World Academy of Science, Engineering and Technology
International Journal of Civil and Architectural Engineering
Vol:13, No:07, 2019

Planning Railway Assets Renewal with a Multiobjective Approach

Authors : João Coutinho-Rodrigues, Nuno Sousa, Luís Alçada-Almeida

Abstract : Transportation infrastructure systems are fundamental in modern society and economy. However, they need modernizing, maintaining, and reinforcing interventions which require large investments. In many countries, accumulated intervention delays arise from aging and intense use, being magnified by financial constraints of the past. The decision problem of managing the renewal of large backlogs is common to several types of important transportation infrastructures (e.g., railways, roads). This problem requires considering financial aspects as well as operational constraints under a multidimensional framework. The present research introduces a linear programming multiobjective model for managing railway infrastructure asset renewal. The model aims at minimizing three objectives: (i) yearly investment peak, by evenly spreading investment throughout multiple years; (ii) total cost, which includes extra maintenance costs incurred from renewal backlogs; (iii) priority delays related to work start postponements on the higher priority railway sections. Operational constraints ensure that passenger and freight services are not excessively delayed from having railway line sections under intervention. Achieving a balanced annual investment plan, without compromising the total financial effort or excessively postponing the execution of the priority works, was the motivation for pursuing the research which is now presented. The methodology, inspired by a real case study and tested with real data, reflects aspects of the practice of an infrastructure management company and is generalizable to different types of infrastructure (e.g., railways, highways). It was conceived for treating renewal interventions in infrastructure assets, which is a railway network may be rails, ballasts, sleepers, etc.; while a section is under intervention, trains must run at reduced speed, causing delays in services. The model cannot, therefore, allow for an accumulation of works on the same line, which may cause excessively large delays. Similarly, the lines do not all have the same socio-economic importance or service intensity, making it is necessary to prioritize the sections to be renewed. The model takes these issues into account, and its output is an optimized works schedule for the renewal project translatable in Gantt charts The infrastructure management company provided all the data for the first test case study and validated the parameterization. This case consists of several sections to be renewed, over 5 years and belonging to 17 lines. A large instance was also generated, reflecting a problem of a size similar to the USA railway network (considered the largest one in the world), so it is not expected that considerably larger problems appear in real life; an average of 25 years backlog and ten years of project horizon was considered. Despite the very large increase in the number of decision variables (200 times as large), the computational time cost did not increase very significantly. It is thus expectable that just about any real-life problem can be treated in a modern computer, regardless of size. The trade-off analysis shows that if the decision maker allows some increase in max yearly investment (i.e., degradation of objective ii), solutions improve considerably in the remaining two objectives.

Keywords : transport infrastructure, asset renewal, railway maintenance, multiobjective modeling
Conference Title : ICCIM 2019 : International Conference on Civil Infrastructure Management
Conference Location : Berlin, Germany
Conference Dates : July 22-23, 2019