Influence of Unscheduled Random Public Bus Stops on Transit Travel Time

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***Abstract*—Transit Travel time can affect to a large extent the service reliability, operating cost, and system efficiency. This research paper aims to study the negative impact of the unscheduled random public bus stops on travel time for a particular bus route in Cairo, Egypt. These unscheduled stops became a usual behavior for Cairo Public buses, which affects more than four and a half million daily users of this transportation service inside Cairo. In this study, a comprehensive research plan was designed to collect the data concerning the bus behavior along a selected bus route, using GPS data logger. The data collection included time, location, speed, unscheduled stops, and scheduled stops. The collected data was then used to develop a trip time model. The developed model revealed the delay time due to the unscheduled bus stops and the scheduled bus stops. The analysis of the data also showed that passengers rely much more on the unscheduled random bus stops than the scheduled bus stops. The study concluded that minimizing the unscheduled bus stops will decrease the trip time, and so improve the service reliability to a large degree.**

***Index Terms*—Travel time, unscheduled random public bus stops, GPS data logger, trip time model, service reliability.**

I. Introduction

Service reliability measures include arriving on time, short travel/run time, and low variance in travel time [1], [2], [3].

CTA (Cairo Transit Agency) database shows that there are more than four and a half million daily passengers use Cairo public buses, categorized according to Table I [4].

These various public bus services in Greater Cairo, Egypt suffer from several problems that affect its reliability. Those problems, shown in Fig. 1, can be summarized to four main categories: congestion, unreliable schedule, deteriorated state of the buses and the stations, and unprofessional management.

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TABLE I. CTA Fleet Characteristics and Daily Passengers

Transport Mode	Fleet		Daily Passengers
	Total	Actually Working.	
Buses.	608399	490039	3952450
Air Conditioned Buses.	50606	35622	132630
Mini-Buses.	180786	157450	572930
Total Daily Passengers			4658010

Figure 1. Cairo public bus transport problems.

This research paper is concerned with one of the critical reasons for those main problems. This reason is the increased presence of the unscheduled random public bus stops. Unscheduled random stops, as shown in Fig. 2, are those stops done by the public bus drivers to pick up/drop off passengers at random points on the route other than the official bus stops.

Figure 2. Unscheduled random stops in Cairo streets

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Those random stops affect the travel time of the bus dramatically and make it very difficult to stick to the original proposed fixed schedule. This leads to unreliable arrival/departure times that were found to be one of the main factors discouraging people from using public transport [5].

Also due to the increased number of the unscheduled random stops, the number of passengers usually increases to an extent that exceeds the bus capacity. This leads to the deterioration of the public buses after short while.

The objective of this research paper is to estimate the delay time due to the scheduled and the unscheduled random stops, and to discuss the service reliability corresponding to a particular bus route in Greater Cairo.

The selected route for the study is Nasr city-Darrasa bus route, shown in Fig. 3. The route is around 10 km in length and consists of segments of different road classes with different widths. The official scheduled peak hour trip time is 30 min and the number of scheduled bus stops is 14 bus stops, where the first and the last bus stations are main bus stations.

