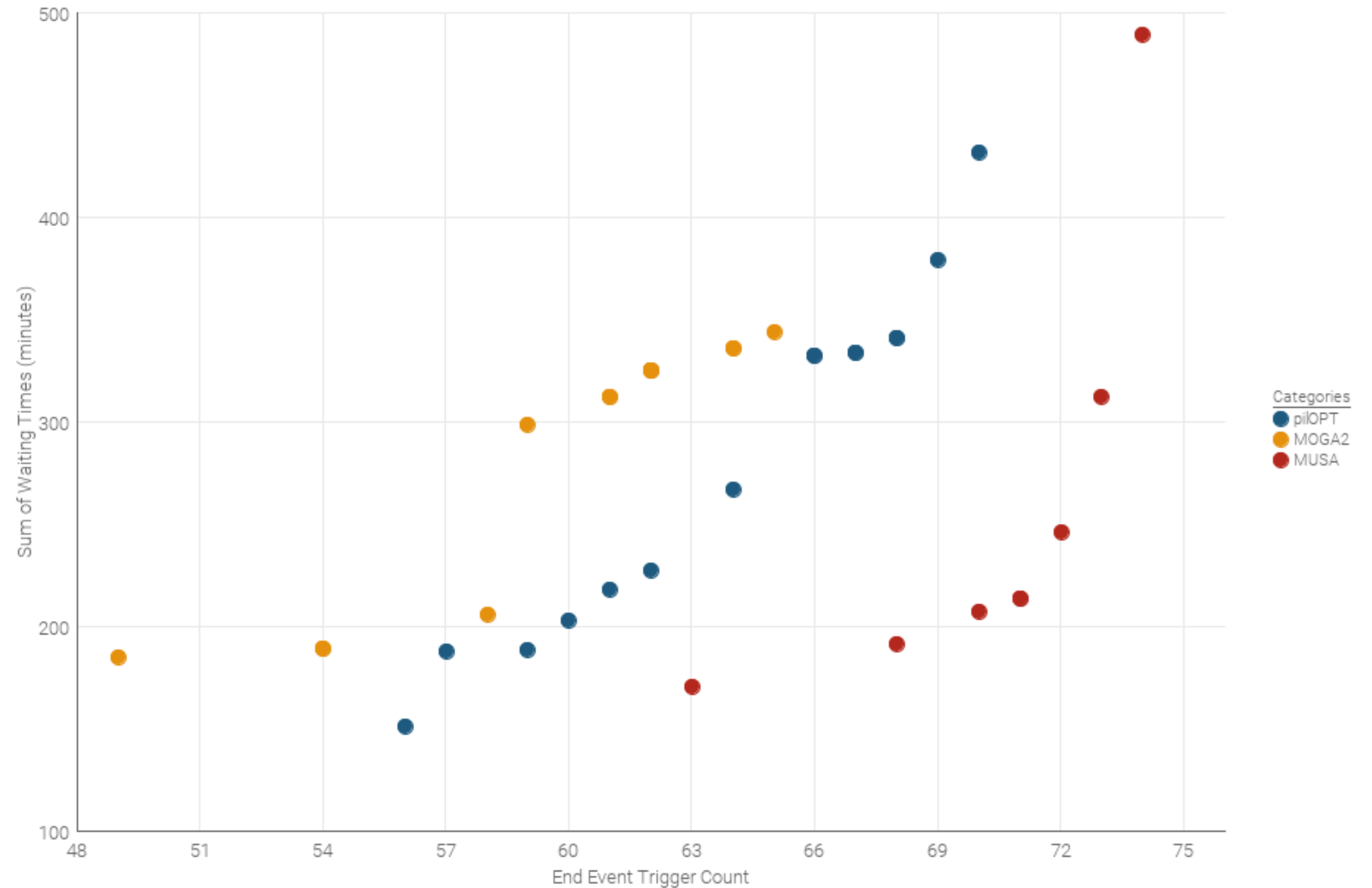
Simulation in modeFRONTIER

- Integration node with L-Sim
 - Java, black box: Lanner L-Sim
- 171 variables, 199 constraints
 - DOE construction
- 2 objectives

