# Pattern-Based Timetables for Metro Lines

**Tommaso Schettini, Ola Jabali, Federico Malucelli**
Politecnico di Milano, Italy
tommaso.schettini@polimi.it

**Michel Gendreau**
Polytechnique Montréal, Canada

**Abstract.** Frequently changing regulations during the COVID-19 pandemic have made managing metro lines extremely challenging. In particular, metro line service operators are often expected to significantly decrease their maximum load factors (i.e., the percentage utilization of capacity).

We investigate a non-invasive strategy to control passenger loads by designing timetables that are adapted to forecasted demand. We propose a flexible timetabling strategy using short-turning, i.e., allowing trains to turn before reaching the terminal station of a line. Our strategy produces timetables that are periodic with respect to a group of destinations, which we denote as service patterns. We present the Service Pattern Timetabling Problem (SPTP). Given a service pattern, the SPTP optimizes the timetable of a bidirectional line considering capacity restrictions. The SPTP is modeled as a constraint program.

In practice, the choice of a timetable requires balancing a number of features. We develop a framework for producing a diverse set of high-quality timetables. The framework evaluates a number of promising service patterns by solving their corresponding SPTPs, and outputs the non-dominated solutions according to the average passenger waiting time, maximum achieved load factor, and number of induced transfers. Through our computational experiments, we demonstrate the effectiveness of the developed strategy.

**Keywords:** Metro Timetabling; Short-turning; COVID-19