DEVELOPMENT OF A SIMULATION PROGRAM FOR THE EVALUATION OF JEEPNEY STOP CONFIGURATIONS WITH FOCUS ON SINGLE LANE ROADWAYS

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abstract: The author presents a general methodology for the examination of various jeepney stop configurations to initiate the development of a practical and effective stop policy. This paper focuses on the initial development of a computer program for the simulation of traffic flow given various stop configurations. The present form of this program is applicable only to single lane roadways and considers a test section composed of seven meter cells. It is envisioned to include more aspects of the jeepney stop environment in the future and be extended to include multilane roadways as well as stops at intersections.

1. INTRODUCTION

In the Philippines, the primary paratransit mode is the jeepney. Since its 'invention' after World War II, the jeepney has risen to become a major transport mode. This is evident in the figures shown in Table 1.1.

Table 1 Transport demand by mode share in Metro Manila. (source : DOTC)

Year	1974	1980	1985	1989
Daily Person Trips, in millions	8.33	10.97	13.08	16.30
Mode Share, %				
Private Vehicle	37.4	25.60	27.50	35.20
Bus	16.4	15.80	15.60	14.60
Jeepney	46.1	58.50	56.50	49.40
Commuter Train	0.10	0.10	-	-
Light Rail	-	-	0.40	0.80
Mode Share, millions				
Private Vehicle	3.12	2.81	3.60	5.74
Bus	1.37	1.73	2.04	2.38
Jeepney	3.84	6.42	7.39	8.05
Commuter Train	0.01	0.01	-	-
Light Rail	-	-	0.05	0.13

The jeepney has acquired a large part of the transport mode for Metro Manila alone, having a much bigger share than the bus. Note that this is probably due to the concentration of bus services along Epifanio De Los Santos Avenue (EDSA). The jeepney evolved and its number increased because of either the absence or the deficiency of bus services offered along many major routes such as Aurora Blvd., Shaw Blvd. and Ortigas Avenue. Meanwhile, similar conditions occur in the provinces, as bus services are limited to long range travel while jeepneys are popular at the short to medium range distances. Such cases effectively give the jeepney a larger mode share compared to other modes, particularly the bus, although the former is considered as a paratransit.

In general, the jeepney stop environment causes two types of problems. These are problems with respect to traffic congestion and traffic safety. It is easy to observe and deduce that jeepney stops cause congestion due to the behavior of vehicles within the direct vicinity and upstream portions of the stop section. Such a scenario is shown in Fig. 1 below.

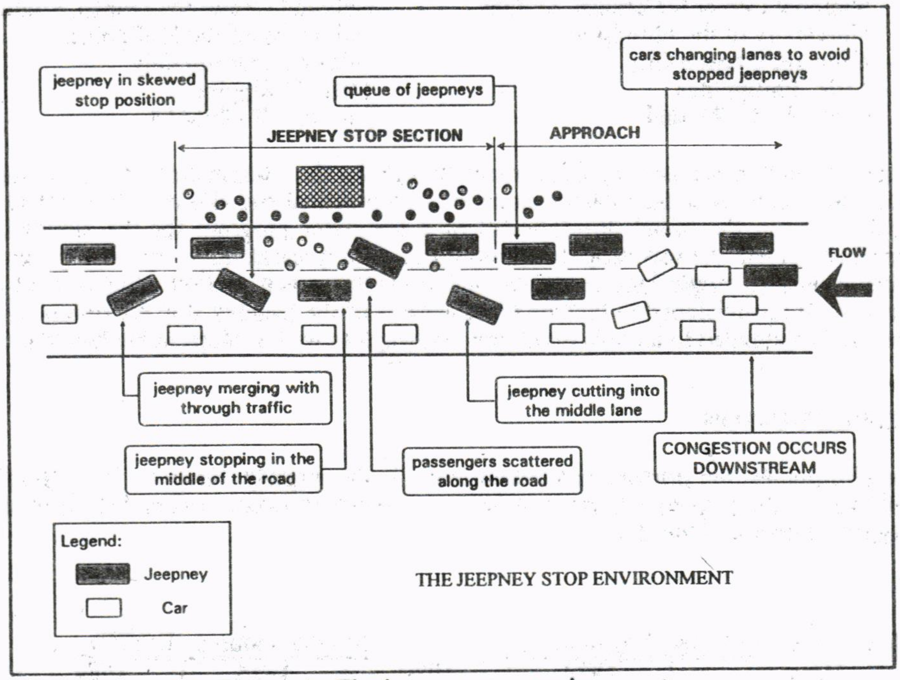

Figure 1 The jeepney stop environment.

Note that a series of stops will bring about significant delays to vehicles slowed down or stopped by loading and unloading jeepneys. Moreover, in reality, the situation in the Philippines is such that there are actually free stops (i.e., jeepneys load and unload at any section along their routes). Therefore, one can just imagine the effect of jeepneys loading and unloading at any time and place. This would be the same as whole road sections being utilized as jeepney stops. This situation is particularly critical near intersections where stopping jeepneys clog traffic and effectively decrease intersection throughput. Less throughput would mean longer queues which would lead to longer delays and the creation of bottlenecks. This situation may be observed throughout Metro Manila although it is already evolving in other cities around the country.

