

Klimatanpassning

Michelle Ochsner – Lund University & K2 – Nationellt kunskapscentrum för kollektiv mobilitet

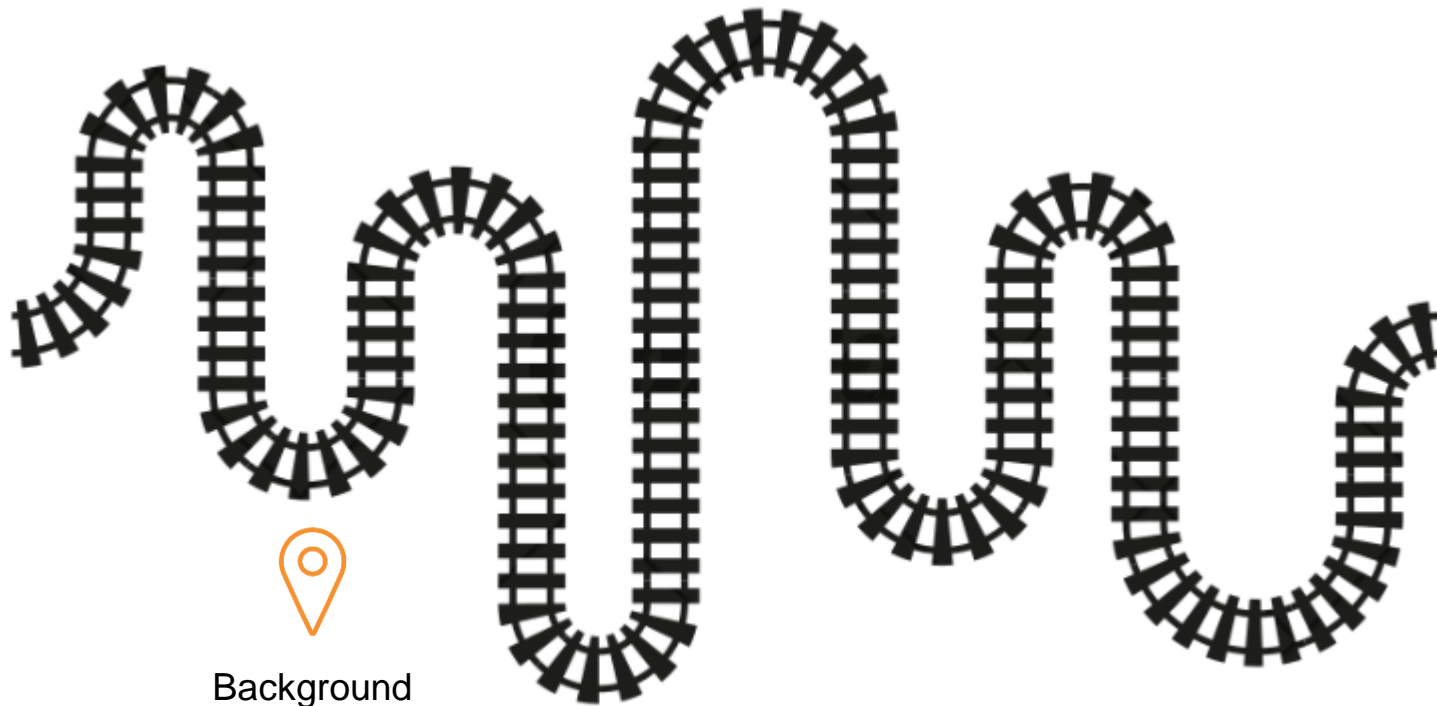
Branschrådet för tunnelbana och spårväg – 21/05/2025



