Train Rerouting During Major Disturbances

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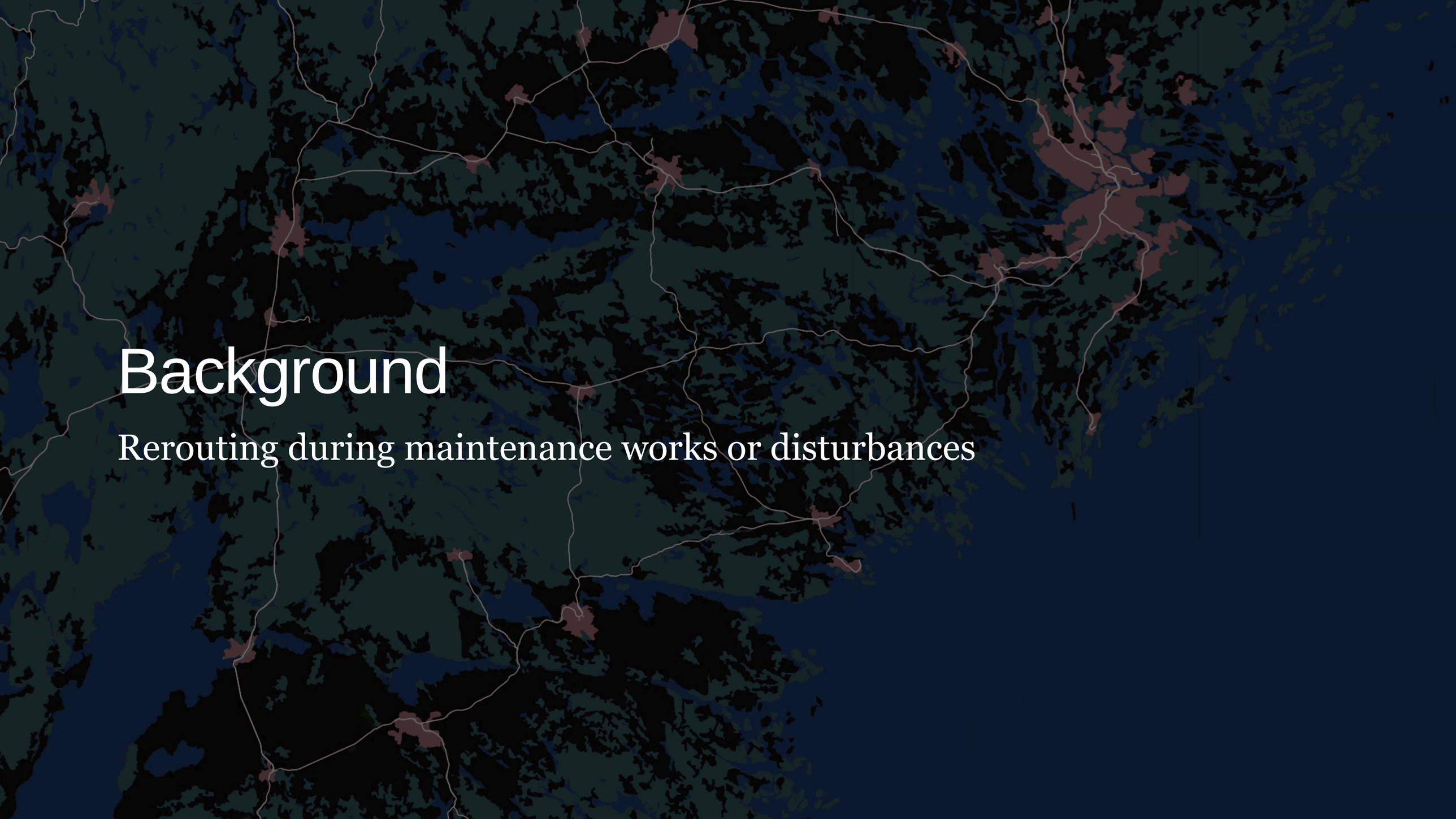