Another problem brought about by jeepney stops concerns traffic safety. Note that vehicle movement in Metro Manila's road network is associated with the use of risky maneuvers by public and private transport drivers. It is not a rare scene to see jeepney drivers employing different tactics (i.e., speeding, cutting, swerving, tailgating, etc. and often, the combination of such maneuvers) in outdoing each other for the best stop positions. Oftentimes, it is required that drivers of other vehicles be able to counter either defensively (i.e., by evading) or by holding their own against aggressive drivers. The frequent use of risky maneuvers account for most of the numerous road traffic accidents occurring in Metro Manila. Such accidents usually entail damages to vehicles with only a few instances where injuries and fatalities have been involved. It is ironic that despite the critical nature of aggressive driving in Philippine roads, most accidents are resolved without proper documentation. Such situations involving risky maneuvers occur within the limited domain of jeepney stop sections and its immediate range of influence. Moreover, given the free stop environment, it may well be assumed that stops directly contribute as hazards to traffic safety.

2. OBJECTIVES

The main objective of this paper is to initiate the development of a simulation program to be used as a tool for evaluating different jeepney stop configurations. The program is not solely intended for the study of congestion due to stopping jeepneys. Instead, it was conceived to assist the user in testing various stop configurations under different conditions (e.g., varying traffic volume, passenger arrival rates, etc.). Comparisons among simulation results from the completed program are to point out the appropriate stop configurations for various prevailing conditions taken into consideration. As such, the fully developed program is envisioned to become the foundation for the development of a concrete guideline or policy in the assignment or designation of public transport stops along Metro Manila's roadways since it will provide the necessary criteria for such an undertaking (i.e., designation of stops). Delay and the traffic volume allowed downstream will be utilized as the measures for evaluating various stop configurations.

The paper concentrates on building the basic components of the simulation program. The tasks for this endeavor includes writing the routines for vehicle and passenger generation, boarding and alighting operations and the creation of the test section. More importantly, the paper will attempt to encode the rules of stopping and moving under a series of conditional statements with focus on the freestop condition. The study will be limited to single lane simulation subject to the assumptions discussed in a succeeding section. However, the computer program will be structured in such a way as to allow for the extension to multilane simulation and the consideration of other pertinent conditions in the future. Traffic surveys will be undertaken at a selected site to derive input and calibration data. The preliminary testing of the program will be subject to conditions which may be appropriate only to the selected survey site and therefore may not be applicable to other cases. This study will also undertake simulation runs to establish trends describing the probable relationships between total delay and traffic volume; and total delay and stop intervals.

3. RESEARCH METHODOLOGY

3.1 Introduction

The research methodology employed in this study consists of two parts which were undertaken simultaneously. One is the development of a computer program for the simulation of traffic flow along a road section given various conditions. The other is the undertaking of various traffic surveys to establish input as well as calibration or validation data.

3.2 Evaluation Tools

The study considered three alternative tools for the evaluation of jeepney stop configurations. These are direct experimentation, mathematical modeling and computer simulation. The first involves the application of either a proposed or approved policy upon a real system. Modifications or adjustments are made depending on the reaction of the real system. The second tool involves the application of a valid mathematical model on an actual system of interest. Given the parameters and constraints (e.g., boundary values, constants, assumptions, etc.) of the desired set-up, the model is solved analytically to see how the model will *react*. The solution to the model will permit the prediction of what may happen to the system once the same set of variables are attained in reality. The third involves the creation of a model of the system of interest and the writing of a computer program which will approximate the system's behavior under variable conditions which may be applied by the user. Computer simulation offers the creation of a workable model where the controlling variables of a dynamic system, such as the jeepney stop environment, may be approximated through both stochastic and discrete methods.

Computer simulation was chosen among the three alternative tools due to its inherent advantages especially considering that the study focuses on a particular problem. Direct experimentation cannot be replicated and may prove to be costly if employed. Meanwhile, mathematical modeling was ruled out because of the dynamic features of the jeepney stop environment which necessitates the application of various stochastic and discrete distributions which may prove to be a theoretical burden if established models are to be applied. Moreover, the development of a new model would be impractical when considering the prerequisites of its acceptance as well as time constraint. Computer simulation allowed replication of experiments and the use of various stochastic and discrete assumptions in the evaluation of traffic flow given various input conditions.

3.3 Traffic Surveys

Four types of surveys were undertaken for the study. These are preliminary site surveys, volume counts, travel time, delay and stopping time surveys and headway surveys. A series of site surveys was undertaken to find a road section appropriate for the objectives of the study. The section of Tandang Sora Avenue between its intersections with Don Mariano Marcos Avenue and Quirino Highway was initially inspected. Also considered was a portion of Quirino Highway leading to Meycauayan, Bulacan. Another road section considered was the Paso de Blas road from MacArthur Highway to Quirino Highway. Finally, a section of Quirino Highway from Greenfields Subdivision to Maligaya Subdivision was surveyed. Among the four possible survey sites, the last one was chosen for the study based mainly on the observed traffic composition and its road characteristics (i.e., two lane - two way, good pavement, essentially straight section with minimal gains and losses of vehicles along its length).