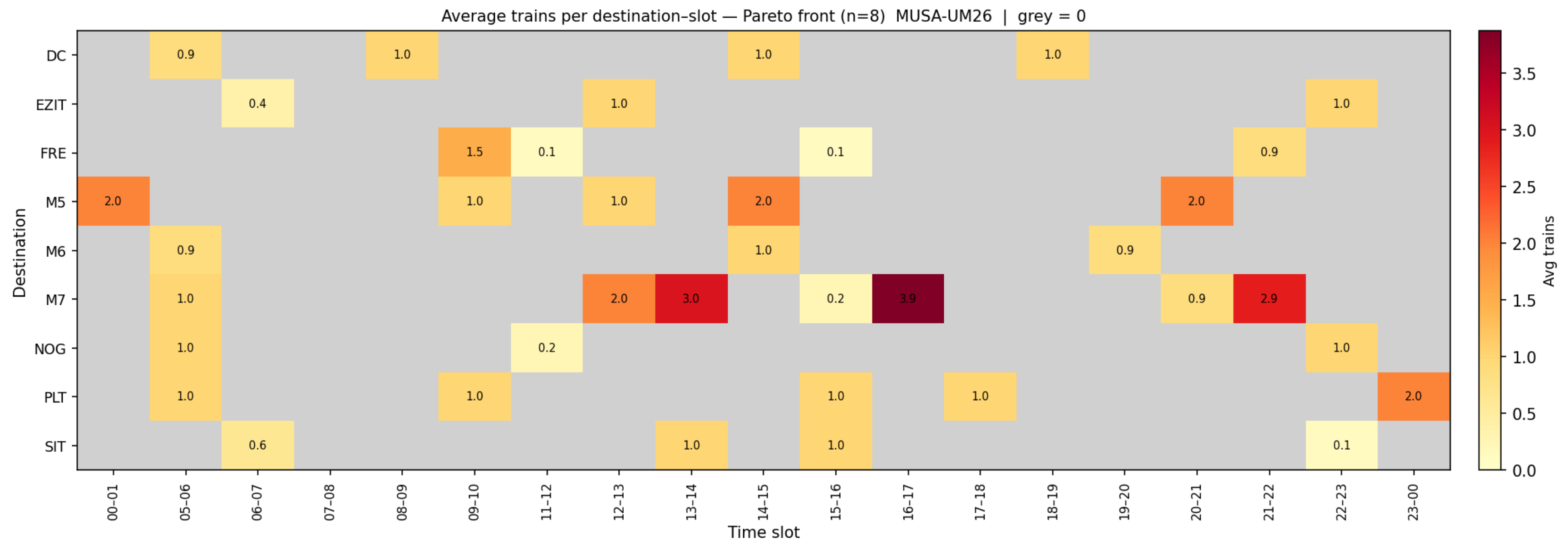


Results - comparing the Pareto fronts

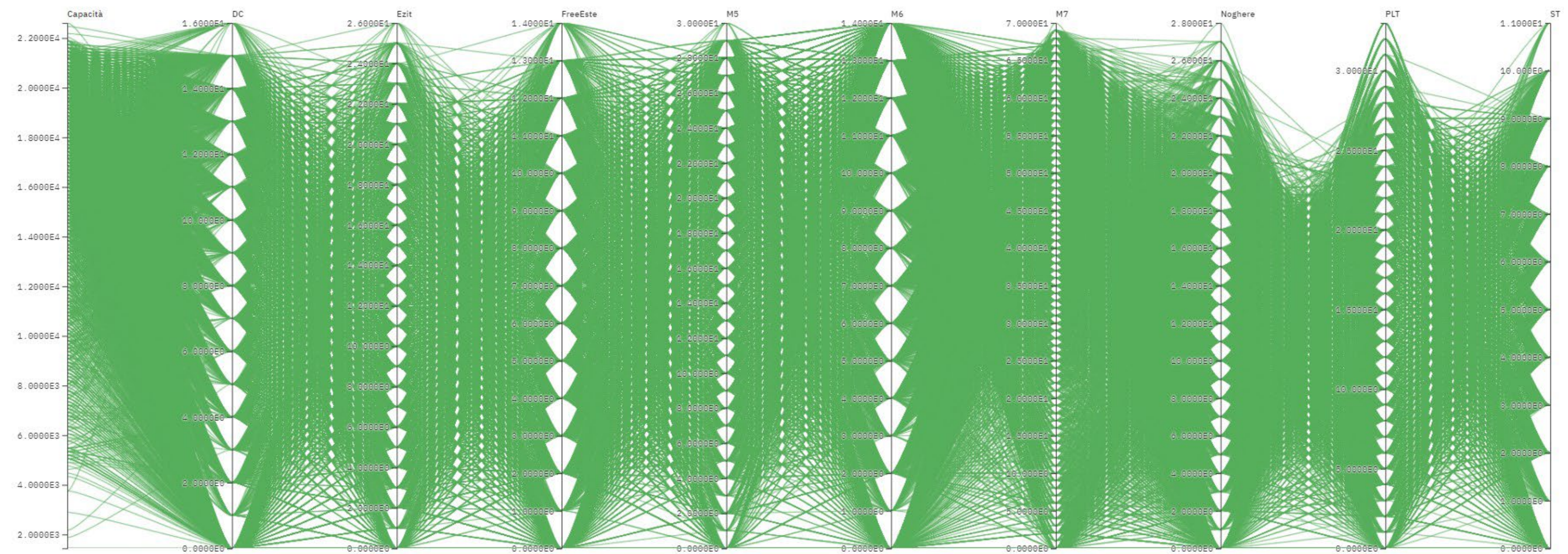
- pilOPT, MOGA-2, MUSA
- 1 or 2 objectives
- 12h warm-up + 36h simulation
- 2000 evaluations
 - 200 DOE
 - 1800 new designs
- Capacity increase with growing waiting times – **contrasting objectives**