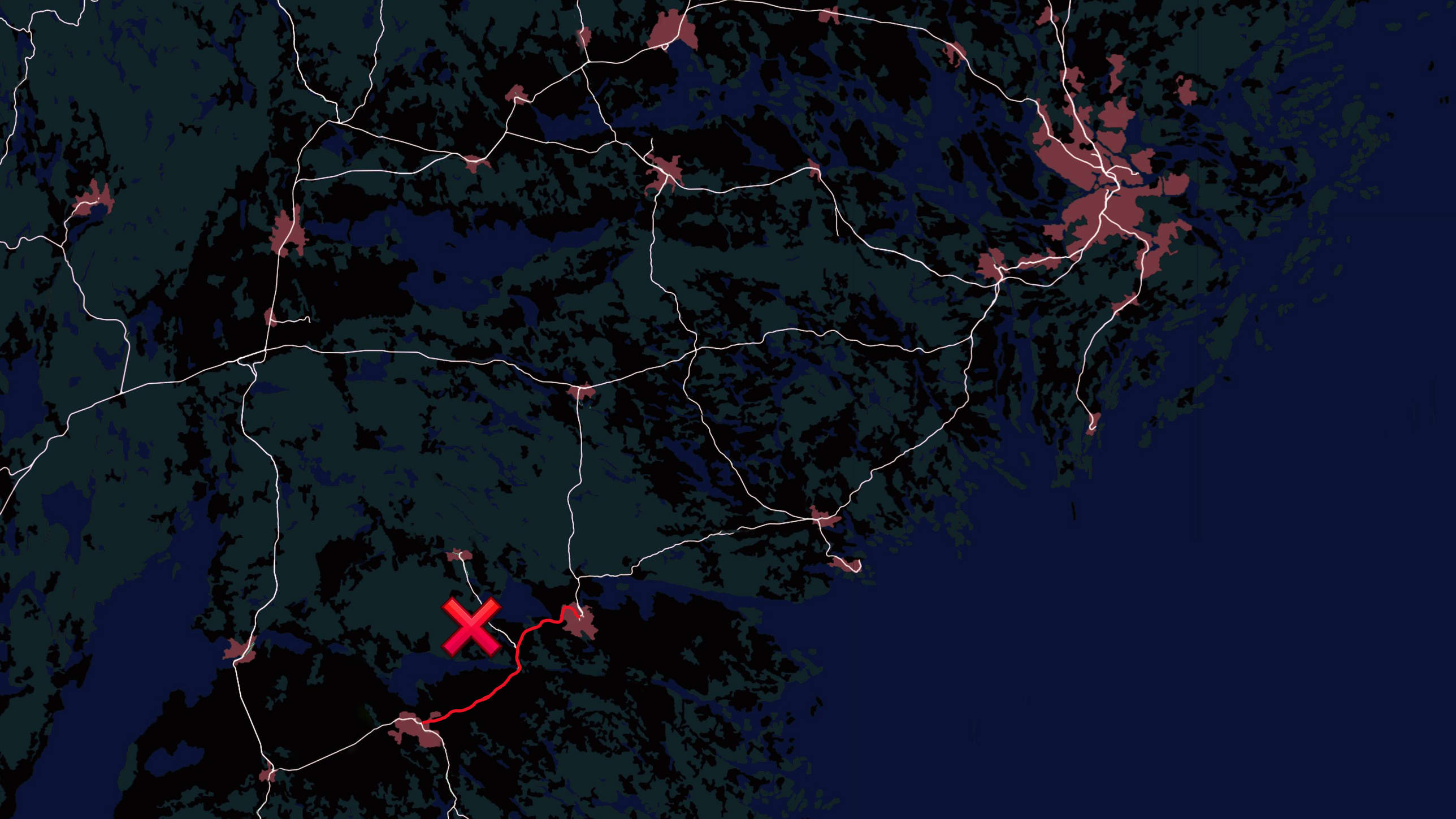
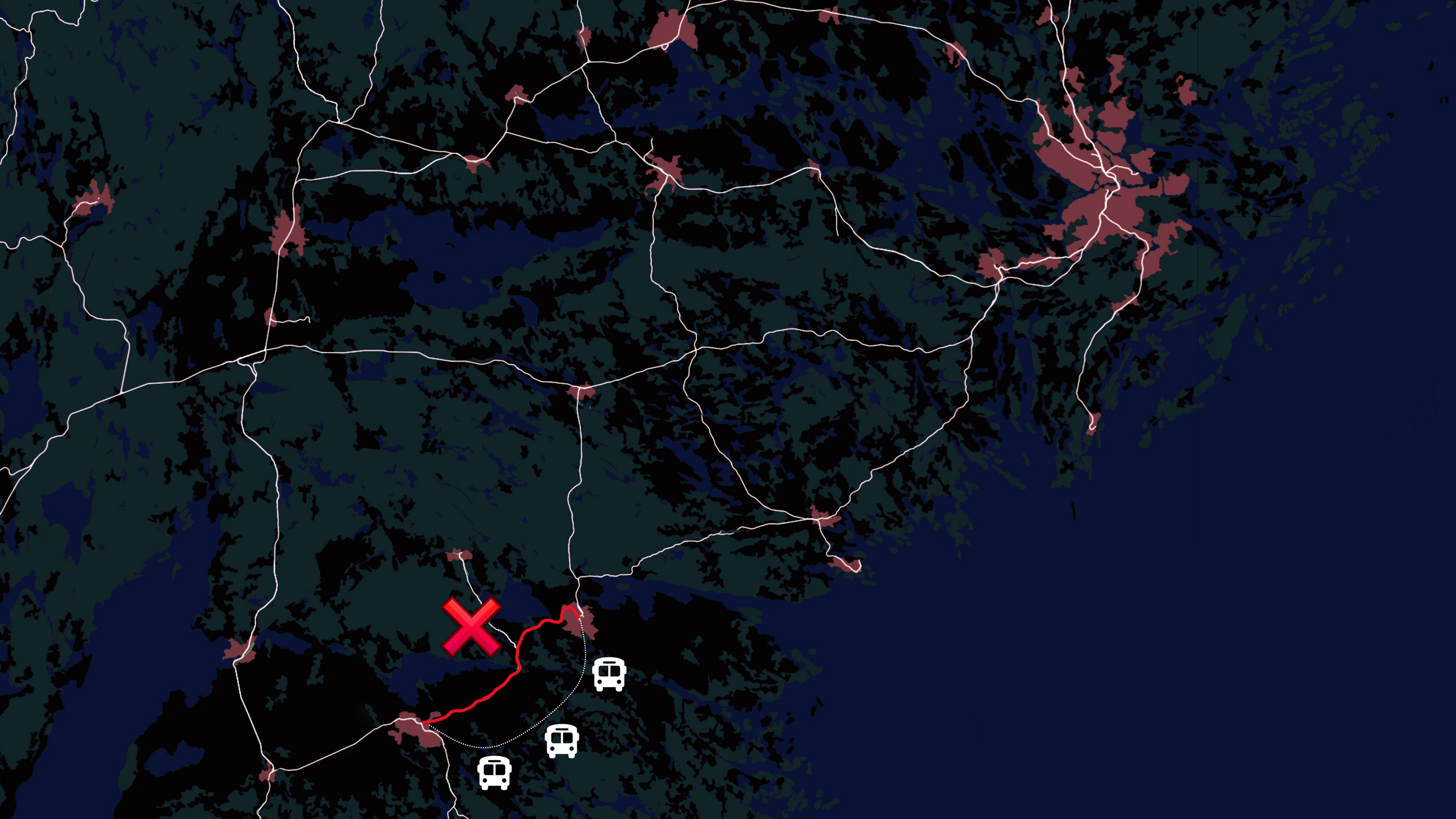
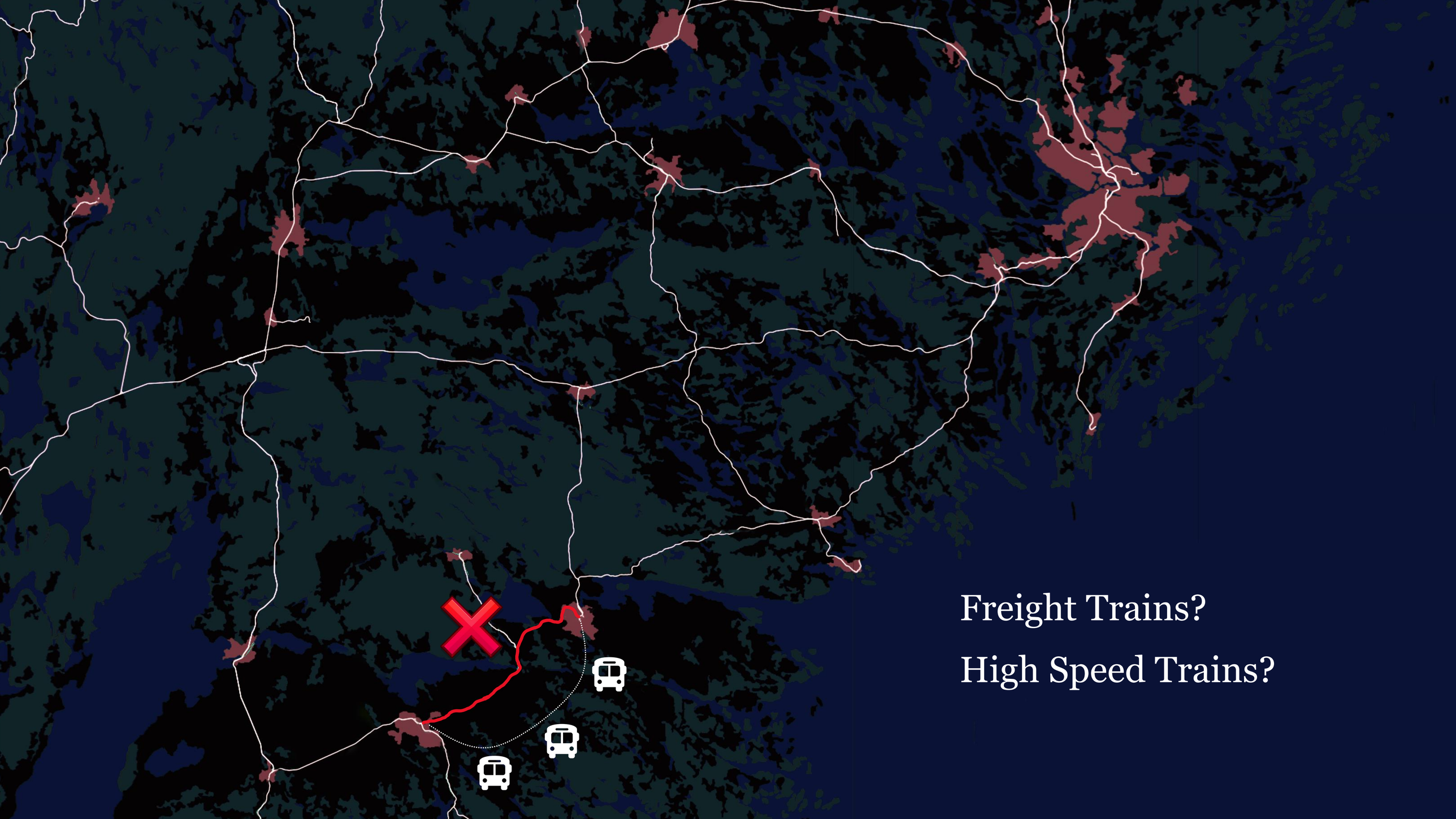


