Attractive methods for tracking minibus taxis in South Africa for public transport regulatory purposes

Jakobus van Zyl  
*University of Stellenbosch, South Africa*  
jvanzyl@sun.ac.za

Kobus Labuschagne  
*Council for Scientific and Industrial Research, South Africa*  
flabush@csir.co.za

**ABSTRACT**

When a country, province or municipality wants to have an integrated public transport system in place, all modes of transport should work together with the aim of moving passengers effectively and hassle free to and from their destinations.

Several South African provincial governments and municipalities are in the process of developing efficient public transport systems i.e. BRT corridors and rolling out of revised operator contracts. All of these efforts require electronic on-board equipment for GPS tracking and integrated ticketing purposes.

As the minibus taxi industry carries currently 65% of all public transport passengers in South Africa, they can not be ignored in these plans. The problem lies in the fact that the taxi owners had been largely self-regulating and is not keen to be monitored by authorities.

The author is researching the willingness of taxi owners to install on-board equipment on their taxis which links to a public transport back-office. Research by means of implementation is done to discover ways to utilise the on-board equipment to generate an extra income for the taxi owner. This generation of revenue for the owner should outweigh the negative aversion the owner has to being monitored by authorities.

The City of Cape Town Municipality needs movement and passenger information of the minibus taxis to issue Operating Licences for specific routes. Currently this information is gathered by people taking manual counts at major taxi stops. As electronic ticketing is still only in a research stage another means of electronic monitoring is crucial for the authorities to accurately plan and issue licenses.

**IMPLEMENTATION AND EQUIPMENT**

The author together with a supplier developed a passenger counter specific for the minibus taxis. It makes use of a combination of image and sensor equipment. The accuracy attained is between 85% and 95% depending on the type of minibus taxi it is installed in. A GPS logs the routes travelled by the taxis. Income is generated by advertisements showing on a LCD screen installed inside the taxi. The adverts are linked to the GPS and passenger counter so that geo-advertising is possible and reach can be calculated which makes it an attractive medium for advertisers.

The equipment communicates to a back office for controlling purposes and is ready to handle electronic ticketing should it become compulsory.
Feedback from taxi owners is positive as they can control their taxis, generate extra income, entertain passengers and comply with authority requirements.

RESUME

Lorsqu’un pays, une province ou une municipalité veut mettre en place un système de transport public intégré, il faut que tous les modes de transport collaborent avec l’objectif de transporter les passagers de manière efficace et sans ennuis en provenance et en direction de leurs destinations.

Plusieurs gouvernements et municipalités provinciaux d’Afrique du Sud sont en train de développer des systèmes de transport public efficaces, c’est-à-dire les Bus Rapid Transit corridors et le déploiement des contrats d’opérateur revisés. Chacun de ces efforts nécessite de l’équipement électronique embarqué à des fins de pistage GPS et de billetterie intégrée.

Étant donné que l’industrie du taxi minibus représente actuellement 65% des passagers du transport public en Afrique du Sud, il faut absolument en tenir compte lors de la planification. Le problème existe dans la mesure où les propriétaires de taxis sont en grande partie autorégulateurs et ne tiennent pas à se faire surveiller par les autorités.

L’auteur examine la question de volonté des propriétaires de taxis pour faire installer de l’équipement embarqué dans les taxis qui est lié à un back-office de transport public. Les recherches de mise en œuvre sont effectuées pour identifier les moyens qui utilisent l’équipement embarqué pour générer des recettes supplémentaires au profit du propriétaire de taxi. Cette génération de recettes au profit du propriétaire doit dépasser l’aversion négative du propriétaire pour la surveillance des autorités.

La Municipalité de la ville du Cap a besoin des informations relatives au mouvement et aux passagers des taxis minibus afin de délivrer des Permis d’Exploitation pour les routes spécifiques. Ces informations sont actuellement enregistrées manuellement aux arrêts de taxis importants. Étant donné que la billetterie électronique se trouve encore à l’étape de la recherche, il faut un autre moyen de surveillance électronique pour que les autorités puissent planifier et délivrer ses permis correctement.

MISE EN ŒUVRE ET ÉQUIPEMENT

L’auteur et un fournisseur ont développé un système de comptage des passagers qui cible les taxis minibus en utilisant de l’équipement qui combine l’image et la détection. L’exactitude obtenue se situe entre 85% et 95% selon le type de taxi minibus dans lequel il est installé. Le GPS enregistre les routes prises par les taxis. Les recettes sont générées par les publicités qui apparaissent sur un écran LCD installé à l’intérieur du taxi. Les publicités sont liées au GPS et au compteur des passagers pour permettre la géopublicité et le calcul de la portée qui en ferait une voie attrayante pour les publicitaires.

