SCHOOL BUS ACCELERATION CHARACTERISTICS

MBTC FR 1054-2

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Research was conducted to collect speed, time, and distance data for Type C and D ("full size") school buses accelerating from a stopped position. Most of the tests were conducted on level terrain. By combining the knowledge of how quickly a school bus can accelerate with assumed speeds of oncoming through-street vehicles, the needed intersection sight distance can be calculated. Another application of the findings is analyzing departure sight distance at railroad grade crossings used by school buses.

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by J. L. Gattis, Ph.D., P.E., Scott H. Nelson, and J. D. Tubbs, Ph.D.

CHAPTER 1

INTRODUCTION

In order to properly design streets and highways, roadway design engineers need to know the dimensions and operating characteristics of vehicles likely to operate on the road. One characteristic that designers need to know is the acceleration performance of vehicles. By knowing the time required for a vehicle to accelerate, one can calculate the amount of sight distance needed at an intersection.

The American Association of State Highway and Transportation Officials (AASHTO) publishes the *Green Book* as a guide for roadway design engineers. The 1994 *Green Book (AASHTO, 1994)* included fifteen "design vehicles". Design vehicles are composite vehicles that represent the longest, widest, slowest, etc. dimensions for each class or type of vehicle. The current *Green Book* does not contain school bus dimensions, turning radii, or acceleration characteristics.

By knowing how quickly a school bus can accelerate from a stopped position, intersections and railroad grade crossings can be designed more safely. The objectives of this research project included investigating performance characteristics of "full-size" Type C and Type D school buses as they entered through roadways from side streets, or accelerated after stopping at a railroad grade crossing. Several school buses were tested to collect data which enabled researchers to construct school bus speed/time/distance curves.

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CHAPTER 2
BACKGROUND

A literature review was conducted to find information related to school bus acceleration characteristics, intersection sight distance requirements, and what kind of equipment and procedures had been used previously to determine this information for other types of vehicles. A survey was sent to state departments of transportation to determine if they had any related information.

ACCELERATION CHARACTERISTICS

A literature review conducted to identify acceleration testing methods found both level terrain and at-grade testing procedures for passenger cars and trucks. No information was found specifically related to school buses.

Level Terrain Testing

To investigate interrelationships between vehicles' acceleration characteristics and highway design policies, one study employed principles of physics to generate or predict vehicle performance *(Fancher)*. The acceleration performance of pneumatic-tired vehicles depended on the difference between the power available from the engine and the power required to overcome resistance to motion.

There was a general trend toward lower weight-to-horsepower ratios from 1949 to 1977. This in turn lead to increased acceleration capabilities. The 1977 "Truck Inventory and Use Survey" *(U.S. Census, 1977)* determined that a 300 lb/hp design vehicle was "substantially below average" rather than "typical". Arguments were made, though, that a 300 lb/hp vehicle represented a reasonable highway and climbing lane design vehicle since this value was within one standard deviation of the mean weight-to-horsepower ratio of 248 lb/hp.

At-grade Testing

Tests have been conducted to find the deceleration rates of vehicles such as trucks traveling up grades *(Gillespie)*. Experimental measurements were taken at twenty sites across the United States. These measurements were compared to the then-current design guidelines in the 1984 AASHTO *Green Book (AASHTO, 1984)*. Methods were developed to model the hill climbing performance at the 12.5 and 50th percentile population level using empirically determined weight-to-horsepower (wt/hp) ratios. A truck's wt/hp ratio was considered to be the most important characteristic affecting hill climbing performance. In this experiment, each truck was tracked throughout its climb up the grade. No attempt was made to observe the trucks' speeds as they entered the grade because it was desired that the trucks be under a full throttle during all measurements. Thus, the first measurements were obtained at a distance of 152 to 305 m

(500 to 1000 ft) up the grade. The final climbing speeds for the 12.5 and 50th percentile trucks are summarized in Tables 1 and 2. Note the AASHTO final climbing speeds were in the range of the 12.5 percentile speeds and generally lower than the 50th percentile speeds.

TABLE 1 Final Climbing Speeds (km/h) of 12.5 Percentile Vehicles

Grade (%)	Straight Trucks	Trucks with Trailers	Tractor-Trailers	65-ft Doubles	AASHTO
1.5	76.4	68.1	76.4	64.2	----
2.0	64.9	54.2	64.9	54.4	----
3.0	49.7	38.6	49.7	41.7	42.6
4.0	40.2	29.9	40.2	33.8	35.4
5.0	33.8	24.5	33.8	28.5	29.6
6.0	29.1	20.6	29.1	24.5	24.9
7.0	25.6	17.9	25.6	21.6	22.2
8.0	22.9	15.8	22.9	19.3	19.6
9.0	12.8	14.2	20.6	17.4	17.1

TABLE 2 Final Climbing Speeds (km/h) of 50th Percentile Vehicles

Grade (%)	Straight Trucks	Trucks with Trailers	Tractor-Trailers	65-ft Doubles	AASHTO
1.5	81.9	77.2	81.9	71.0	----
2.0	73.5	67.3	73.8	62.4	----
3.0	60.8	53.6	60.8	50.4	42.6
4.0	52.0	44.4	52.0	42.2	35.4
5.0	45.4	38.0	45.4	36.2	29.6
6.0	40.2	33.2	40.2	31.7	24.9
7.0	36.2	29.5	36.2	28.3	22.2
8.0	32.8	26.4	32.8	25.4	19.6
9.0	30.1	24.0	30.1	23.2	17.1