Volume counts were undertaken in order to confirm the vehicle type distribution observed in site surveys conducted previously. Traffic volume and vehicle type distribution data are among the input parameters of the simulation program. Moreover, observed traffic volume will be utilized to calibrate program outputs. Five general vehicle classifications were made. These are cars, jeepneys, buses, trucks and others. Surveys undertaken January 17, 24 and 31 (1995) established two 500 meter survey sections instead of one 1 kilometer section due to observations of notable vehicle gains and losses at the midsection of the 1 km. section. Volume counts for these two 500 meter sections were recorded at 5 minute intervals (Jan. 24) and 3 minute intervals (Jan. 31). Also, it was established through the volume counts that traffic was composed mainly of jeepneys and cars and it was safe to assume that trucks and buses may be distributed among cars and jeepneys. The volume counts were undertaken at three stations along a 1 kilometer section corresponding to the two 500 meter sections.

Travel time, delay and stopping time surveys were undertaken to gather data pertaining to jeepney dwell times, travel and running time, and the initial number of jeepney passengers. Such data were used for the development of the computer program as well as for input to the queuing model used in the study. Jeepney dwell times were derived from the stopped time (i.e., Boarding time, alighting time, both) and the times allotted for acceleration and deceleration. Dwell times were incorporated in the computer program's algorithm for loading and unloading of passengers by jeepneys. Data for total travel and running times were used to compute vehicle running speeds as well as the travel speed along the test section. Collection of initial jeepney passenger data allowed for the derivation of a stochastic function for initializing jeepney loads at the start of program execution. Two methods were employed in undertaking travel time, delay and stopping time surveys. The task of data gathering was done by either on-board jeepney survey or jeepney chase. The only difference between the two methods is the location of the surveyor when he is taking data. On-board surveys involved surveyors taking a jeepney ride from a location just upstream the test section to the end of the section. Meanwhile, jeepney chase surveys involved surveyors riding a car and tailing a randomly chosen passenger jeepney plying a route including the test section.

Headway surveys involved the taking of video footage's of vehicular traffic upstream of the test section. This allowed for data extraction and repetition of such in the laboratory. A survey vehicle equipped with a hydraulic platform and video equipment (i.e., camera installed on platform, monitor, timer, generator for power supply) enabled the undertaking of this survey. The only requisite was finding an adequate area for parking the survey vehicle at an appropriate location upstream of the test section. This was important such that normal headway between vehicles may be observed. Normal pertained to almost uninterrupted flow with minimal speed variations (i.e., essentially no slowing down except during cases when queuing reaches the video location and when there are jeepneys stopping in the vicinity). The vehicle arrival distribution function employed in simulation is derived from headway data. Also, headway surveys yielded the minimum headway used as input to the simulation program. Note that headway and travel time, delay and stopping time surveys were undertaken simultaneously with the volume counts.

4. SIMULATION PROGRAM

The simulation program was initially developed on the personal computer using Turbo Pascal version 7.0, a general purpose language. However, because of limitations in computer memory due to the extensive use of static variables in programming, the SUN Workstation was employed to avail of more memory. Encoding was still undertaken on the PC and the Turbo Pascal program code was translated into C language which can be compiled into an executable file under the Workstation format. This was done because there were no Turbo Pascal compilers available in the SUN Workstation. The transfer from PC to Workstation in effect limited the aesthetic (i.e., user interface) features of the software. However, this was not important at this point of development since the study focused on the functional features of the computer simulation program.

The computer program involves discrete event simulation employing a periodic scan time handling technique. The program utilizes both stochastic and deterministic components in order to simulate traffic flow along a road section given various jeepney stop configurations and traffic conditions (e.g., traffic volume, traffic composition, etc.). The following assumptions were made for program development:

- The test section is composed of seven meter long cells instead of a continuous medium.
- Only two vehicle types were considered - jeepney and others.
- Only traffic along midblocks (i.e., section between two intersections) were considered.
- The study was limited to stop and go situations.
- The study assumed a common running speed for all vehicles.
- Jeepneys will stops if there are passengers alighting, waiting, or both at a particular cell.
- Maximum stopping time fixed within the program where jeepneys will not wait for passengers and there is a maximum loading time.
- Passenger arrival at the test section was assumed to be normally distributed.
- Maximum number of jeepney passengers = 18.

