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Citation: Slingsby, A. ORCID: 0000-0003-3941-553X, Hyde, J. and Turkay, C. ORCID: 0000-0001-6788-251X (2019). Visual Analysis of Reactionary Train Delay from an Agent Based Model. Poster presented at the EuroVis 2019, 3-7 Jun 2019, Porto, Portugal.

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Link to published version: <http://dx.doi.org/10.2312/eurp.20191153>

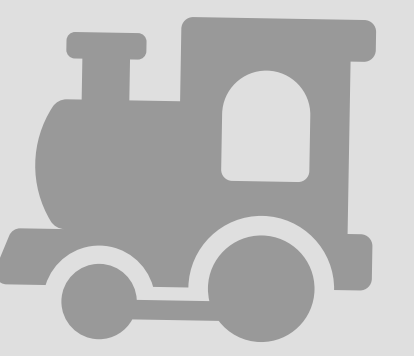
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Visual Analysis of Reactionary Train Delay from an Agent Based Model

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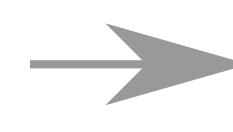
Problem

Reactionary ("knock-on") delay is an increasing problem for UK train operators and is hard to understand. Train operators want to know the key locations and reasons, so they can design interventions.

What is reactionary delay?

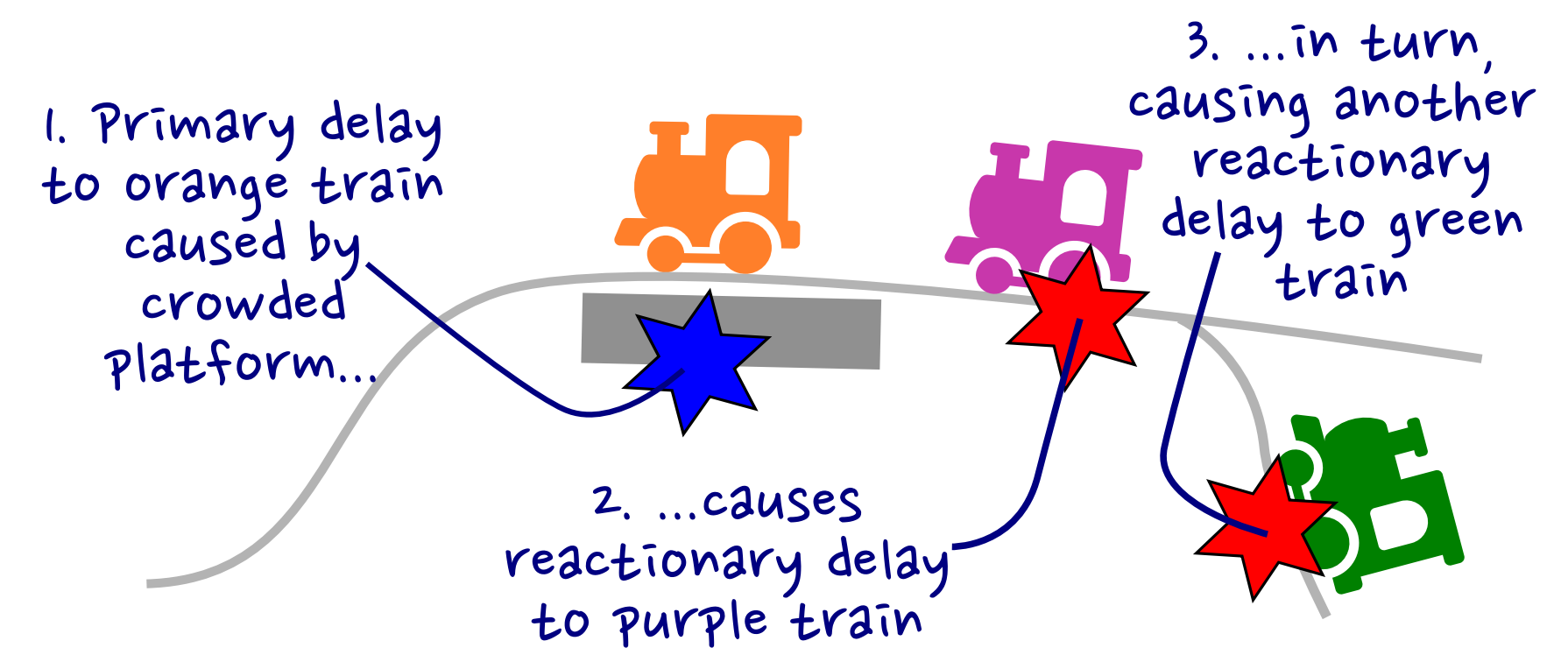
Primary delays...

