EFFECTS OF ON-BOARD TICKET SALES ON PUBLIC TRANSPORT RELIABILITY

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ABSTRACT

Public transport punctuality and reliability are key factors in traveler mode choice decisions, but they also impact operating costs. When travel time on a route varies significantly, public transport operators need to increase scheduled buffer time to maintain punctuality and reliability. This increases costs by increasing staffing and equipment needed to offer a given level of service. The variability in route travel time depends on many factors including traffic conditions, number of passengers and operating practices (e.g. boarding processes). This research evaluated the impact of one boarding sub-process, ticket sales, on bus dwell time at stops. The research confirmed that onboard ticket sales can significantly impact a public transport line's travel time and reliability. The research showed that onboard ticket sales sub-processes are relatively long and vary significantly; consequently they strongly influence schedule reliability. Results showed that the time spent selling tickets can be up to 20% of the total run time. However, the biggest problem is the large variance in time spent on the ticket sales process.

1. INTRODUCTION

Public transport punctuality and reliability are key factors in traveler mode choice decisions. Furthermore, their importance is growing as more public transport systems adopt integrated schedules. In an integrated schedule the timetables of two or more public transport routes are closely coordinated so that passengers can transfer between the routes with a minimum wait time and thereby have access to more destinations. In this type of timed transfer system, small delays in arriving at the timed transfer point can result in the passenger missing the connection and relatively long waits for the next connection.

Schedule reliability also has a large impact on public transport operational efficiency. A perfect system would operate with zero schedule variance – enabling planners to develop an extremely efficient schedule. In the real world travel time varies and therefore planners include buffer time between the scheduled arrival time at the destination and next departure. When travel time on a route varies significantly, schedule planners must increase buffer time to maintain punctuality and reliability – thereby increasing the personal and equipment costs required to provide a given level of service.

Travel time on a route can be divided into driving time and dwell time; driving time is the time when the public transport vehicle is moving and dwell time is the time when the vehicle is stopping to pick-up or discharge passengers. Both parts are susceptible to schedule variance. This research focuses on one part of dwell time: the ticket sales process. In many European public transport systems (especially in rural areas) the driver sells tickets; this research was designed to evaluate the impact of ticket sales on reliability.

The research also has relevance for public transport systems that do not sell tickets onboard as it breaks-down the ticket sales process into sub-processes. Some of these sub-processes (e.g. information provision from the driver) take place on all public transport systems. Furthermore, the methodology used in this research could also be applied to the other parts of the boarding process to better understand their impact on schedule reliability.

Earlier research has shown that the passenger boarding and alighting process is a frequent cause of delays and therefore has significant impact on the overall journey time due to its duration and especially due to its large variation. While there is little research quantifying the influence of onboard ticket sales on bus line schedule stability, it is clear that this process increases dwell time and schedule variability. A key problem in evaluating dwell time processes has been the difficulty in obtaining accurate data. However, new sensor and data systems in public transport vehicles are now available to automatically and precisely measure data including the dwell times, the number of boarding and alighting passengers as well as the exact position (station) of the vehicles at each stop. The availability of this data makes it possible to complete detailed research on dwell time processes.

This paper presents results of a study evaluating the impact of ticket sales on travel time and schedule reliability completed by the Institute for Transport Planning and Systems. The study was done in cooperation with two Swiss bus companies: PostAuto Schweiz and Verkehrsbetriebe Glattal (VBG) operating several urban bus lines in and around Zurich. The bus lines offer frequent service, are well integrated in synchronized timetables and offer onboard ticket sale. In Zurich's public transportation network, only one ticket is needed for using all public transportation modes, including bus, trolley and light rail systems as well as cable cars and ships. The busses of VBG and PostAuto Schweiz operate on roadways without significant public transport priority and therefore are negatively impacted by significant automobile traffic.

The analysis consisted of two parts. In the first part automatically collected dwell time data was used with ticket sales information collected by the driver to quantify the length of a ticket selling process for different types and numbers of tickets sold. The second part of the study consisted of a controlled study (completed in the bus maintenance yard) in which the ticket sales sub-processes (e.g. payment, information process etc) were quantified to better understand the factors influencing the duration and variation of these sub-processes. Finally, the impact of different ticketing strategies (e.g. selling different ticket types, offering several paying possibilities) on the timetable stability of regional bus lines was evaluated and recommendations made for improving the ticket sales process.

Section 2 of this paper presents a review of previous research on dwell process and the influences of fare collection strategies. In Section 3 the dwell process is analyzed. Section 4 describes results of the field evaluation and summarizes the results used as input for planning the schedule. Differences and effects for dwell processes with and without selling tickets by drivers are explained in detail. Section 5 analyses the dwell process and its sub-processes in detail based on the controlled study. Finally, section 6 presents conclusions and recommendations.