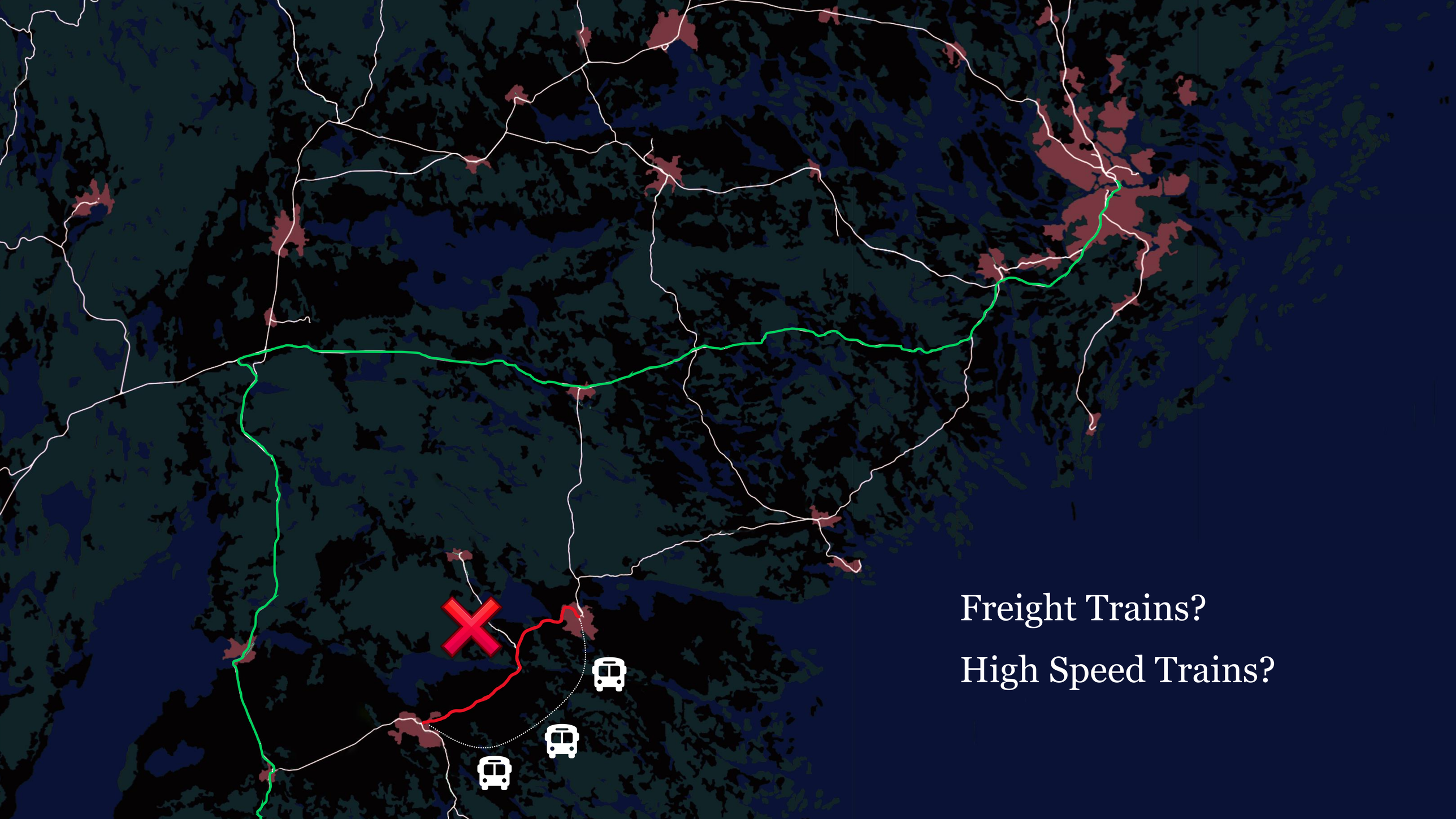
Background

Rerouting during maintenance works or disturbances






Freight Trains?
High Speed Trains?


Freight Trains?
High Speed Trains?

Problem Setting

Input: Railway network with some missing link, an existing timetable and a set of trains that have to be rerouted.

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Output: A timetable that includes the rerouted trains.

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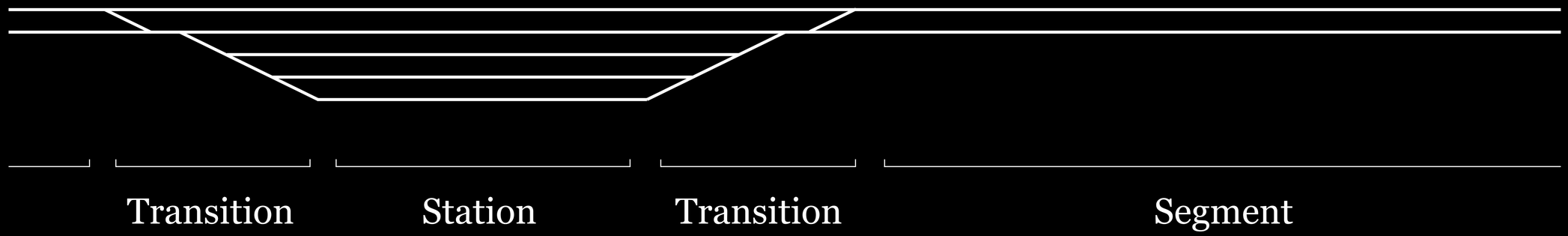
Input:	Railway network with some missing link, an existing timetable and a set of trains that have to be rerouted.
Output:	A timetable that includes the rerouted trains.
Assumptions:	The existing timetable is fixed.

