APPROPRIATE TECHNOLOGY FOR AUTOMATIC PASSENGER COUNTING ON PUBLIC TRANSPORT VEHICLES IN SOUTH AFRICA

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ABSTRACT

The National Land Transport Transition Act 2000 requires that Current Public Records (CPTRs) be completed by each planning authority. The CPTRs consist of data on infrastructure, fleet, timetables, routes, passenger volumes, etc regarding public transport in the planning authorities region.

However this data is collected manually and therefore time consuming and subject to inaccuracy. The main aim of this project is to explore possibilities of collecting most of the data required for transport planning electronically.

A market survey was conducted to establish the need for automated passenger counting systems. The results showed that indeed there is a need for automated passenger counting systems.

This paper contains a technology scan on the automated passenger counting systems that gives a basic understanding of these systems. Furthermore, an extensive research was undertaken to identify automated passenger counting systems developers. Ten systems developers where identified. A database of such developers was developed together with their contact details.

Passenger counters can be categorized according to four groupings based on the key technology used for counting.

The following groupings exist:
- **Manual (Turnstiles)**
- **Infrared (IR) beams**
- **Infrared optic sensors**
- **Low ultrasonic frequency sensors, and**
- **Treadle mats. (Load cells)**
- **Video camera**

A field trial was undertaken with Infodev on the City of Johannesburg's Metrobus. The main objective was to test the system on real life situation and its acceptability to passengers. It was found that people did not notice the presence of the sensors on top of the door. Also the system gave accuracy levels around 99%.

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1. OVERVIEW OF PROJECT

1.1 Description of Project

Transport planning authorities are required by national legislation to complete Current Public Transport Records (CPTRs) on an annual basis. A number of municipalities and provinces have already completed surveys to comply with these requirements. These surveys were very expensive (varying between R300 000 to R1 million per district or metropolitan municipality) and quite often, either not in a useful form or too questionable to be used for transport planning purposes.

The CPTRs consist of data on infrastructure, fleet, timetables, routes, passenger volumes, etc. The information collection process on routes and passenger volumes was most challenging and required surveyors to travel on taxis, buses, and trains. These surveys were subsequently most expensive and time-consuming, and the accuracy questionable since it is difficult to report the route the taxi or bus is travelling.

The aim of this project is to explore possibilities of electronic data collection on public transport services for transport planning and contract management purposes. The project will also focus on technologies that can track vehicle movements along a route (with the use of Geographical Positioning Systems).

2. MARKET NEED

2.1 Market Survey Conducted

The market survey consisted of one-on-one discussion with consultants, municipalities and operators involved in passenger data collection. The response for these stakeholders was in favour of an automatic counting technique, except for one of the consultants.

One consultant suggested that the existing ticketing information should be used. The research team is not aware of one project where available ticket information was available in a suitable format to be included in the Current Public Transport Records (CPTRs). The information from tickets sales is furthermore unable to point the actual point of boarding and alighting, and the actual frequency of ticket use. CSIR Transportek, who has also been involved in CPTR projects in the past and can thus also be considered as a representative of the consultancy industry, believes that an automatic counting procedure will be less labour intensive, less intrusive to the passenger and more accurate, and eventually less expensive.

The operators and municipalities that were contacted were in favour and believed that there was a real need for it.

During the market survey, contact was also made with a South African manufacturer of an automatic passenger-counting device (APC). Their design specification was however more focused around the operator in order to monitor onboard ticket sale and verification with actual passenger counts.

3. PROJECT PHASING

The project will be carried out in five phases, each phase consisting of a number of tasks. The project will consist of the following phases:

Phase One:	Project initiation and technology scanning
Phase Two:	Interaction with technology developers and local operators
Phase Three:	System trials and evaluation
Phase Four:	System implementation (pilot)
Phase Five:	Project reporting

4. TECHNOLOGY SCAN

4.1 Introduction

A technology scan of automatic passenger counting systems was conducted as part of the project. This provided useful background to the topic.