2. LITERATURE REVIEW

Research on dwell times for public transport systems is available since the late 1970s. Among others, Kraft and Bergen *(1)* identified the main influence factors for the dwell process. In 1995, Weidmann *(2)* analyzed and measured the dwell process in detail for different kinds of public transport systems. In that research the impacts of passenger characteristics and number of involved passengers (in particular the total number of boarding and alighting passengers; the density and distribution of waiting passengers in and outside the vehicle), the vehicle design (especially the number and distributions of doors; levels of entry; technical parameters) and the station layout (number of entrances) were described.

Daamen et al. *(3)* evaluated dwell time by identifying four different factors influencing dwell time: passenger mobility, platform design, vehicle design, and crowding effects. This research showed especially the influence of the passenger distribution and crowding effects were. Buchmueller et al. *(4)* describes the flow rates at doors for rail systems and develops a relationship between the number of involved passengers and dwell time.

The fare collection strategy can significantly influence public transport operational efficiency and passenger convenience. Ticketing strategies can also be used to attract passengers. There are three key elements of ticketing strategy: ticket sales, ticket types and ticket control.

Originally conductors sold tickets onboard public transport vehicles. Since the 1950's conductors have been eliminated from most systems (although they have been re-instated in some systems such as Amsterdam's tram network to improve security and fare revenues). Three main types of ticket sales systems have been developed to replace conductors: sales of tickets by drivers, sales of tickets by machines and pre-travel sales (e.g. customer service centres, convenience stores, smart-card systems and mobile IT device/cellular telephone sales).

Most public transport operators offer a variety of ticket types ranging from single trip to monthly or yearly passes. From the operator's perspective the passes are optimal because they reduce the costs of fare collection and the costs of ticket control. From the passengers perspective the more fare types the better since this enables passengers to minimize costs based on their specific travel patterns.

In addition to selling tickets, the conductors were also responsible for ensuring that all passengers had a valid ticket. With the elimination of conductors new methods for controlling tickets were necessary. The two main approaches are control by drivers (i.e. entry through the front-door only) and self-service (also know as proof-of-payment or barrier-free) systems. In self-service fare collection controllers make random checks of vehicles and therefore only a percentage of riders are checked for proper payment, but all doors can be used for boarding. Self-service systems are very popular in urban areas for bus, trolley and light rail systems since they reduce dwell time (since all doors can be used for boarding).

The public transport ticket sales and control process varies depending on the system and specific route characteristics. In most European urban areas off-vehicle ticket sales (via machine or pre-travel sources) are generally combined with self-service ticket control. In rural areas with lower demand, it is too expensive to provide ticket vending machines at all stops, so drivers are responsible for selling tickets. It is interesting to note that, in contrast to the United States, very few European public transport operators that sell tickets on-board require exact change; drivers often sell several types of tickets and give change, even for relatively large denomination currencies. The TCRP Report 80 *(5)* gives an overview of fare collecting strategies. This report identifies two major disadvantages for paying on boarding: first, boarding time is increased and second, drivers can be distracted from their main responsibility, to operate the vehicle safely.

In contrast studies by Lehnhoff and Janssen (6) showed that onboard ticket sales only increases the dwell times for light rail systems but not for bus services,. Also Guenthner and Hamat (7) observed no significant relation between the fare structure and the type of payment on dwell delays. Levinson (8) compares different fare media and describes the advantages of Smart Cards, which become more and more popular. These advantages include high security for passengers as well as simple, fast and contact-less use. While it is clear that smart cards provide significant advantages for both public transport operators and customers, it will take time before these systems can be fully deployed and furthermore there will almost always be passengers without a smart card (e.g. occasional users or tourists) who will need to purchase individual tickets. Thus, an onboard ticket strategy or ticketing machines at stations will be needed in the future.

The literature research also shows, that prior work mainly focuses on the overall boarding and alighting process neglecting the influence of onboard ticket sales. The few studies that do consider on-board ticket sales show contradictory results. Therefore the goal of this paper was to analyze the impact of the on-board ticket sales process in detail with the objective of providing recommendations for improving the process. The research methodology can also be used to provide a structure for analyzing other sub-processes in the dwell time process.

3. PUBLIC TRANSPORT STATION DWELL PROCESS

The public transport vehicle station dwell process consists of two parts: a fixed part for door opening and preparation for the departure and a variable part for passenger boarding and alighting (which can be divided into several sub-processes including onboard ticket sales). Figure 1 illustrates the sequence and conditions for all station dwell sub-processes.

In addition to the time required to complete the dwell processes at the stop, dwell times can be increased due to scheduled waiting times or waiting for connections. These elements must be filtered out of the analysis when determining minimum dwell times (i.e. for this research), but are absolutely necessary in the process of designing the actual schedule.