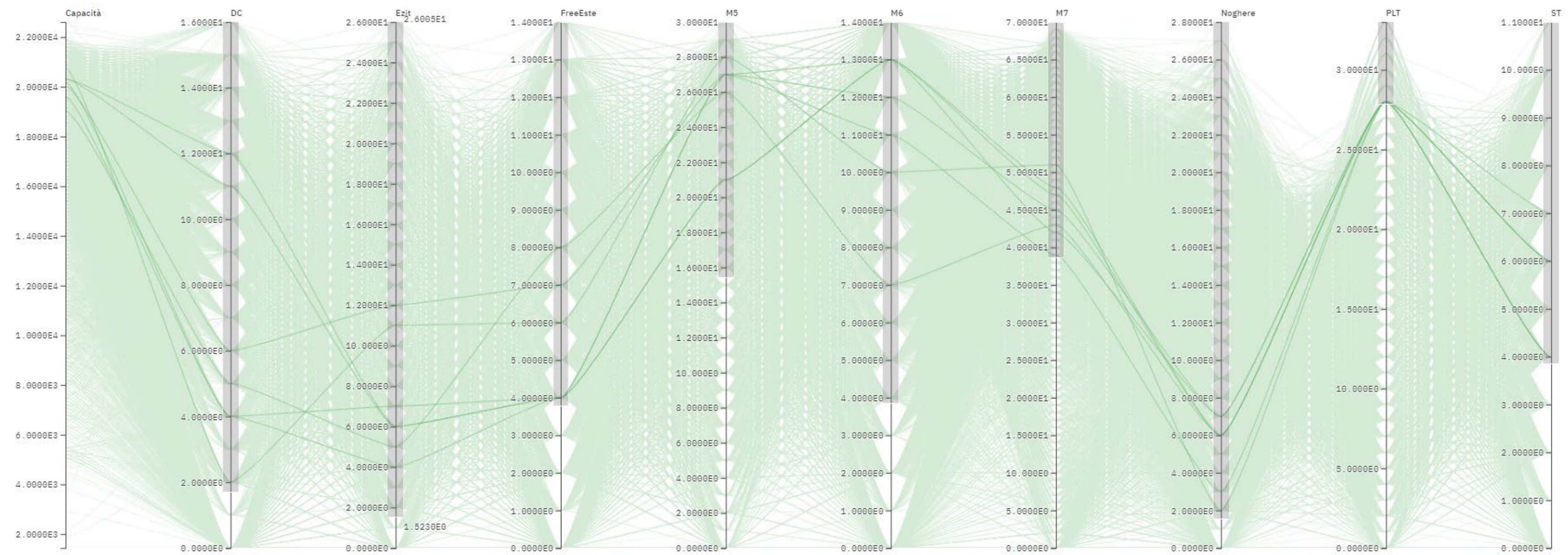
Results - heatmap



Results



Results



Conclusions

- Great model complexity of railway system processes
- Need of specific adjustments in using BPMN and BPSim standards
- Effective support of Cardanit and mF in process modelling, simulation and optimization
- Results support decision making for port strategic planning
- Future developments:
 - Model extension to the regional railway system
 - Comparing Cardanit model with process mining-generated model
 - Implementation into VOLTA for end users (port decision makers)

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Thank you

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