L’équipement communique à un back-office à des fins de contrôle. Celui-ci serait prêt pour mettre en place la billetterie électronique au cas où cela deviendrait obligatoire.

L’information en retour des propriétaires de taxis est positive car ils sont capables de contrôler leurs taxis, générer des recettes supplémentaires, divertir les passagers et respecter les règles édictées par les autorités.
1 INTRODUCTION

The South African Vision for a Public Transport Legacy: 2007-2020 as stated in the National Public Transport Strategy makes the following statement: “Integrated rapid public transport service networks (IRPTN) are the mobility wave of the future and are the only viable option that can ensure sustainable, equitable and uncongested mobility in liveable cities and districts” (Public Transport Strategy: 2007).


It is envisaged that the Network will consist of a core of road and rail trunk corridors with feeder systems that will be integrated (Public Transport Action Plan, Phase 1: 2007). The minibus taxis will therefore play an integral role in the IRPTN. It is furthermore stated that all Public Transport vehicles will have electronic equipment installed in them and through it be monitored by the relevant Public Transport authority. The main functions of the equipment will be Automatic Vehicle Location (AVL), Electronic Fare Collection and Management (EFM) and signal priority (Public Transport Strategy: 2007).

Taxi owners are small business entrepreneurs and the incentive to make a profit is higher than the motivation to supply a reliable public transport. Some taxi operators still have a negative perception to the idea of being monitored by an authority. The general view is that a monitored taxi will have to disclose the number of passengers it transports per day and will have to pay a larger percentage of its income towards tax. The Department of Transport, through the Public Transport Strategy, aims to move more passengers from their private cars to public transport, which will increase the number of taxi passengers. The taxi operators’ fear of losing profit is therefore ungrounded.

Minibus taxi operators do not receive any state subsidies currently largely because the taxi-industry is to a large extent unregulated. By being monitored the taxi’s movements can be verified and subsequently subsidies can be introduced to encourage route-adherence.

The paper aims to show that the taxi operator can use the on-board electronic equipment to satisfy Public Transport Authority requirements and at the same time generate additional income. The requirements from transport authorities and taxi operators will be discussed. This will be followed by the explanation of the equipment needed for the different applications. A pilot project is currently underway in Cape Town and preliminary results are given. The conclusion and some suggestions follow in the last section of this document.

2 REQUIREMENTS

2.1 Public Transport Authorities

The minimum requirements for Public Transport Operators are AVL and EFM. On-board equipment on Public Transport vehicles should send this information to a Municipality- or Provincial Government owned Control Centre or Back Office.

In terms of section 23 of the National Land Transport Transition Act (Act 22 of 2000) each planning authority must prepare a Current Public Transport Record (CPTR), which must form
the basis for the development of its Operating Licence Strategy and Public Transport Plan. The CPTR must include all of the scheduled and unscheduled services that are operated in the area of the planning authority, including services to and from neighbouring planning authorities. The CPTR must include service capacity and capacity utilization information. The CPTR must be updated annually and in updating it, planning authorities must take into account changes in the demand and supply of public transport services (Government Gazette 21493, 2000).

The current method of collecting CPTR data is by rank surveys undertaken at all minibus-taxi ranking points throughout the City. During the survey, the surveyor records the arrival and departure times of vehicles as well as the number of passengers boarding and alighting at the facility. The rank surveys are augmented by roadside monitoring surveys to identify vehicles that are not rank based. This method is not very accurate and the results listed in the CPTR for minibus-taxis are therefore a fairly conservative estimate (LTE Consulting, 2007).

From this it is derived that the Municipality Planning Authorities need at least AVL and passenger number information. The essential on-board applications to fulfil these requirements are:

- GPS tracking
- Passenger counting

2.2 Taxi Operators

Some taxi owners have a tracking system installed in their taxis. This is mainly for insurance purposes, especially in cases where the taxis are new or still in the process of being paid off. It also gives the owners control over the drivers of their taxis since they can follow their movements on the internet.

The research goals and methods were discussed with a taxi association in Cape Town. The taxi owners explained that they do not know how many passengers are transported by their taxis during a day. Therefore they do not know exactly what income is generated by the taxi driver.

Most taxis are equipped with radios, CD players and in some cases even DVD players with LCD monitors. This is mainly for the entertainment of the passengers.

The drivers, who are not owners of the taxis, can be in contact with the owners via cell phone communication.

The requirements from the taxi owner side are:

- GPS tracking for insurance purposes
- GPS tracking for security purposes
- Passenger information
- Entertainment for passengers
- Communication

2.3 Research Institutions

No statistical information exists about minibus taxi movements and their operations. A comprehensive set of data regarding minibus taxis and the people they transport will enable
Research Institutions to assist the industry with decision making for public transport operations and city planning.