In the first stage of the research observations were made of dwell time at various stops. A key observation was that at stops with a small number of passengers the dwell time was impacted by selling tickets onboard the vehicle, while at stops with a large number of passengers dwell time was not impacted by this process. One reason for this observation is the fact, that due to the self-service in Zurich's public transport vehicles, the passengers having a ticket can use all of the three doors for entering the bus while people with ticket demand have to use the front door. Hence, passengers with ticket demand do not delay passengers without ticket demand. Figure 2 shows a bus used by the VBG.

Since the purpose of the study was to quantify the impact of the ticket sale duration on the dwell time, the detailed research in Chapter 4 is focused on evaluating stops where only a small number of passengers were waiting (maximum 5) but at least one sold ticket was sold. This results in a situation where the ticket sale becomes the dominate factor for the dwell time duration.

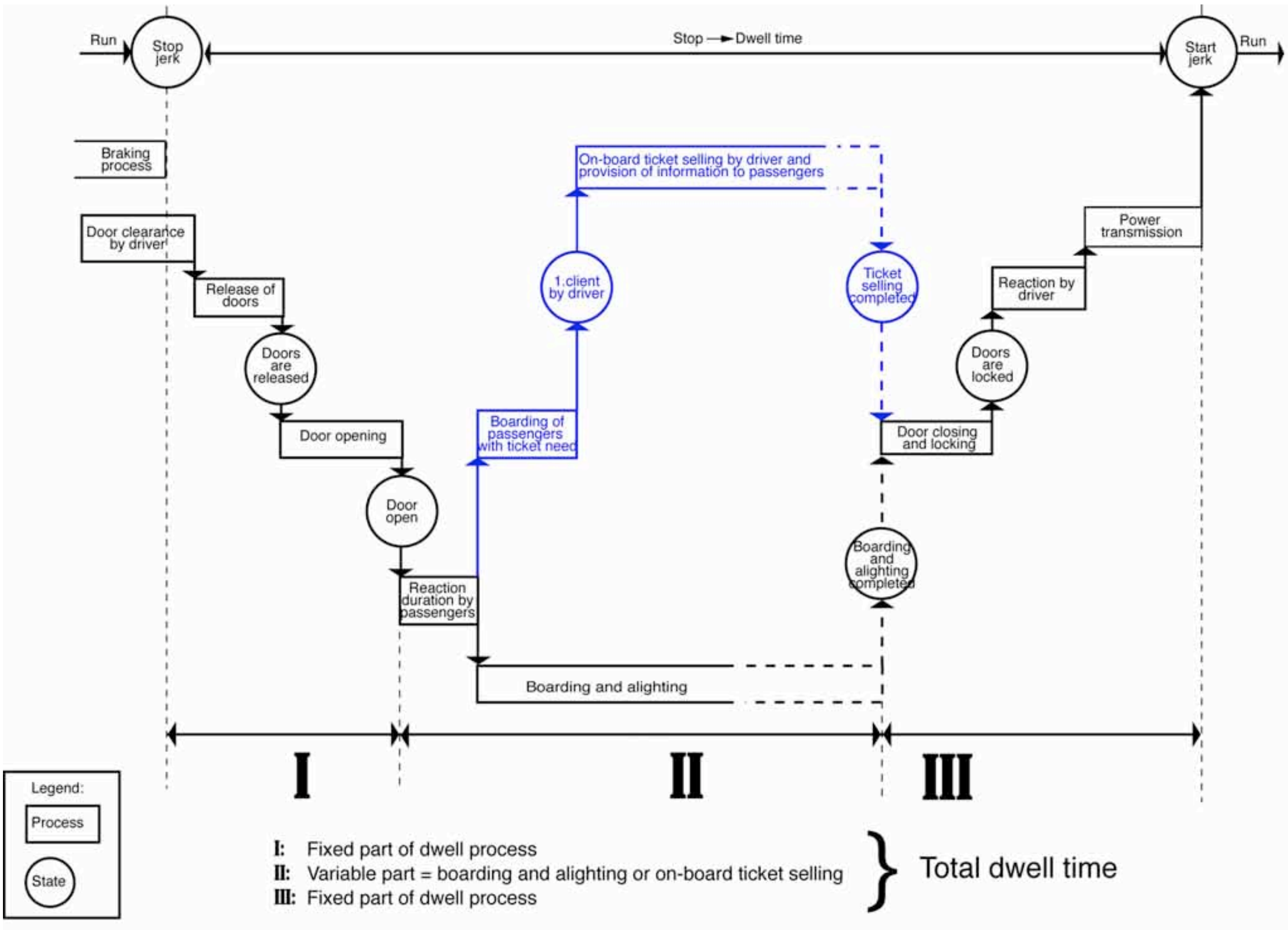

FIGURE 1: Components of the public transport station dwell process

4. DATA COLLECTION AND ANALYSIS OF DWELL TIME

4.1 Automatic passenger counting system and collected data

In order to efficiently determine the dwell duration, automated and accurate measure of the dwell process is needed. AFAZ, an automatic passenger counting system developed by DILAX AG (see *(9)* for more details), measures the number of boarding and alighting passengers and the dwell time duration at each stop. The system uses active infrared sensors (2 sensors located in a row to detect direction) installed at each door. Plausibility checks are used to assure a high quality of the measured data. The sensors are connected to an onboard computer where the data is collected, processed and stored.