A 1979 study in California *(Ching and Rooney)* recorded speed information using calibrated radar guns; radar was not being used for law enforcement purposes along rural freeways and expressways in California at that time. Most of the speed readings were made from unmarked vehicles. The vehicles were usually parked eight to twelve feet from the edge of the outer lane. The radar equipment was set up in the van so that it would not be easily visible to passing drivers. Some of the radar information, though, was obtained without a vehicle present. The speed information was obtained during weekday free-flow traffic conditions, when the weather was pleasant and wind velocities were seven knots or less. Speeds were measured without regard to whether the trucks were empty, partially loaded, or loaded. Speeds were not recorded for trucks which were following other trucks in a lane at intervals of less than seven seconds. This report presented some information for intercity buses. Sustained speed information for 50 intercity buses along a +3.00% grade follows.

Speed Limit = 55 mph

Mean Speed = 53.70 mph

15th percentile speed = 45.63 mph

50th percentile speed = 53.00 mph

85th percentile speed = 58.50 mph

INTERSECTION SIGHT DISTANCE

Available sight distance at street and driveway intersections should be great enough so that vehicles on the side road about to make a maneuver (e.g., crossing, left-turn, right-turn) can avoid a collision with a through roadway vehicle operating at the design speed and appearing after the side road vehicle has begun its maneuver. Providing proper sight distance would improve safety and result in better operating conditions (*Bhesania*). Many times in the design process, intersection sight distance is overlooked. This leads to traffic operations problems that are difficult to solve once the roadway has been built.

Acceleration characteristics of design vehicles are critical parameters in intersection design. Each intersection requires a different minimum intersection sight distance based on the speed of the approaching vehicle, the acceleration of the stopped vehicle, and the type of maneuver that is being performed.

Departure Sight Triangle Conditions

For a vehicle stopped at an intersection, the presence of a triangular area to the side of the road, free of obstructions, allows the driver to make a safer departure and enter the intersection. The design of the intersection should provide a "sight triangle" adequate for any of the maneuvers that side street drivers will make at the intersection.

The unobstructed sight distance needed by the side street driver is determined by the following equation:

$$d = 0.28\,V\,(J + t_a) \qquad (2\text{-}1)$$

where: d = sight distance measured along the major roadway from the intersection, m,

V = design speed on the major roadway, kph,

J = the sum of the perception time and the time required to actuate the clutch or automatic shift, assumed for design to be 2.0 sec. and,

t_a = time required to accelerate and traverse a certain distance, such as the distance S to cross the major roadway, sec.

The total distance of a crossing maneuver is the distance S, which is the sum of three components:

$$S = D + W + L \qquad (2\text{-}2)$$

where: D = distance from the near edge of the pavement to the front of a stopped vehicle, m,

W = pavement width along the path of crossing vehicle, m, and

L = overall length of vehicle, m.

For general design purposes, D is assumed to be 3 m. The value of W depends on the number of lanes the side street vehicle must cross. A value of 3.6 m is a commonly-assumed lane width.

The needed sight distance is based on the time it takes for the stopped vehicle to accelerate and clear the intersection and the distance that an oncoming through road vehicle will travel in that same amount of time. The value for t_a is dependent on the driver and the vehicle's performance. The passenger car (PC) solid line in Figure 1 is the recommended time-distance relationship of a passenger car for calculating t_a. The acceleration times of the SU and WB-15 vehicles in Figure 1 are 140%-170% of those for passenger cars. The time-distance data were developed from research at the University of Michigan Transportation Research Institute *(Fancher)*. The acceleration rates of buses and trucks are substantially lower than those of passenger cars.

A somewhat different situation exists when a side road vehicle is turning right or left onto a through road. For this, it is necessary to calculate a sight distance that permits the side road driver to turn onto the through road and accelerate up to speed before an oncoming through road vehicle could overtake and collide with the turning vehicle. The current *Green Book (AASHTO, 1994)* procedure incorporates the assumption that the oncoming through road vehicle will slow down to 85% of the roadway design speed.

Railroad Crossings

It is also necessary to analyze the adequacy of the available sight distance at railroad grade crossings. There are two design cases to consider at a railroad crossing without train-activated warning devices. The first case considers a vehicle approaching a grade crossing: the vehicle operator can either safely cross the railroad tracks before the oncoming train arrives or the vehicle operator can stop the vehicle in advance of the railroad tracks. The second case considers a vehicle stopped at the railroad crossing. The available sight distance must be great enough to permit the driver to see any oncoming train that is close enough to strike the vehicle before that vehicle can accelerate and cross the railroad tracks.

