TRAIN DELAY RESILIENCE

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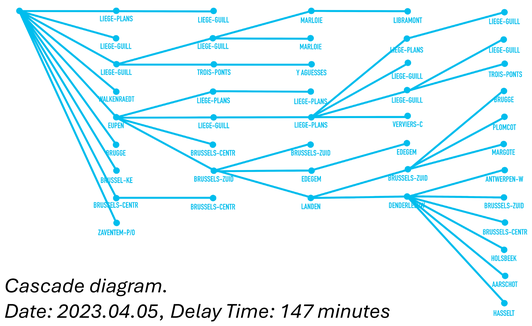
BACKGROUND

The sole provider of Belgian rail infrastructure, entrusted with the construction, maintenance, and improvement of the country's railway network.

- **2200+** — Miles of Rail
- **11M +** — Population
- **86.8%** — Current Punctuality

PROBLEM

A resilience metric is needed to display system adherence to the published timetables.



Cascade diagram.
Date: 2023.04.05, Delay Time: 147 minutes

OBJECTIVES

Develop a **resilience metric** validated by Infrabel experts with a survey and presentation.

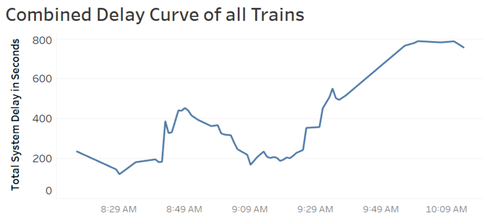
Establish a **relationship** between the resilience metric and system punctuality.

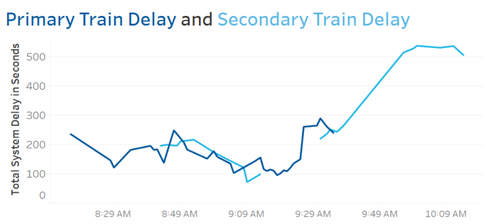
Create a **visualization** of the resilience metric with 80% reliability using historical data.

SOLUTIONS

Methods

1. **Catalog all related delays**
   Gather primary delay data
2. **Sort and format data**
   Sort delays by time
3. **Develop delay curve**
   Graph using formatted data
4. **Calculate resilience metric**
   Use graph to develop values





Reasoning

A delay curve was developed to represent **cumulative delay on the system** caused by one initial incident.

Delay curves were created by **combining primary delays** with all **related** subsequent delays.

IMPACT

- **Increase** Resilience by 2%
- **Increase** Punctuality by 1%
- **Increase** Resilience Awareness
- **Increase** Response Solutions

PROJECT APPROACH

Problem Definition
- Identify the problem
- Conduct literature reviews

Data Analysis:
- Define Infrabel data terminology
- Perform analysis to identify trends

Construction of Resilience Metric:
- Develop an R script to automate the calculation of resilience scores

Visual Dashboard Prototype:
- Propose prototype design ideas
- Display resilience graphs

TERMINOLOGY

Incident
Any disruption to the system resulting in a delay ≥ 90 seconds

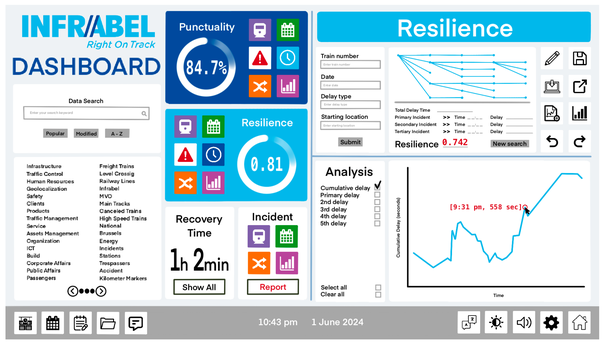
Cascade
A chain of delays caused by an incident

Resilience
The system's ability to recover from incidents

Robustness
The reliability of the published timetables

RESULTS

Dashboard



Example dashboard adapted for resilience and delay analysis.

Metrics for Analysis

Maximum Delay Value: Highest latency post-incident

Area Under the Curve (AUC): Uses trapezoidal integration to show delay trends

Time to Recovery: Time for the system to show a negative linear trend line within the delay curve

System Resilience: Combination of the above metrics

Resilience

1.0 - 0.85^{+} = Adheres to schedule
0.85^{-} - 0.7^{+} = Improvement needed
0.7^{-} - 0.0 = Fix immediately

0 ——— 1

KEY DELIVERABLES

Resilience Metric

- Define key indicators
- Develop a metric to monitor and measure
- Enhance system robustness

Visual Dashboard

- Design a dashboard to monitor resilience
- Create a user-friendly interface
- Ensure compatibility with existing systems