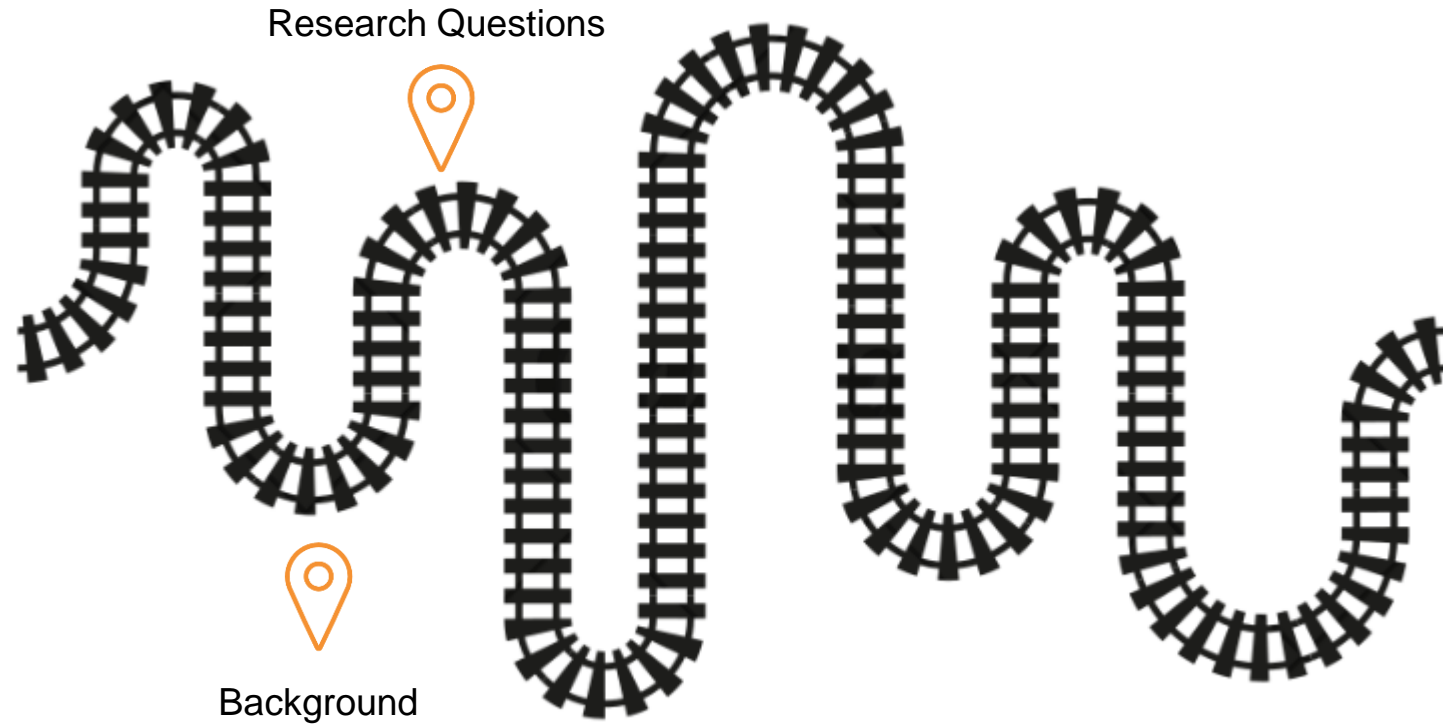
LUNDS UNIVERSITET



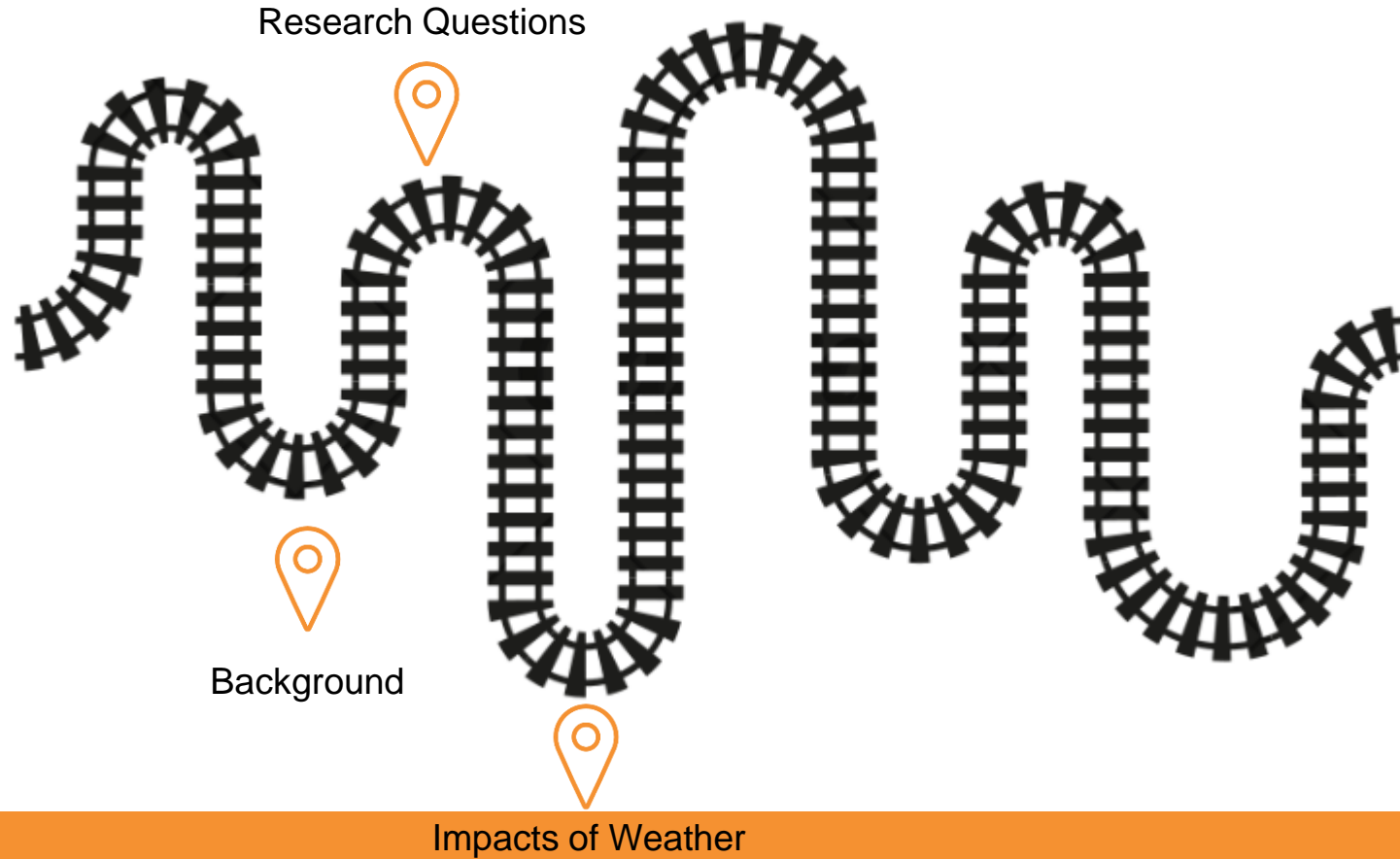
Agenda



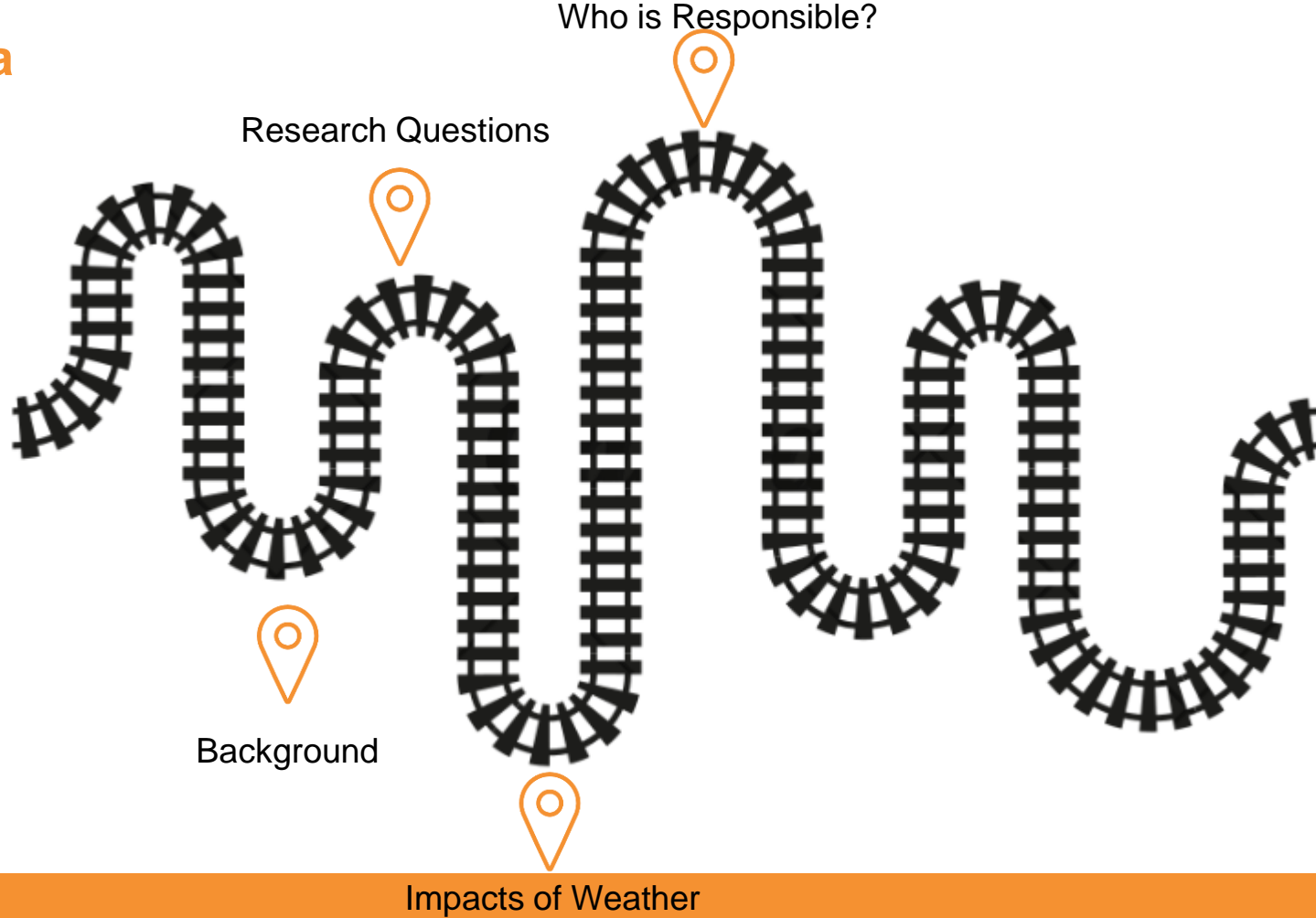
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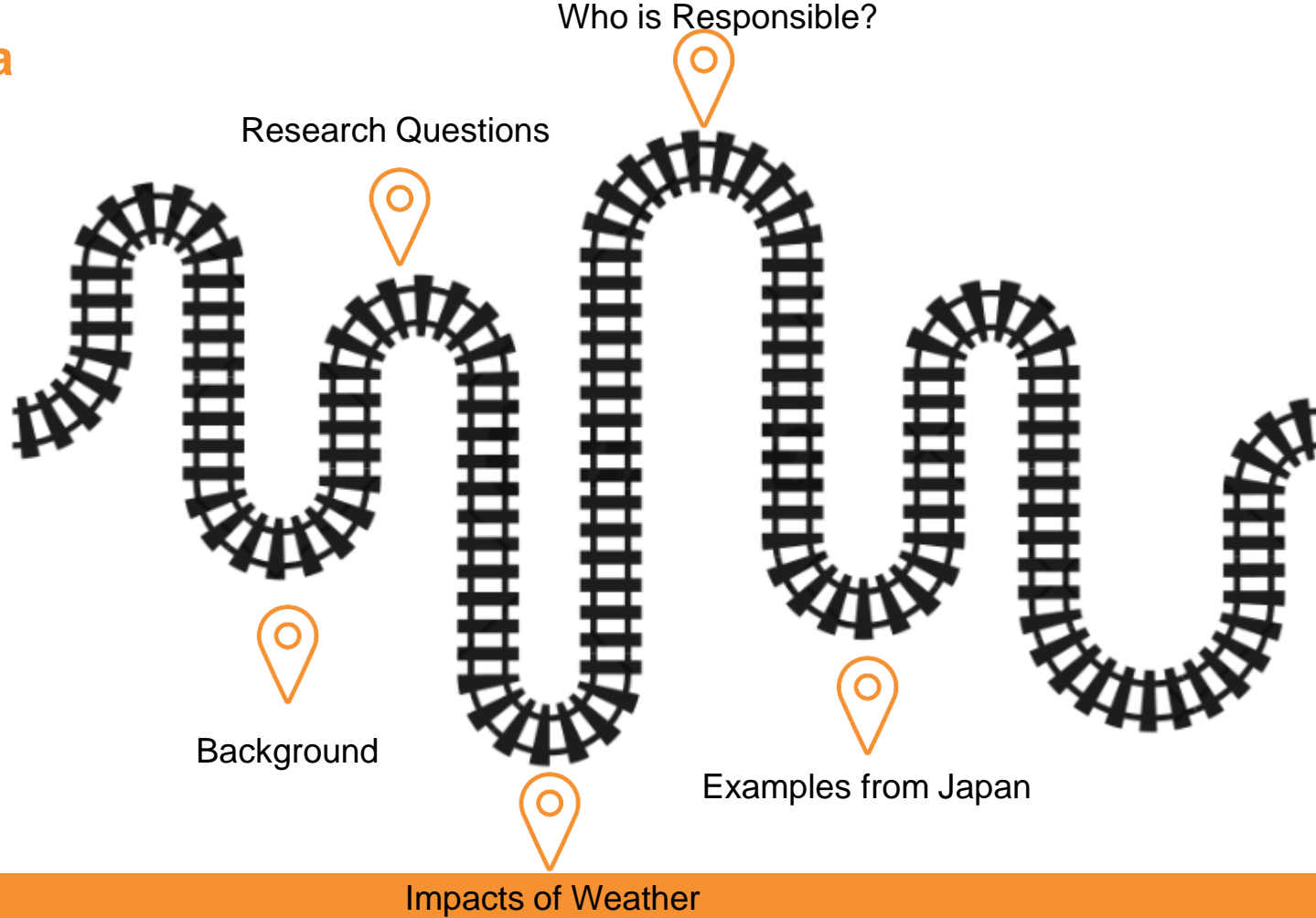
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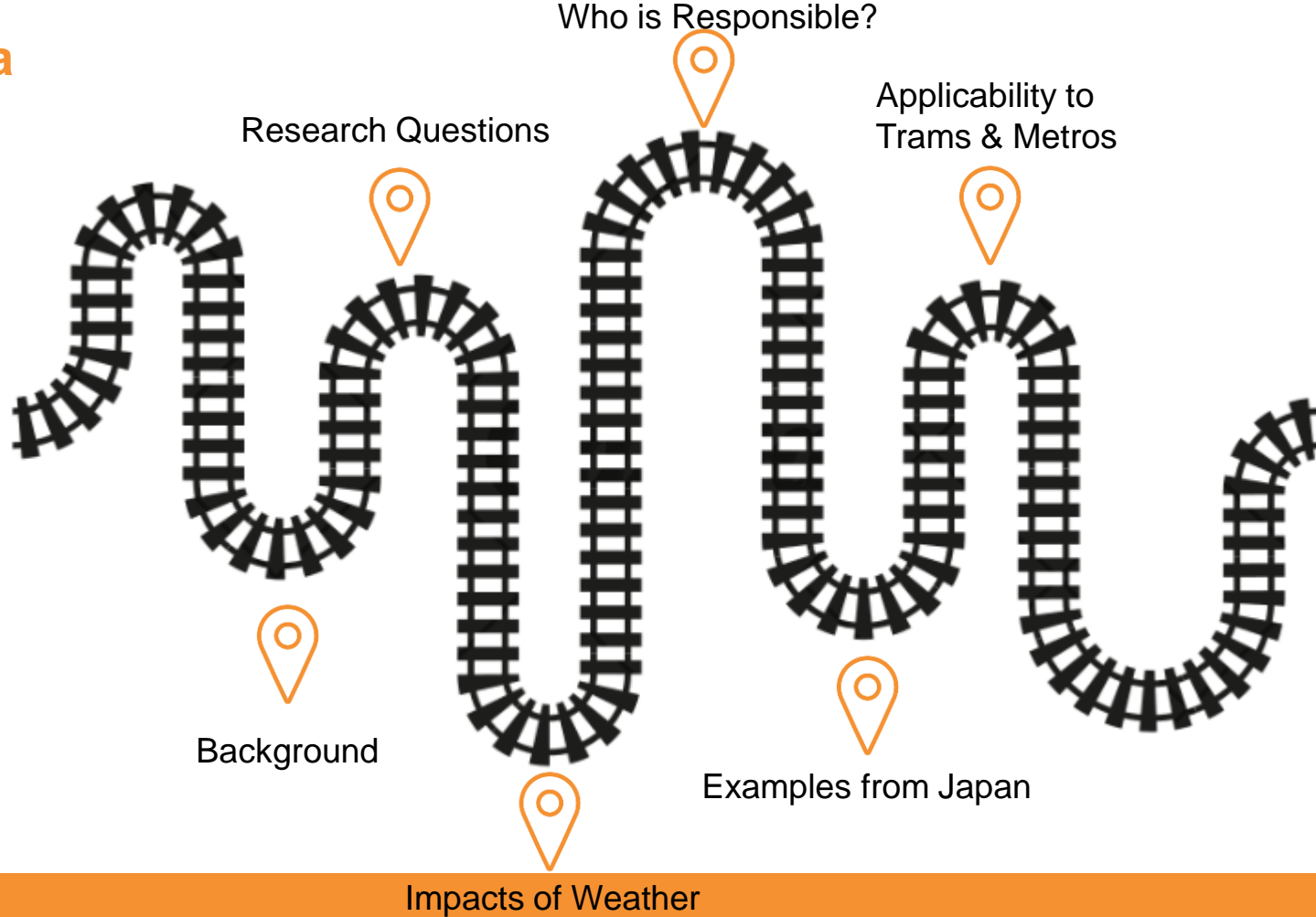
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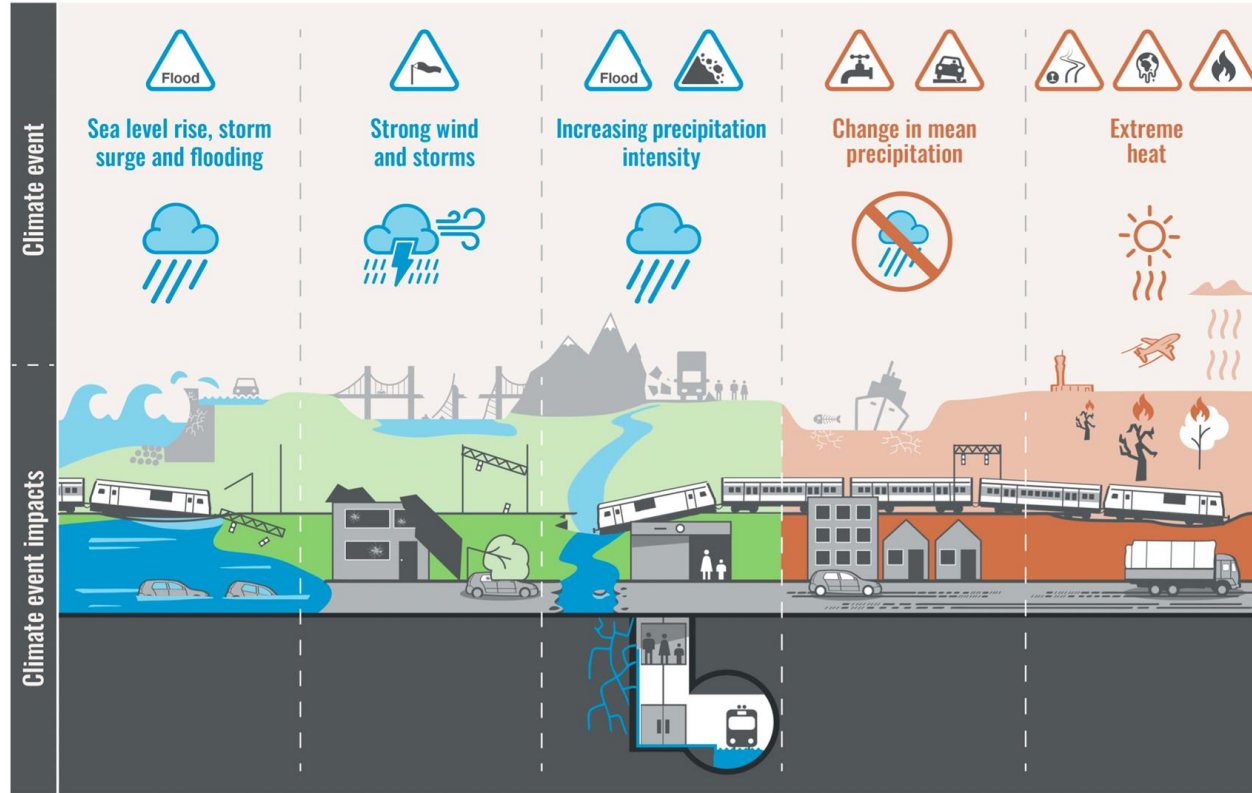
Agenda