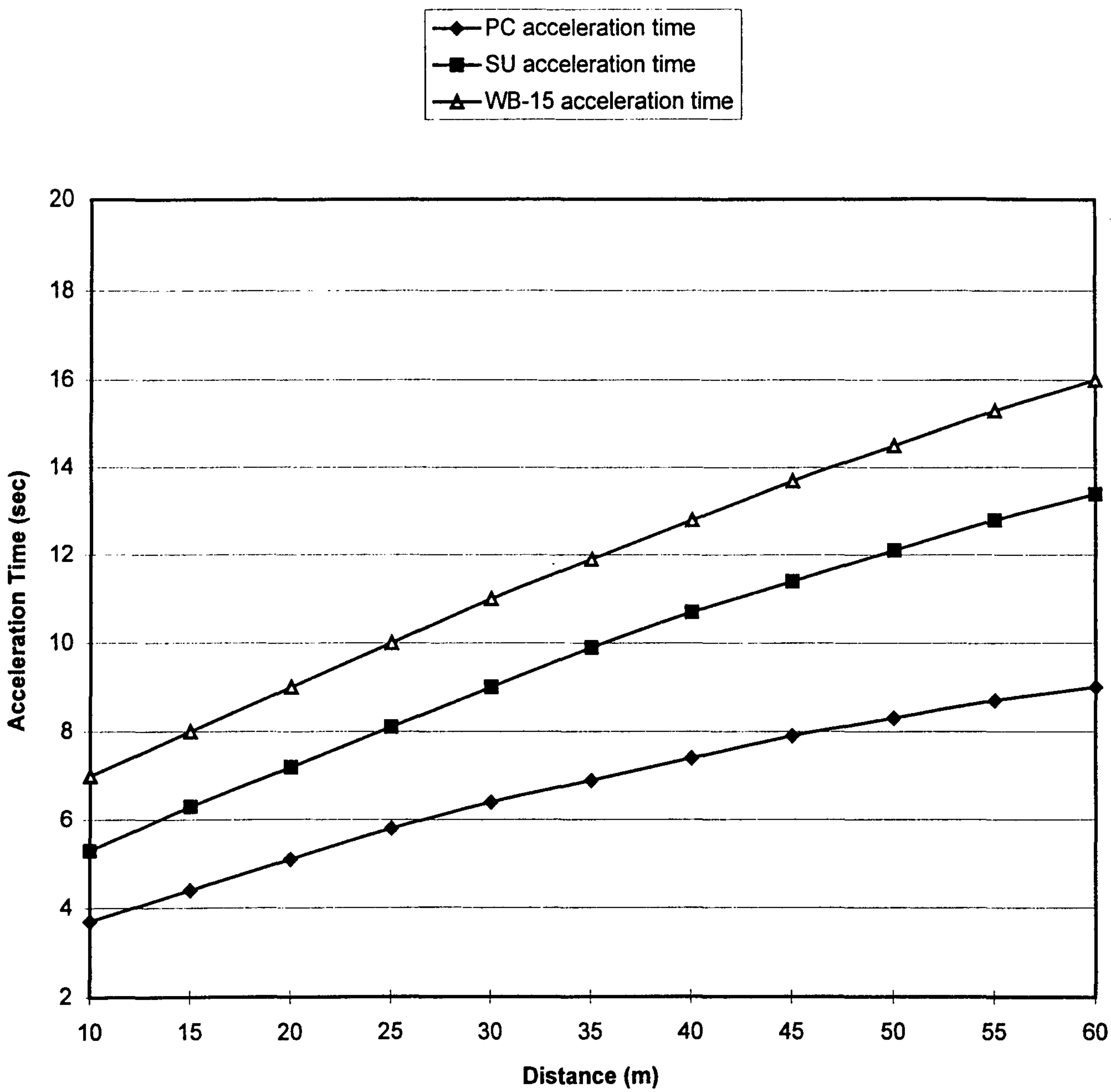

FIGURE 1 Time/Distance Relationship for PC, SU, and WB-15

For this second case, the *Green Book* presents the following equation to calculate the needed sight distance along the railroad track.

$$d_T = 0.28\ V_T\ [\ V_G/a_1 + (L + 2D + W - d_a)/V_G + J] \quad (2\text{-}3)$$

where: d_T = sight distance along railroad tracks, m,

V_T = velocity of a train, kph,

V_G = maximum speed of a vehicle in first gear, assumed to be 2.7 m/s,

a_1 = acceleration of a vehicle in first gear, which is assumed to be 0.45 m/s^2,

L = length of a vehicle, which is assumed to be 20 m,

D = distance from stop line to nearest rail, which is assumed to be 4.5 m,

W = distance between the outer rails; for a single track, this value is 1.5 m, and

$d_a = V_G^2/2a_1 = 8.1$ m.

SCHOOL BUS SURVEY

A school bus survey (Appendix A) was sent to the departments of transportation for the fifty states and Puerto Rico. This survey was sent to determine what information they currently possessed and what methods they currently employed, if any, to determine roadway design needs to accommodate school buses. The survey included questions related to:

1. school bus vehicle design dimensions,
2. inner and outer turning radius at both crawl and at normal turning speeds,
3. vehicle acceleration capabilities when making intersection turns, and
4. vehicle acceleration capabilities going up grades.

Responses were received from 36 states and Puerto Rico. Only two of the states (Indiana and North Carolina) sent information about the acceleration capabilities of school buses.

Indiana's Department of Transportation forwarded their survey to the Indianapolis Public Schools (IPS) Transportation Department. IPS stated that an 84 passenger school bus with a 210 horsepower engine and a gross vehicle weight of 36,400 lb could accelerate to 95 kph in 67 seconds.

North Carolina's Department of Transportation forwarded their survey to the North Carolina Department of Education's Division of Transportation Services. The Division of Transportation Services provided speeds of a Thomas school bus over known distances. Table 3 summarized the information that was provided by the Division of Transportation Services.

TABLE 3 Speed/Time/Distance Information Provided by N. Carolina Survey

Speed (kph)	Cumulative Acceleration Time (sec.)	Distance (m)
0.0	0.0	0
27.0	4.2	18
48.2	11.7	100
60.3	18.6	200
68.0	23.2	300
74.0	29.1	400
78.4	33.8	500

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CHAPTER 3
RESEARCH PROCEDURES

To determine school bus acceleration rates, the researchers had to identify suitable school bus testing sites and then collect speed and travel time information for the school buses at the sites. Before any testing could begin, equipment that would record the field data had to be identified and purchased.