Our Model

Our Model



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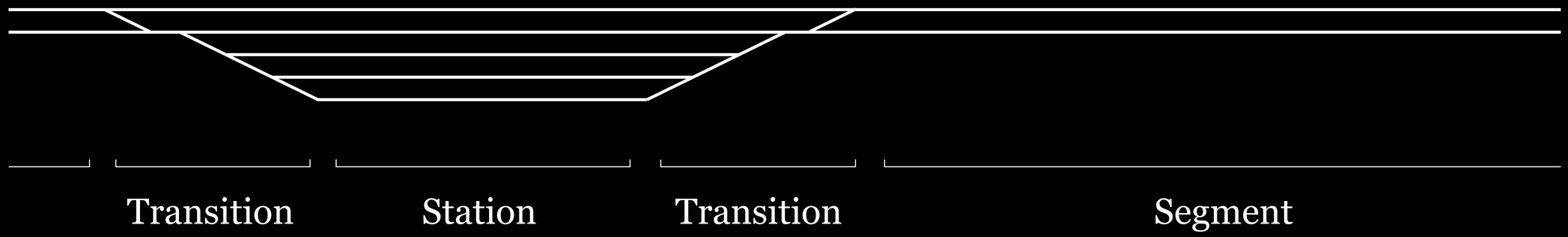
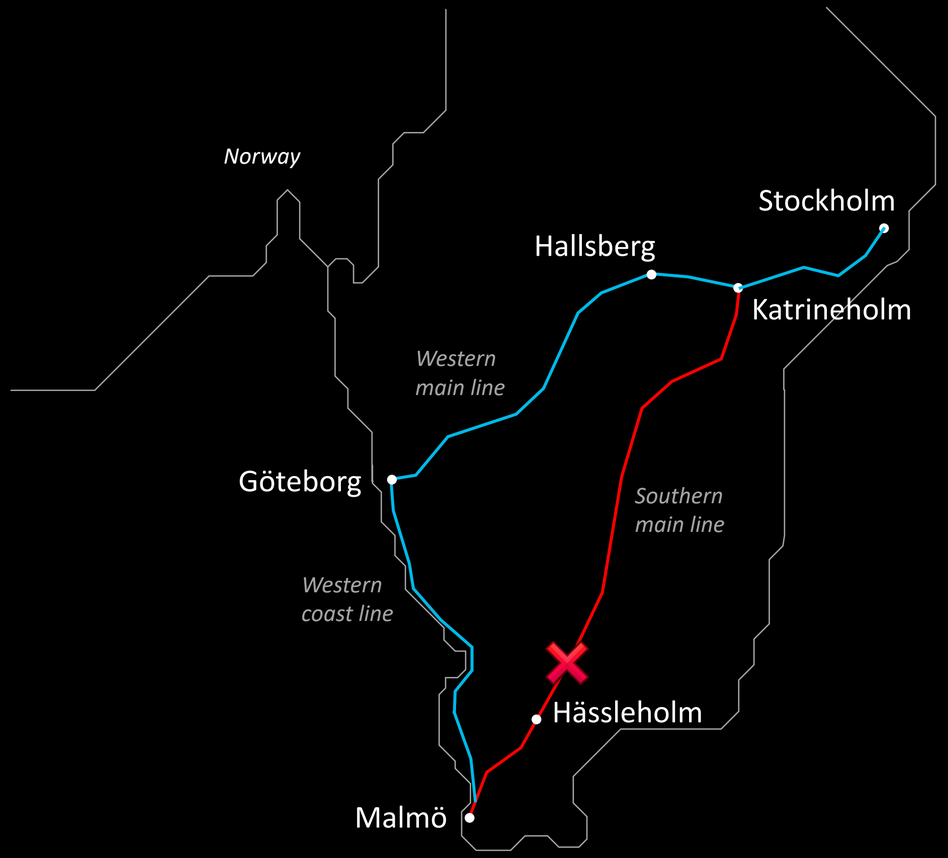


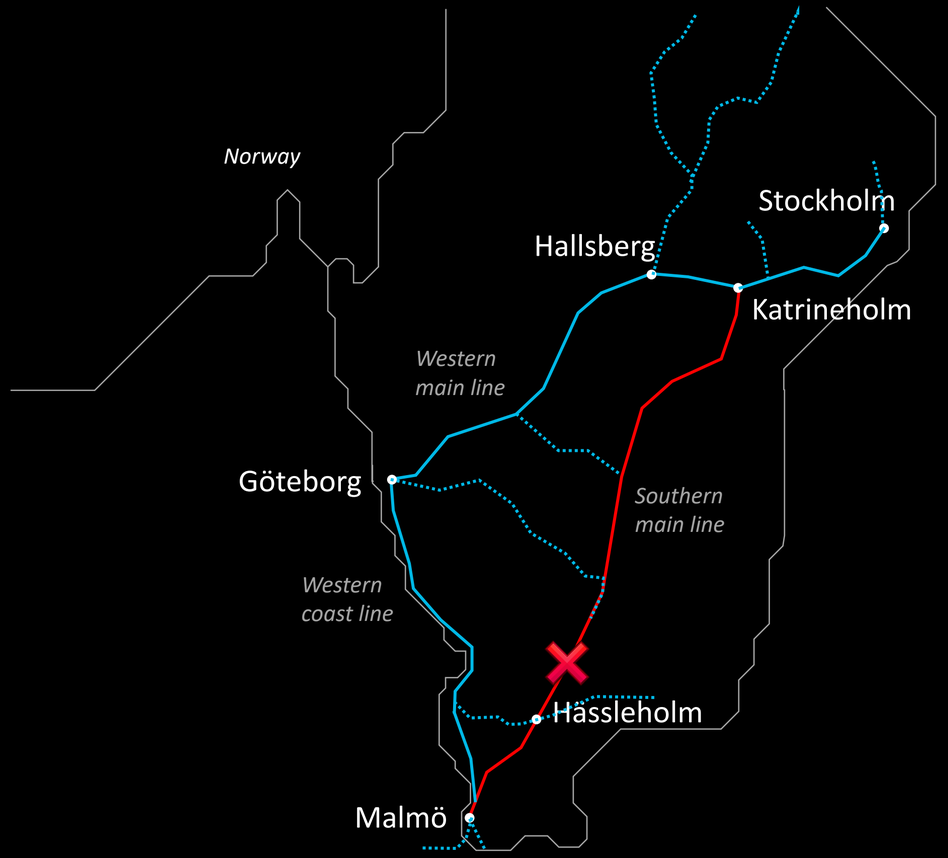
This enables us to use macroscopic data, while also avoiding conflicts on a microscopic level.

The latter requires knowledge of minimum time differences between trains on given tracks; we assume general values here.

Our Model


Norway
Stockholm
Hallsberg
Katrineholm
Western
main line
Göteborg
Southern
main line
Western
coast line
Hässleholm
Malmö

Our Model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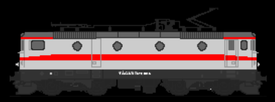
Algorithmic Framework

Algorithmic Framework

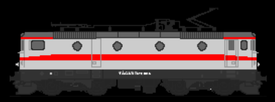


Algorithmic Framework

Stockholm C	07:20
Stockholms södra	07:22
Årstaberg	07:23
…	

Hallsbergs rbg	04:59
Tälle	05:05
Östansjö	05:10
…	

Falköpings C	05:10
Floby	05:21
Källeryd	05:27
…	



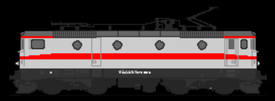
Kristinehamn	05:45
Björneborg	05:58
Strömtorp	06:08
…	

Algorithmic Framework

Cst	07:20
Sst	07:22
Åbe	07:23
…	

Hrbg	04:59
Täl	05:05
Öj	05:10
…	

F	05:10
Fby	05:21
Kä	05:27
…	



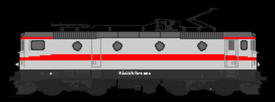
Khn	05:45
Bjb	05:58
Srt	06:08
…	

Algorithmic Framework

Cst	07:20	Cst	06:45	Cst	07:32	Cst	06:45
Sst	07:22	Sst	06:46	Sst	07:34	Sst	06:47
Åbe	07:23	Åbe	06:48	Åbe	07:35	Åbe	06:48
...		...		...		...	

