Predicting infrastructural failures using vehicle data

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Background

In this thesis it has been investigated if vehicle sensors can be used to detect an infrastructural failure. If an infrastructural failure can be detected in an early stage, the failure can be repaired before the train traffic is affected.

This thesis is a continuation of a previous sprint in a collaboration project called Together for Trains on Time, developed by Järnvägsbranchens Samverkansforum (collaboration forum for the railway industry).

Failures categorized as *Cant irregularities, Incorrect position of the contact wire* and *Damage and wear on the contact wire* is investigated. The failure called *Cant irregularity* is when there is a rail-tilt deviation from the design geometry, see figure 3. *Incorrect position of the contact wire* is when the position of the contact wire is incorrect in height- or horizontal length. It can occur if, for example the steady arm is broken, see Figure 4.

Map 1: Lines trafficked by Skånetrafikens Pågatåg.

Figure 2: Pågatåget. Picture taken from Alstom press release 9 Jan 2019.

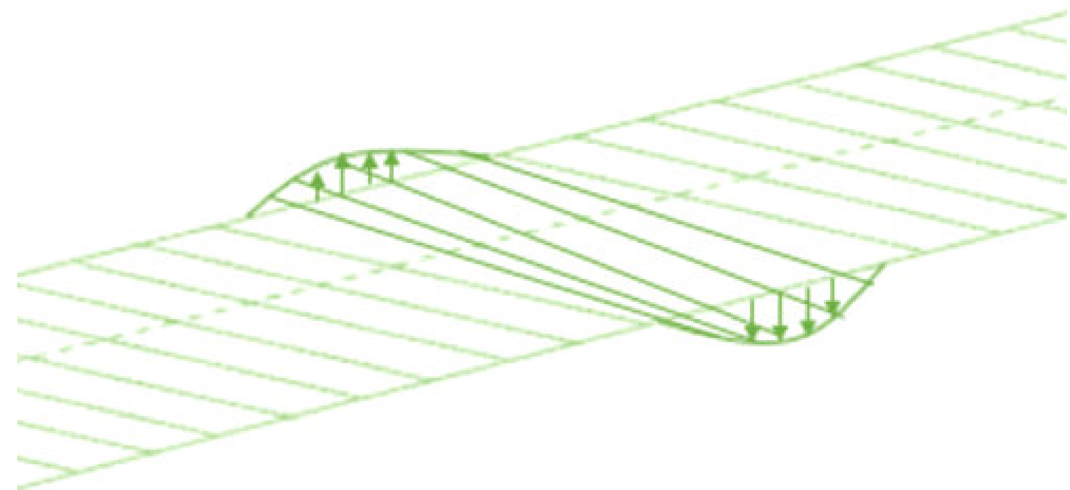

Figure 3: Cant irregularity. Figure created by Cajsa Åkerlund.

The investigated trains are Skånetrafikens Pågatåg, since they run on two of the most trafficked railway lines in Sweden, detecting an infrastructural failure here could have a major positive impact on the Swedish railway system, see map 1.

The failures categorized as *Damage and wear on the contact wire* is when there is a damage occuring at the contact wire, like broken stands or spot wear.