EQUIPMENT SELECTION

This project required equipment that could record and store data for each individual school bus as the school bus drove by a data collection point. This necessitated a machine that could both identify each vehicle separately (since there would be other vehicles on the roadway besides school buses) and store data such as speed for each vehicle into a file, where the information could be retrieved at a later time.

Equipment Testing

Several traffic recording equipment manufacturers were contacted. Conversations with these businesses about the project requirements led to the decision that a "traffic classifier" was needed for this study. Classifiers are machines that, when connected with appropriate sensors, can identify each vehicle separately, classify the vehicle by the axle spacing and number of axles, and determine each individual vehicle's speed. The various brands have differing capabilities, so an evaluation of research needs and product capabilities was made.

The Arkansas State Highway and Transportation Department (AHTD) lent one Phoenix classifier and two sections of road tube. The AHTD classifier and road tubes were tested in the field to see if the setup would provide the needed information on the school buses. This equipment was able to provide the desired information.

Final Equipment Selection

Two Diamond Traffic Products Phoenix Classifiers were purchased. The Phoenix classifier could be set up to display the time to hundredths of a second and speeds to tenths of a mph. It would also display the axle spacing of each vehicle as it passed over the sensors. All of this information could also be stored individually into a file to be retrieved and downloaded for analysis at a later time.

A software program created for the Phoenix classifier called "Trafman" came with the classifiers. For this project, the software was programmed to:

1. record each vehicle individually as it crossed over the sensors,
2. display the time to hundredths of a second,
3. display the speed to tenths of a mph, and

4. display the axle spacing of each individual vehicle to tenths of a foot.

A pneumatic tube placed across the roadway sensed the passage of each vehicle.

SITE SELECTION

Several potential school bus study sites were identified before any field tests were done. For a school bus site to be considered acceptable, it had to meet several testing criteria.

Site Criteria

In order for a site to be suitable, the roadway had to be fairly straight (and level for the level terrain tests) so that the buses would be under full acceleration during testing and not be slowing down for a curve. The sites had to have relatively higher speed limits, preferably greater than 64 km/h (40 mph). This criterion was established so it would be possible to test a wider range of travel times, speeds, and distances.

There had to be at least five school buses operating at the site. Fewer than five would produce too little speed/acceleration information to make the site worthwhile for testing.

The school bus testing site had to be free from traffic congestion. Areas with high traffic volumes, and/or having several driveways or intersections would cause too many situations in which the school bus would not be under a full acceleration.

Potential Sites

Maps of northwest Arkansas, northeast Oklahoma, and southwest Missouri were used to identify a list of possible school bus sites. Table 4 lists the school bus testing sites that were considered.

Once the list of possible school bus sites was created, the superintendent or bus garage manager of each school was contacted by telephone. The following questions were asked:

1. Does your district have any schools located adjacent to a roadway with a speed limit greater than or equal to 40 mph?
2. Is the roadway in front of the school two lanes or four lanes?
3. How many buses turn right, left, or go straight?
4. Is the roadway in front of or near the school flat or on a grade?
5. Are there any sharp turns on the roadway near the school that may affect the school buses' performance?

Telephone conversation responses reduced the number of potential testing sites in the region to eight. Trips were taken to field inspect the remaining potential testing areas and verify that the sites were suitable for testing the school buses. The Alma school district had two possible testing sites; the middle and the primary school. The middle school testing site at Alma was considered unacceptable after observing

TABLE 4 School Districts Contacted

County	School District	Telephone conversation outcome
Benton, AR	Bentonville	not a possible site
	Decatur	not a possible site
	Gentry	not a possible site
	Gravette	not a possible site
	Pea Ridge	not a possible site
	Rogers	not a possible site
	Siloam Springs	not a possible site
Carroll, AR	Berryville	not a possible site
	Eureka Springs	not a possible site
	Green Forest	not a possible site
Crawford, AR	Alma	possible level grade testing
	Cedarville	not a possible site
	Mountainburg	not a possible site
	Mulberry	not a possible site
Franklin, AR	Altus-Denning	not a possible site
	Charleston	not a possible site
	County Line	not a possible site
	Ozark	not a possible site
	Pleasant View	not a possible site
Johnson, AR	Clarksville	not a possible site
	Lamar	not a possible site
Logan, AR	Booneville	not a possible site
	Magazine	not a possible site
	Paris	not a possible site
	Scranton	not a possible site
Madison, AR	Brashears	not a possible site
	Huntsville	possible level grade testing
	Kingston	not a possible site
	Saint Paul	not a possible site
Scott, AR	Waldron	possible level grade testing
Sebastian, AR	Fort Smith	not a possible site
	Greenwood	possible level grade testing
	Hackett	not a possible site
	Hartford	not a possible site
	Lavaca	not a possible site
	Mansfield	not a possible site
Washington, AR	Elkins	possible level grade testing
	Farmington	not a possible site
	Fayetteville	not a possible site
	Greenland	not a possible site
	Lincoln	not a possible site
	Prairie Grove	not a possible site
	Springdale	not a possible site
	West Fork	not a possible site
	Winslow	not a possible site
Barry, MO	Washburn	possible straight line acceleration
McDonald, MO	McDonald Co.	possible level and upgrade testing
Adair, OK	Stilwell	not a possible site
	Watts	not a possible site
	Westville	not a possible site
Delaware, OK	Colcord	not a possible site
	Jay	not a possible site
	Kansas	not a possible site
	Moseley	not a possible site

several traffic congestion situations near the school caused by traffic to and from the post office. The seven following sites were judged acceptable for testing.