Hrbg	04:59	Hrbg	04:21	Hrbg	05:20	Hrbg	05:46
Täl	05:05	Täl	04:27	Täl	05:26	Täl	05:52
Öj	05:10	Öj	04:32	Öj	05:31	Öj	05:57
...		...		...		...	

F	05:10	F	04:32	F	04:59	F	05:46
Fby	05:21	Fby	04:43	Fby	05:10	Fby	05:57
Kä	05:27	Kä	04:49	Kä	05:16	Kä	06:03
...		...		...		...	



Khn	05:45	Khn	05:12	Khn	06:23	Khn	07:03
Bjb	05:58	Bjb	05:26/34	Bjb	06:36	Bjb	07:16
Srt	06:08	Srt	05:46	Srt	06:46	Srt	07:26
...		...		...		...	

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Åbe	07:23	Åbe	06:48	Åbe	07:35	Åbe	06:48
...		...		...		...	

Hrbg	04:59	Hrbg	04:21	Hrbg	05:20	Hrbg	05:46
Täl	05:05	Täl	04:27	Täl	05:26	Täl	05:52
Öj	05:10	Öj	04:32	Öj	05:31	Öj	05:57
...		...		...		...	

F	05:10	F	04:32	F	04:59	F	05:46
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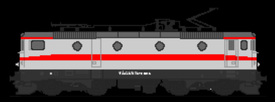
...		...		...		...	



Khn	05:45	Khn	05:12	Khn	06:23	Khn	07:03
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...		...		...		...	

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Sst	**07:22**	Sst	06:46	Sst	07:34	Sst	06:47
Åbe	**07:23**	Åbe	06:48	Åbe	07:35	Åbe	06:48
…		…		…		…	

Hrbg	04:59	**Hrbg**	**04:21**	Hrbg	05:20	Hrbg	05:46
Täl	05:05	**Täl**	**04:27**	Täl	05:26	Täl	05:52
Öj	05:10	**Öj**	**04:32**	Öj	05:31	Öj	05:57
…		**…**		…		…	

F	**05:10**	F	04:32	F	04:59	F	05:46
Fby	**05:21**	Fby	04:43	Fby	05:10	Fby	05:57
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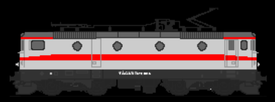
…		…		…		…	



Khn	05:45	Khn	05:12	**Khn**	**06:23**	Khn	07:03
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Srt	06:08	Srt	05:46	**Srt**	**06:46**	Srt	07:26
…		…		**…**		…	

Algorithmic Framework

: options 1, 2 and 3.

: options 4, 5 and 6.

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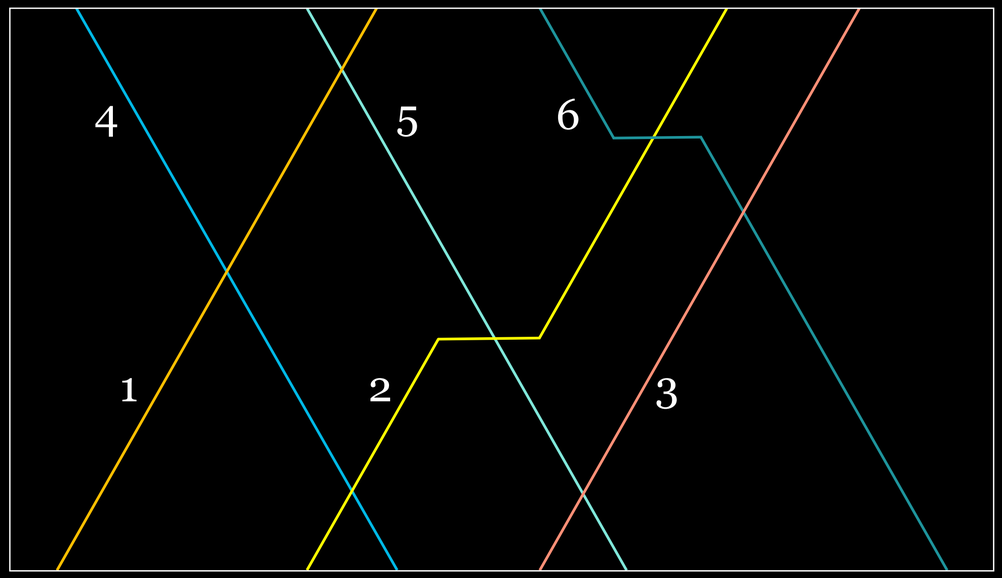

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: options 1, 2 and 3.

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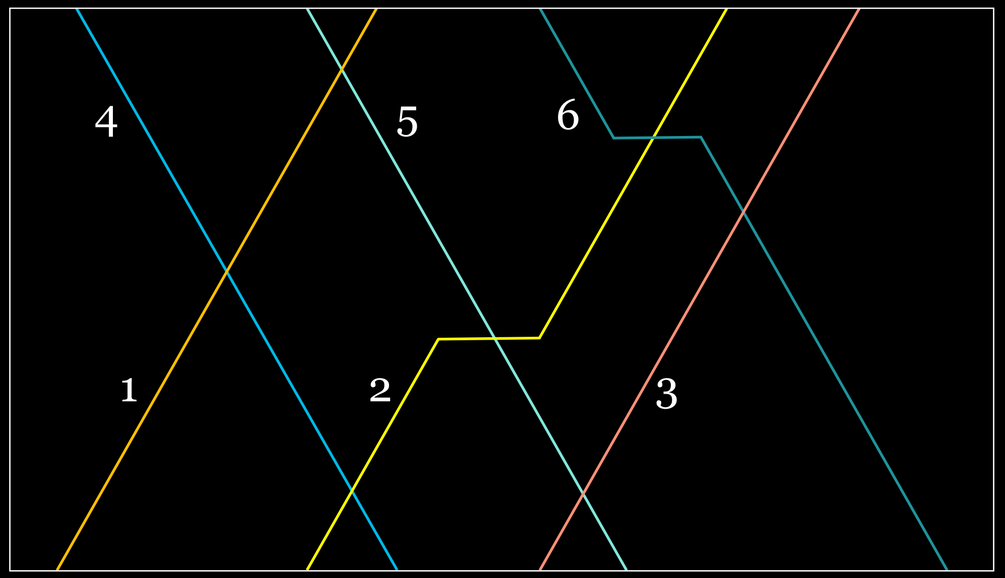

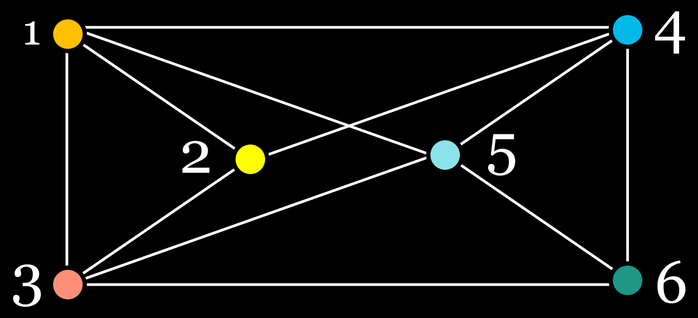

Algorithmic Framework

General idea:

Generate multiple possible paths for each train that has to be rerouted, and associate a cost to each path.

Algorithmic Framework

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Generate multiple possible paths for each train that has to be rerouted, and associate a cost to each path.

Then select one path for each train, such that the cost is minimized, without creating conflicts between pairs of paths.