Agenda



Impacts of Weather & Climate Change on Transport Infrastructure



Background

**Stressed supply chains snarled anew as B.C. floods
wash out rail lines, roads** (Canada, Fall of 2021)



<https://www.cbc.ca/news/business/bc-floods-rail-impact-1.6250554>

Background

German railway: Floods caused \$1.5 billion damage to network
(Germany, Belgium, Austria, Summer of 2021)

July 23, 2021



<https://apnews.com/article/europe-floods-0637d4aaaa9469595b9df8c98b488a2d>

Background



**UK heatwave: Significant Great
Western Railway disruption warning**
(UK, Summer of 2022)

<https://www.bbc.com/news/uk-england-gloucestershire-62199856>

Background



<https://www.swissinfo.ch/eng/two-swiss-trains-derail-in-strong-winds--several-injured/48409580>

Three injured after train derails in Sweden as storms cause havoc across northern Europe

(Sweden, summer 2023)



<https://www.euronews.com/2023/08/08/three-injured-after-train-derails-in-sweden-as-storms-cause-havoc-across-northern-europe>

Background – What is Adaptation?

IPCC: Adapting society to the impacts and consequences of a changing climate, i.e. taking action to prepare and adapt society to both the current impacts of climate change and the expected impacts in the future.

SMHI: Klimatanpassning innebär åtgärder för att anpassa samhället till de klimatförändringar vi redan märker av idag och de som vi inte kan förhindra i framtiden.

Overall PhD Research Aim & Questions

Aim: By using a mixed methods approach, the overarching aim is to understand how climate risks and uncertainties can be handled within the railway sector.

RQ 1: What is the impact of weather on railway infrastructure?

RQ 2: Who is responsible for adaptation in the railway sector?

RQ 3: What can Swedish railways learn from other countries in terms of climate change adaptation?



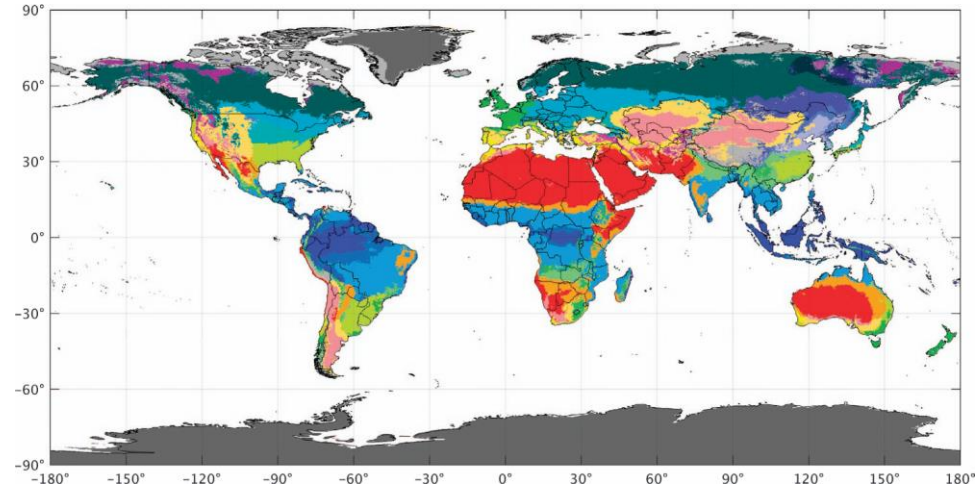
The Impacts of Weather on Railway Infrastructure

Aim: the aim of this paper is to quantify the vulnerability of Swedish railway infrastructure to different types of weather. Additionally, we use Köppen-Geiger climate zones defined by Beck et al. (2018) to further analyse the relationship based on different climate zones in Sweden to compare zones and take into account geographical differences.



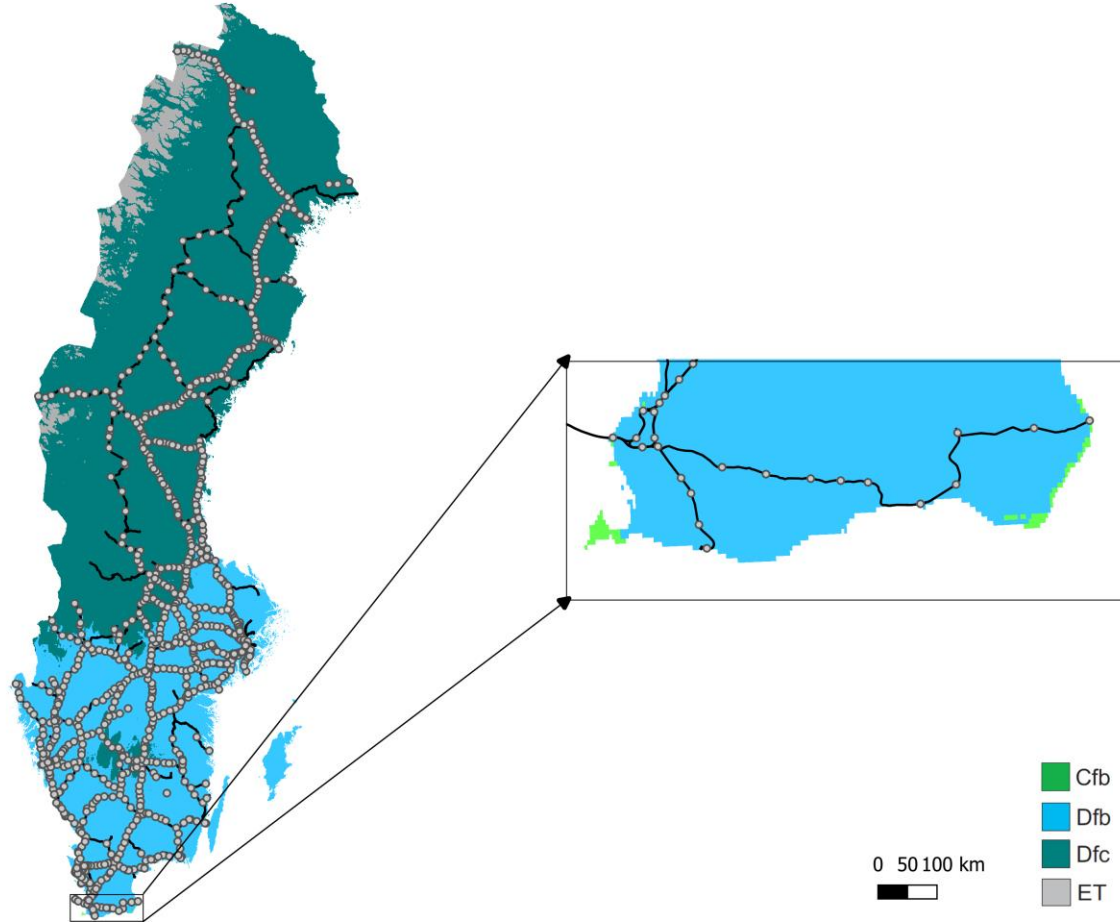
The Impacts of Weather on Railway Infrastructure