Most of the parameters used in simulation may be classified into two - input and output. The input parameters consisted mainly of pertinent information used to set-up (a) the simulation section, (b) the rules for vehicle movements and (c) the generation of vehicles and passengers during simulation. The number of 7 meter cells approximating a certain section length (e.g., 72 cells (504 meters) ≈ 500 meters) was considered to set-up the simulation section. Stop conditions were also defined (i.e., freestop or designated stops) in order to determine the cells where jeepneys are allowed to load and unload passengers, as well as to define where passengers would be generated. To generate vehicles, the program considered parameters such as the upstream traffic volume, the minimum headway between vehicles in the upstream flow, and the vehicle type distribution. In addition to this, the initial number of passengers for jeepneys entering the simulation section was assigned based on data from actual surveys. Meanwhile, to generate passengers, the mean and standard deviation of passenger headways were assumed. In addition to these input parameters, the program allowed the user to define the lengths of the simulation and warm-up periods.

The output parameters consisted mainly of those used in the evaluation of the stop configuration applied during simulation. These are the downstream traffic volume and the computed vehicle delay incurred due to the operations of jeepneys within the simulation section. Note that while most of the controlling parameters for simulation were variable, some parameters were fixed within the program. These included the maximum stopping time for jeepneys, the vehicle running speeds and the maximum number of passengers that can be accommodated by a jeepney. Thus, the program utilized both fixed and variable parameters during simulation.

Two major variable types were considered for the simulation program. These are the vehicle and cell variables which were stated as record types (i.e., array of records). Most of the valuable information pertaining to simulation initialization and results are recorded under the different attributes included in the records. Example of this is the recording of computed delay values under a particular vehicle's delay attribute. Another is the periodic updating of the number of passengers waiting at a designated stop cell under that cell's queue attribute.

The computer program consists of four main procedures which include within them thirteen local functions and procedures. Among these global routines are a random number generator; a text file creation procedure, a program initialization procedure, and the main traffic flow simulator. The random number generator is utilized by routines which involve stochastic or probabilistic functions. A good example of this is the program initialization procedure where random numbers are used to generate vehicles as well as to determine their vehicle type.

The initialization routine employs a shifted negative exponential headway distribution to generate vehicles for simulation. Generation of either a jeepney or another vehicle is decided by the percentage composition of jeepney. Thus, if the random number generated is 0.271 and the percentage jeepney is 30 % (i.e., 0.300), then a jeepney is produced. If the random number happens to be greater than 0.300 then an 'other' vehicle is generated.

The file creation procedure is tasked to create and open text files for writing of simulation results. The computer program creates three output files. The first file is for the recording of incremental volume counts which are similar to that derived from actual surveys. The second file is a table consisting of detailed descriptions of all vehicles able to enter and exit the specified test section within the designated simulation period. Included are a vehicle's type, number of passengers on board (if jeepney), arrival time, entry time, exit time, and delay incurred in the test section. The third file is a summary of the simulation results and includes output of the computed total delay incurred by all vehicles able to traverse the test section within the simulation period as well as the computed entry and exit traffic volumes and the number of passengers still remaining (i.e., waiting for a ride) inside the test section.

The main simulation procedure consists of conditional statements or rules which control the flow of traffic (e.g., vehicle entry, vehicle movement, etc.) along the test section. More importantly, it includes the statements for jeepney operations. The conditional statements for vehicle activity within the simulation section are illustrated in the flowchart of Figure 2. The simulation routine includes local procedures for passenger loading and unloading and a procedure for checking the entry of vehicles in the test section. Vehicle delay is computed according to the conditional statements for vehicle movement and jeepney operations.

