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Rapid Transit Automation and the Last Crew Member

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Rapid Transit Automation and the Last Crew Member

Abstract
Rapid transit systems in many cities are being automated, but most transit officials reject the idea of operation without crews on the train as idealistic. At the same time large resources are spent on development of full automation for numerous new systems such as PRT, many of which have no defined role in urban transportation. Programmed train movement eliminates any possible improper driving practices. However, nearly all rapid transit vehicles have indirect controls which prevent the driver from improper acceleration and assist him in braking. Thus improvement through A TO is again not significant.

Disciplines
Engineering | Systems Engineering | Transportation Engineering
Network integration aids the urban passenger
Rapid transit systems in many cities are being automated, but most transit officials reject the idea of operation without crews on the train as idealistic. At the same time large resources are spent on development of full automation for numerous new systems such as PRT, many of which have no defined role in urban transportation.

Programmed train movement eliminates any possible improper driving practices. However, nearly all rapid transit vehicles have indirect controls which prevent the driver from improper acceleration and assist him in braking. Thus improvement through ATO is again not significant.

**Increased passenger comfort** due to smoother preprogrammed running. The comment from the preceding point also applies here.

**Precise schedule maintenance and recovery of delays.** A well-organised manual operation provides precise schedule maintenance and the drivers, particularly when they have good communications with central control, are able to recover delays quite efficiently.

A recent preliminary study by the Operational Research Group of London Transport comparing ATO on the Victoria line with manual operation on the Piccadilly line found the difference in reliability very slight: average variation in running times between stations is ±3.1 sec on the Victoria line and ±4.6 sec on the Piccadilly line.

**Increased line capacity.** Minimum headways on a line can be decreased through ATO. Although this decrease is rather small, the benefits obtained in terms of increased reliability at capacity-level operation may be significant.

**Increased system safety.** Theoretically, an automated system is safer than the manually-operated one. However, due to the fail-safe feature, many non-automated systems have operated for decades without a single accident. Advantages through ATO are therefore negligible.

**Improved working conditions for personnel.** This can hardly be a valid argument. First, driving of trains is generally not a physically or mentally difficult task; and second, when trains are automated, one of the most serious problems is fatigue and lack of alertness of the driver, who becomes idle; thus change in working conditions can be more a disadvantage than an advantage of ATO.

The two major disadvantages of the ATO are:

**Increased investment costs.** Most systems do not have accurate data about the amount of system cost increase through automation, but they generally report that the increase is substantial.

**Increased complexity of the system.** There is no doubt that mechanical and electronic complexity increases considerably with ATO. Thus maintenance cost increases and the ability of the driver to intervene effectively in the case of breakdowns on the line diminishes. In addition to often very serious initial breakdowns of the system (such as those on BART in San Francisco), mechanical reliability of the system may actually be permanently decreased with some ATO systems.

This analysis leads to the conclusion that for the systems which operate close to capacity, such as some metro lines in Paris and the s-bahn in Munich, the shortening of headways through ATO is significant and results in an improvement of service reliability. However, for most other systems, which generally do not operate at capacity, the benefits are often marginal and in many cases they do not outweigh the disadvantages of increased cost and complexity. A logical question is then: is ATO a major step forward, as it is often presented, or is it sometimes a rather extravagant unjustified increase in system cost?

It is very likely that the introduction of ATO in some rapid transit systems which operate well below capacity is done more because of fashion than for economic and operational benefits; this is particularly the case with medium-sized cities which have difficulties meeting initial capital costs for high quality transit systems even without

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ATO. The additional investment could often be better used for network extensions.

The last man problem

Yet, introduction of ATO can be justified easily for any system when the final step in automation is made—removing the last man of the train crew. This step will not be so important because of the reduced labour cost; its major significance will be in the fact that at the moment this last man is eliminated, the operation of three two-car trains will not be more costly than the operation of one six-car train; in other words, since cost of each car-km will be constant regardless of train size, frequency of service can be drastically increased without any extra cost by dividing trains into smaller units.

To illustrate this important point, frequency of service (F) and total cost (C) are plotted in Fig. 1 as functions of passenger volume for different degrees of system automation. The diagram is based on the assumption that each car has a capacity of 100 persons, that a minimum frequency of five departures per hour is provided regardless of passenger volume, and that additional cars are provided at the minimum operating cost and maximum frequency for any given cost; this is a common practice.

The diagram shows that compared with manual operation (m), automated operation with the driver (d) has a higher cost because of the cost of automation, but provides the same frequency of service. Fully-automated operation (a) will in most cases produce a figure between the costs for the preceding two cases, with automation cost similar to case (d) but no labour costs, but it will provide a drastically higher frequency. As soon as the demand reaches a capacity of 20 and 30 cars per hour, this system will offer three- and two-minute service, respectively.

The short headways would be retained for growing demand, while the number of cars per train gradually increases. The dashed lines for F, represent frequencies when all trains have the same number of cars. For example, for 6000 passengers one can provide all two-car trains with frequency of 30 (dotted line), or 20 one-car and 20 two-car trains with a frequency of 40 (solid line). Depending on operating policies either of these two, or any intermediate combination, may be selected; all of them would have the same cost.