- Study period: 14 years (2006 – 2020)
- Infrastructure Fault Data – Trafikverket
 - Switch, signal, track, catenary
- Weather data (daily averages) – SMHI
 - Temperature, precipitation, snow depth, and wind speed
- Köppen-Geiger Climate Zones – Beck et al. (2018)



Beck et al. (2018)

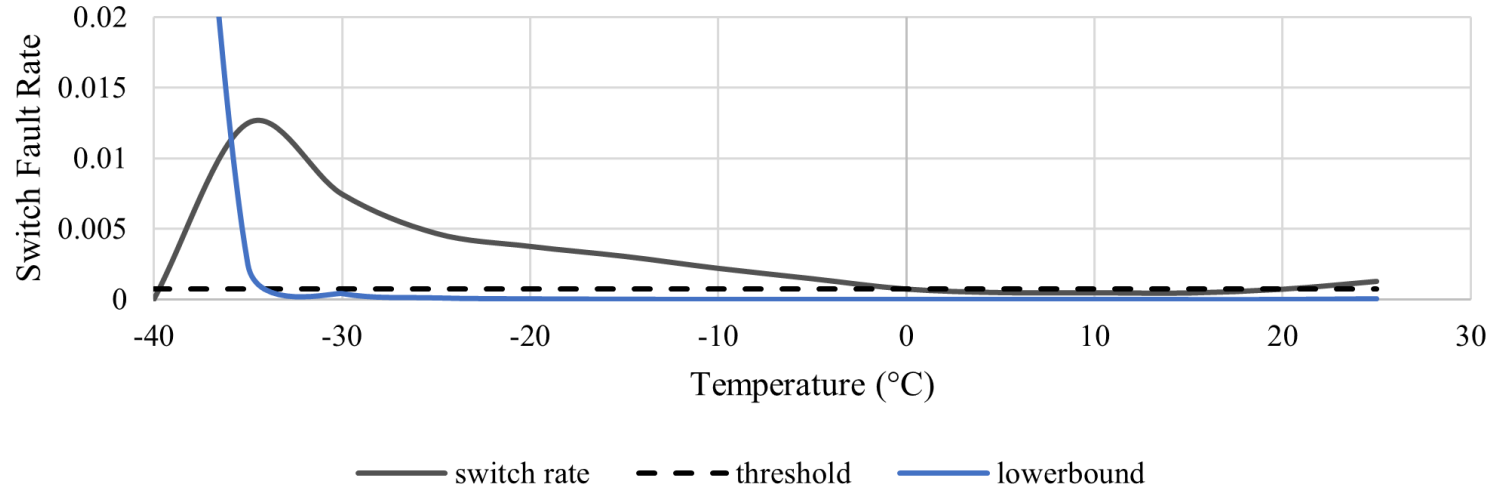
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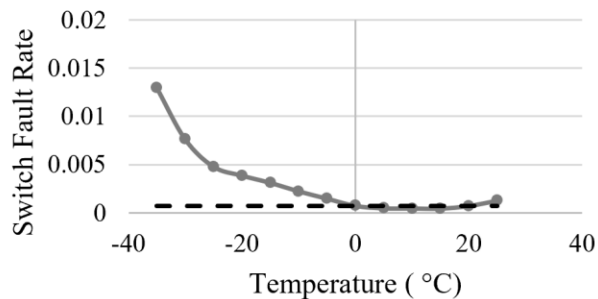
The Impacts of Weather on Railway Infrastructure

$$\textit{Fault Rate} = \frac{\textit{Number of Faults}}{\textit{Exposure}}$$

The Impacts of Weather on Railway Infrastructure

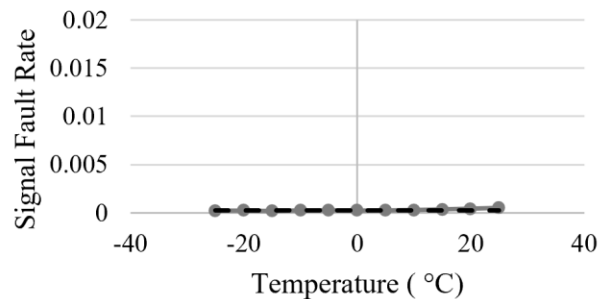


The Impacts of Weather on Railway Infrastructure



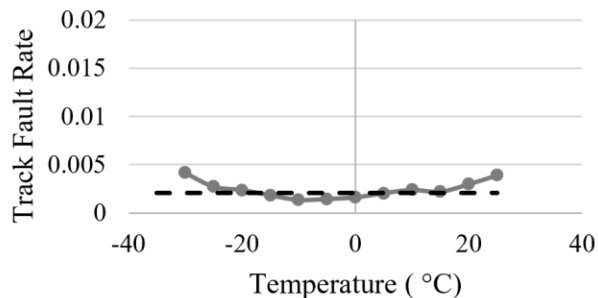
—●— fault rate - - - threshold

a



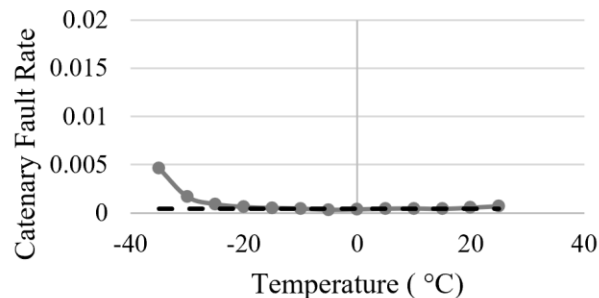
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b



—●— fault rate - - - threshold

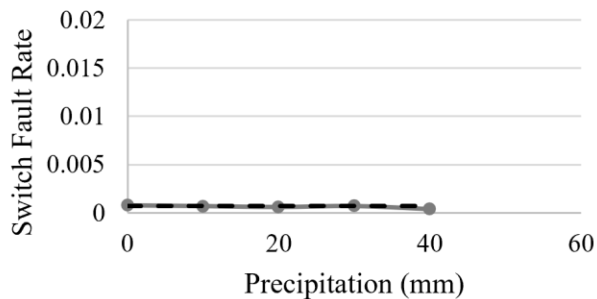
c



—●— fault rate - - - threshold

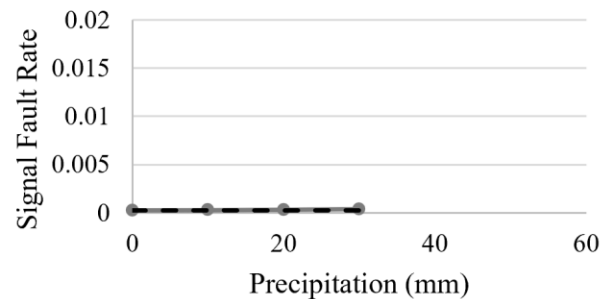
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The Impacts of Weather on Railway Infrastructure



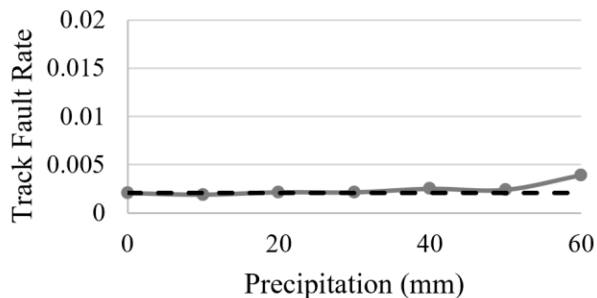
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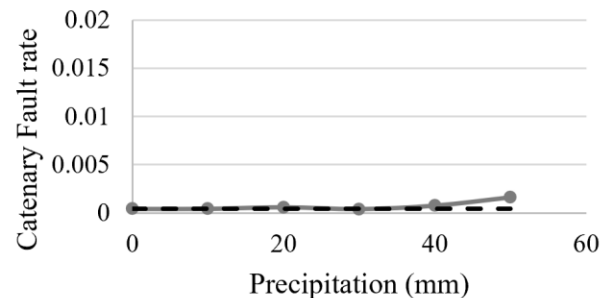
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b



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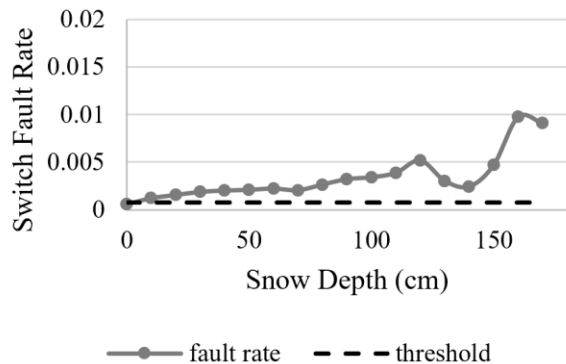
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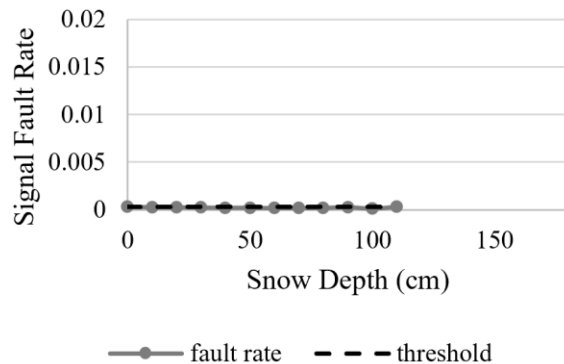
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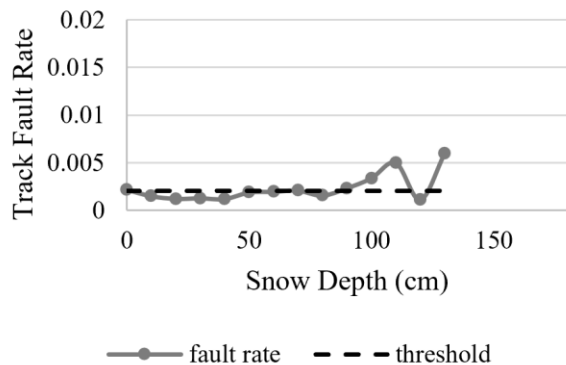
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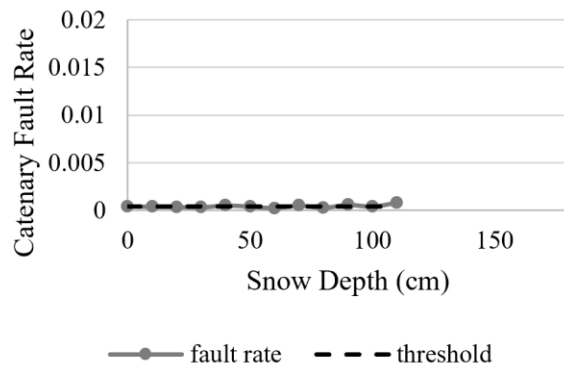
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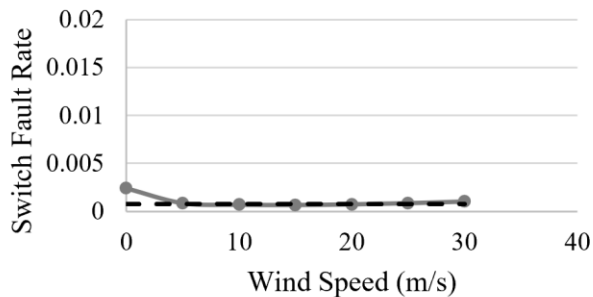