The buses have a ticket sales machine that prints tickets and provides coin change located similar to fare boxes in US transit vehicles. Several types of tickets are sold onboard (e.g. single ride, daily) and for purposes of this research it would have been good if these machines could have recorded ticket sales by type at particular stops, but unfortunately, only aggregated data is available through the ticket machine. Thus, drivers had to note the type of ticket sold at each stop.

The machine collected data and ticket type was then combined to determine the influence of selling tickets on the dwell process. The data was collected on the Verkehrsbetriebe Glattal (VBG) line 759, which is located in a suburban area of Zurich. This line is operated with Mercedes-Benz Citaro 530 standard buses with a capacity of 70 passengers (seated and standing) with 3 doors and low-floor entry (Figure 2).

FIGURE 2: Bus service offered by VBG

4.2 Dwell time analysis without on-board ticket sale

The impact of ticket sales on dwell time was evaluated by comparing the dwell time at stops where no ticket was sold to stops where tickets were sold. The first step was to estimate the dwell time for public transport vehicles at stops where no tickets were sold. Figure 3 shows the relationship between dwell time and number of passengers boarding and alighting the vehicle in cases when no ticket was sold.

As shown in Figure 3, a logarithmic regression between the total number of boarding and alighting passengers with the dwell time fits very well. The figure also shows many outliers, especially for small number of passengers involved in the dwell process. The reasons for these outliers include vehicles running ahead of schedule waiting for their scheduled departure time, waiting for late passengers (runners), drivers providing information to passengers without selling a ticket, crowded buses or passengers with luggage or baby-carriages. In spite of these outliers, Figure 3 shows that most measurements are within a small bandwidth of several seconds.

These results show that using the average of a logarithmic regression (or a fixed defined upper boundary, e.g. 80 percent) could be a good way of scheduling stop dwell times when developing a new schedule. Combining this relationship with a detailed analysis of demand (i.e. measured number of passengers at each station), dwell times can be planned very precisely.

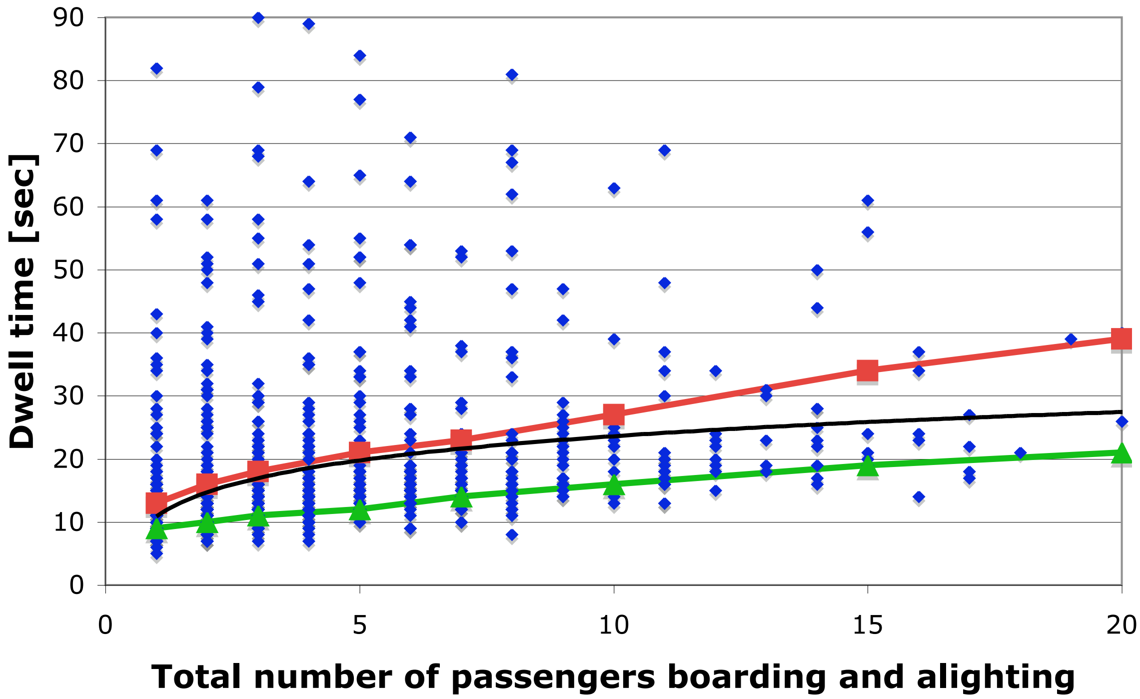

FIGURE 3: Relationship between total number of boarding and alighting passengers with dwell time (no tickets sold by driver). (Red line: 80 percentile, black: logarithmic regression, green: 20 percentile)