The important observations here are that automated operation with the driver involves increased cost but does not increase frequency; and fully automated operation may be cheaper than ATO with the driver, and can provide much greater frequency of service than the preceding two types of operation.

It is important to notice that the region in which this greater frequency is offered is the one which is commonly found on most lines during all but peak hours. The advantage of full automation diminishes with demand increase toward capacity level.

Is full automation realistic?

Most rail transit system operators and planners are very sceptical toward proposals for full automation. But it should be noted that there is still some disbelief that one man could operate four-car or six-car trains, although in Hamburg one-man operated eight-car trains have been in operation since 1957! Many operators do not believe that it is possible to operate stations without employees, although the Lindenwald line in Philadelphia has had unstaffed stations since 1969. And it should be remembered that at one time the Paris metro was operated with a driver and one man in each car. The argument for this appeared convincing at the time: how could there be a car in the train without a single employee who would be ready to intervene in emergencies?

To find whether the scepticism of officials is realistic and proposals for

LEFT: Fig. 1. Frequencies (F) and costs (C) of a service for manual (m), automated but with driver (d), and fully-automated (a) operation.

LEFT: On London Transport's Victoria line, normal functions of the man in the cab are reduced to opening and closing the doors and initiating the automatic drive process.
full automation idealistic, one should examine all major problems which would have to be resolved for full automation, some of which are often believed to be insoluble.

Contact with passengers in cases of emergency. This problem would not become much more serious than it is at present. The fact is that on many systems when a train stops in the tunnel the driver does not contact passengers anyway; actually, in many European systems he cannot pass from one car to another because there are no head doors. The problem can, however, be solved for both manual and automated systems by a communication system with a two-way radio and, possibly, a closed circuit television in each car, which are both technically feasible at present.

Boarding and departure control at stations. Examples of solutions to this problem already exist. For example, the Lindenwold line and the A-1 Line in Frankfurt operate without station personnel; Hamburg has been using TV monitors for 16 years; and automatic pretimed door closing is in use in Frankfurt and San Francisco. Centralised control of stations and train departures is therefore entirely feasible.

Control of rights-of-way for obstacles. This is the most serious and probably the only technical problem of automation which requires additional research and testing. In tunnels and on elevated sections the control of rights-of-way is virtually complete; in station areas and on level sections additional control measures or surveillance will be required.

Employees should not be left without jobs. This is a short-term problem which can be resolved by attrition, retraining, and provision of more productive jobs. Actually, systems which experience labour shortage at present would not have this problem at all. However, a problem related to this—opposition by trade unions—is an extremely serious one, particularly in US cities. Although very difficult to solve, this is a temporary obstacle rather than a permanent insoluble problem.

Laws requiring presence of an operator in a transit car. Laws of this kind were made in some countries because there was no reliable automated system, and not with a purpose to prevent creation of one. Although change of such laws will require some time and effort, this should certainly not be considered as an absolute barrier.

In conclusion, the problems related to full automation will vary from city to city and some work will obviously be needed to solve them; however, there is generally no permanent obstacle which would prevent full automation for all time.

PRT systems

Numerous proposed systems are being presented as capable of fully automated operation. Similar to rail, these systems are mechanically guided, but generally have much more complicated guidance mechanisms, higher energy consumption and complicated switching. With respect to operational aspects which affect automation, there is virtually no difference between rail and the proposed systems. The often-advanced belief that smaller vehicles provide higher security is incorrect. A vehicle for four to six persons provides less protection from crime than a vehicle for 50 to 100 persons.

Due to the tremendous experience accumulated on rail systems and because of their simplicity, they have a natural advantage for conversion to full automation over all proposed systems. But if, because of conservatism, nothing is done toward this goal, some new, much less efficient mode may be the first one with full automation, leading to the absurd belief that it is necessary to create more complicated guidance, suspension and propulsion systems in order to achieve and reap the benefits of full automation.

Summary and conclusions

Benefits from the introduction of automated transit in rapid transit systems vary considerably. In some cities the benefits do not outweigh costs and problems created by increased complexity, at least as long as the driver is maintained on the trains. Automation is sometimes accepted more on fashion grounds than for sound technical reasons.

Contrary to predominant opinions in the transit industry that elimination of the last man from the train will never be possible, virtually all elements for this step already exist, although some additional work is needed before a fully automated system is made operational. The fact is that the rail systems, including suburban railroads, rapid transit, and light railways on sections with full control of right-of-way are much more conducive to full automation than are the numerous proposed systems often presented as the only ones capable of such operation.

Elimination of the last man from the trains will allow a drastic increase of frequency of service on virtually all rapid transit systems during all operating hours without any increase in operating cost. That would make rapid transit much more attractive for service in medium-size cities with moderate passenger volumes, which are served at present only by much lower quality surface transit. This potential for improvement in urban transportation is so great and so easy to achieve that it should no longer be ignored.
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