- Driver late
- Signal failure
- Doors jammed
- Crowded platforms



...can cause reactionary delays...

...which are the knock-on effects that are hard to predict.



Our approach

We build an Agent Based Model that explicitly models interactions between trains, then design interactive visualisation to help understand the problem to inform designing interventions. We can then run the model again to see if this works.

Agent Based Model

The agent-based model stochastically generates primary delays (including small natural variation) according to historical data, the interactions between trains and the resulting reactionary delay. The model runs 150 times (Monte-Carlo style) and it generates thousands of delays for hundreds of trains.

Interactive visualisation

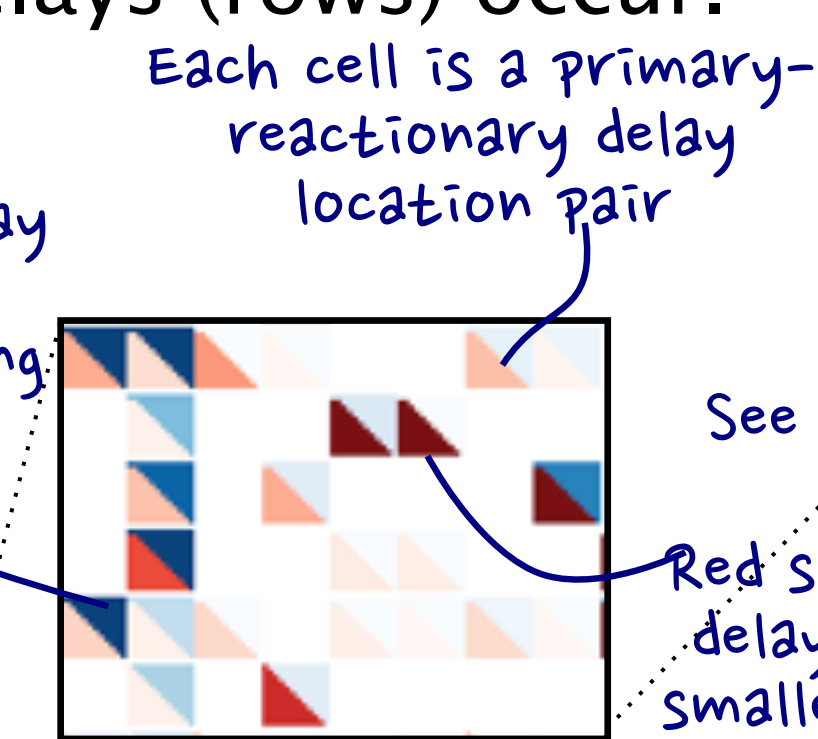
Our interactive visualisation takes the model's output and [A] provides the association between primary and reactionary delay location, [B] gives the uncertainty around this result through model run agreement, and [C] explains the mechanism of the chain of delays.

[A] Association between primary and reactionary locations

The matrix shows the association between locations where primary delays occur (columns) and where the resulting reactionary delays (rows) occur.