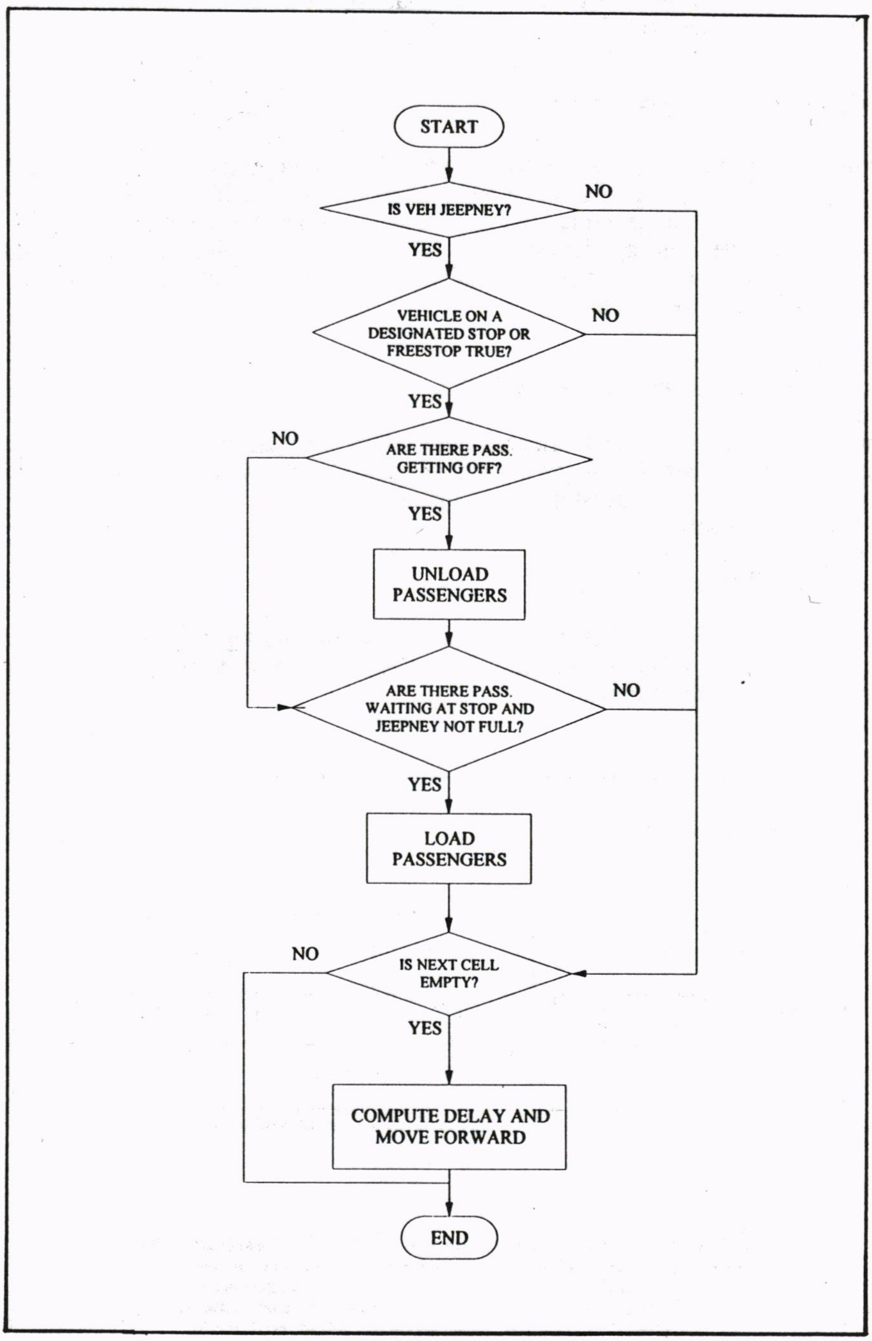

Figure 2 Flowchart of vehicle activity at time increment dt while the vehicle occupies a cell along the simulation section.

Incremental volume is computed periodically within the main simulation routine and is written on an open text file. At the end of simulation, the detail and summary of results are written on two separate text files.

5. SIMULATION AND RESULTS

Two rounds of simulation were initially undertaken. Trends in the relationship between total delay and the number of designated stops in the test section were established in the first round. The second provided validation as well as more detailed outputs of the relationships between the applied stop configuration and variables like delay and traffic volume. The input data for computer simulation included the following parameters which were cited in the previous section:

- Entry traffic volume
- Minimum time headway between vehicles
- Percentage jeepneys
- Test section length (i.e., the number of cells comprising the section)
- Passenger arrival data (i.e., mean passenger arrival headway and standard deviation)
- Stop configuration (i.e., freestops or designated stops)
- Duration of simulation
- Warm-up period
- Random number seed

Figure 3 shows a diagram of the assumed situation during simulation. It shows the simulation set-up for the cells composing the road section and notes the assumptions made for vehicle and passenger arrivals.

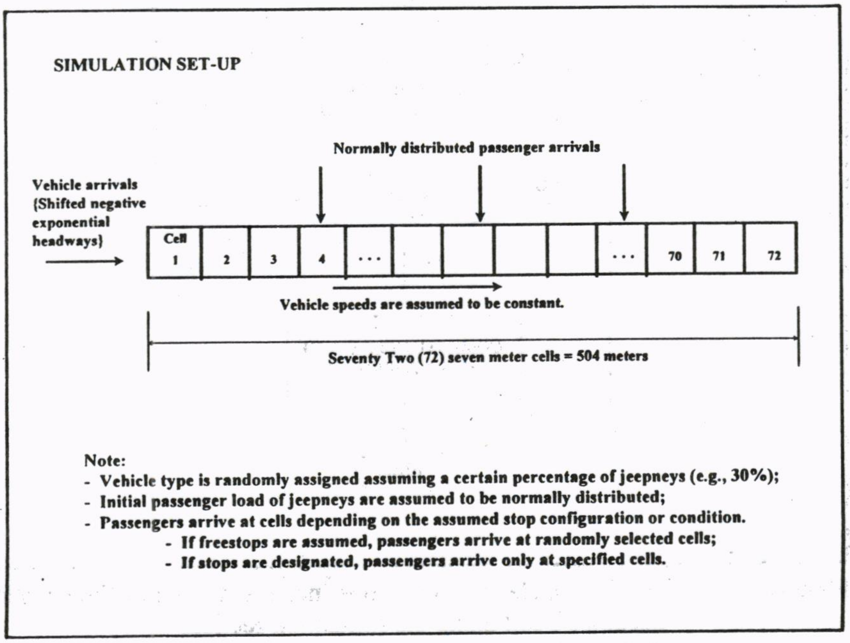

Fig. 3 Sketch of assumed situation during simulation.