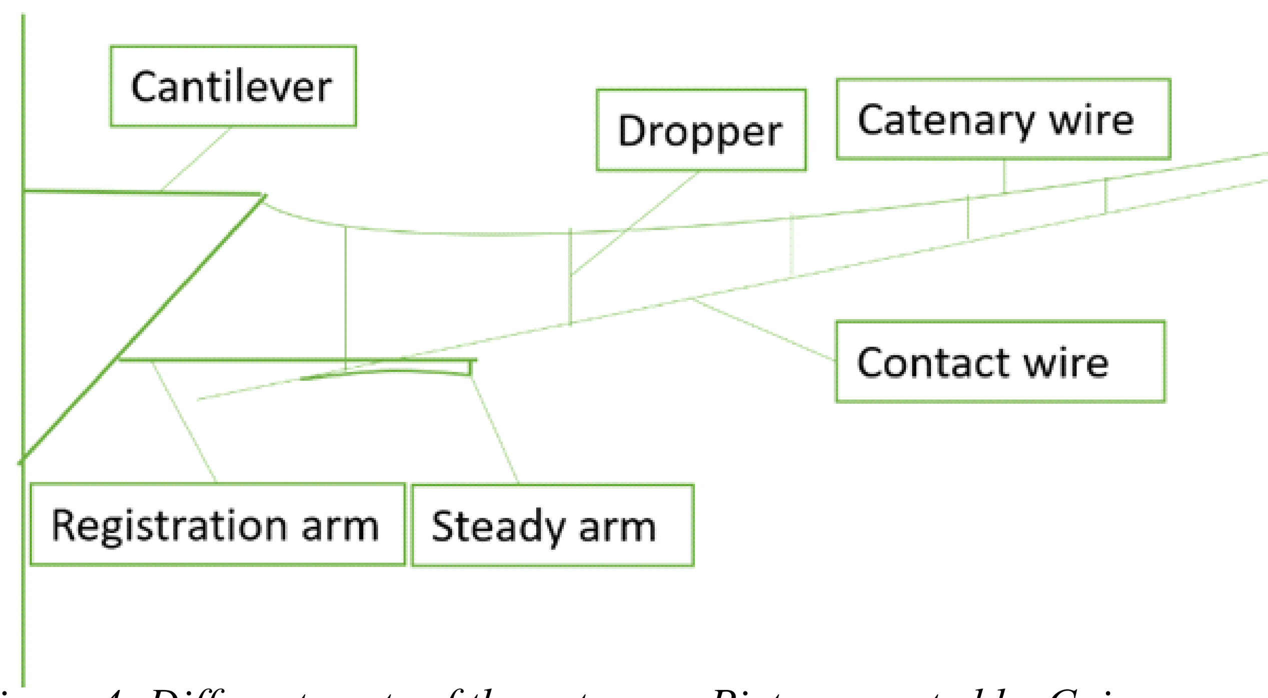

Figure 4: Different parts of the catenary. Picture created by Cajsa Åkerlund

Method

Historical data has been used to investigate which event codes that generate near an infrastructure failure. To investigate if the event code is generated more often when there is an infrastructural failure, risk ratio has been calculated. A 2x2 matrix were created that included four different subsets of data, see Figure 1. *IE* is the data generated from one event code when there is an infrastructural failure. *IN* is the data from all other event codes except for the investigated event code when there is an infrastructural failure. *CE* and *CN* is the corresponding data when there is not an infrastructural failure. In this case, the used reference data was data generated during two weeks after the infrastructural failure had been fixed.

	Infrastructural failure exists (I)	Infrastructural failure not exists (C)
Specific event code (E)	IE	CE
All other event codes (N)	IN	CN

Figure 1: Calculating Relative Risk.

To further investigate the connection between the infrastructural failure and the event code, a confidence interval was calculated. A confidence interval is a way to determine how far the true value can be from the calculated value. In this thesis a confidence of 99,9% has been chosen. That means that the true value is within the confidence interval with an 99,9% accuracy. We have chosen 1000 degrees of freedom in this thesis. We investigated all event codes that had a relative risk higher than one. We investigated which vehicles generated the event code, what the event codes can detect and the lowest value of the confidence interval. Therefore, the list of event codes narrowed down to only a few.

Result and conclusion

The results for *cant irregularities* show that the lowest value of the confidence interval is lower than one. This means that there is a risk that the true value of relative risk is lower than one and therefore there is no connection between the event code and an infrastructural failure. After further investigation of the event codes it was set as unlikely for the event codes to be able to detect a *Cant irregularity*.

Table 1: Results for Incorrect position of the contact wire (IP) and Damage and wear on the contact wire (D&W)

Event code	RR - IP	Confidence interval - IP		RR – D&W	Confidence interval – D&W		Fault Message
		Highest value	Lowest value		Highest value	Lowest value	
15014	1789	1895	1683	-	-	-	Current / Voltage Overload Fault
2022	367	473	261	108	214	3	High Voltage Converter A1+A2 off, no DC800V available
2005	324	430	218	-	-	-	Neutral Section Fault

The results for the two categories occurring on the catenary, *Incorrect position of the contact wire* and *Damage and wear of the contact wire* the lowest value of the confidence interval were higher than one for all event codes presented in Table 1. The event codes presented in the list are the ones that are most likely to be able to detect an infrastructural failure. However, the event codes need to be further investigated to see what the sensors can detect. In conclusion it may be possible to use the existing sensors on Pågatågen, but further investigation is needed.