The requirements for gathering information for Research Institutes will be:

- GPS tracking
- Passenger counting

3 EQUIPMENT AND APPLICATIONS

To test the aforementioned requirements the following equipment was installed in a current operating taxi:

- On-board computer;
- GPRS modem and antenna;
- GPS antenna and receiving module;
- Door sensor;
- Passenger counter;
- Security cameras and
- LCD monitor.

With this equipment the following applications are run on the taxi:

- Automatic Vehicle Location (AVL);
- Data communication to a back office;
- Passenger counting;
- Security via on-board monitoring and
- Advertising and information display.

These applications satisfy the basic requirements from the parties mentioned above. The equipment installed on-board the vehicle is modular and further applications can be added by merely attaching the relevant peripheral modules, i.e. a smart card reader can be attached to add EFM capabilities.

A Back Office was created to receive all the generated data from the on-board equipment via GPRS. The data can be viewed by the taxi owners from a web site.

3.1 Automatic Vehicle Location

The GPS module receives the GPS co-ordinates and passes the data on to the on-board computer. The computer makes the data available for the other applications and puts it in a format ready to send to the back office. The back office stores all the AVL data received from the taxi. It also makes the AVL data available for a mapping application on which the latest position of the taxi is plotted on a map.

3.2 Data communication

Data communication between the on-board equipment and the back office takes place via GPRS communication. The AVL information is send to the back office every 15 seconds. The back office can also request information from the on-board equipment via the GPRS communication.

3.3 Passenger counting
The passenger counter is developed by a private South African company specialising in on-board equipment for the public transport sector. It makes use of sensor equipment and software which detects the presence of people. Together with the passenger counter, cameras are used for monitoring the effectiveness of the passenger counter software. One sensor and camera are installed close to the sliding door just behind the front seats to monitor the first two rows of passenger seats. The other sensor and camera is installed in the middle of the roof to monitor the back two rows of passenger seats.

A door sensor sends the open or closed status of the sliding door of the taxi to the passenger counter software. Each time the door closes the passenger counter counts the seated passengers and append the count number to the AVL information that is send to the back office.

3.4 Security via on-board monitoring

Three Internet Protocol (IP) cameras are place inside the taxi at roof level. One is situated behind the driver looking forward and the other two are sharing the Passenger Counter application. The cameras record at 2 frames per second and each frame is stored as a compressed file in the on-board computer. Only images of the last three days are kept on the on-board computer. On the fourth consecutive day the Security application overwrites the images of the first day. Images can be downloaded either via a memory stick, GPRS or WiFi.

3.5 Advertising and information display

A LCD monitor is installed behind the driver seat, slightly off centre to the right. The screen is viewable from all the passenger seating positions but not from the driver position or the two passengers sitting next to him in the front of the taxi. Everything that is displayed on the screen is controlled by the on-board computer. Material that is displayed on the screen can be downloaded via GPRS onto the on-board computer.

The screen is divided into three sections:
• An outer frame in on which advertisements from only two advertisers are displayed. The frames alternate once every minute between the two advertisers. This space is reserved for primary advertisers who will get the most exposure.
• An inner rectangular area where advertisements from secondary advertisers are displayed. These adverts change every 30 seconds and can be still images or Mpeg clips. The number of secondary advertisers can be unlimited but are determined by the operations of the taxi. A maximum of 20 advertisers are considered favourable.
• A scrolling text line which contains relevant passenger information, such as route and time. The text line can also be updated via GPRS with information such as the soccer score of a live game.

The advertising application makes use of the available GPS co-ordinates to display advertisements according to the geographical location. This means that an advertisement from Company A is only displayed when the taxi is in a 2 km radius of Company A’s premises.

When an advertisement starts to play, its ID is given to the on-board computer to be sent to the back office. The back office therefore knows which advertisement was shown at what physical location at what time to how many passengers. This information is used in reports to advertisers.

4 RESULTS AND DISCUSSION

From discussions with taxi association members and taxi owners it was found that they are keen to have on-board equipment that can meet their requirements. The on-board equipment described in the previous section was installed in a Toyota Hi-Ace which is operating along a route in Cape Town. The following results were obtained from the different applications:

4.1 GPS tracking

The GPS data was plotted on a map using MapInfo. The received co-ordinates were not always on the roads due to tolerances from the GPS receiver. Correcting software was used to move the co-ordinates to the closest road on the map and an accurate track of the travelled route could be traced on the map.

Stops where people boarded or alighted from the taxi could be plotted from the door sensor information: each time the door was closed the GPS co-ordinates were sent to the back office with an indication that the door was closed at this location. The passenger counter calculated the number of passenger on board the taxi after the door closed. This count was received by the back office together with the GPS information and the number was displayed along the route after each stop shown in figure 4.1. The total number of passengers that travelled on specific sections of the road is calculated and displayed graphically in Figure 4.2.