1. Elkins High School in Arkansas, where 5 buses were tested for level grade acceleration after turning left from a driveway
2. Huntsville High School in Arkansas, where 6 buses were tested for level grade acceleration after turning right from a driveway
3. Raymon E. Wells Middle School in Greenwood, Arkansas, where 12 buses were tested for level grade acceleration after turning left from a driveway
4. McDonald County High School in Anderson, Missouri, where 16 to 17 buses were tested for level grade acceleration after turning left from a minor roadway onto a highway, and 4 buses were tested for acceleration up a grade
5. Alma Primary School in Alma, Arkansas, where 21 buses were tested for level grade acceleration after turning right from a driveway
6. Waldron Schools in Waldron, Arkansas, where 26 to 28 buses were tested for level grade acceleration after turning right from a minor roadway onto a highway
7. Washburn Schools in Washburn, Missouri, where 7 buses were tested for straight-line acceleration

FIELD DATA COLLECTION

Field tests were conducted to obtain full-size Type C and Type D school bus acceleration characteristics. All tests were conducted when the pavement was dry and there were no heavy winds. Information was gathered as each school bus accelerated from a side street or driveway onto the through roadway. Data was also gathered for school buses accelerating up a grade, and for school buses accelerating from a stopped position at a railroad crossing.

Data Collection Stations

Speed, time, and distance data were needed to determine how much time it took and what speeds were reached at specified intervals after a school bus accelerated from the stopped position. Data collection sites were set up at specified distances (stations) from the school buses' starting position to record speed and time information. The starting position for level terrain acceleration testing was the school's driveway or where the bus pulled onto the main roadway from the side street. The starting position for the upgrade acceleration testing was determined out in the field after plotting the profile of the McDonald County testing area. The Missouri Highway and Transportation Department furnished plan-profile design sheets for the roadway. The starting position at the railroad crossing site was a wide white stripe (i.e., pavement marking) where the school buses were required to stop in advance of the tracks.

Data collection stations were positioned at 18 m, 100 m, 200 m, 300 m, 400 m, and 500 m from the school buses' starting position. A few stations were not set up at these exact distances, because at these locations there were obstructions such as islands in the roadway or intersections, so the speeds had to be interpolated later on to reflect the speeds at the 18 m, 100 m, 200 m, 300 m, 400 m, and 500 m interval stations.

The station distances were measured from the point at which the bus entered the roadway. For buses turning right, stations were measured from the right edge of the drive, and for buses turning left, from the centerline of the driveway. However, the station distances do not reflect the actual distance that the school bus traveled. The actual distance was slightly longer due to the turning path of the school bus.

For some of the early tests at Elkins and Huntsville, the initial data collection station was set at 15 m. During the early tests it appeared that buses were barely able to straighten out from their turn out of the school's driveway at this distance. The distance to the first station was increased to 18 m to allow a margin in case buses in subsequent tests required more than 15 m to straighten out from a turn.

Data Collection Procedure

Field personnel collected the data with the classifier/road tube and a video camera. The field setup consisted of placing two road tubes across the road. A knot was tied in the middle of the road tube to cut off any pulses produced by vehicles in the far lane. This was necessary because only one direction of traffic, the near lane, needed to be monitored. The road tubes were spaced ten feet apart (common setup spacing for the classifier) and brackets holding the tubes were nailed into the gravel shoulder with six inch spikes. The classifier was placed on the side of the road that the school buses would be traveling. The two ends of the road tubes were placed in the appropriate inputs on the classifier. Input one was for the first road tube to be driven over, input two was for the second road tube. The classifier was turned on, and input codes were entered. The classifier was then ready to record the data. The classifier/road tube setup was able to provide all of the school bus speed and real time information at each of the setup stations.

A video camera was used to monitor the buses from 0 m (i.e., the side street or driveway) to 18 m. The video tapes were viewed in the office to record the time each bus took to travel from the starting position to the 18 m station. Some of the 0 m to 18 m times were recorded in the field (when personnel were available) and then compared to times from the videotape as a check.

The school bus numbers were not readable in the video record. The field person at the first testing station recorded the number of each school bus. Persons at the subsequent stations were asked to record the bus numbers if they had time.

All buses were supposed to stop before proceeding onto the main roadway. Some buses made "rolling stops" because of the absence of traffic on the main roadway. A note was made as to whether the school bus stopped or had a "running start". This was done to see if there were any significant differences in speeds between the school buses that stopped with those that did not.

Only two classifiers were available for the first four days at Elkins, the last day at Waldron, and the one day of testing at Washburn. All of the other setups employed three sequential stations. Usually there were three people in the field, one person to monitor each station. Each person was responsible for recording the speed and axle spacing that the classifier displayed when a school bus ran over the road tubes. The time and number of axles were also displayed by the classifier, but there was not enough time between buses to record all of the information in the field, and it was determined that these two numbers (axle spacing and speed) were more crucial when later trying to decipher the downloaded data as to which bus went with which speed. Field personnel also recorded if a bus slowed for some reason or turned off.