4.3 Influences of onboard ticket selling on dwell time

In a second step, the impact of onboard ticket selling on the dwell time was analysed. In the analysis, ticket sales data were aggregated into single trip or daily tickets (drivers sell 13 different types of tickets although the majority are single trip or daily tickets). The analysis was only carried out at stops with 5 or fewer passengers boarding and alighting (this made it possible to guarantee that the ticket selling process was critical to determining the dwell time duration rather then the boarding and alighting process). Also, the analysis omitted data collected at both terminal stops and other stations where the dwell process is delayed by other factors than the ticket sale. This includes stations, where the dwell time was enlarged due to connecting services or too early arrival times.

Figure 4 illustrates the analysis results. It shows that the dwell time takes a little less than 30 seconds on average when one ticket is sold on board (either a single trip or daily ticket) and is 17 seconds longer than when no tickets are sold. It also shows that the dwell time variation in cases when a ticket is sold onboard is 3-5 times larger than when no tickets are sold. Interestingly the average time needed to sell a a monthly or daily ticket onboard is approximately equal, but the variation is larger for single trip tickets. Finally, the ticket selling duration and variation was much larger for tickets other than single ride and daily tickets.

Figure 4 also shows that when two tickets of the same type are sold, the dwell time is only on average 10 seconds longer than for one ticket. The field observations showed two reasons for this reduced relative duration. First, when passengers are waiting, information exchange between the driver and passenger is reduced. Second, there are some synergy effects when passengers purchase identical tickets one after the other (i.e. the second ticket could be printed more quickly).

On the route level, the analysis showed that drivers sold tickets on average at approximately every fourth station. On the VBG route 759, which has an overall travel time of about 30 minutes, the travel time was increased by 2 minutes on average because of selling tickets. In the worst cases, where many tickets were sold and/or with complex transactions (e.g. particularly long sales processes) the on-board ticket sales represented up to 20% of the total trip time. In these cases the large amount of time spent selling tickets on-board can destabilize a line and connections to other busses or trains will be missed. Therefore, on-board ticket sales should only be allowed when schedules are robust enough to accommodate the increased travel time without significantly impacting schedule reliability (e.g. if the same ticket is ordered and no additional information is needed).