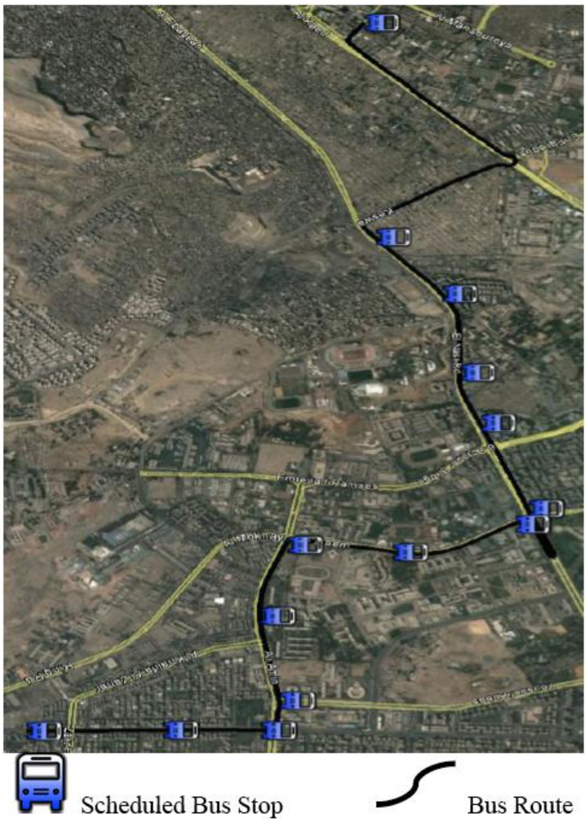

Figure 3. Nasr city-darrasa route.

Time, Position, unscheduled stops and scheduled stops data was collected using a GPS (Global Positioning System) data logger starting 6.00 A.M. in the early morning. Thirty runs were carried out on the route, and then the analysis was done to develop a trip time model. The developed model was then used to assess delay time due to the scheduled stops and the unscheduled random stops. The trip time model developed is a function of unscheduled stops time, scheduled stops time, route distance and average nonstop speed. Other statistical analysis was also carried out to show the negative influence of the stops on reliability aspects.

Finally, the research paper provides practical recommendations that can be applied by the public transit decision makers to overcome the unscheduled random stops behavior and its negative consequences. Also further research recommendations were provided.

II. Data Collection

GPS data logger was used for the data collection phase. GPS receivers are now used for measuring travel time and speed. It was found that GPS collects more accurate and reliable data than other traditional methods and at a lower affordable cost [6]. A low cost (85 $) GPS data logger was used with an accuracy 3-5 m, which is a relevant reliable accuracy for such study. A low cost GPS was used to prove that this study can be afforded by the CTA (Cairo Transit Agency) for similar applications, if it is to be generalized on Cairo`s bus routes. The GPS data logger is operated on tracking mode. The collected data included position, time, heading and speed at 1Hz. The positions of the scheduled and unscheduled random stops were logged in as points of interests or by voice tagging at the locations of these stops, which make it easy to differentiate if the bus stopped for unscheduled/scheduled stop or whatever other reason (congestion, obstacle, hump, etc.). Table II gives a sample of the GPS data logger output data, and their representation on Google Earth is shown in Fig. 4.

TABLE II. GPS Data Logger Output Data Sample

Index	Date	Time	Latitude	Longitude	Speed
1	120918	164634	30.050N	31.318E	0
2	120918	164635	30.050N	31.318E	3
3	120918	164636	30.050N	31.318E	5
4	120918	164637	30.050N	31.318E	6
5	120918	164638	30.050N	31.318E	7
6	120918	164639	30.050N	31.317E	8
7	120918	164640	30.050N	31.317E	9
8	120918	164641	30.050N	31.317E	10
9	120918	164211	30.050N	31.317E	0

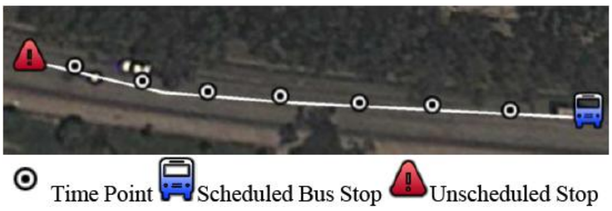

Figure 4. Data output sample on Google Earth.

According to [7], there are basic factors that affect bus run times that are agreed by many researchers [8], [9],[10]. Those basic factors include

- Segment Length (Distance).
- Number of Signalized Intersections.
- Number of bus stops.
- Road Characteristics.
- Weather.

- Traffic Volume.

In this study, thirty runs were undertaken on the same route starting 6.00 A.M.; the runs were done on the same route so that the physical road characteristics variations are constant in all the runs.

At 6 A.M. in the early morning, traffic volume in Cairo streets tends to be near free flow condition. Accordingly, congestion factor shall not affect the bus route and the study. Also, the signalized intersections are controlled manually by traffic officers who are not present at this time in the morning, so the bus almost doesn`t stop at the intersections.