On those days when only two people were available to work, those people monitored the first and last stations, while the classifier at the middle station was unmanned. Not having a person monitor the middle classifier while buses were traveling over the road tubes did not lead to any confusion with subsequent data processing. Before taking the equipment to the field each day, the real time was entered into the classifier. The accuracy of the time between the classifiers was sufficient to permit having only two people in the field. Identifying the school bus data recorded by the middle classifier only required comparisons with the times and axle spacings of the buses from the first and last classifier. Figures 2 and 3 show the field data work collection in progress.

Once testing at each school had been completed, additional information was gathered. Each school district was asked to provide information regarding weight, horsepower, transmission (automatic or standard), engine age, and number of students riding each of the school buses that had been tested. Appendix B presents a summary of this information. This data was used to determine if any of these factors had statistically significant effects on school bus acceleration characteristics.

Elkins School District

Elkins' elementary, middle school, and high school were all located together on the western edge of town, so the buses were tested with a full load of students. Nine buses operated on the afternoon routes. Five buses turned left, heading west from town. The other 4 buses turned right, going through town. Data collection stations were placed on the highway west of the school, so data for the 5 buses was collected. This section of highway had two through lanes plus a continuous left turn lane. The schools were located in a 35 mph speed zone, but the speed limit changed to 40 mph at 210 m from the driveway, 50 mph at 310 m from the driveway, and 55 mph at 500 m from the driveway. The buses were only going 30-35 mph when they reached the 40 mph speed limit, so the 35 mph speed limit was not limiting the school buses' performance.

FIGURE 2 Field Data Collection Setup

FIGURE 3 School Bus Passing Over Sensors

Six days of data were collected at Elkins. The third classifier became available after the fourth day of testing. One set of 15 m data, three sets of 18 m data, and two sets of 105.60 m, 200 m, 300 m, 400 m and 500 m data were collected.

The first day of data was taken at 15 m and 105.60 m. It was not known exactly where the buses straightened out from their turn, so 15 m was originally selected for the initial data collecting station. After observing the buses in the field and viewing the video camera tape, it was determined that 18 m was a more appropriate starting distance. The second setup station was located at 105.60 m instead of 100 m because a driveway was located at 100 m.

The last or fifth bus usually had to stop near the 300 m station. Data from the 200 m, 300 m, 400 m, and 500 m stations were tagged so that the data for this bus would not be included when evaluating the performance times later on.

Huntsville School District

Huntsville High School was located on the south edge of town. The buses already had picked up the elementary and middle school students before arriving at the high school, so these buses were loaded when they left the high school. There were 31 buses used for afternoon routes. Twenty-five of the buses turned left, heading back into town. The other 6 turned right, or south, heading away from town on Highway 23 (a two-lane highway). The 6 buses that turned right were tested because the roadway was level and straight and the buses were able to achieve the higher speeds required. The speed limit was 45 mph in front of the school, but 75 m south of the driveway it changed to 55 mph.

Six days of testing were conducted at Huntsville High School. Two sets of data were taken at 15 m, 96 m, 205 m, 300 m, 385 m, and 500 m. Due to the wide variation of school bus speeds in the initial data, two more sets of 96 m, 205 m, and 300 m data were taken . The two extra sets of data showed more consistent bus speeds.

There was a gentle curve to the left on Highway 23 approximately 550 m south of the school's driveway. Both observation and data analysis showed that the school buses were not slowing to negotiate the curve.

Greenwood School District

Raymon E. Wells Junior High was located about two miles east of Greenwood on Highway 10 (a two-lane highway). Twelve buses started at this school. All 12 turned left, or west, on Highway 10 and headed toward town.

All 12 buses were tested. The speed limit was 55 mph, so there were no concerns about any buses not being under a full acceleration. The geometry of the roadway limited the number of stations at which data could be collected, though. There was a gradual upgrade hill approximately 220 m from the school's driveway. This limited the number of stations used for testing to the 18 m, 100 m, and 200 m stations, so only two days were required to gather the speed information for Greenwood.

McDonald County School District

McDonald County High School was located in Anderson, Missouri on US Highway 71 (a two-lane highway). The speed limit on US 71 in front of the school was 45 mph. Depending on the test day, 16 to 17 buses turned left onto Highway 71, heading south from the high school. The high school was the starting point for most of these routes, thus, the school buses had few passengers.

Speed data was collected for four days. Two sets of data were collected for all the buses at the 18 m, 100 m, 200 m, 300 m, 400 m, and 500 m stations. Data for the last 8 buses at the 400 m and 500 m stations were tagged for exclusion because these buses slowed at an intersection to make a right turn.

Other McDonald County school buses were also used for upgrade testing. Two days of data were collected for the upgrade tests. The school itself was located in a long valley, and the few buses that turned right or north proceeded up a grade. Four buses were tested, so only a small amount of information was collected.

The upgrade testing area included a 150 m long bridge. The bridge itself was on a +2.95% grade (Figure 4). The testing stations were set up at 150 m south of the south end of the bridge (to measure the school bus speed on level terrain as it entered the upgrade portion of the roadway), the south end of the bridge (to measure the speed as the school bus reached the constant +2.95% upgrade portion), and the north end of the bridge (to measure the speed after an interval on a constant upgrade).

Alma School District

Alma's school district had two school sites (the middle school and primary school) that were thought to be suitable for testing. The primary school was tested first, since it was located farther east of town, which meant that these buses traveled more open highway and therefore had a better opportunity to achieve higher speeds.