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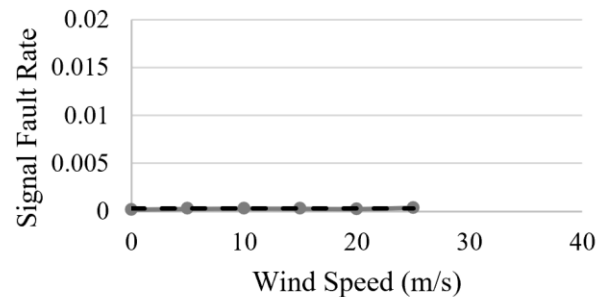
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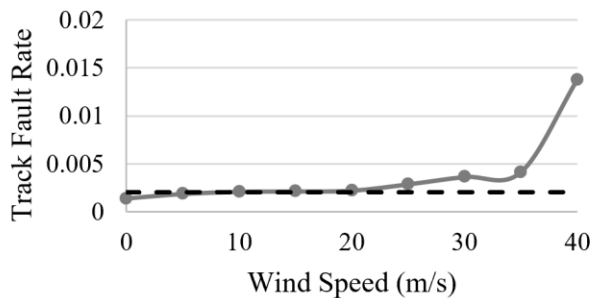
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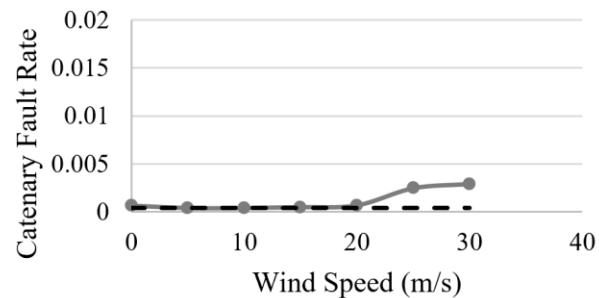
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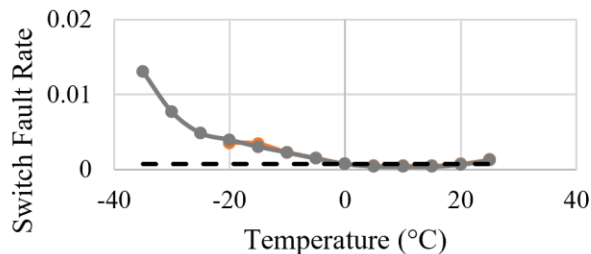
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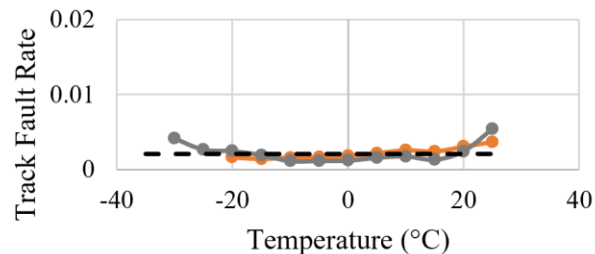
	Switches	Signals	Track	Catenaries
Temperature	<0°C & >+25°C	>+15°C	<-20°C & >+10°C	<-10°C & >+5°C
Precipitation	<0mm	>10mm	>20mm	>20mm
Snow Depth	>10cm	<0cm & >110cm	<0cm & >70cm	<0cm & >40cm
Wind Speed	<5m/s & >25m/s	>10m/s	>10m/s	>15m/s

	Switches	Signals	Tracks	Catenaries
Temperature	X		X	X
Precipitation			X	X
Snow Depth	X		X	
Wind Speed			X	X

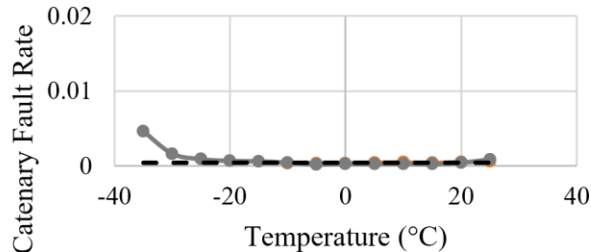
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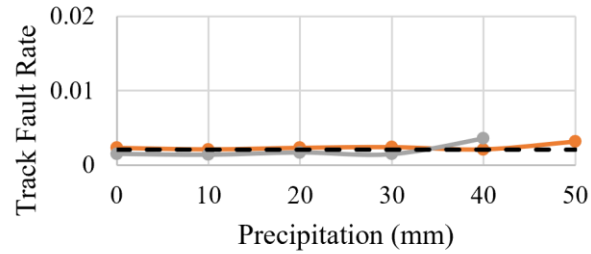


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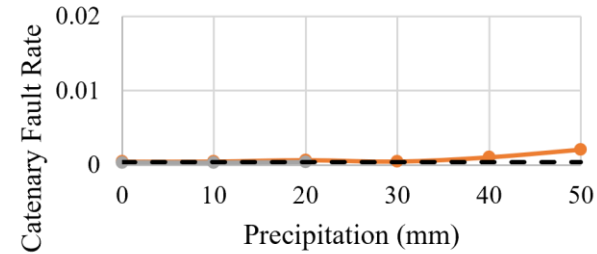
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The Impacts of Weather on Railway Infrastructure



—●— fault rate Dfb —●— fault rate Dfc
- - - threshold

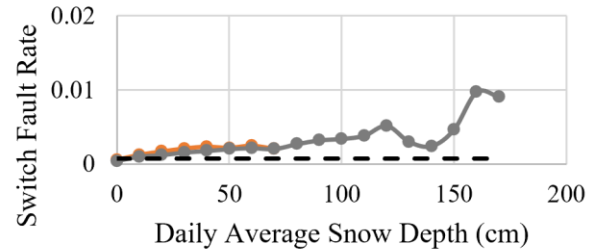
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—●— fault rate Dfb —●— fault rate Dfc
- - - threshold

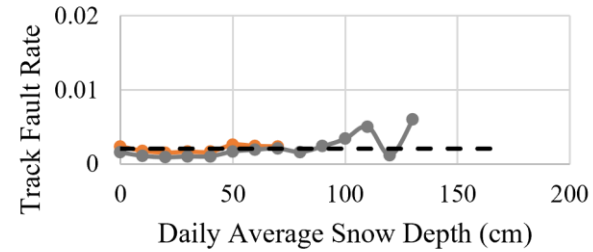
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—●— fault rate Dfb —●— fault rate Dfc
- - - threshold

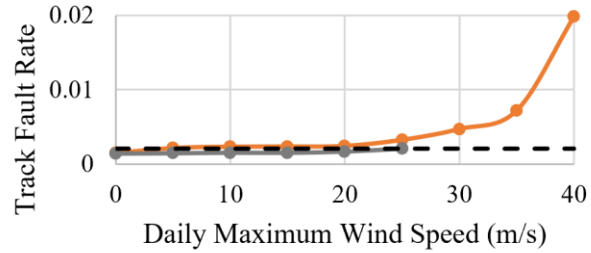
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—●— fault rate Dfb —●— fault rate Dfc
- - - threshold

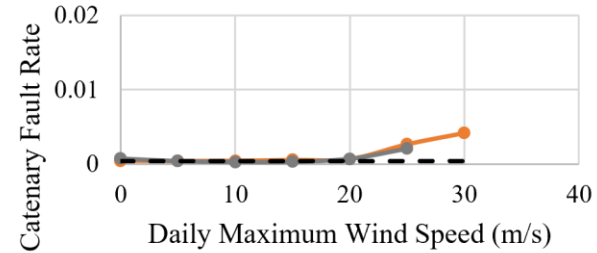
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The Impacts of Weather on Railway Infrastructure

	Switches	Signals	Tracks	Catenaries
Temperature		-	X	
Precipitation	-	-	X	
Snow Depth			X	
Wind Speed	-	-	X	

	Tracks, Dfb	Tracks, Dfc
Temperature	>5°C	<-20°C & >+20°C
Precipitation	>0mm	>40mm
Snow Depth	>50cm	>90cm
Wind Speed	>5m/s	N/A

The Impacts of Weather on Railway Infrastructure

- Signals most “resilient” asset
- Tracks most vulnerable asset
- Switches vulnerable to low temperatures and snow depth
- Catenary vulnerable to low and high temperatures, precipitation, and wind
- Only notable difference across climate zones for track assets
- Important insights for increasing railway resilience to climate change



Who is Responsible for Adaptation?

Aim: To analyse the responsibilities of climate change adaptation in the railway sector in Sweden.

- What are the written responsibilities and how do these differ in practice?



Who is Responsible for Adaptation?

