A Stochastic Approach for Life-Cycle Cost Analysis of Railway Turnouts Exposed to Climate Uncertainties [†]

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A turnout, a component on modern railway tracks, provides operational flexibility by diverting the vehicles to different directions between two routes. A crossing area is a part of turnout where two tracks intersect at a point. At this part, the rail profiles vary along the track and moreover, some of crossing types (i.e., common crossings) have a discontinuity. As a result, high-frequency high impact forces emerge at the crossing area, especially on the crossing nose [1]. Inherently, the repeated forces result in a fatigue problem over turnout crossing noses, which is the root cause of high maintenance costs in railway operations [2]. Most of the studies conducted to date is about the physical phenomena such as environmental effects, material properties, dynamic characteristics of the vehicle/track or management such as maintenance strategies [3–9]. However, regarding the high costs owing to turnouts in the maintenance budget, an investigation of the problem from an economic aspect is believed to be beneficial for Infrastructure Managers, since it is the top concern for IMs [10].

A common tool for this purpose is the Life-cycle cost analysis (LCC). LCC is an estimate of the total cost from acquisition to disposal of a component or a system. LCC could be categorized under two topics: Simple and Stochastic. The simple analysis is to evaluate the feasibility, which is deterministic and commonly uses an expert's comment to estimate. On the other hand, a stochastic or complex analysis refers to statistical theories covering also the uncertainties, which is better to decide the cost of whole built-in project. The first step to conduct a life-cycle cost analysis is to create a breakdown work structure. In this study, the breakdown work structure is based on writers' another paper [11]. In addition to this, the data representing the probabilistic effects while calculating the life-cycle cost is collected from official sources such as Office for National Statistics (see Figure 1).

Several studies addressing the life-cycle cost analysis of a turnout could be found in the literature. However, most of them do not consider the extreme weather events which has an influence on the system resilience [2,12–16]. Writers' first article on the subject considers this effect; however, it was conducted with a deterministic approach, which was a preliminary study. Therefore, in this study, writers' aim is to develop their first preliminary work and build a more complicated work. By using stochastic theories (i.e., Bayesian Network), writers believe that the problem is represented more accurately.
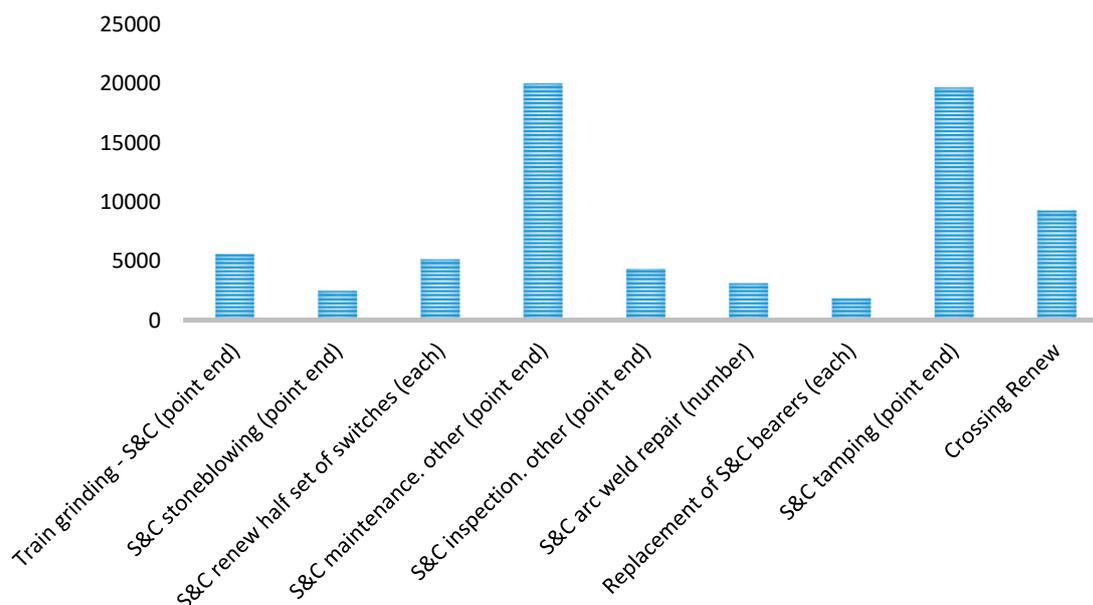
Figure 1. LCC analysis based on the breakdown work structure [11].

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