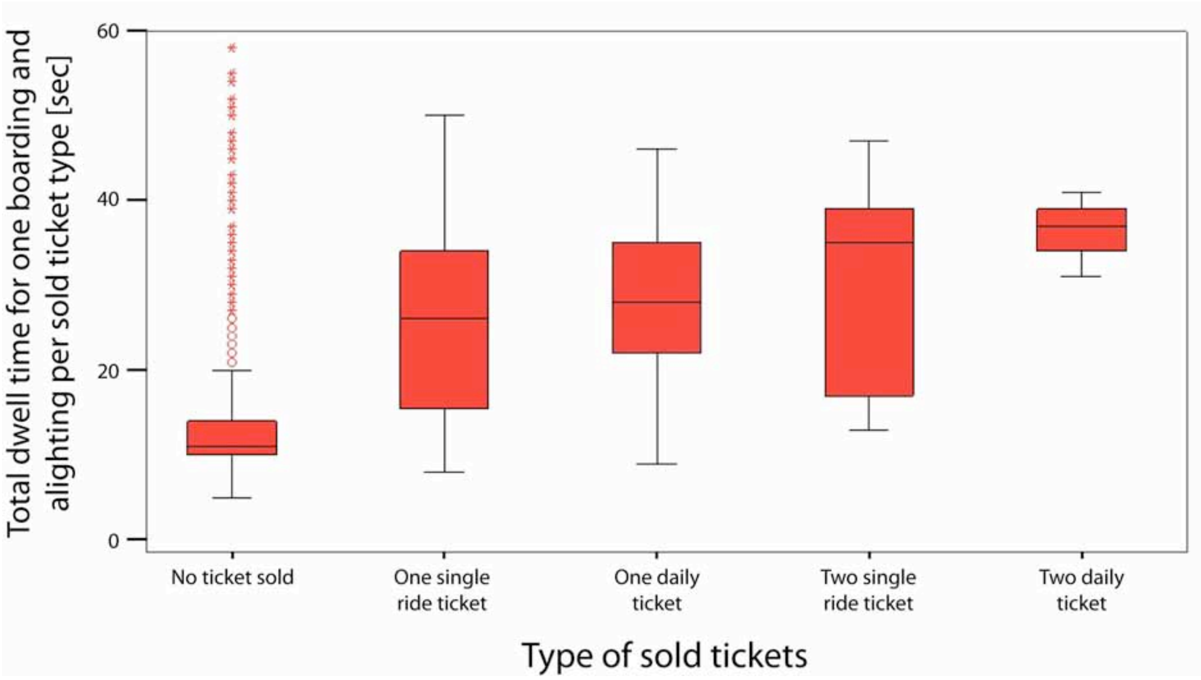

FIGURE 4: Box plot of dwell time duration for different ticket types sold on-board

The research results show clearly that onboard ticket sales by the bus driver increases the dwell time at a station. The ticket selling in the vehicle needs additional 15-20 seconds per customer depending on the type of sold ticket and other influencing factors. What makes this result even more problematic for developing schedules is the large variation in additional time caused by onboard ticket sales. The second part of the research study evaluated the ticket sales process in more detail to more fully understand the reasons for the dwell time variation and to develop ideas for reducing the time needed to sell tickets. Results of this analysis are outlined in the following section.

5. DETAILED ANALYSIS OF ONBOARD TICKET SALES

As outlined above, dwell time is made up of several processes one of which is onboard ticket sales. The onboard ticket sales process can be further divided into a set of sub-processes. This section summarizes the onboard ticket sales sub-processes and presents results of a controlled experiment completed to analyze these sub-processes.

5.1 Onboard Ticket Sales Sub-process Evaluation Methodology

Given the relatively low frequency of actual onboard ticket sales on the observed bus lines, it was necessary to perform measurements of onboard ticket sales sub-processes in a controlled situation (to obtain enough data). The controlled measurements were completed in a VBG garage using a real bus, real bus drivers, a real onboard ticket vending machine and four test customers (all male, 20-30 years).

Figure 5 illustrates the sub-processes involved in onboard ticket sales. As shown in the figure, onboard ticket sales consists of: boarding, consultation to determine what ticket to purchase, data entry by the driver into the ticketing machine, payment and the process of leaving the passenger entry area.

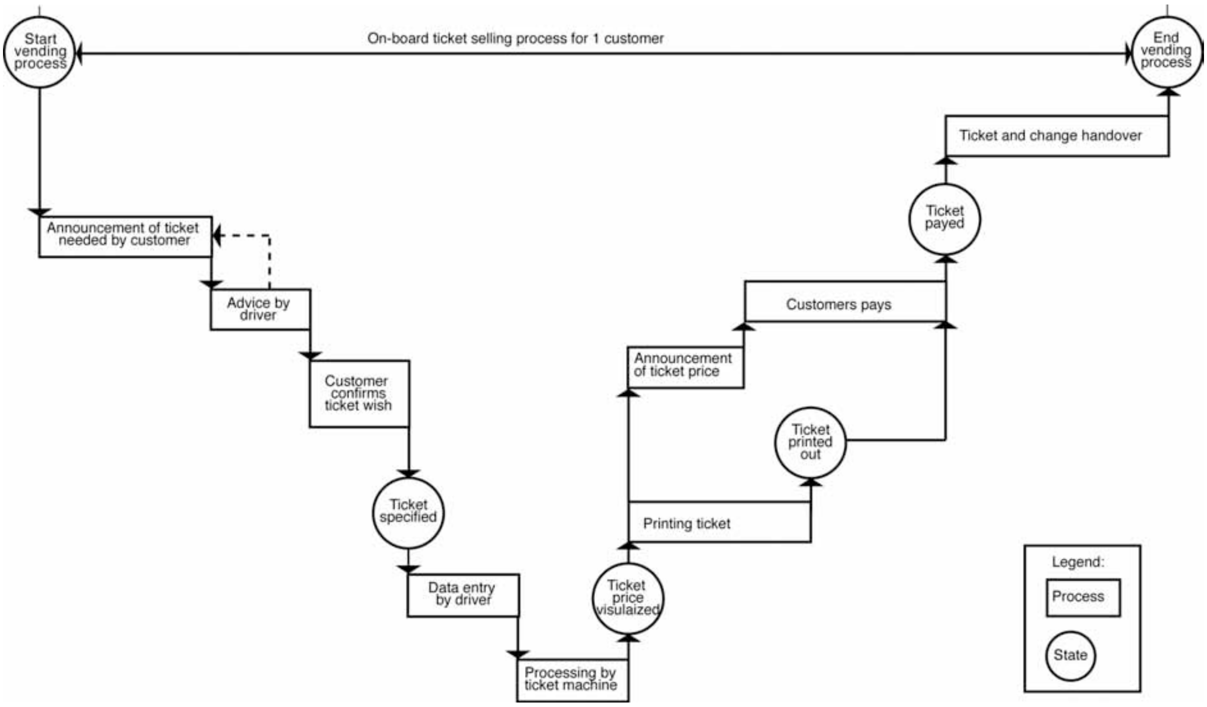

FIGURE 5: Components of the ticket-selling process

These onboard ticket sales sub-processes are described in more detail in Table 1. In the controlled experiments measurements were made of the duration of each sub-process to better understand their influence on ticket sales duration and variance.