Developed countries have a long history of counting passengers on their buses. Passengers have been counted manually; handheld units have been used, electronic registering fare boxes, smart cards and more recently automatic passenger counters.

Different APC systems operate on different technologies. The following principle technologies were identified. Namely:

- Manual (Turnstiles)
- Infrared (IR) beams
- Infrared optic sensors;
- Low ultrasonic frequency sensors, and
- Treadle mats. (Load cells)
- Video camera

Turnstiles are devices that are used for admitting people as they get in and out of a vehicle or building with barriers that revolve around a central post as each individual passes through.

The IR beam technology counts the total number of boarding and alighting by counting the number of times the beam(s) is "interrupted" by a passenger entering or exiting the bus, they can either be passive or active. Passive sensors are sensitive to the infrared radiation generated by a human body to determine directional differentiation while active sensors are able to determine the presence of a person. The infrared optic sensors combine the registration of the thermal radiation of the passengers and the reflection of emitted infrared radiation on people in a high tech sensor.

The ultrasonic counting technologies are similar in operation but differ only in how the passenger's presence is detected and counted.

Treadle mats are usually placed on the steps of the vehicle and through the image of the footprint on mat algorithms are used to count passengers.

APC systems can however be customized to fit the needs of the operator or transport planning authority that installed it.

A simplified process of automated passenger counting goes through the following stages [1].

- Counting (e.g. treadle mats, IR sensors and IR beams)
- Locating (e.g., signpost or GPS)
- Data storing
- Downloading
- Analyses and reporting

Automatic passenger counting systems are used for various reasons in buses and transit systems. The systems can be used for total counts with the view of fare verification. Such systems may also be used for collecting ridership data for planning and route scheduling.

These people counting systems are also used in malls, shops airports, etc, where the pedestrian traffic could be of interest.

The following is a list of typical components for APC systems. It should be noted that not every APC system has all of these components at once.

- Counting sensors (such as treadle mats or IR beams)
- An odometer sensor;
- An internal clock in the microprocessor to determine the time that the passenger activity occurred;
- A microprocessor to tabulate, accumulate, and store passenger activity data onboard the vehicle;
- Manual or automatic data storage/retrieval devices;
- A power supply to convert primary vehicle voltage (usually 12 or 24 volts DC nominal) to that of the APC system;
- Engine sensors to register engine dwell and idle times;
- Wheelchair-lift sensors to register wheelchair lift activity (optional); and
- Door sensors to register door openings and closings.

4.2 Set System Specifications for Local Use

The objective of this task was to establish the systems specification to be used when assessing the different available systems.

The primary objectives of the CPTR are to provide the status quo of public transport operations and infrastructure. These served as input into transport planning processes. The data captured through CPTR data capturing process should be able to be translated into route location, passenger numbers and capacity utilisation by route and service characteristics.

Since the electronic data collection system is intended for transport planning purposes, no emphasis will be put on ticketing matters and driver monitoring

For the scope of this study, the selected system has to meet the following generic requirements.

Table 1. Description of each criterion.

Criteria	Description
Accuracy of at least 95%	This level of accuracy can be deemed acceptable for transport planning purposes.
Operate to local climate conditions	South Africa is characterised with seasonal rains, temperatures ranging between –10 to +40 degrees Celsius, most rural and semi urban areas have high levels of dust.
Dust	Public transport in South Africa operates in dusty areas as well
Heat	Temperatures in South Africa range between –10 to +40 degrees Celsius.
Splash	South Africa is characterised with seasonal rains
Spatial Analysis	Systems with GPS often have the ability to produce results that can be analysed spatially. This can be useful fin relating route to development
Ability to integrate with other systems e.g. MS Excel or MS Access	It is appreciated that the selected system will focussed on data collection. Therefore there is a need for the system to integrate with other system in order to translate the collected data to the needs of those who need it
Not intrusive to passengers and driver.	Local experience has shown that items that are perceived to be valuable and yet left unattended are subject to theft and vandalism. Also a visible system could also be perceived to be invading on the privacy of the passengers and result in passenger discomfort. International experience has shown that systems that are visible to the driver could be perceived as a means of constantly monitoring the drive.