The City of Cape Town (CoCT) Municipality found this tracking information very useful as they can determine route adherence which is essential information when subsidies are involved. The passenger number information which is related to a geographical position is helpful in the compilation of the CPTR. The road-use in terms of passengers carried by taxis can be determined which is helpful with infrastructure planning. From the stop positions the city planners can determine future taxi- and bus stops.
4.2 Data communication

The on-board computer receives the information from the GPS every 15 seconds. The last passenger count, door sensor status and advertisement ID are then amended to the GPS co-ordinates and this information is sent via the GPRS modem to the back office.

4.3 Passenger counting

The passenger counter runs as a separate application each time after the door closes. A picture is taken of each instance when the counting takes place. This picture is used as a reference to calculate the accuracy of the passenger counter. Accuracy is given in terms of passengers counted against actual passengers present. Figures 4.3 and 4.4 show the people counted by the equipment. Accuracy was calculated over the period of 1 day at a time and was found to be between 85% and 95%.

To get the best results, the Passenger Counter and cameras are positioned against the roof of the taxi. Therefore a taxi with a high roof, like the Toyota Quantum or Fiat Ducato is the ideal vehicle to test these applications. The counter was temporarily installed in a high roof Toyota Quantum to make a comparison in accuracy and an overall accuracy of between 90% and 100% was achieved. This is because the passengers are better visible to the passenger counter sensors.

The passenger counter has settings e.g. sensitivity and resolution, that can be set to an optimum to achieve the best results. These were set in a controlled situation where people...
posed in various positions inside a Toyota Quantum taxi. The count that was achieved in this situation was 100%. The taxi in which the equipment is placed for this pilot demonstration is a low-roof Toyota Hi-Ace. It was found that to obtain a high level of accuracy, the equipment needs to be calibrated for a specific vehicle.

4.4 Security

The security cameras are displayed on the LCD monitor every ten minutes in between advertisements. The passengers can therefore see themselves while the following message is displayed: “For your own safety you are being monitored by CCTV”. Feedback from the passengers is very positive. The passengers mentioned in a survey that they feel safe because thieves are now discouraged to steal while they are being watched.

![Figure 4.5 Images from front security camera](image)

4.5 Advertising

For the pilot project on one taxi only, generic advertisements of cars and clothes were shown. Ten 30 second advertisements were rotated with a live feed from the security cameras. The taxi driver reported that the passengers enjoyed the distraction of the advertisements.

The reporting on adverts includes: time, position and number of viewers. This level of reporting is very valuable because the client can determine the ‘spread’ and ‘reach’ of adverts. Advertising agencies confirmed that they will prefer to use this media when it becomes available.

The accurate level of reporting also means that an advertiser can be billed for the amount of people watching his/her advertisement. Various price structures can therefore be put together for the different needs of the clients. Together with geo-based advertising, smaller clients can have similar exposure and benefits as corporate clients because the smaller client’s advertisements are only displayed in the relevant area where his/her business is located; whereas a corporate client advertises continuously during the day over a wider area.

Advertising rates, if calculated on a similar basis as television advertising (OMD,; 2007), can give the taxi owner an income of between R200 and R500 per secondary advertiser per month. An average of 20 secondary advertisers can be accommodated in the current setup. Negotiations with primary advertisers can lead to the sponsoring of the on-board equipment. Taxi owners can also source their own advertising clients which can raise their profit from this application.
5 CONCLUSION

The pilot project was presented to a group of 10 taxi owners and the different applications were explained and discussed with them. The owners’ general consent was that the benefits of having electronic on-board equipment on a taxi outweigh the negative feeling they used to have against being monitored by transport authorities. The pilot that is currently under way demonstrates different applications to the taxi owner and the City of Cape Town Municipality. It is shown that both parties will benefit from the implementation of these applications.

The cost of the equipment together with installation is R55,000 to R60,000 depending on the vehicle type and which applications are being installed. The operating cost is between R3,000 and R5,000 per month including on-site maintenance, advertising management, equipment lease and sundry costs. Advertising income is estimated from R6,000 to R10,000 per month depending on the number of advertisers and the type of advertisements. The taxi owner can therefore have an additional income of between R1,000 and R5,000 per month from the advertising application alone. This will be an extra income of between 10% and 50% per month on top of the normal transport income.

The tracking and security applications already show positive results. An effective passenger counter is essential to both the tracking and the advertising applications. It can be seen that with the advertising application alone the taxi owner should be able to generate a sufficient secondary income to pay for the cost of the on-board equipment and still make a substantial profit. The next step is to enter into negotiations with the relevant parties in the advertising industry, who are already interested to enter this untapped market.

With the on-board equipment installed on a taxi, it is a simple process to test other applications as equipment can be added in a modular way. These applications can add to the secondary income of the taxi owner and driver which is the motivation for having the on-board equipment installed.

6 REFERENCES