Alma Primary School was located approximately two miles east of Alma on US Highway 64 (a two-lane highway). Data was initially collected for 21 school buses at the 18 m, 100 m, and 200 m stations. After reviewing the speeds recorded, it was suspected that a small downward slope on the roadway about 30 m from the school's driveway might be helping the buses accelerate. A surveying transit was used to profile the roadway (Figure 5). After reviewing the profile and the data, it was determined that the 1.68% grade could be helping the buses accelerate, so only the 18 m speeds were deemed valid. Two days of data were collected at the 18 m station.

Alma Middle School was located one mile east of town on US Highway 64. The post office was located next to the school and caused several traffic congestion situations. During the first day of testing,

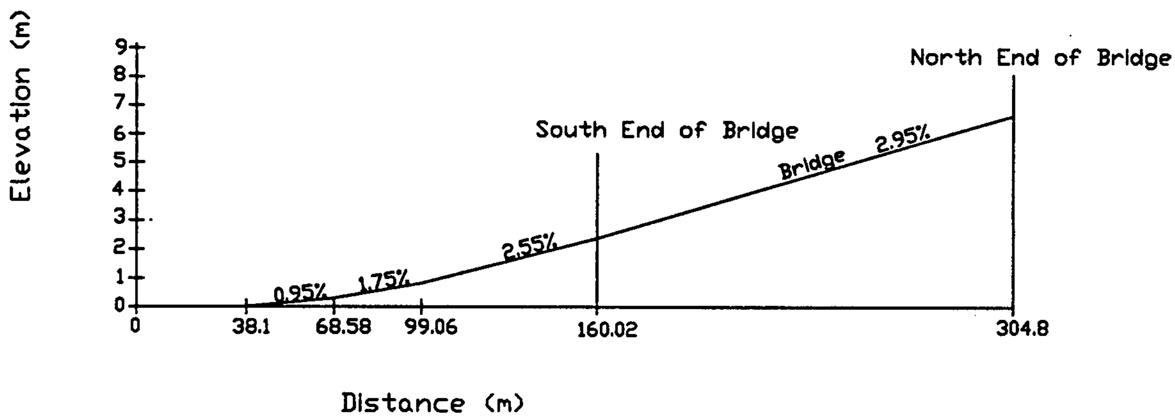


FIGURE 4 Profile of McDonald County Upgrade Testing Area

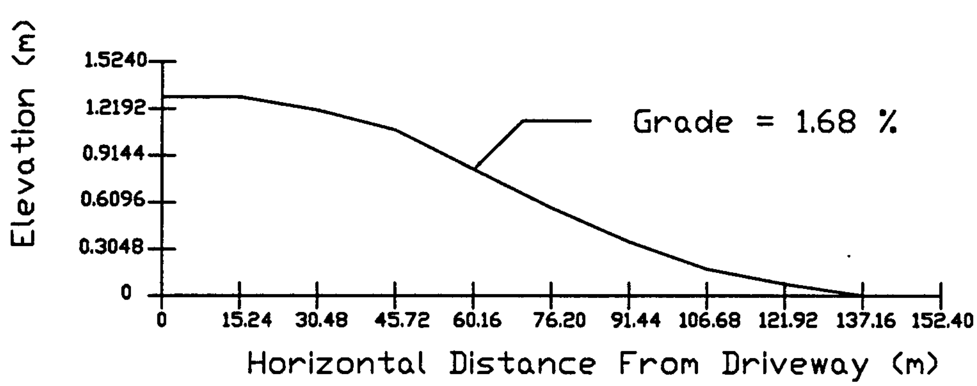


FIGURE 5 Profile of Alma Primary School Testing Area

only one of the 21 buses leaving this school was under full acceleration through all of the stations (18 m, 100 m, and 200 m). Due to the congestion at this site, it was abandoned.

Waldron School District

Waldron's elementary and middle schools were located on the west edge of town along the bypass. The testing area was a 650 m section of US 71 Bypass (a two-lane highway with a continuous left turn lane) that the buses traveled to get from the middle school to the high school.

Depending on the test day, 26 to 28 buses were observed. Two days of testing the 18 m, 100 m, and 200 m and one day of testing the 300 m and 400 m stations were conducted. Data was not collected at the 500 m station because it was too close to the intersection where the buses turned off.

Washburn School District

Washburn's elementary, middle, and high schools were located in Washburn, Missouri. There was a railroad grade crossing approximately 305 m west of the school. Seven buses turned right and headed west on Highway 90 (a two-lane highway). The buses were required to stop at the railroad tracks and then accelerate (i.e., the straight-line acceleration test). Data was recorded for 7 buses at the 18 m and 100 m stations.

DOWNLOADING DATA

Field personnel had collected speed and time-of-passage data with the Phoenix classifiers for each school bus as it proceeded through a sequence of data collection stations. After each day of data collection, the classifiers were brought into the office so that the information could be retrieved.

The classifiers were connected to a laptop computer equipped with the "Trafman" software. The "Trafman" software was used to retrieve the data files and convert these files into a readable format where the data could be analyzed.

Once the data files from the field tests were retrieved and converted into a readable format, the files were imported into a spreadsheet (Appendix C). This spreadsheet contained all the raw data that had been collected at each of the level grade acceleration testing sites (including the Washburn straight-line acceleration data). The raw data contained the speeds, time-of-passage, and axle spacing of each school bus from the classifier.

Information recorded by the field personnel was also added to the spreadsheet. This included the school bus number, the school buses' 0-18 m travel times, whether the bus stopped or ran the stop sign, and notes of any school buses that slowed down or stopped. Some of these notations were added to identify buses that should be eliminated from the raw data set, before the data was analyzed.