Blue shading is the number of primary delay minutes - here it is more than the resulting reactionary minutes

rows are locations where reactionary delays occur, ordered by total reactionary delay



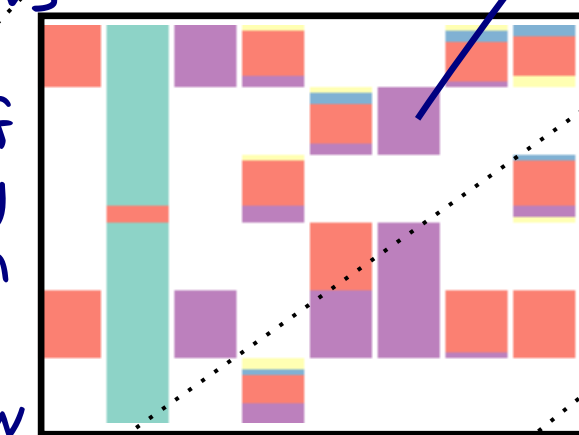
columns are locations where primary delays occur, ordered by amount of reactionary they cause

This mode shows relative proportion of primary delay type for each location pair

Red shading is the number of reactionary delay minutes - here it was caused by a smaller amount of primary delay minutes

Bars are total number of primary delay minutes

All primary delay is "subthreshold"



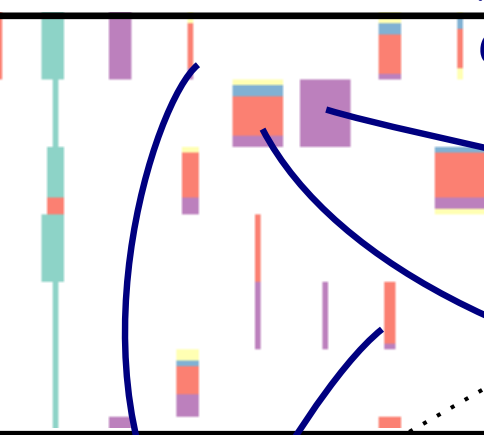
Delay types by proportion of primary delay minutes for mouseovered location ("EALINGB") - see bottom for colour key

[B] Uncertainty, through comparison of model runs

Looking at the variation between model runs indicates the certainty (or likelihood) of that outcome

As left, but width indicates proportion of model runs that generate a delay

Most model runs indicate "subthreshold" primary delay



A primary delay only occurs rarely

Each vertical bar is a model run, its width is the primary delay minutes and the relative proportions of delay type shown in the bar.