Finally, the effective factors used in the study are the number of the scheduled/unscheduled stops, and the distance covered by the bus at an average speed.

III. Data Analysis

The data collected was analyzed to get the number of unscheduled/scheduled stops, route distance and the nonstop average speed values. These variables will be used in assessing the passengers' reliability on scheduled stops compared to unscheduled ones, and in developing the trip time model. A sample list for random analyzed runs is shown in Table III, and discussed below.

TABLE III. A Random Sample of Data Analysis Output.

Trip No	No of Unsch. stops	No of Sch. stops	Nonstop Speed (km/hr)	Distance (km)	Distance/speed (sec)	Trip Time (sec)
1	14	2	37.7097	10.381	991	1136
2	14	4	34.1760	10.481	1104	1382
3	11	3	40.1366	10.343	927	1157
4	22	5	35.9178	10.468	1049	1421
5	13	5	35.5317	10.375	1051	1303
6	3	0	35.8399	10.360	1040	1084
7	7	2	36.5104	10.493	1034	1185
8	9	3	39.6453	10.308	936	1063
9	15	6	29.7208	10.684	1294	1603
10	16	4	29.8348	10.627	1282	1498

A. Variables Used in the Analysis

Unscheduled/Scheduled Stops: The stops from the GPS database are divided into two categories unscheduled stops and scheduled ones according to the point of interest shape or according to the voice tag. It shall be noted that the first and the last main bus stations aren`t taken in consideration, while calculating the number of scheduled stops.

Distance: The distance along the route segments is computed from the coordinates acquired by the GPS data logger.

Average Nonstop Speed: It was concluded that the stops either, scheduled stops or unscheduled stops, decrease the average bus speed, and that the speed can be improved by consolidating those stops [11], [12].

The trip time delay includes deceleration/acceleration time, dwell time and reentering traffic delay [13]. To be able to determine the trip time delay caused by the unscheduled/scheduled stops directly, the effect of these stops on the average bus speed shall be neutralized.

The methodology, shown in Fig. 5, is followed to calculate average nonstop bus speed after omitting the unscheduled/scheduled stops effect. It goes as follows:

First, the route is divided into a number of segments. Each segment starts/ends with a stop point either a scheduled stop point or an unscheduled stop point.

Second, omit ten time points (10 seconds time span) before the stop point, and another ten time points after it. Those 10 seconds were removed from the segment and route speed calculations because according to analysis done, it was found that in this period the speed is affected by the stops. This time span period contains deceleration/acceleration time, dwell time and reentering traffic delay. The analysis was done on thirty different stops. According to the speed profiles, it was found that omitting 10 seconds span time before and after the stop point is sufficient to totally remove the influence of the stops on average nonstop speed.

Third, the average nonstop speed was calculated for each segment after removing the data recorded in the 10 seconds period mentioned before. This is done by averaging the time points' spot speeds.

Fourth, the distance is calculated for each segment.

Finally, the average nonstop weighted speed of the route is calculated by averaging the nonstop speeds of the segments related to the distance of each segment.

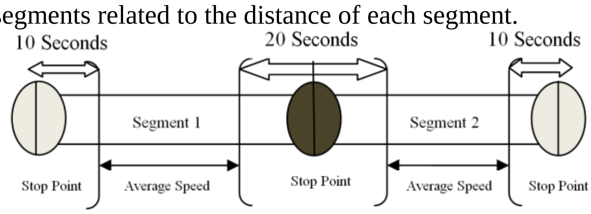

Figure 5. Schematic diagram shows average non-stop speed estimation.

B. Passengers' reliability on scheduled stops compared to unscheduled ones:

It is obvious from the data collected for this route that the number of unscheduled stops is greater than the scheduled stops, as shown in Fig. 6. If the average for both the unscheduled and scheduled stops is taken in consideration, it will be found that the average unscheduled stops for the 30 trials is approximately 8 stops, and for the scheduled stops is 3 stops. This means that passengers began to abandon the bus stops and became more reliable on the unscheduled stops, probably because they lost confidence in scheduled stops timetable.