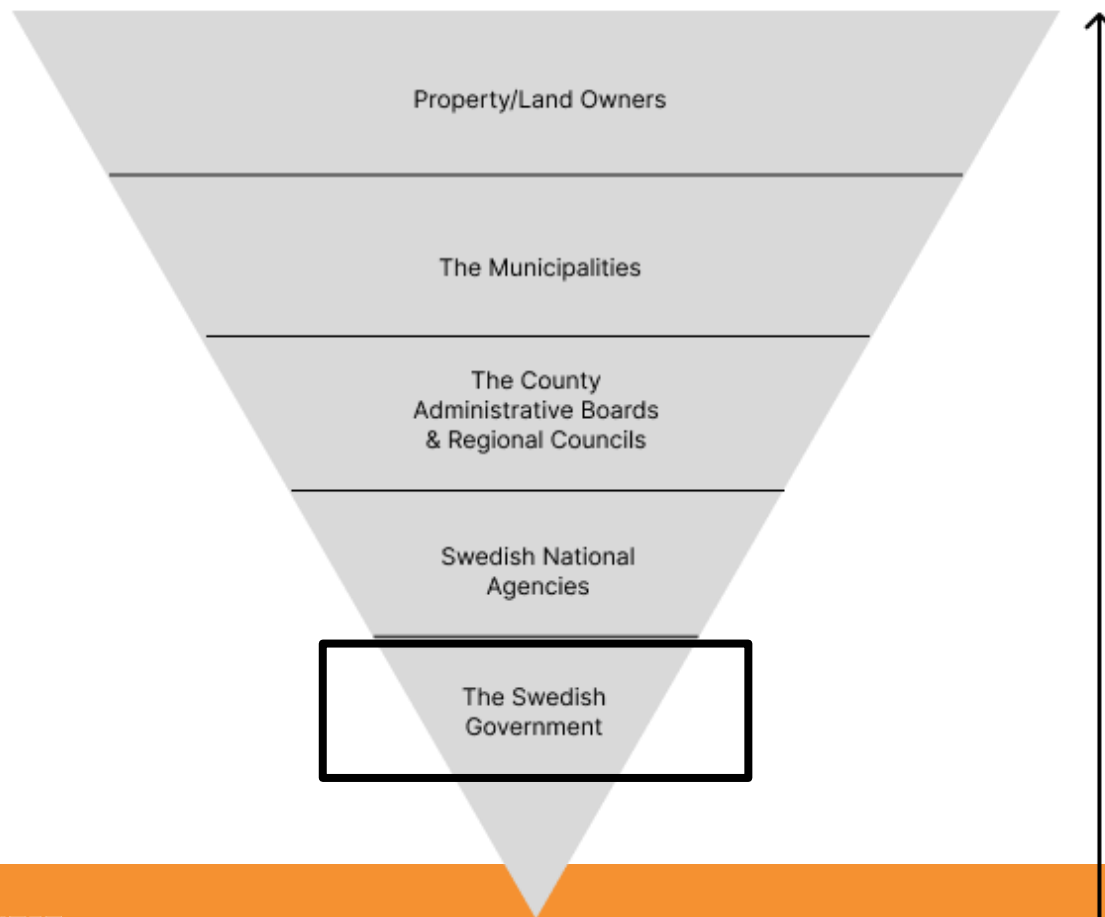
- Analysis of different documents
 - Examples:
 - Trafikverket adaptation strategy
 - Transportstyrelsens adaptation strategy
 - National adaptation strategy
 - Expertrådet för Klimatanpassning report



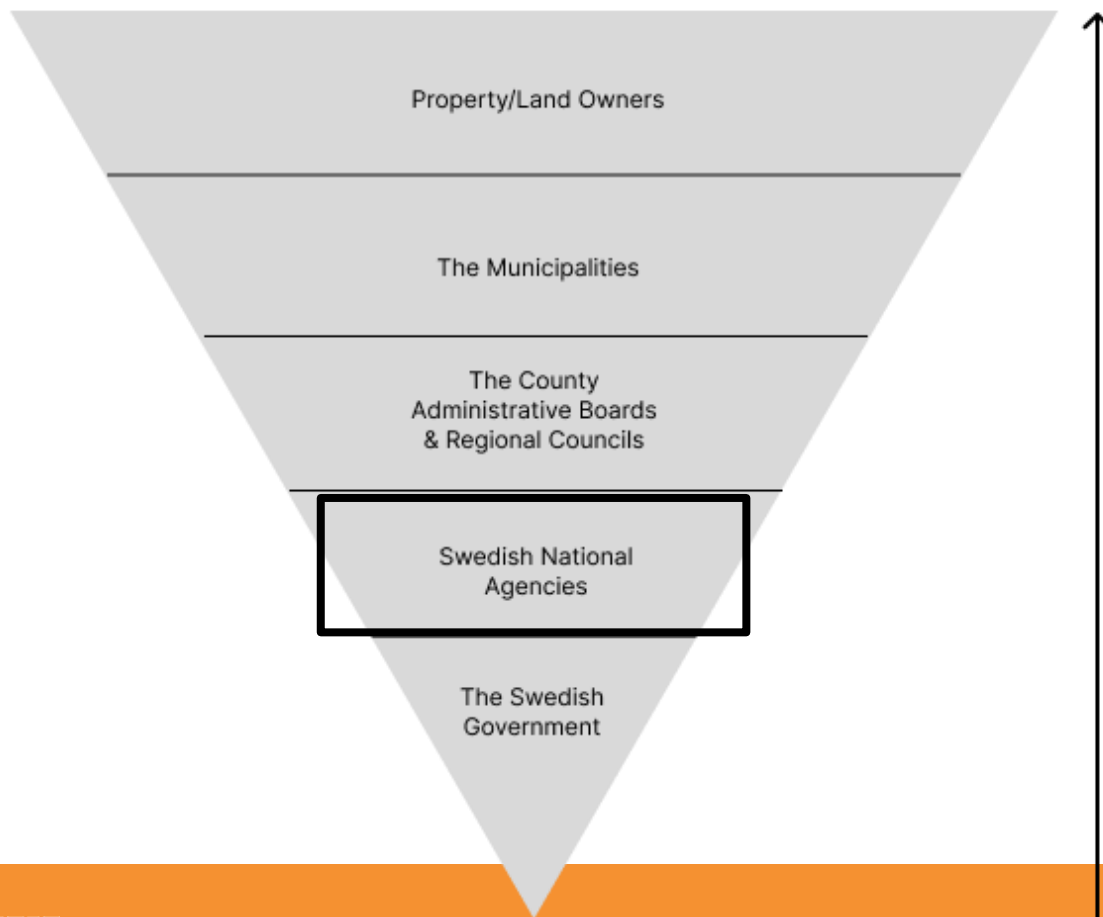
Who is Responsible for Adaptation?

Type of Stakeholder	Organisation
Public Agency	Trafikverket Transportstyrelsen MSB Boverket SGI SMHI
Länstyrelsen	Länstyrelsen Gävleborg Länstyrelsen Skåne
Regional Councils/Regional Public Transport Authorities	Region Västra Götaland Region Värmland Region Stockholm Region Skåne
Municipality	Trelleborg Municipality Stockholm Municipality Norrköping Municipality Lund Municipality

