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PREDICTION OF CYCLIC TOP IRREGULARITY GROWTH INDUCED BY FREIGHT VEHICLE OPERATIONS

Miguel Marques[(1)], Joao Pagaimo[(1)], João Torres[(1)], Hugo Magalhães[(1)], Filipe Marques[(2)], Paulo Oliveira[(3)]

[(1)]IDMEC, Instituto Superior Técnico, Universidade de Lisboa, Lisboa, Portugal
[(2)]CMEMSUMinho & LABBELS – Associate Laboratory, Braga/Guimarães, Portugal
[(3)]MEDWAY Maintenance & Repair

miguel.gomes.marques@tecnico.ulisboa.pt, joao.pagaimo@tecnico.ulisboa.pt, joao.p.torres@tecnico.ulisboa.pt, hugomagalhaes@tecnico.ulisboa.pt, fmarques@dem.uminho.pt, paulo.oliveira@medway.com

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Summary: Railway infrastructure managers are tasked with ensuring that track irregularities remain within the thresholds defined by standards. Track irregularities include both lateral and vertical deviations of the rails relative to their as-built reference geometry. Over time, the ballast supporting the rails deteriorates under repeated loading from passing trains, leading to the worsening of these irregularities. To mitigate this, periodic inspections are necessary to evaluate and quantify the extent of track irregularities.

A specific type of track irregularity, known as cyclic top, has been identified in technical reports investigating freight vehicle derailments. Cyclic top is characterized by periodic vertical displacements of both rails, which can excite pitch and bounce motions in freight vehicles depending on their dynamics and operating speeds. While passenger vehicles equipped with viscous dampers effectively manage cyclic top, freight vehicles, which utilize friction-damped suspensions, exhibit poor damping performance. Despite its significance, cyclic top is not yet formally addressed in current standards. However, a pioneering study has introduced an algorithm for detecting cyclic top and its defining parameters, based on an extensive computational investigation. This study included a series of multibody simulations of vehicle-track interactions, where derailment was observed under cyclic top conditions, and nonlinear analyses to identify the natural frequencies of the vehicles.

This work presents a robust computational tool designed to predict the onset and progression of cyclic top. A dedicated, parameterized freight vehicle model is developed to represent a broad spectrum of freight traffic. The goal is to equip infrastructure managers with a predictive capability that enhances maintenance planning, minimizes the risk of derailments, and ensures safer rail operations.

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