There are idle scheduled bus stations that aren`t used and this is obvious from Fig. 6. The scheduled stops rate increase with the increase of unscheduled ones until certain limit close to 6 scheduled bus stops out of total 12 official scheduled stops. On the other hand, unscheduled bus stops may reach high rates up to 22 stops. It can be concluded that drivers at some extent stop stopping at the bus stops and depend more on unscheduled ones. Moreover, It can be concluded that some bus stations aren`t used because of their deteriorated state or due to the unplanned location.

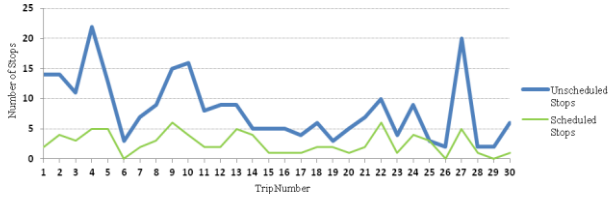

Figure 6. Relation between the number of unscheduled stops and scheduled ones for each trip number.

C. Trip Time Model

The trip time model, shown in (1), is developed as a function of unscheduled/scheduled stops delay time, and time consumed to cut the route distance at an average nonstop speed.

$$T\,(s) = f\,(N_{us} \text{ x } T_{us} + N_{ss} \text{ x } T_{ss} + D/U) \quad (1)$$

where N_{us}= number of unscheduled bus stops; N_{ss}= number of scheduled bus stops; D= distance cut by the bus; U= average nonstop bus speed. T_{us} and T_{ss} are constants for each route which represent the delay time due to each unscheduled and scheduled bus stop respectively. This delay time includes deceleration/acceleration time, dwell time and reentering traffic delay. Linear Regression analysis was used to develop the following best fit model for this route as shown in (2):

$$T\,(s) = 50.34 + N_{us} \text{ x } 8.93 + N_{ss} \text{ x } 23.69 + 0.997 \text{ x } D/U \quad (2)$$

The results indicate that for this route, each unscheduled bus stop consumes around 8.93 seconds and the one scheduled bus stop consumes 23.69 seconds. The data analysis revealed that R^2= 0.933, with 95% significance level for the parameters. The normal probability plot of the data analyzed is shown in Fig. 7.

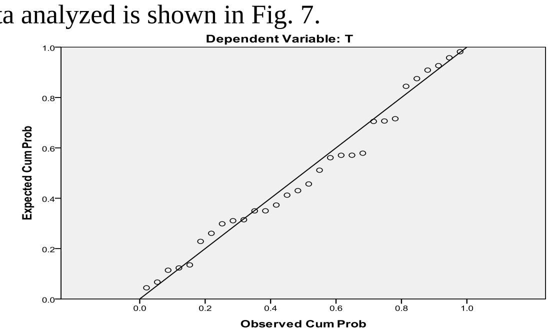

Figure 7. Normal probability plot of the data analyzed.

For the runs carried out on this bus route, if the average number of unscheduled and scheduled bus stops is taken in consideration, it will be found that the unscheduled stops increase the trip time by 6% while the scheduled stops consumes another 6% of the trip time. It shall be taken into consideration that these percentages shall increase dramatically when the runs are done in the peak hours.

IV. Conclusion and Recommendations

It is clear from the performed study that the delay time due to the average number of unscheduled stops approximately equals to that of the scheduled ones, which has a significant impact on the trip time. It was found that the passengers rely more on the unscheduled stops and uses it rather than the scheduled official ones, because they lost confidence in the schedule reliability. There are a percentage of scheduled official stops that are rarely used, probably due to the unplanned location, or due to the deteriorated state of the station. It is recommended to redesign the scheduled bus stops locations, and upgrade them to overcome stopping in unscheduled stops. This can be done in further research work by surveying the regions of the unscheduled stops through GIS (Geographic Information Systems), and add new scheduled bus stops at these points of interest instead of the unscheduled ones. This will not only decrease the trip time, but will also increase the reliability on public buses and its corresponding reliable schedule. Finally it is recommended to conduct this research during peak hours to reveal the impact of unscheduled stops in this case.

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