Impacts of Unattended Train Operations (UTO) on productivity and efficiency in metropolitan railways

Introduction

Metro subway systems worldwide are choosing increasing levels of automation for new and refurbished lines. Despite significant investment in this technology, empirical evidence for the financial impacts of UTO in metros remains scarce. Investment in UTO technology should be assessed in terms of maximising metro productivity, service quality, and efficiency. Are the additional costs of the more advanced equipment justified by benefits to operating costs and/or the capacity and reliability of service?

Key Research Questions

- What is the additional capital cost of technology that enables UTO?
- Assuming a constant number of stations and trains in service, what level of staffing is required on a UTO line compared with a conventional one?
- How is the operational cost of a UTO line different to a conventional line (including effects related to staffing)?
- How does UTO affect metro service outputs such as capacity and reliability?

The Railway and Transport Strategy Centre (RTSC)

The RTSC is based at the Centre for Transport Studies (CTS) at Imperial College London. We work with two metro operator benchmarking groups [CoMET and Nova], which share performance data and good practice information in a confidential environment.

Methods and Data

We used questionnaires and semi-structured interviews with the 32 metros of the CoMET and Nova benchmarking groups to assemble emerging evidence for how automation affects costs, staffing, service capacity and reliability. Because of the small number of automated lines operated by CoMET and Nova members, three additional metros participated in the study: Copenhagen Metro, Milan Metro (Line 5), and Vancouver SkyTrain.

Responses were received for 21 existing and planned lines capable of unattended operations (UTO), plus 2 lines operated by an attendant who is not based in a cab.

In addition to data collected specifically for this study, we used existing CoMET and Nova benchmarking data, which benefits from many years of refined definitions and data validation. A confidentiality agreement enabled participating metros to provide sensitive data, but requires that research results must be anonymised for publication. Thus metros are referred to throughout by grade of automation or by continent.

Metro automation terminology

The word ‘driverless’ reads as a synonym for ‘unattended’ but is sometimes used for trains with an attendant but no driver’s cab, creating confusion. Grade of Automation (GoA) terminology is more precise and thus preferable:

- GoA1: Manually driven but has Automatic Train Protection (ATP).
- GoA2: Driven by Automatic Train Operation (ATO), with a driver in a cab performing critical functions such as closing doors and starting the train in motion.
- GoA3: Driven by ATO, but replaces a driver in a cab with an attendant in the passenger area. This attendant is performing a critical function such as supervising safe door closure.
- GoA4: Capable of fully Unattended Train Operation (UTO).

Costs

Capital Investment

The capital cost of GoA4 comes from ensuring the system has these four essential features:
1. Ability to control train movements (and train sub-systems) remotely
2. Remote monitoring and reset of train systems
3. Two-way communications system between operations centre and train
4. A platform edge safety system – either platform doors or an obstacle detection system

The additional cost to enable unattended operations varied from 0-30%. In metros with more advanced technology on their comparator conventional lines (e.g., in Asia), the cost uplift for unattended operation was lower. For the two metros that could provide data, the return on investment in GoA4 (compared with GoA2/3) was 10-15%.

Operating Costs

It is not possible to directly translate lower typical staffing levels on UTO lines to lower operational costs, because multi-skilled staff may be paid more than drivers or station staff on conventional lines.

The key feature of UTO is that it de-links number of trains from number of drivers, so staff costs do not limit service frequency increase. Traction energy becomes the key operational cost constraint. Absence of drivers enables UTO lines to operate shorter trains more frequently, making the service more attractive without increasing cost.


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Staffing models
Automated lines have four distinct staffing models.

- **Roaming Multiskilled Staff**: Attended trains and stations
- **Roaming Multiskilled Staffing by location**: Roaming multiskilled staff moving between trains and stations in a particular area
- **Fixed station staff and roaming multiskilled staff**: Station staff (customer service, staff in station control room) + roaming multiskilled staff
- **Fully attended train, most stations unattended**: Fully attended trains, most stations unattended

The number of operational staff compared with the total number of trains and stations has a direct impact on operating cost.

Capacity: Service frequency

- **Very high frequencies are possible on conventional and automated systems** – communications-based train control (CBTC) signalling systems are essentially the same for GoA2, GoA3 and GoA4. However, UTO enables higher frequency by reducing turnaround times and improving regularity.
- 40 of 162 lines operate or plan a service >30tph, of which 15 are or will be automated lines.
- The top 10% of lines operate a service >30tph; 10 of these 17 are or will be automated.

Train frequencies of automated lines compared with all line frequency data available from CoMET and Nova metros

Conclusions
Our findings indicate that UTO is a means to a more flexible and reliable operating model that can increase metro productivity and efficiency.

- Capital costs of lines that can be operated unattended are higher, but internal rate of return has been estimated by two metros at 10-15%
- UTO can reduce staff numbers by 30-70%, with the amount of wage cost reduction depending on whether staff on UTO lines are paid.
- Automated lines are capable of operating at the highest service frequencies of up to 42 trains per hour.
- The available data suggest that automated lines are more reliable.