# 捷運司機員輪值問題之研究－以台北捷運公司為例

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## 摘要

提供好的服務品質一直以來是捷運系統所追求的目標。捷運系統具有全年無休、班次密集、營運時間長的服務特性，營運時間內皆需有司機員執勤以服務旅客，司機員對於捷運系統的服務品質具有一定的影響力，輪值班表結果之良窳更攸關司機員服務的品質與工作的士氣。司機員輪值班表的排定除了要符合各項輪值相關限制外，也要儘量兼顧司機員之偏好及滿意。過去國內對於捷運系統司機員輪值問題尚無深入探討，本研究即針對此做詳細的研究。

求解人員輪值問題，傳統大都使用數學規劃或啓發式解法，求解效率較差或是較難完整描述複雜限制問題。因此，本研究運用數學規劃及限制規劃法求解能夠符合複雜限制的捷運司機員輪值班表。而為有效率求解大規模的實務問題，本研究將問題分為三階段求解並依問題特性不同選擇不同方法求解。第一階段為「排休」模式，運用數學規劃中的整數規劃產生司機員的休假日及工作日，並考慮各司機員在輪班期內休假數及例假休班天數公平性。第二階段為「輪班」模式，以限制規劃法求解每位司機員工作日需值班的班別，除考慮各項限制條件外亦考慮司機員儘量值同一班別的目標。最後，第三階段「派卡」模式同樣以限制規劃法決定各值班司機員需執行哪張任務卡。

本研究以台北捷運公司淡水段該月於北投上班的司機員的班表資料為測試實例，包含七、八十位的司機員。測試環境為 Windows XP 作業系統、1.29 GHz 處理器速度，以 OPL Studio 3.7 執行求解，三個階段求解時間約為 5 分鐘。本研究求解結果與實際班表比較除了滿足所有輪值相關限制外，在休假天數及例假休班天數這兩個公平性指標，本研究的各司機員間差異天數較小，優於實際班表，而在司機員員儘量輪值與組別相同班別的目標上，實際班表平均違反皆超過五十次，本研究並無違反，結果良好，只是在各司機員任務卡平均分鐘數要儘量相同這項公平性指標由於著重重點在前面指標上，因此造成這項指標略遜於實際班表，整體來說，本研究除了滿足所有一定要滿足的輪值限制（硬限制）外，在公平性目標（軟限制）之結果也大致良好。由此可知，本研究發展之司機員輪值模式，確實能有效率地產生具實用價值的輪值表外，亦能避免司機員輪班期內值多種班別的狀況，提高司機員的工作效率，增加捷運列車營運時的安全。後續研究可以考慮研究前段排班問題，產生較公平的任務卡，讓每位司機員在值班時的駕駛時數相同。

關鍵字：人員輪值問題、限制規劃、整數規劃、大眾捷運系統

# The Rostering Problem of Mass Rapid Transit Drivers: A Case Study of Taipei Rapid Transit Corporation

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## Abstract

The goal of Mass Rapid Transit (MRT) system is to provide good service quality. The roster has great influence about the service quality and morale of drivers. The crew rostering of MRT drivers is an important problem. The scheduler not only has to provide a roster to satisfy all labor and the corporation regulations (hard constraints) but also needs to consider fitting individual preferences (soft constraints) as much as possible. This research is focused on the rostering problem for the Taipei Rapid Transit Corporation (TRTC), which has not been studied before.

Traditional methods to solve crew rostering problem are usually based on mathematical programming (MP) or heuristic method that is not efficient or difficult to describe the problem with complicated constraints in detail. In this research, we formulated the equitable crew rostering problem as a three-stage model with mathematical programming and constraint programming (CP). The first phase is the off-day scheduling problem, to which we applied integer programming to solve the problem. The second phase, shift scheduling problem, was formulated as constraint satisfaction problem (CSP) and solved by a CP model. The third phase, rostering problem, was also formulated as CSP and solved by a CP model to obtain an equitable roster.

We have applied our models to a case study of rostering data provided by TRTC. Using 1.29GHz personal computer and ILOG OPL Studio 3.7, we obtained a one-month roster which has 84 drivers in 5 minutes. In addition to all hard constraints, our results satisfied all the flexible constraints regarding the equity of the allocation of off days to drivers. Our model can generate feasible and equitable rosters very efficiently and provide as a reference for the scheduler. Future research may take crew scheduling problem into account to allocate driving hours more equally among drivers.

Keywords: Crew Rostering Problem, Constraint Programming, Integer Programming, Mass Rapid Transit System