# ATTRACTIVE METHODS FOR TRACKING MINIBUS TAXIS FOR PUBLIC TRANSPORT REGULATORY PURPOSES

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## 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 provincial governments and municipalities are in the process of developing efficient public transport (PT) systems like for instance BRT corridors and rolling out revised operator contracts. All of these efforts require electronic on-board equipment for integrated ticketing purposes. Some PT systems requires GPS tracking for the monitoring of route adherence.

As the minibus taxi industry carries currently 65% of all public transport passengers, they can not be ignored in these plans. Although some taxi owners are using electronic tracking equipment, these are for private fleet management and are paid from their own pockets. The problem lies in the fact that the taxi owners had been largely self-regulating and are not keen to be monitored by authorities.

The authors are 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 attractiveness of applications such as electronic advertising and SMS 'taxi calling' are being tested.

## 1. INTRODUCTION

The 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).

The Public Transport Strategy and Action Plan aims to spell out how to move from a operator-controlled, commuter-based, uni-modal routes to user-friendly, municipal controlled, fully integrated, mass rapid public transport networks ((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 the network will be managed and controlled through Public Transport Intelligent Transport Systems – including Global Positioning System (GPS) tracking of all trunk and feeder road vehicles – linked in real time to a central Control Centre (Public Transport Strategy: 2007).

According to the Public Transport Strategy and Action Plan all minibus taxis 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).

A pilot project was introduced by the Tshwane Municipality in 1998 involving a basic smartcard for automatic fare collecting in conjunction with a GPS. The Menlyn smartcard system could not be rolled out in Tshwane even though the pilot project was very successful with the operators and rank marshal and especially the originally opposed drivers accepting the system. The reason for the failure to rollout was due to the subsequent escalation of taxi violence in 1999, partly based on rivalry with respect to smartcards (Baloyi, 2005).

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.

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 as described in the Introduction. The on-board equipment on the vehicle 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).

Currently the City of Cape Town Municipality is seen as a leader in the field of CPTR

productions and is the only planning authority with documents prior to 2002. The method used for the collection of minibus-taxi information is not very effective. Rank surveys are 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 figure listed in the CPTR for minibus-taxis is 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 Institutes

Students and researchers from universities, colleges and institutions such as the CSIR have the need for statistical information like public transport vehicle and passenger numbers and their movements. This is used in research papers and reports that supports the industry.

Currently there is no database available with statistical information about minibus taxis and their operations. A comprehensive set of data regarding minibus taxis will enable the Research Institutions to assist the industry with decision making for public transport operations and city planning.

The CSIR is in the process of establishing the Nyanda Web, the same concept as the

Sensor Web (Sensor Web-Alliance.com). The aim is to have sensors, currently installed or new, that will feed transport related data to a central database. Data will include environmental, weather, traffic, people movements, road infrastructure and other information that is relevant to transport. The minibus taxi can act as a sensor that will gather positional information about itself, driver behaviour, passenger behaviours and movement patterns and even road conditions.

The requirements for gathering information for Research Institutes will be:

- GPS tracking
- Passenger counting
- Camera imaging

## 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. A more comprehensive range of applications which will include a driver console will be tested at a later stage.

A Back Office was created to receive all the data from the on-board equipment via GPRS. The data can be viewed by the taxi owners from the web site. Data from only one taxi is currently available on the website. The website is ready to accept data from more than one taxi and will give viewing privileges via secure login to the relevant owners. Live information from all the applications on the taxi is available on the website.

### 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. The requested information is then sent in addition to the AVL information. This is usually additional log files or pictures from the security camera.

## 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.

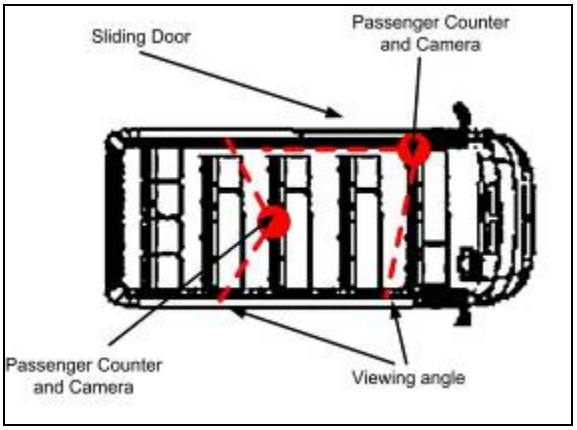


**Figure 1 Diagram of taxi showing Passenger Counter and Camera positioning**

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. A separate folder is created for the images recorded on each day. 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.