Table 1 also shows factors influencing the time required to complete each ticket sales sub-process. In the experiment, researchers created several scenarios for the test customers. Each scenario consisted of buying a common type of ticket and incorporated one or more of the influence factors (e.g. carrying luggage). Since it was not possible to test the impact of all influence factors, the factors of most interest to the research sponsors were selected. These factors are highlighted in bold in Table 1.

Sub process	Description	Influencing Factors (Factors in bold were considered in the experiment)
Boarding	Boarding the vehicle: Putting away the luggage; Going to the driver	**Customer: Different luggage;** Customers with limited mobility (e.g. disabled or pregnant people); Alighting passengers at front door; Passenger density in the vehicle; Weather; Door defects.
Consultation	Starting the consultation process; Consultation (questions and answers); Determining the appropriate ticket	**Character of bus driver and customer;** Knowledge of the line plan and tariff system; Speaking foreign languages (bus driver and customer); Fast consultation caused by other passengers waiting to buy tickets.
Data Entry	Printing the ticket; Finish the Consultation	**Ticket type; Knowledge and skills of the bus driver when entering the data;** Ticket sales machine failures (e.g. broken printer).
Payment	Saying the ticket price; Payment; Taking ticket and change from the bus driver	**Different payment scenarios; ticket price; skills of customer and bus driver;** Foreign customers not knowing the national currency; Fast payment caused by other passengers waiting to buy tickets.
Leaving the passenger entry area	Leaving the passenger entry area; Next customer starts consultation or bus departure	**Different customers; different luggage**; Customers with limited mobility; Departure time; Fast leaving of the entry area due to other customers.

TABLE 1: Onboard ticket sales sub processes

The onboard ticket selling process analysis revealed that the average transaction has a duration of approximately one minute per ticket but that it varies significantly.

This value is much higher than the field experiment measurements shown in Figure 3. The reason for this difference is likely due to the actual passengers having experience with buying tickets (e.g. they had exact change, they did not need to consult regarding the type of ticket needed, etc.) and the bus drivers' experience perhaps enabling him or her to multi-task (e.g. begin the door closing process before completing the ticket sale).

Table 2 summarizes the time required for completing each of the onboard ticket sales sub-processes.

Ticket sales sub process	Mean Value [seconds]	Standard Deviation [seconds]
Boarding	5	3
Consultation	13	14
Data Entry	12	14
Payment	23	13
Leaving the passenger entry area	4	4
Total	55	29

TABLE 2: Duration and variance of the ticket sales sub-processes

The following sections summarize the experiment results for each ticket sales sub-process. It is important to emphasize that while there are many specific aspects of the way tickets are sold on Swiss public transport systems that are not found on all public transport operators (e.g. making change, selling a large variety of tickets), many of the ticket sales sub-processes are the same. Passengers still need to board the vehicle, they consult with the driver regarding the fare, then put their money into the fare box and they leave the passenger entry area. Therefore, the research methodology is applicable in for other public transport operators and the Swiss results provide a good benchmark for comparable sub-process completion times.

5.2 Boarding Process

The boarding process lasts an average of 5.3 seconds with a standard deviation of 3 seconds. The boarding process for passenger carrying heavy luggage is longer since luggage influences which door the customer uses to board (i.e. they board on a middle door) and consequently increases boarding time as the customer stores the luggage and moves through the bus to the front door to purchase the ticket. In this case, the boarding process takes an average of 11 seconds (mean) and has a standard deviation of 4 seconds.

5.3 Consultation

The consultation takes an average of 12.5 seconds (mean). There is a significant amount of variation in the time required for the consultation sub-process with very high values in case of foreign customers or other passengers with a high demand for information. In Zurich lots of different ticket types are sold based on a zone tariff system. This leads to large information demand by foreign people.

It proved to be very difficult to separate the consultation sub-process from the data entry sub-process since drivers began entering information into the ticket sales machine before the consultation was finished. Therefore these sub processes should be regarded as one process.