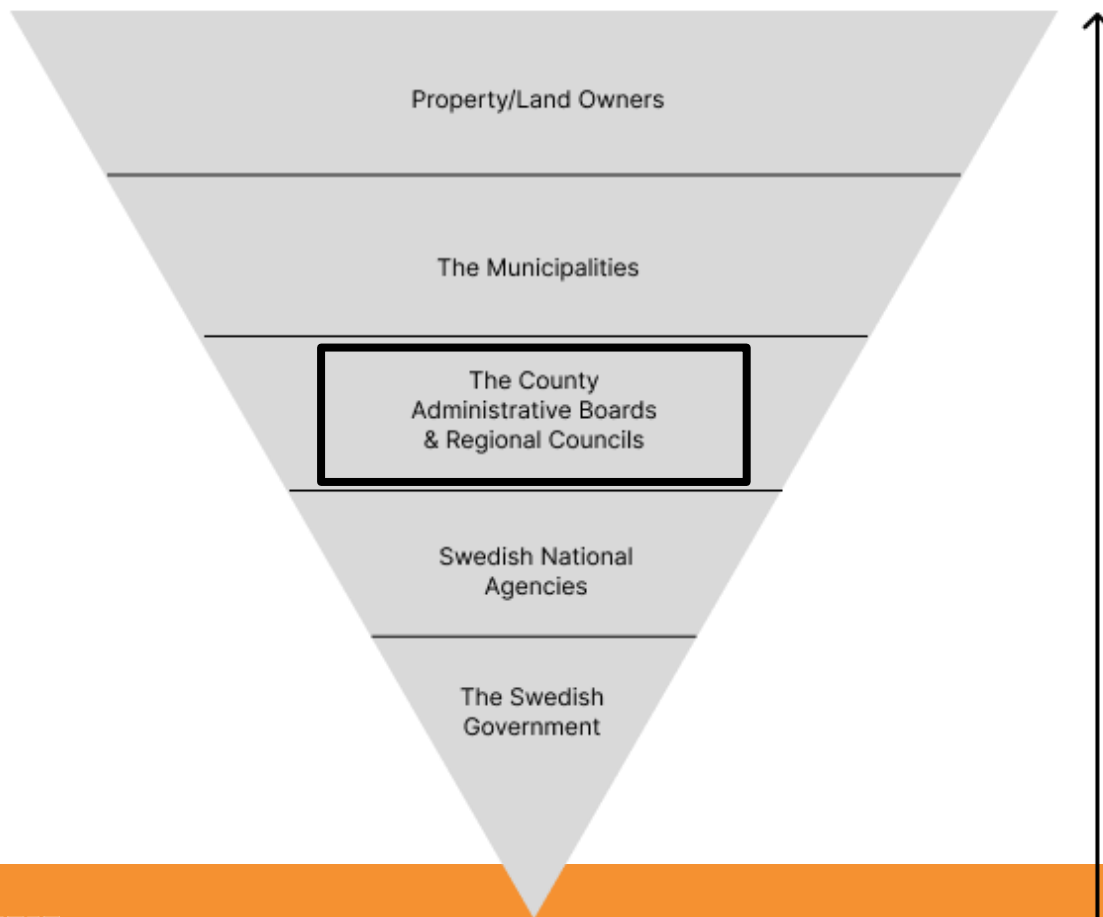
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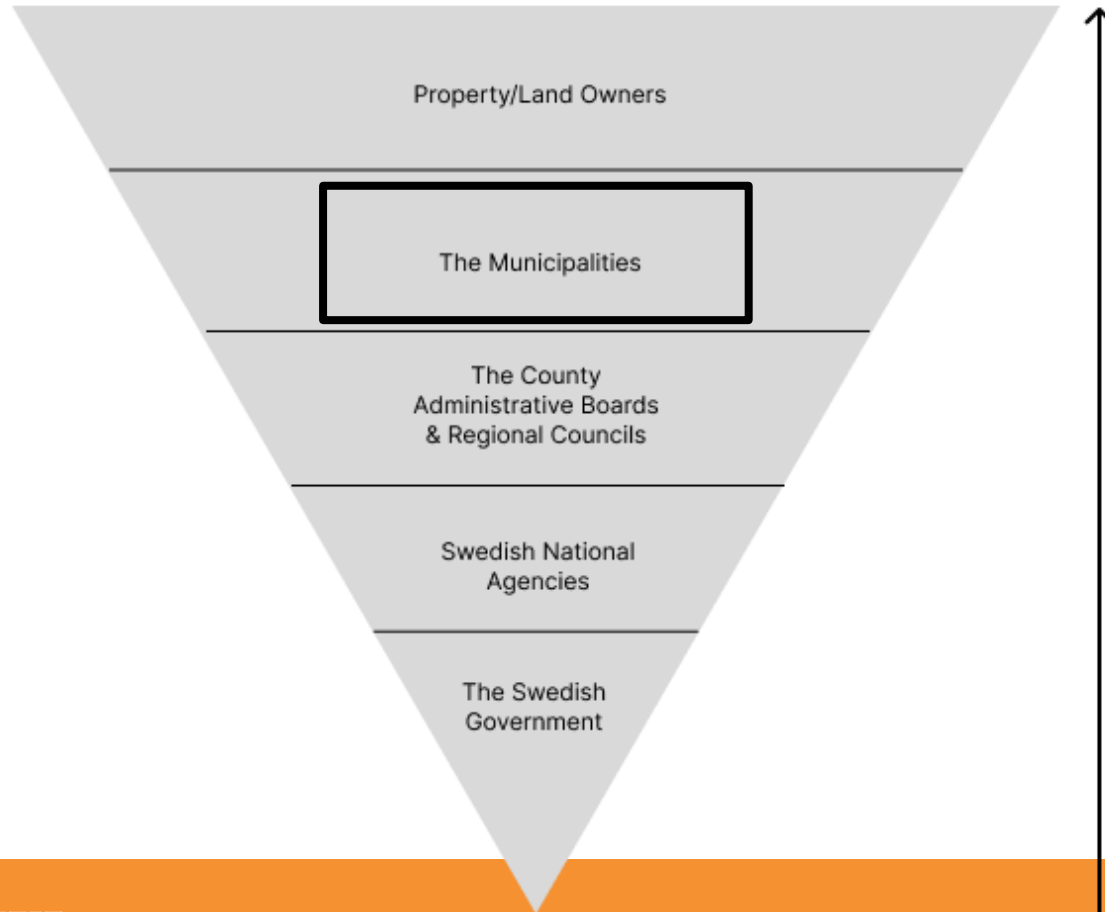
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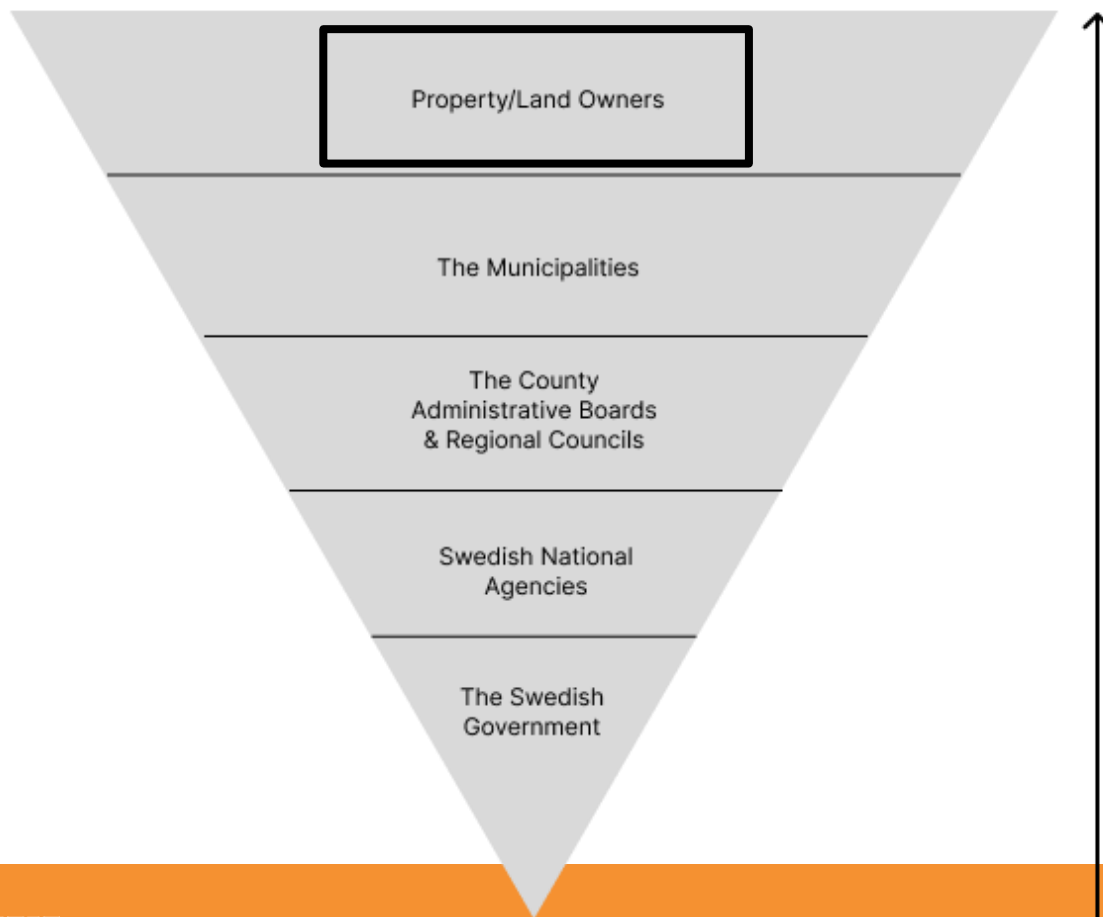
Who is Responsible for Adaptation?



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Who is Responsible for Adaptation?



Who is Responsible for Adaptation? – Preliminary Results

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 - Who is owning the land vs. tracks vs. platforms vs. rolling stock

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- **Financing**
 - Who should pay?
 - Lämnstyrelsen's cut in funding

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- Ownership can be unclear in some areas
 - Who is owning the land vs. tracks vs. platforms vs. rolling stock
- Financing
 - Who should pay?
 - Lämnstyrelsen's cut in funding
- **Resources**
 - Small vs. big municipalities
 - Different types and amount of infrastructure in different Trafikverket Regions

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 - Less on heat

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 - KSA vs. regular risk analysis
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- **Maintenance of infrastructure vs. construction of new infrastructure**
 - Trafikverket working towards more work on adaptation in maintenance practices

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- Maintenance of infrastructure vs. construction of new infrastructure
 - Trafikverket working towards more work on adaptation in maintenance practices
- **Moving society forward**
 - Moving away from reactive management to more proactive

Adaptation in Japan



Fig. 1. The six JR companies and business areas after privatization.

Tomikawa & Goto 2022

Vertical Integration

Railway Operation

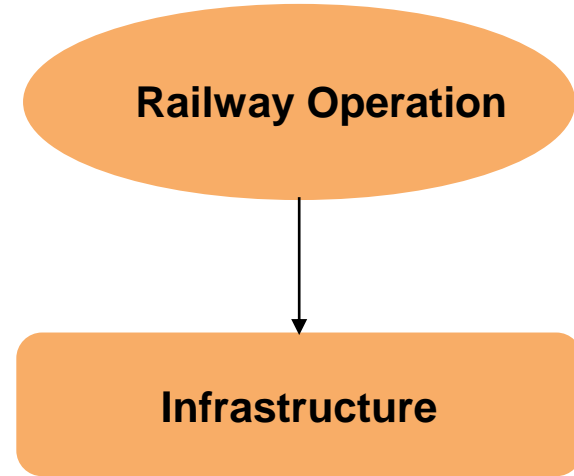
Infrastructure

- A railway company pays the costs of infrastructure.
- The company is responsible for maintenance, traffic control, timetabling, etc.



TRAFIKVERKET

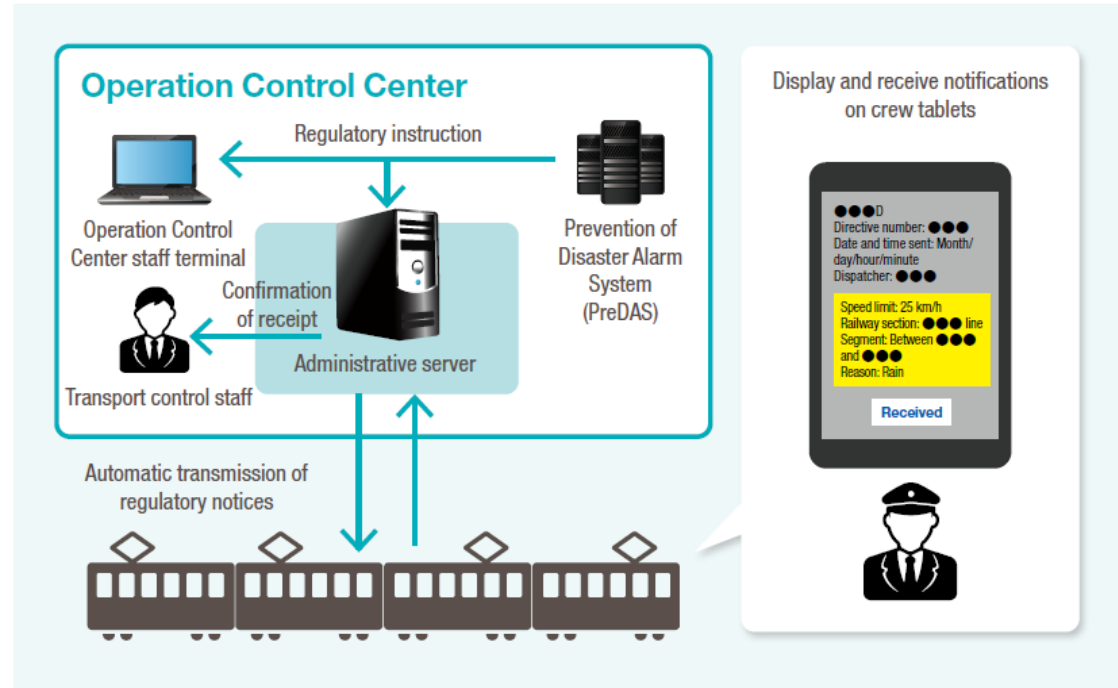
Vertical Separation



- The public sector pays the costs of infrastructure.
- Trafikverket responsible for maintenance, timetabling, traffic control, etc.
- Operator/PTA operates and bids for slots on track.