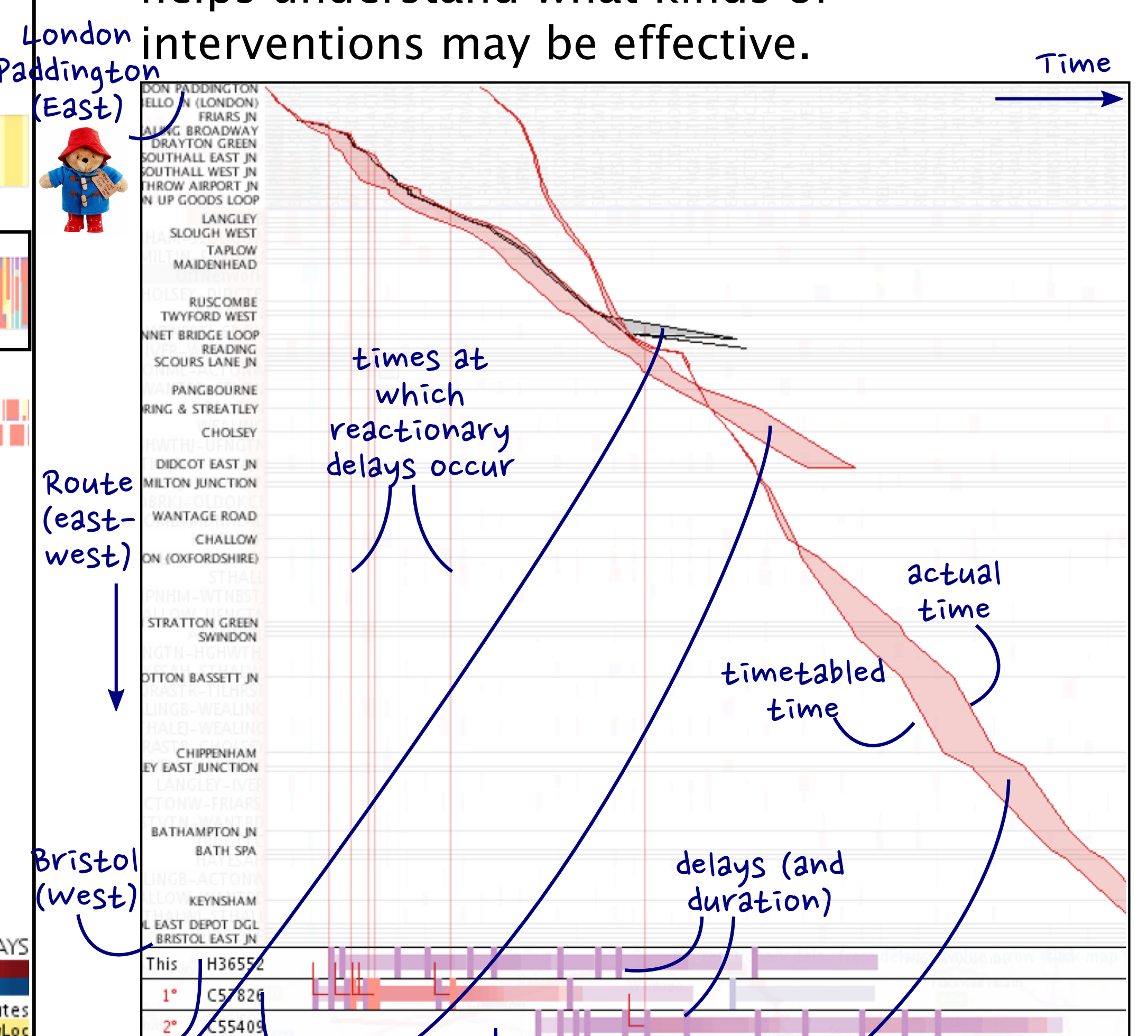
As the chart above it, but by model run.

Most model runs indicate "reactionary" causing delay, but a minority of runs attribute this to "subthreshold" and "offnetwork"

"Reactionary" and "offnetwork" both feature in most model runs, but occur in different amounts, but "track" and "network" only happen in some model runs.

[C] Explain mechanism of reactionary delay chains

Looking at the interaction between trains helps understand what kinds of interventions may be effective.



London Paddington (East)