**Figure 2 Security cameras**

It is possible to download some or all of the recorded images from the on-board computer via GPRS. This can be done via a web interface. Either the last recorded still image can be downloaded or a range of images over a specified period can be downloaded.

## 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:

**Figure 3 LCD monitor**

- 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 operational 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 as stated in section 2.2. They were very helpful in supplying an operating taxi which can be used for the pilot demonstration. 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 co-ordinates that were sent from the on-board equipment to the back office 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.


**Figure 4 Tracking of taxi on map**

The City of Cape Town (CoCT) Municipality found this tracking information very useful as they can determine route adherence from this. The passenger number information which is related to a geographical position is helpful in the compilation of the CPTR. However, this data is given in a graphical display currently and the raw data needs to be converted to a meaningful database which links the location and passenger information to routes and operating licences.

### 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.

File requests by the back office for camera images works well and the images are displayed on the web interface. Sample images from the security camera is shown later in this section.

### 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, i.e. 5/7 indicates 5 counted out of 7 present. Accuracies of 5/5, 5/6, 6/6 and 5/6 were achieved. On average one person was not counted in 70% of the counts and everybody was counted in 30% of the counts. This gives an overall accuracy of 85%.

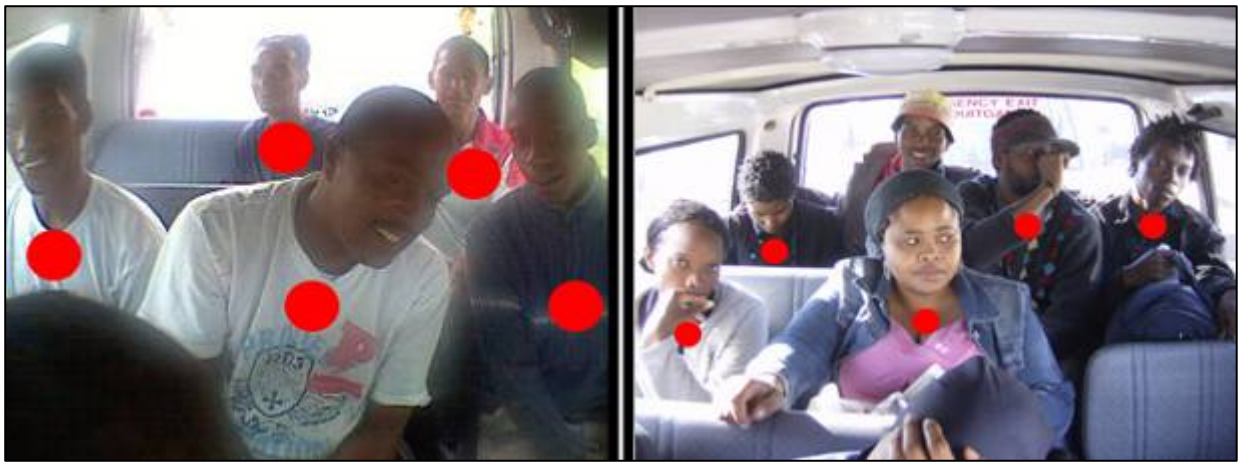

**Figure 5 Passenger counting in back two rows**

**Figure 6 Passenger counting in front two rows**

To get the best results, the Passenger Counter, cameras and LCD monitor 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. The settings set in the controlled environment are being used to determine whether the settings are generally applicable..

Before a constant high level of accuracy can be achieved, 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 passenger 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.

## 4.5 Advertising

**Figure 7 Images from front security camera**

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 his passengers enjoyed the distraction of the advertisements.

The advertising opportunities and the level of reporting were explained to an advertising agency. They were very excited about the fact that the reporting can give the number of viewers per advertisement. This 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 area where his/her business is located; whereas a corporate client advertises continuously during the day over a wider area.

The taxi owners can also source their own advertising clients. This will increase the taxi owner’s income. The advertising agency indicated that they are available to enable the taxi owner to get a bigger portion of the advertising income than the normal rental fee because of the level of reporting.

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 need to be held with primary advertisers in order to get them to sponsor the on-board equipment.

## 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. The back office that receives and distributes the relevant data was set up for R75,000.

Depending on the existing infrastructure of the municipality, they may need to spend up to a maximum of R60,000 towards servers, workstations and software to enable the relevant department to receive and process the incoming data for CPTR.

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 have extra money available. 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.

## 6. REFERENCES


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