Adaptation in Japan – Weather Monitoring

- Rainfall
- Wind
- Temperature of the railway
- River water level
- Snow depth
- Earthquake



JR East, 2023

Adaptation in Japan – Actions Against Heavy Rainfall



<https://www.andemagazine.jp/2023/07/27/infrastructure-maintenance-jreast-02.html>



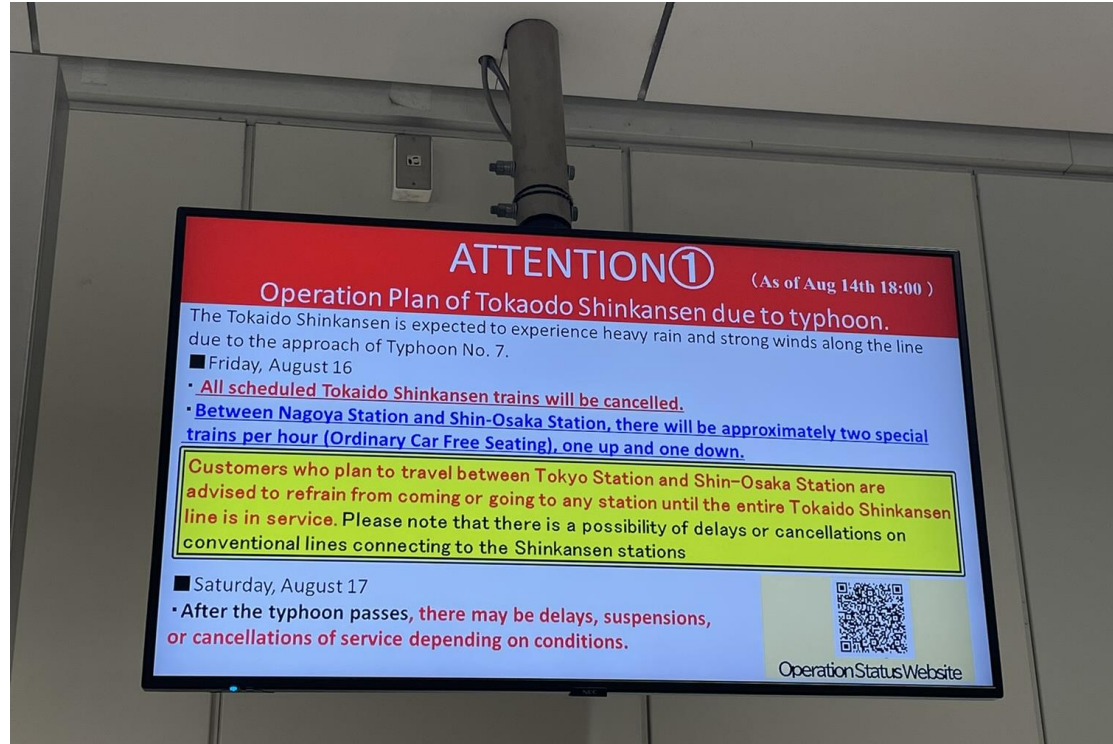
<https://english.kyodonews.net/news/2019/11/4e7dfd267c83-all-10-typhoon-flooded-shinkansen-bullet-trains-to-be-scrapped.html>

Adaptation in Japan – Actions Against Heavy Rainfall



https://www.tokyo-metro.jp/safety/prevention/wind_flood/index.html

Adaptation in Japan – Actions Against Heavy Rainfall



Adaptation in Japan – Actions Against Heavy Rainfall



Adaptation in Japan – Actions Against Wind



JR East, 2023



<http://www.mcfw.jp/hakonetozanrail.htm>

Adaptation in Japan – Actions Against Snow



<https://japannews.yomiuri.co.jp/society/general-news/20230227-93827/>



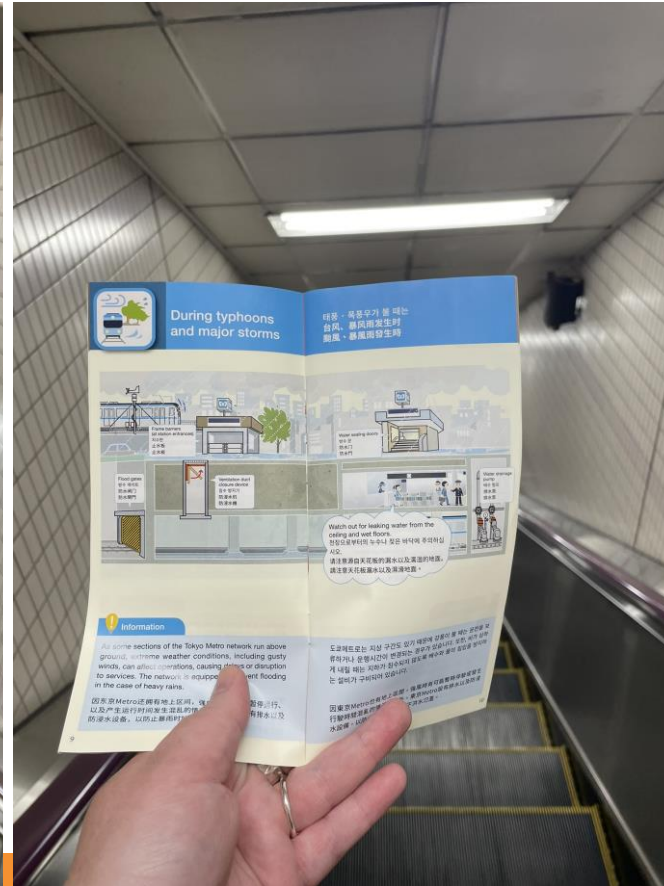
<https://www.progressiverailroading.com/railproducts/product.aspx?id=6002>

Adaptation in Japan – Actions Against Heat



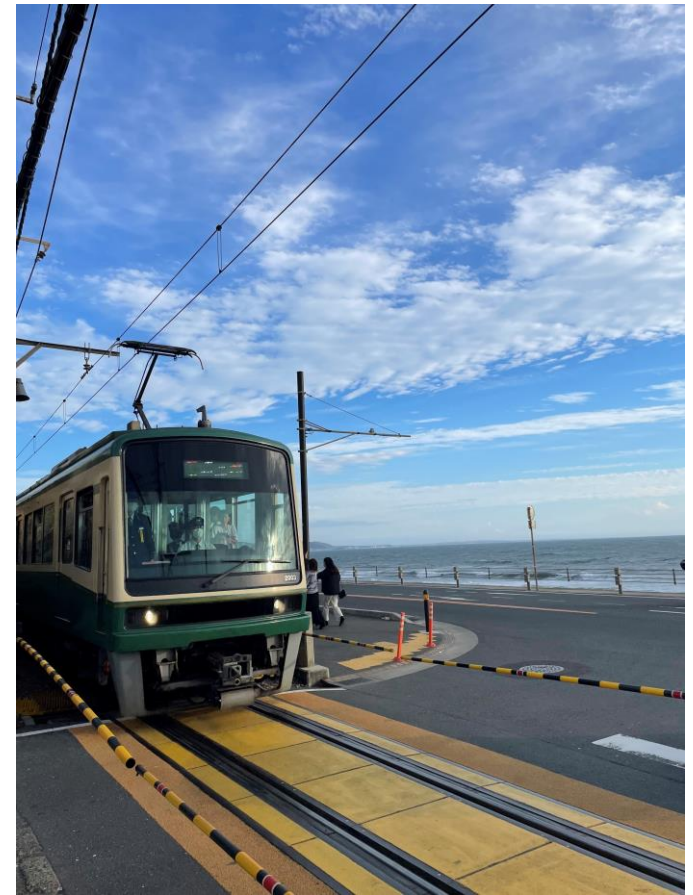
<https://www.japantimes.co.jp/news/2024/08/15/japan/heat-warping-railway-tracks/>

Adaptation in Japan – Risk Communication



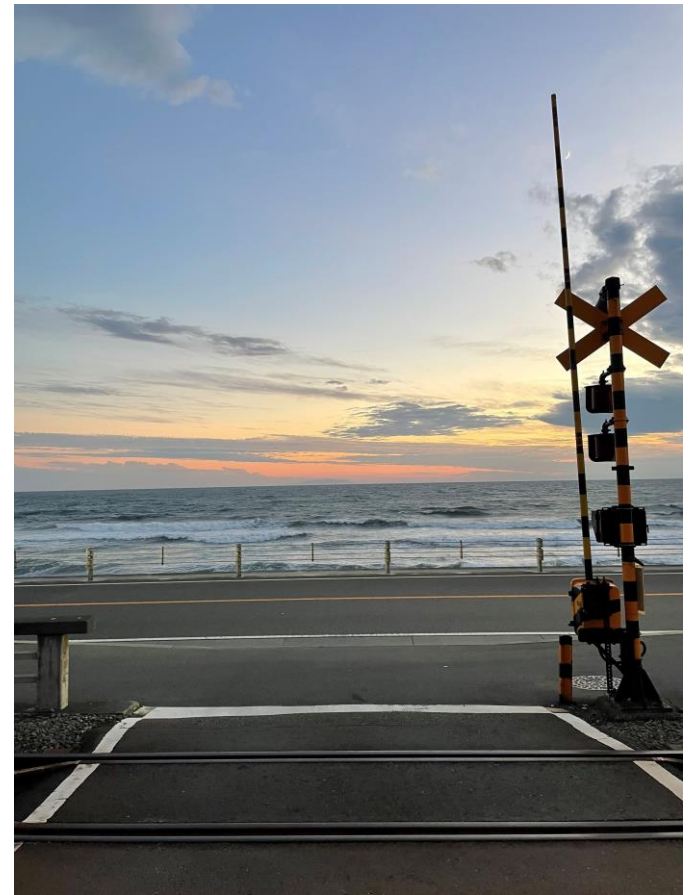
Adaptation in Japan

- Many railway companies feel they are able to handle the situation today but need to continue to monitor.
- DRR is deeply rooted in the business culture in Japan. Always learning and adapting from past disasters.
- More recognition and efforts of CCA from the government. Things may be moving towards more long-term perspectives.
- Still some challenges in rural areas due to the vertically integrated structure.



Applicability to Trams & Metros

- Different regulations than mainline railways.
- No clear written responsibility for Region but if they own infrastructure, they have the responsibility to adapt their land.
- How to collaborate between overlapping landowners?





My Research
Profile



Tack!