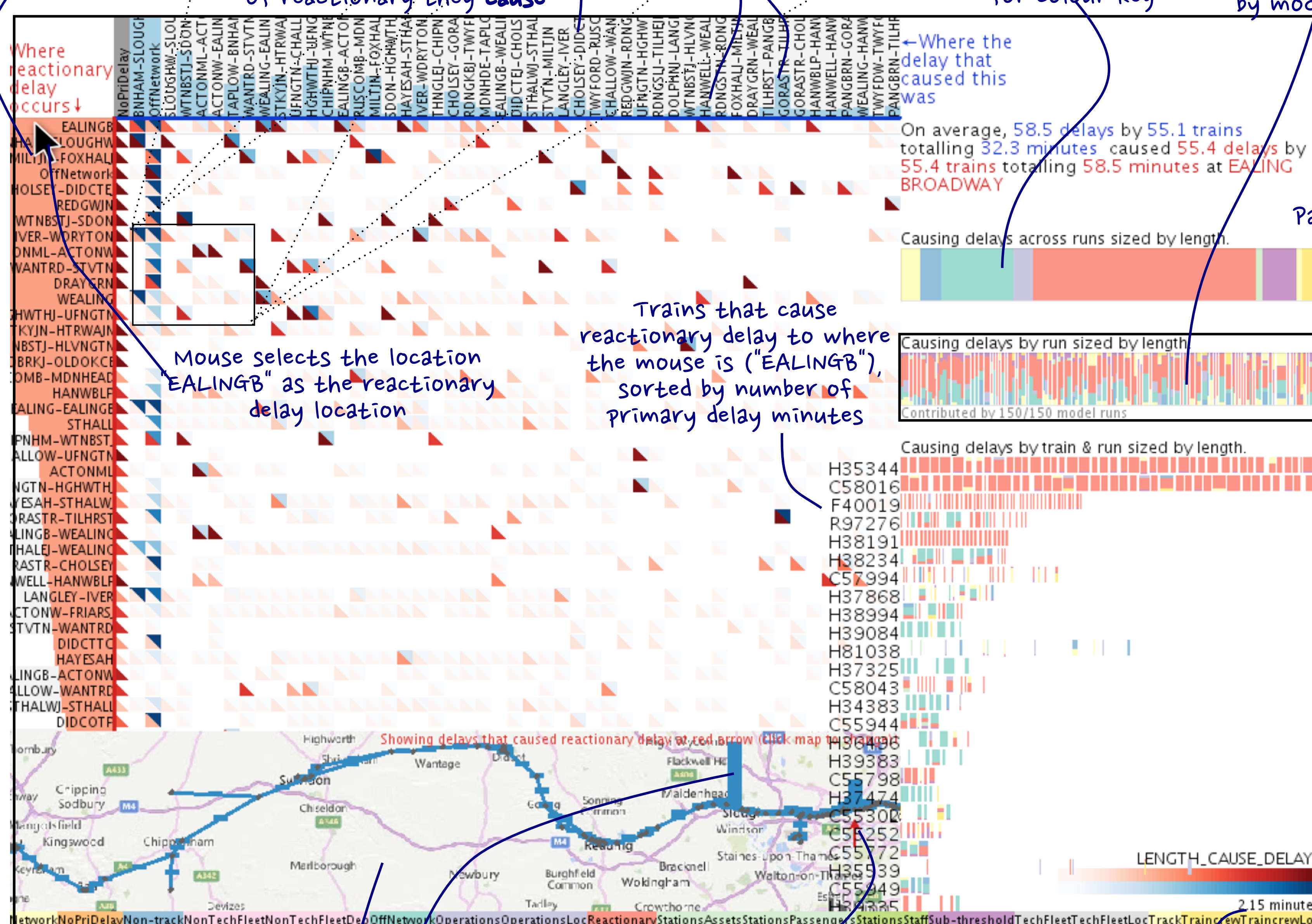
Route (east-west)

Bristol (West)

selected train (grey)

train this causes delay to (red)

train at end of reactionary chain (also red)



Map of the route between London (East) and Bristol (West)

Red arrow shows the reactionary location where the mouse pointer is ("EALINGB"). The blue bars are the primary delay minutes that cause the reactionary delay at "EALINGB" where the mouse cursor is

Trains that cause reactionary delay to where the mouse is ("EALINGB"), sorted by number of primary delay minutes

On average, 58.5 delays by 55.1 trains totalling 32.3 minutes caused 55.4 delays by 55.4 trains totalling 58.5 minutes at EALING BROADWAY

Causing delays across runs sized by length.

Causing delays by run sized by length. Contributed by 150/150 model runs

Causing delays by train & run sized by length.

H35344
C58016
F40019
R97276
H38191
H38234
C57994
H37868
H38994
H39084
H81038
H37325
C58043
H34383
C55944
H38496
H39383
C57798
H37474
C53308
C58252
C55772
H35939
C57449
H34725

colour legend for primary delay types (colour scaled to 215 minutes)