Table 1. Continued

Criteria	Description
Counters to have directional differentiation	The directional differentiation feature will be required to establish boarding and alighting passengers at a given station. The real time passenger counting is required to establish the utilisation of the service at a specific time.
System interface to allow capturing of vehicle numbers and vehicle capacity	The system interface will be essential in order to capture vehicle and route specific information. Information such as the vehicle number and maximum capacity can be preloaded at installation. This will only be done once during installation. This will identify the vehicles on which it was used and establish capacity utilisation. Other use of the system interface could include preloading route names and description
GPS or any other system that can establish physical location of the vehicle	It is essential to establish the physical location of the vehicle in order to determine demand supply relations per route. Such information assists in the process of issuing bus/taxi permits.
Time Based Data collection	This information is important in order to link the demand supply relation to real time. Frequency and running time decisions can be made to have the supply of service correspond precisely with the actual demand for that service.
Identify on-off stops with arrival and departure times	This is essential to determine the demand against supply and be able to relate this to time.

4.3 Scanning of Systems

An extensive scan of commercially available APC systems was undertaken. The main sources of information were the Internet, journals and magazines.

Table 2. List of available systems.

Name of the APC system	Name of system developer	Basic counting technology	Web- address
CleverDevices APC	CleverDevices	Infrared	http://www.cleverdevices.com
Fultron/Greyhawk fixed route MDT	Greyhawk Technologies	Infrared	http://www.greyhawktech.com
Microtronix	Microtronix Vehicle Technologies Ltd	Treadle Mat Technology	http://mvt.microtronix.ca
Matex Treadle Mats	LondonMat Industries	Treadle Mat Technology	http://www.londonmat.com
Infodev	Infodev EDI inc	Infrared	http://www.INFODEV.CA
Eyeone	Apricot Technology	Infrared	http://www.apricot.de
IRMA	Iris-GmbH infrared & intelligent sensors	Infrared	http://www.irisgmbh.de

Table 2. Continued.

Name of the APC system	Name of system developer	Basic counting technology	Web- address
Acorel APC	Acorel Automated people counting systems	Infrared or Video camera	http://www.acorel.com
PMT	PerMetrics Technologies	Treadle Mat Technology	http://www.permetricstech.com
DILAX	DILAX Intelcom GmbH	Infrared	http://www.dilax.de
Cuper System	Cercanias Renfe/Eliop	Load Cell	Tel (34) 91 383 57 47 Fax (34) 91 302 9249

4.4 Evaluation of Systems

The evaluation of the systems is only based on criteria that were used above. Also, the privilege that the research team had during its interaction with the Infodev system developers (due to its local presence) gave a deep understanding of the system beyond the information supplied by the brouchers that are supplied by all systems developers. As such it is possible that if the same privilege was afforded more information and understanding of all the other systems would have been obtained.

Based on this evaluation the Infodev system appear more favourable, but it must be stressed that it was the only system which was represented by a local agents which improved the level of understanding of the system. Based purely on the evaluation process with the information available, the Microtronix and PMT systems will also be considered in the subsequent phases.

5. INTERACTION WITH TECHNOLOGY DEVELOPERS AND LOCAL OPERATORS

All the identified system developers where approached to establish their willingness to participate in the 3rd phase of the project. Also, they were asked to give an indication in terms of costs implication for their participation. Their participation will involve allowing their system to be subjected to a trial in a controlled environment.

Furthermore, the system will then be tested in the field. This means the systems will be installed on a vehicle and operated on selected routes. A service operator will be engaged to make a vehicle and route(s) available.

The preferred system developers had indicated their willingness to participate in the 3rd phase of the project. However, at the time of this report, only one of the developers have indicated the costs implications for their participation.

Infodev, through their local agent gave a total estimate of R28 000/ bus assuming 1 sensors/door.