Cost Function

Three main parameters:

Cost Function

Three main parameters:

1. The total travel time.

Cost Function

Three main parameters:

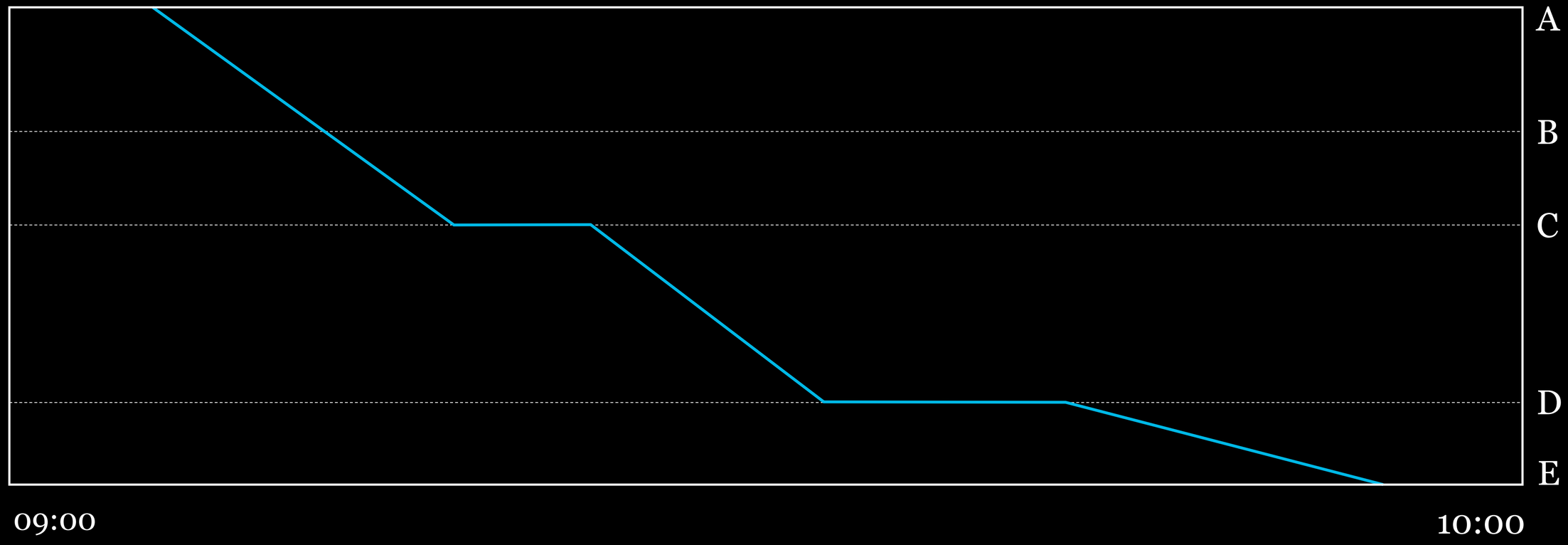
1. The total travel time.
2. Difference with requested departure time.

Cost Function

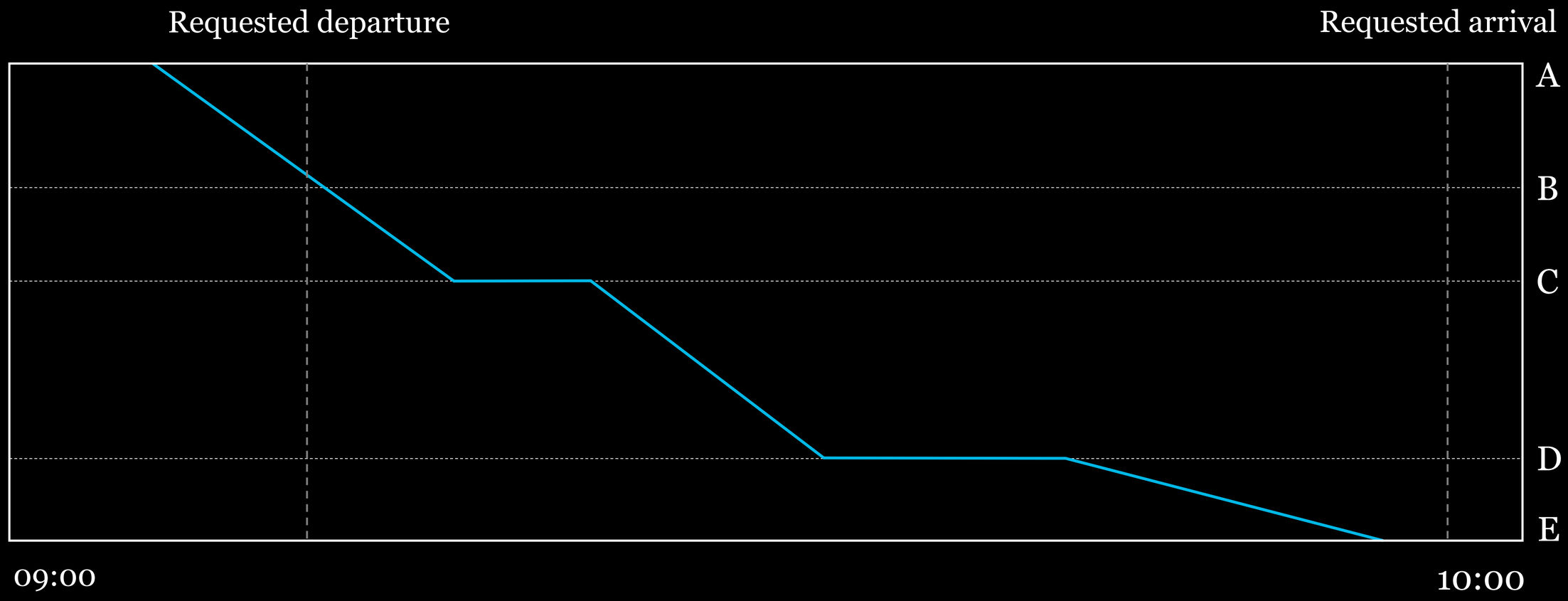
Three main parameters:

