QUANTIFYING UK RAILWAY RESILIENCE TO MULTIPLE STRESSORS VIA DELAY METRICS

ABSTRACT The UK rail network experiences escalating disruption from climatic extremes (flooding, heatwaves, storms) compounded by operational stressors (equipment failures, demand surges). High-impact events such as the 2014 Dawlish storm surge exemplify network fragility and motivate a system-level resilience assessment (Dawson et al., 2018). Existing literature predominantly addresses single hazards or asset-level recovery, limiting inference on compound stressors and network-level recovery (Green & Chmutina, 2019; Pant et al., 2016).

This study analyses how do multiple and concurrent stressors affect UK mainline rail network performance and assess their influence on operational delay severity and subsequent recovery. An integrated statistical framework operationalises the assessment across different phases such as disruption onset, delay magnitude, persistence, and recovery (see Figure 1). Delay-tail percentiles, median recovery time, and recovery rate serve as core metrics for the resilience assessment. Delay severity will be characterised through extreme-value and mixture-model approaches; persistence will be quantified using time-to-event analysis; recovery trajectories will be fitted with flexible regression or spline methods to extract recovery-rate parameters.

The outputs provide a reproducible, empirical toolkit for multi-hazard resilience assessment that supports evidence-based prioritisation for resilience-building measures (Green & Chmutina, 2019; Dawson et al., 2018; Pant et al., 2016; London Assembly, 2024; Kamalian, 2025; Boura, 2025).