The research did find differences in the time needed for consultation depending on the ticket type and the travelled distance. A single ticket only needs 5 seconds for consultation. In contrast, a customer asking for a daily ticket takes an average of 14 seconds (mean).

5.4 Data Entry

It has been mentioned that the two sub-processes consultation and data entry overlap, especially in case of passengers with a high demand for information. Therefore defining a clear border between these two sub processes is a difficult. Since data entry begins before consultation is completed, the actual amount of time spent on data entry is larger than measured using a process of ending one sub-process before starting the next.

The data entry takes an average of 12 seconds (mean) but this average varies enormously with a standard deviation being 14 seconds. Simpler tickets (e.g. local or single-ride tickets) need much less time for the data entry than longer distance multiple zone tickets (7 seconds compared to 17 seconds).

5.5 Payment

Six different scenarios of customer payment alternatives were developed and tested in the evaluation. Table 3 summarizes the results of these experiments.

Payment Type	**Exact Change**	**No high notes**	**High notes**	**Exact Change**	**No high notes**	**High notes**
Cash available?	Customer has money ready			Customer searches for money		
Case	1	2	3	4	5	6
Mean Value [seconds]	14.6	17.4	29.9	22.5	18.4	30.0
Standard Deviation [s]	5.3	9.2	16.5	10.1	10.6	14.6

TABLE 3: Variations of the payment durations with different payment scenarios

The research results are as expected, customers that have exact change ready take the least amount of time and have relatively low variation, while those paying with high denomination notes take the longest amount of time and have a relatively high variation in time needed.

5.6 Time for Leaving the passenger's entry area

The mean amount of time needed for leaving the passenger entry area is 4 seconds. If there are other customers needing to purchase ticket at the same bus stop, then time between the two customers is 5 seconds which is not much longer. Having luggage or bags increases the amount of time needed to leave the passenger entry area by an average of 2 seconds since the bag needs to be picked up after the ticket sales process has been completed.

6. CONCLUSIONS AND RECOMMENDATIONS

This study confirmed the fact that onboard ticket sales reduces bus line reliability. While the research showed that up to 20% of the total trip time could be spent on ticket sales (for the routes studied), the most significant problem is the variability in time spent in the ticket sales process. This variability makes it very difficult for schedule planners to develop accurate and reliable schedules, which increases costs and reduces service efficiency.

These results support implementation of strategies designed to reduce onboard ticket sales. In general onboard ticket sales should only be used if the total number of tickets sold on the line is small. Even in these cases, onboard ticket sales should only be used if it is possible to include significant time buffers in the schedule and that these time buffers do not significantly impact service attractiveness and connectivity to other public transport routes. There are several techniques for minimizing the impact of onboard ticket sales including:

- Minimize the number of different ticket types offered for sale;
- Add a surcharge to the price of tickets bought onboard the vehicle;
- Set ticket prices to minimize the need for drivers to make change (e.g. by rounding);
- Require exact change (or at least refuse to accept high denomination notes);
- Provide better information at public transport stops on ticket cost and options for purchasing tickets in advance (this enables passengers to have correct fares ready and minimizes the amount of time spent discussing ticket options with the driver);

Moreover, applying some of these techniques may even increase the revenues, as described in Oram *(11)*. Finally, it is also important to recognize that providing better customer information (e.g. on public transport routes, directions to major locations) also helps to minimize the amount of time drivers spend providing this information, another factor that increases dwell time.

While the impact of onboard ticket sales can be reduced, the best situation is to eliminate onboard ticket sales whenever possible. Every customer buying a ticket in advance reduces the number of ticket buyers on the bus and consequently the time needed for selling tickets onboard. This helps improve the line reliability and reduces costs for the public transport operator. There are many techniques that can be used to encourage passengers to buy tickets before boarding public transport vehicles. These include:

- Ticket vending machines at stations (when machines are available eliminating onboard ticket sales should be considered);
- Ticket vending machines onboard vehicles (these have the disadvantage of allowing customers to buy a ticket only when they notice ticket inspectors, but the advantage of easily allowing operators to charge more for tickets purchased onboard – thereby encouraging the use of passes and tickets purchased in advance);
- Programs to encourage the purchase of monthly/yearly passes;
- Increase the number of distributors selling advance tickets;
- Make tickets available using new technologies (e.g. cell phone tickets).

Increasing the use of passes is an especially effective strategy because it can reduce administrative costs and provide revenue in advance to public transport agencies.

In summary, the research confirmed that onboard ticket sales impact a public transport line's travel time and reliability. The research results can be used to help other public transport operators benchmark their own on board ticketing activities (e.g. exact change fare boxes, on board ticket machines) against the Swiss example. The methodology used in this study could be used to evaluate other parts of the dwell time process with the objective of developing recommendations to minimize the overall dwell time thus making public transport more attractive to customers and more efficient to operate.

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