Below are the components included in their estimate:

- Sensors: R 9000/sensor
- Modems:
- Installation:
- Professional fees:

These prices can be assumed to average, and therefore can be assumed to give an indication of what the other system developers would require. However, one would need to take into account the exchange rate. Furthermore, Infodev have a local agent and. The same cannot be said about the other system developers, and would also need to take into account international travel costs and accommodation.

6. PRELIMINARY TRIAL OF THE INFODEV SYSTEM IN THE FIELD

6.1 Introduction

Infodev SA was able to make their system available for a preliminary trial in the demo as they were at the time installing an APC system for demo purposes on the City of Johannesburg (CoJ) Metrobus.

Transportek's involvement was that of an observer that was given access to a sample of the collected data for analysis. Infodev provided the system and CoJ Metrobus provided a bus, route and premises.

6.2 Objectives

The main objectives of this exercise was as follows:

- To establish the accuracy of the system
- To verify integration of the system with other software packages such as MS Excel and MS Access
- To verify compatibility to local conditions such as climate, dust etc.
- To get a general perspective of issues related to system testing to assist with the next phase of the project.

6.3 Methodology

Metrobus made available a bus that operates on different routes between Johannesburg CBD and surrounding suburbs. The APC system was installed on the bus on a weekend to avoid disrupting weekly services.

On some trips, a portable camera was installed to survey passengers as they climb on and off the bus. The objective of this was to compare the camera results with those of the APC system. The camera was not used frequently as it was highly visible to passengers. Data was collected on different days during the week.

The collected data was downloaded from the system into the computer that is installed at the bus depot.

6.4 System Assessment

During the on- bus surveys, it was observed that passengers did no notice the existence of the sensors that are placed on top of the door. The research team had anticipated that passengers could notice the sensors. Although it was not the emphasis of this project, it was however observed that bus drivers were not comfortable with the system. They felt it was there to monitor their day-to-day operations.

In terms of accuracy, two methods were used to verify the counts done by the system. Firstly, manual counts where used in routes with fewer passengers getting on and off at a time (queues of +-3 people at a time). Then during routes with higher demand (queues of 5 people or more at a time), a portable video camera was used. It was established that in both instances the accuracy level was at 99% percent. This accuracy level was obtained using three sensors per door (double door). When one sensor per door was used, the accuracy level reduced to 95 %. This level is still considered acceptable for transport planning purposes.

The on-bus surveys were undertaken on both warm, and rainy days. It was found that climate did not affect the system.

The information collected from the system was considered adequate for general public transport planning such as the capacity utilisation, route scheduling, and obtaining the number of people that get on and off the bus at known stops.

7. CONCLUSIONS

Based on the above findings, the following conclusions can be made:

- Several automatic passenger counting system developers exist globally
- The most common technologies upon which APC systems are developed are infrared optical sensors, infrared beam sensors and treadle mats
- The market survey showed that there is a need for automatic passenger counting systems for local use
- Most of the identified systems can operate under local conditions
- In particular, three systems were identified to merit further consideration for local use, namely, Infodev, Microtronix and PMT (only the Infodev system was tested).
- Based on a preliminary field test the Infodev system demonstrated levels of accuracy up to 99 % under local conditions. The level of accuracy decreased to 95% with only one sensor installed per door.
- Passengers were not aware of the presence of the system.
- It appears that the drivers felt the system was there to monitor them on their daily operations and as a result felt uncomfortable with the system
- It appears that an appropriate APC system will capture the essential passenger information and route information for CPTR purposes.

8. RECOMMENDATIONS

Based on the above findings and conclusions, the following recommendations can be made:

- Phases 3 and 4 to be implemented during the next financial year as the need for the automatic passenger counting system has been established and identified system developers have indicated a willingness to participate
- The Infodev, Microtronix and PMT system developers be engaged during the next phases.
- Results from the next phase be workshoped with the stakeholders in the industry

9. REFERENCE

[1] Boyle, DK, 1998. Passenger Counting Technologies and Procedures: A Synthesis of Transit Practise, Academy Press Washington D.C.