1. The total travel time.
2. Difference with requested departure time.
3. Difference with requested arrival time.

Cost Function



Cost Function



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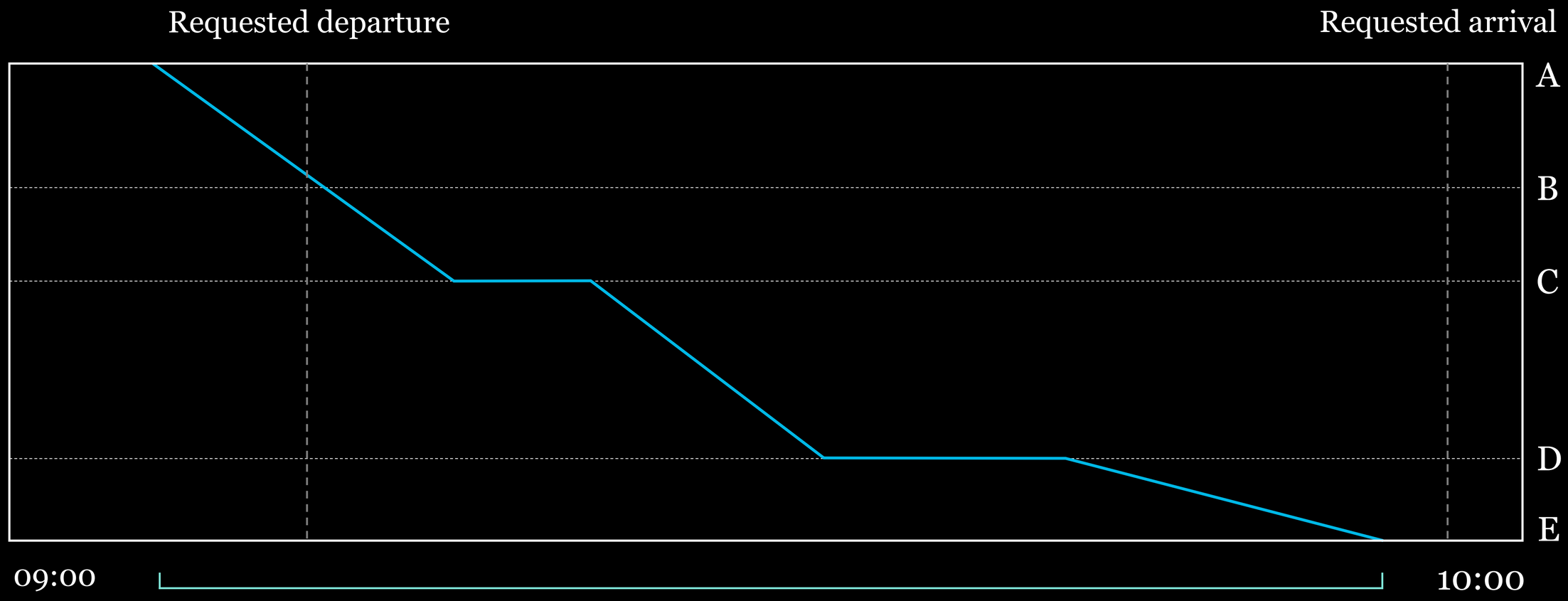
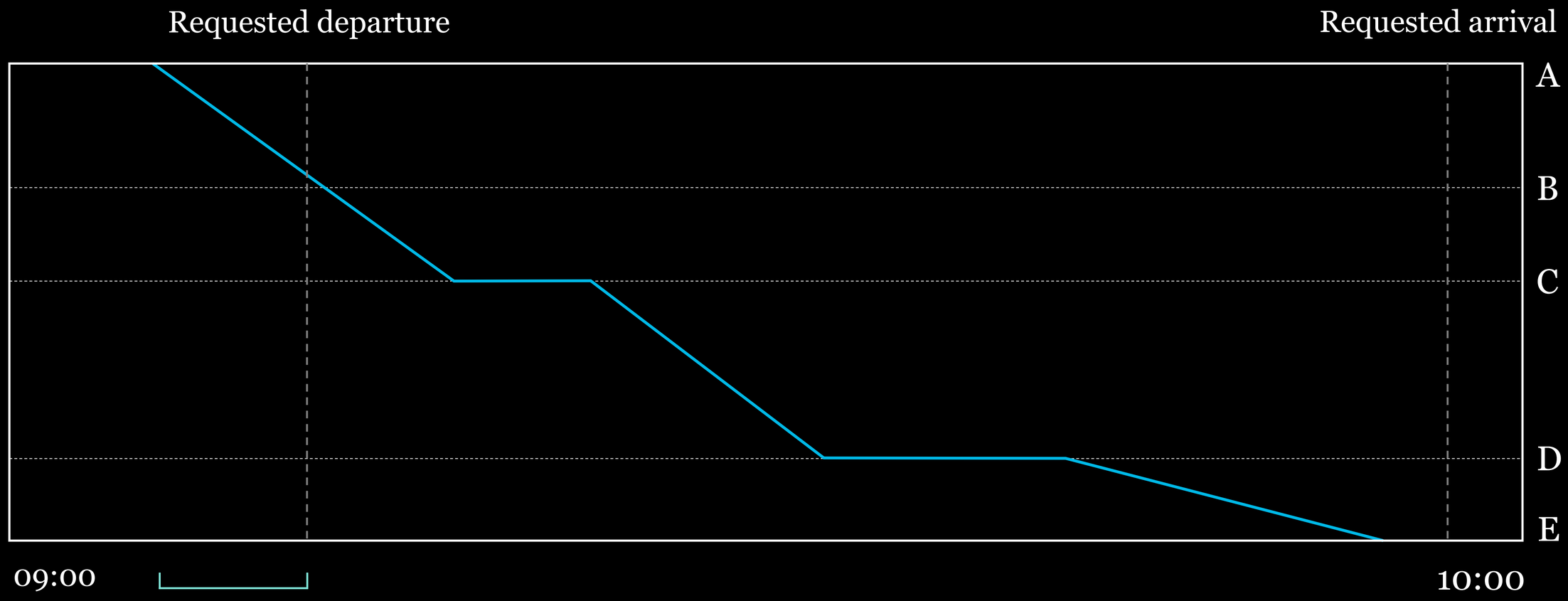


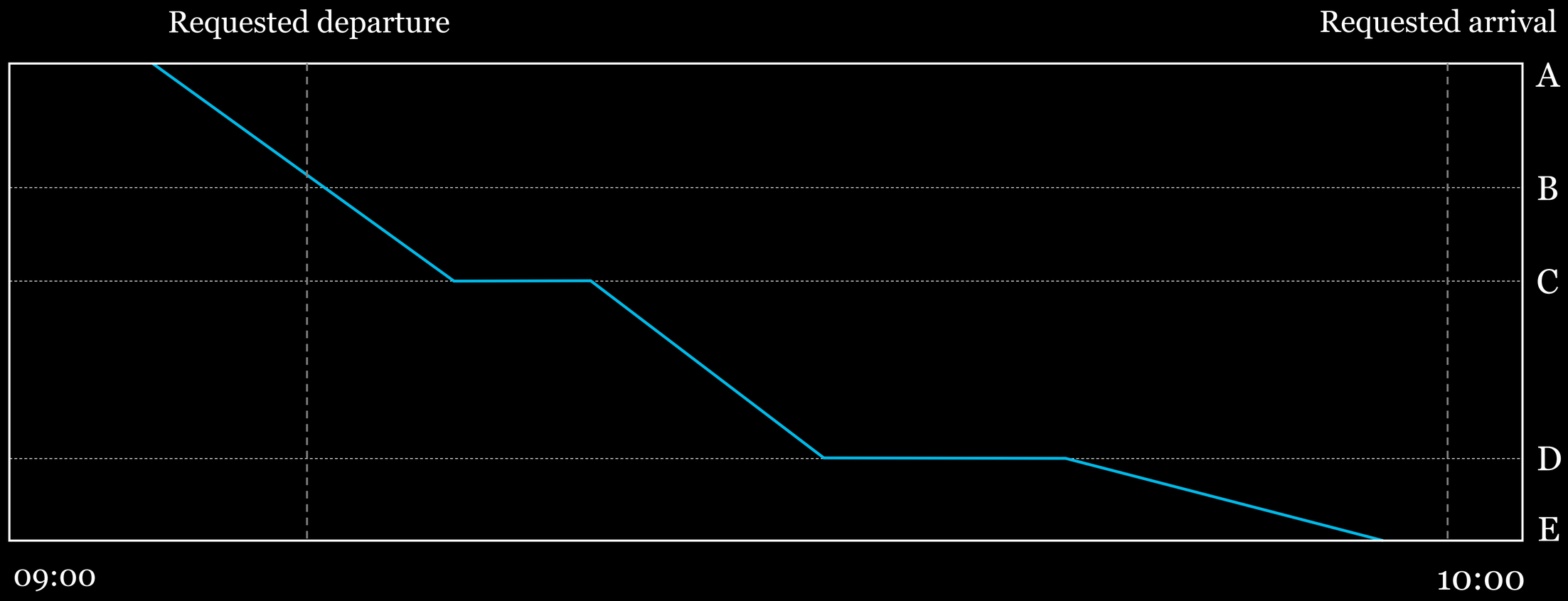
Travel time: 45 minutes.