A good number of simulations runs were undertaken for different combinations of traffic volume and stop configurations while holding other variables constant. The average walking distance for passengers in a given jeepney stop configuration was derived from the number of stops designated at equal intervals along the test section. The output of the simulation runs were graphed and established the following results:

- There is a significant increase in the total delay as the traffic volume was increased regardless of the stop set-up.
- There is a significant increase in delay as stops were spaced at closer intervals (stops at closer intervals were indicated by shorter walking distances where zero walking distance corresponded to the freestop case).

The above results can be clearly seen in Figure 4 where the total delay values for all vehicles were plotted against the average walking distance of passengers. A separate curve was produced for each of the traffic volume values considered in simulation.

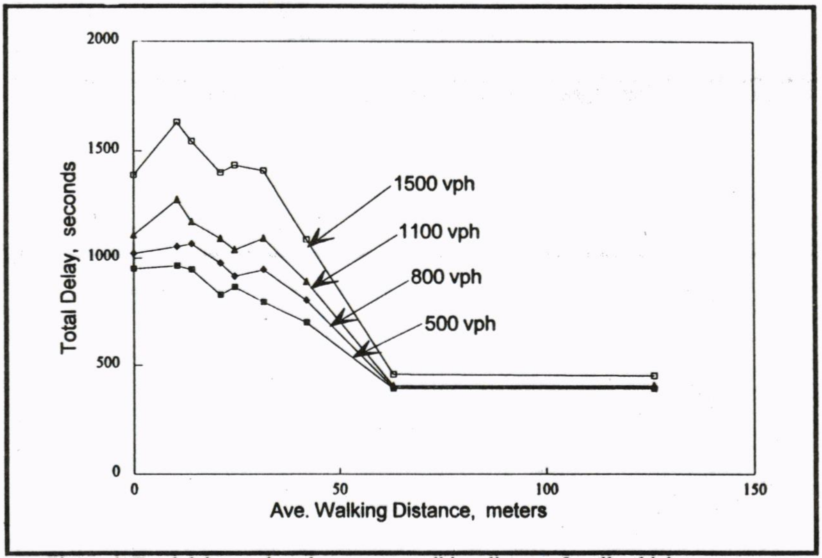

Figure 4 Total delay against the average walking distance for all vehicles.

The decrease in delay values as jeepney stop intervals became longer was expected. Note that this was due mainly to the fact that as stops were designated farther apart, jeepneys would make fewer stops. Fewer stops meant less delay. Under the freestop set-up, it was probable for a jeepney to stop at every cell along the test section and thus, incur delay for the vehicle as well as those queued behind it. This case was replicated for other jeepneys within the test section, resulting in large delays for both vehicle and passenger. Meanwhile, under a single stop throughout the test section, delays were effectively decreased as every jeepney entering the section is obliged to stop only once and then at a limited period. The first result of initial simulation should be taken with caution. Note that an increase in the total delay due to a subsequent increase in traffic volume may be attributed to the increased number of vehicles incurring delay as they traverse the test section. Therefore, such an increase in total delay may not necessarily reflect an increase in the average delay per vehicle. However, it can be shown that a large part of the delay increment was contributed by the non-jeepneys rather than by the jeepneys themselves. Such is shown in Fig. 5 and Fig. 6.

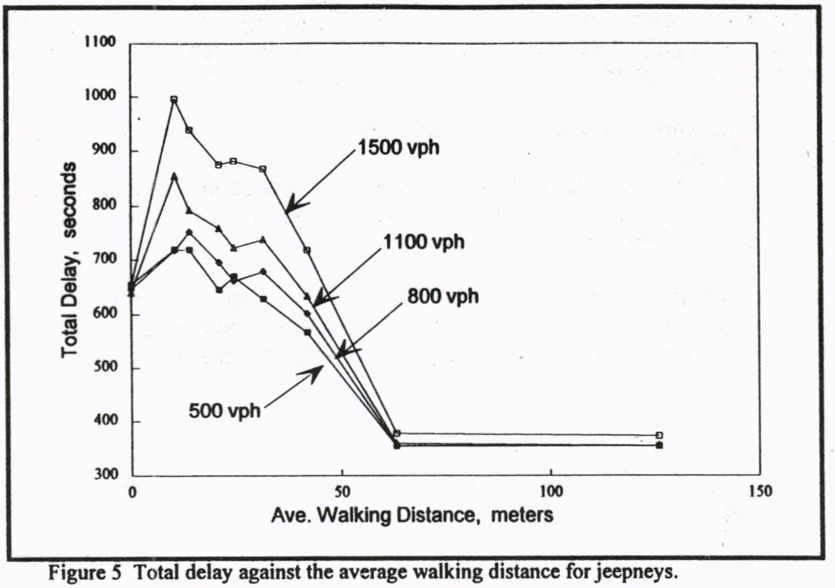

Figure 5 Total delay against the average walking distance for jeepneys.