Cost Function



Travel time: 45 minutes. Difference with requested departure: 6 minutes.

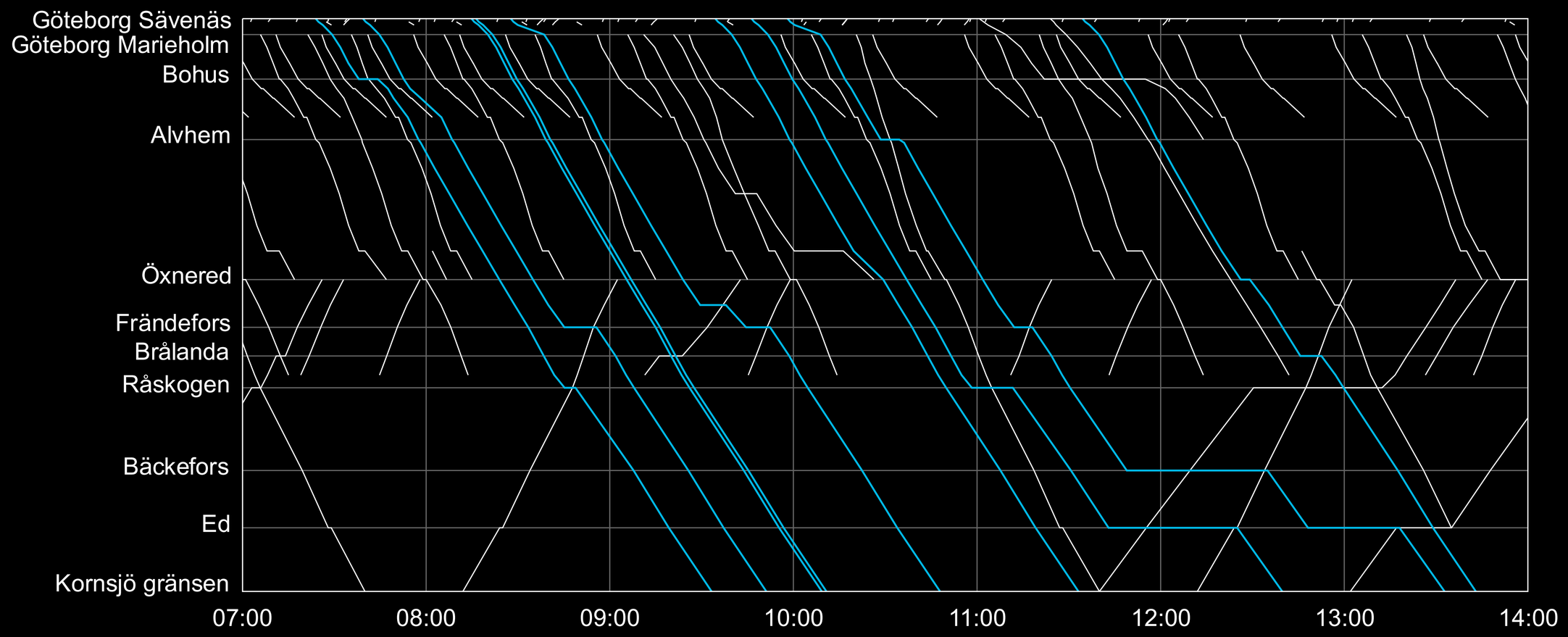
Cost Function



Travel time: 45 minutes. Difference with requested departure: 6 minutes. With arrival: 0 minutes.

Greedy Algorithm

Greedy Algorithm



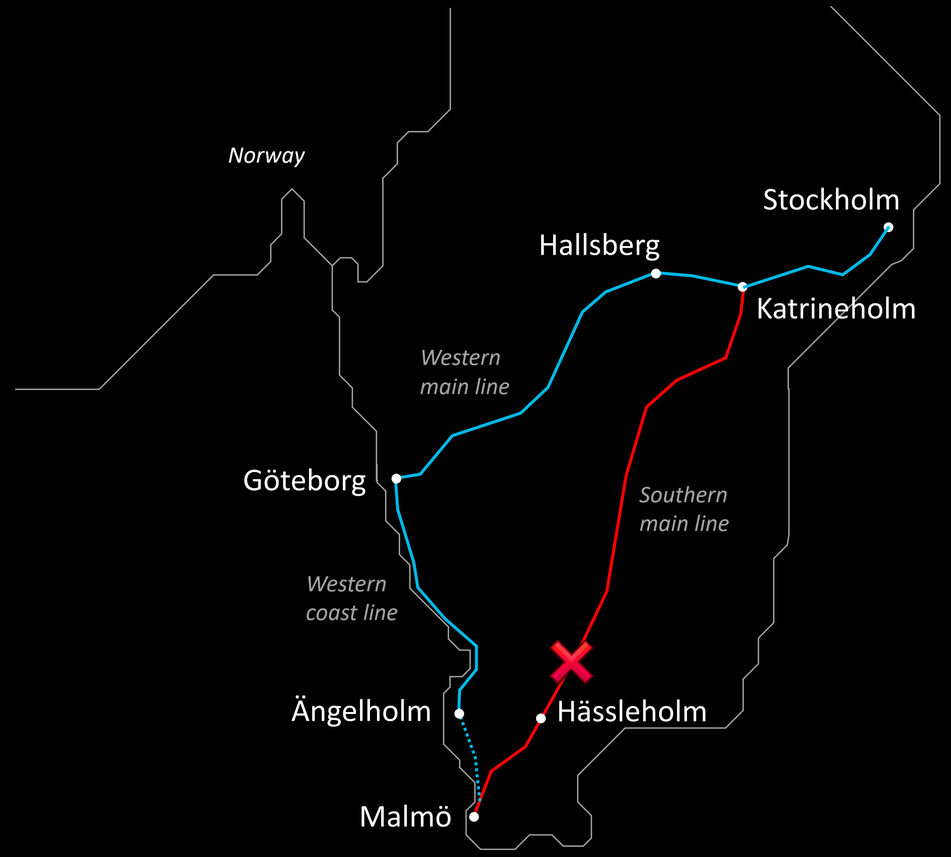
Case Study

- 50 trains to be rerouted via Göteborg during a weekend: 660 km long line.
- For now, we only consider the double track part north of Ängelholm.
- Cancellation is allowed.

Case Study

Solution cost for different methods:
(lower is better)

- 59.0: lower bound, where every train gets their optimal path, without solving conflicts between them.
- 63.2: greedy, passenger trains first.
- 67.3: two-phase independent set.
- 67.4: greedy, freight trains first.
- 75.8: independent set approach.



Future work

- Implementing iterative path generation to improve the independent set approach.
- Shifting focus to TTR: how should pre-planned freight paths look like?


Thank you!