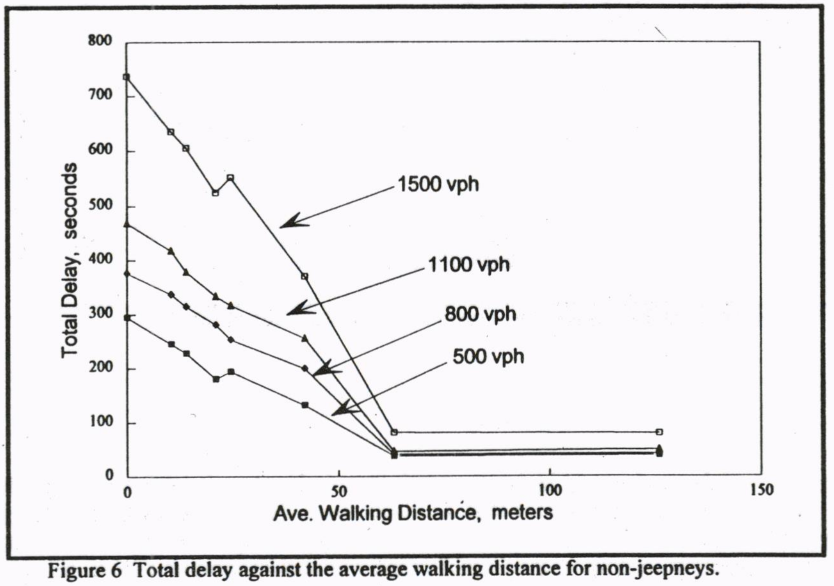

Figure 6 Total delay against the average walking distance for non-jeepneys.

It would be significant if it can be firmly established that jeepney stopping behavior has a significant effect on the delay incurred by other vehicles as was indicated by Fig. 6. However, jeepneys (as well as other vehicles) may incur more delay when the demand for public transit is increased. This meant that by decreasing the mean headway between passengers it was possible to have longer delays since jeepneys will stop at longer intervals. To show this, additional simulation runs were undertaken with the results shown in Fig. 7.

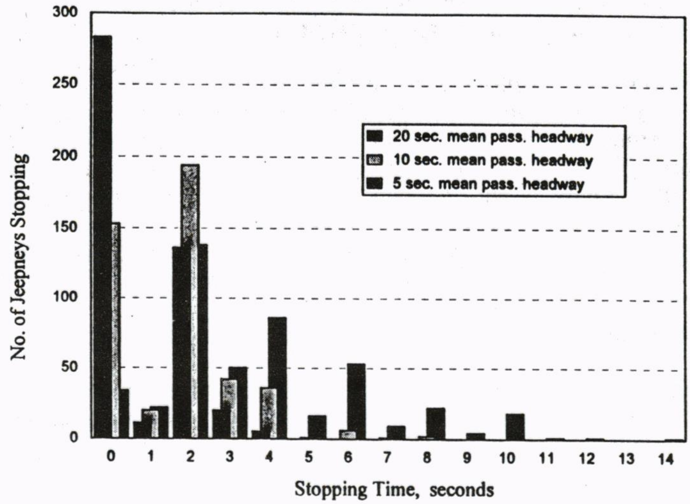

Figure 7 Effects of increasing passenger arrivals to jeepney stopping time.

It is clear from the above figure that it is possible to increase delay when the demand for public transport is increased. However, it is quite difficult to either establish or estimate the increase in traffic volume or percentage jeepneys which may correspond with demand increase. Such an estimate is important in order to come up with the appropriate stop set-up (i.e., the proper interval between stops). In addition to the above mentioned results it can also be shown that delay for all vehicles will tend to decrease when the percentage of traffic composed by jeepneys is increased when demand is held constant. This observation can be explained by the fact that there will be more frequent and longer stops for jeepneys when there are less of them than when there are more of them for the same number of passengers along the test section. This trend may be affected, however, if the number of passengers are increased. Thus, it may be said that the demand for public transport is an important variable which can be directly related with the delay incurred by vehicles.

6. CONCLUSIONS AND RECOMMENDATIONS

A computer program for the simulation of traffic flow along the midblock of a single lane roadway given various traffic conditions and jeepney stop configurations was developed. The present software, however, is limited by the assumptions made upon its development. Moreover, there is much space for improvement in program algorithm and a need for modifications in several conditional statements. Needless to say, it represents the initialization of the development of a more complete program which is envisioned to cover the simulation of traffic flow for multilane roadways.

The following results were established based on the simulation runs undertaken in this study,:

1. There is a significant increase in the total delay of vehicles as the traffic volume is increased.
2. There is a significant increase in the total delay of vehicles as jeepney stops are spaced at closer intervals.
3. There is an increase in the total delay of vehicles as the demand for jeepneys are increased.

The study considered the plotting of points derived from simulation runs to come up with curves describing the relationships previously cited as results. Such curves are shown in Section 5. These curves lack detail and it is necessary to come up with better plots which can then be used for planning and design or analytical purposes.

The authors recommend the following for further studies relating to the development of a complete program for simulating traffic flow for various jeepneys stop configurations:

1. Further improvement and/or modification of the existing program's algorithms to come up with a more efficient program which can be used on the personal computer; and the inclusion of other elements not included at present (e.g., jeepneys stopping to wait for passengers) without making the program too complex;
2. Further development of the program to consider traffic flow along multilane roadways;
3. Undertaking of more surveys in order to acquire more data for the calibration and validation of the computer program;
4. Consideration of the jeepneys stop's influence on passenger behavior.

The last one is essential in order to establish the effects of passenger behavior on traffic flow. Note that changes in ridership due to either the designation or undesignation of stops may affect the stopping behavior as well as the number of jeepneys plying a certain route. Therefore, it is necessary to explore the stop's influence on passenger behavior while at the same time estimating its influence on traffic flow.

As of present, there is an absence of concrete government policies or guidelines regarding the designation of public transit stops. The current practice is to apply rules of thumb passed on by elder engineers to the younger generation (Regidor, 1994). The basis for such rules are untraceable and therefore invites questions as to the credibility of such guidelines. Moreover, the uniformity of the current policy shows the neglect of important factors such as road and traffic flow characteristics; as well as the influence of passenger behavior on the designation of stops. The consideration of these factors are vital for the effectiveness of a policy concerning the designation of public transit stops in Metro Manila. The completed simulation program is envisioned to be able to take note of the important factors mentioned and thus, produce results which may serve as the foundation for an effective stop policy in the future. Among the possible contributions of the simulation program is the development of curves that may be used for the estimation of the intervals between designated stop sections. An example of such curves is shown in Figure 8.

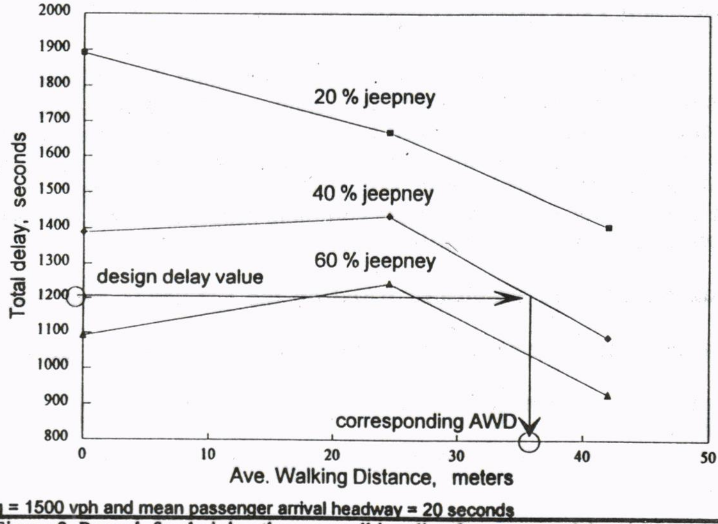

Figure 8 Proced. for deriving the ave. walking dist. from a spec. delay value.

It is possible to produce a compilation of such graphs and develop others to provide a reference for planners and policymakers. Such will indeed provide the scientific basis for planning and the formulation of effective policies. From Fig. 8, it is evident that if given information such as traffic flow and passenger characteristics, it is possible to estimate the intervals between stops using a design delay value. The appropriate curves will guide the user in the approximation of the suitable intervals under the prevailing traffic conditions. Conversely, it is possible to use the curves such as those in Fig. 8 for analytical or evaluation purposes. If the direction of the arrows in Fig. 8 are reversed, then it is possible to estimate the delay for given stop intervals. These derived delay values may be compared with values taken from the field for evaluation. Note that as cited in section 5, the average walking distance is directly related with the interval between designated stops (e.g., longer walking distances mean longer stop intervals and zero average walking distance implies freestop conditions).

At this point, it is important to mention that while the paper focused around the jeepney, the material presented may also be applicable to buses. Except perhaps for the differences in size and capacity, jeepneys and buses in the Philippines 'behave' similarly. Therefore, it is possible to adapt the findings from this paper as well as future extensions and discoveries to the bus. The ideal scenario would be to have a computer program which would simulate the interactions among vehicles at any particular roadway considering the behavior of jeepneys and buses.

Finally, many will argue that studies pertaining to the jeepney are not necessary since the ultimate role of this vehicle is to complement the bus by plying minor/feeder routes. Yet, it is a fact which cannot be refuted that the jeepney has already taken a role more important than that of the bus in many parts of the country and not just in Metro Manila. There is promise that the government can provide a more efficient and attractive mode of transport. This may be seen from policies encouraging the increase and spreading out of buses (note: most buses in Metro Manila ply routes along Circumferential Road 4 or EDSA) and plans for a comprehensive light rail network in Metropolitan Manila. Until such promise is realized, the jeepney will continue to provide transportation for a great number of people and remain the king of the road. The majority of government plans and policies are limited to Metro Manila and her adjacent areas. Situations in other Philippine cities are envisioned to follow the present state of traffic conditions in the Philippine capital. Therefore, studies with respect to jeepney stopping behavior are seen as significant and worthwhile endeavors which will yield policies ensuring the smooth flow of traffic along Philippine roadways.

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