ADDING WEIGHT, POWER, ENGINE AGE, AND TRANSMISSION

The total school bus weight (bus + student weight column in Appendix D) included the gross vehicle weight and the passenger weight. The passenger weight was calculated using 120 lbs/student and 150 lbs for the driver *(CMSU)*.

Some of the school districts did not have engine horsepower ratings for some buses in their fleet. The school bus engine manufacturers were contacted to see if they could provide any additional horsepowers that the school bus districts could not. The engine manufacturers were able to provide horsepowers for two additional school buses. The rest of the horsepowers were not identified because there was not enough information provided by the school districts to ascertain what the engine size was in the school bus, so only the horsepowers that the school districts and engine manufacturers were sure of were used in the analysis of the school bus speed data.

A next-generation spreadsheet (Appendix D) was created from data sets that were the most complete and had the fewest omissions. This spreadsheet contained the "cleaned up" data: buses that slowed down or had less than three second headways were deleted. The weight, horsepower, and other information provided by the school districts was also added to this spreadsheet.

Separate tables were created to analyze the Washburn straight-line acceleration tests (Appendix E) and the McDonald at grade acceleration tests (Appendix F). Information was also added to the spreadsheet for the school buses' weight, engine age, transmission, and horsepower.

CHAPTER 4

DATA ANALYSIS AND RESULTS

Once the data had been collected from each of the school bus testing sites and retrieved from the classifiers, the data were analyzed. A few of the data points had to be removed because of testing problems.

The school bus speed data were used to create figures using the school bus speeds. Later, the weight and horsepower, engine age, and transmission of the school buses were factored into the analysis to see what effects these factors had on the school buses' speed.

DATA INSPECTION AND ADJUSTMENT

The initial spreadsheet contained all of the raw data that had been collected at each of the level terrain testing sites. This data was inspected, and appropriate adjustments were made.

Eliminating Obvious Problems

The data were first visually inspected for omissions and possible errors. Inspections were also made for instances where one bus was closely following another bus (i.e., short bus headways).

At two of the Alma stations, school bus data were not used. The Alma data was deemed invalid at the 100 m and 200 m station because the downward grade along the highway seemed to be helping the school buses accelerate.

On one occasion, the classifier misidentified two school buses as one four-axle vehicle on March 20 at McDonald County. This data was also deleted.

The raw data spreadsheet was inspected to find any sequential passage times of less than 3.0 seconds at any station, because it was felt that a headway of less than 3.0 seconds could cause a driver to be influenced by the speed of the school bus in front of him/her. In such cases, the school bus may not have been under full acceleration. The real time associated with the passage of each vehicle was used to identify school buses that were following too close behind a preceding bus. For the few cases of less than a 3.0 second headway found, the data for the following bus was removed from that station.

Other school buses were deleted from the spreadsheet because of characteristics observed in the field. In some instances, school buses had to make a stop to discharge students. Other times, school buses had to slow down to make a left or right turn off of the highway.

Selecting Best Data Sets

At least two sets of data were collected at most stations at each of the testing sites. The two best (most complete) sets of data from each station were those chosen for Appendix D.

At the Elkins and Huntsville sites, more than two sets of data had been collected at some stations because of problems encountered in the field. Extra test days were required at Elkins due to inexperience with the equipment causing faulty data collection. Extra days were required at Huntsville because some of the school buses did not fully accelerate on one of the days. There was no apparent reason why the Huntsville school buses did not accelerate, so additional testing days were required to gather good data.

Other Adjustments

Elkins testing stations were located at 18 m, 105.6 m, 200 m, 300 m, 400 m, and 500 m. Huntsville testing stations were located at 15 m, 96 m, 205 m, 300 m, 385 m, and 500 m. For those instances where the data collection station could not be located exactly at the specified 100 m, 200 m, etc. interval, a speed for the even-interval station was estimated from the field-measured speeds. Straight-line interpolation was used to estimate the speeds at these stations. These speeds are in the "Real Speed" columns in Appendix D.

Travel Time Between Stations

The real time had been entered into the classifiers each day before performing field tests, so each classifier would be synchronized with the others. The classifiers had recorded the time-of-passage of each school bus as the bus passed over the road tubes. By using the real time, it was hoped that one could subtract the passage times at sequential stations and arrive at the actual travel time between the stations.

Unfortunately, the real times between the classifiers were off anywhere between four and ten seconds in a 24-hour period. This time differential made the passage times recorded by the classifier too inaccurate for comparisons between two different classifiers. Therefore, the school bus travel times between stations were determined by averaging the beginning and ending velocities over a known distance:

$$t = 2 * 3.6\,(d_{A,B}) \,/\, (V_A + V_B) \qquad (4\text{-}1)$$

where: t = school bus travel time between stations A and B, sec.,

$d_{A,B}$ = distance between stations A and B, m,

V_A= Velocity of school bus at station A, km/h, and

V_B = Velocity of school bus at station B, km/h.

DATA ANALYSIS

Once the school bus data had been gathered and reduced into a spreadsheet of acceptable school bus tests and weight, horsepower, etc. information had been added, the acceleration characteristics at each of the six data collection stations (18 m through 500 m) were examined. Several figures were generated from the school bus speed data.

Statistical analysis tables were generated using a spreadsheet. The t-test was used to compare the differences of two means assuming unequal variances and unequal sample sizes. This test was performed to determine if there were any statistical differences in the mean speeds of various bus groups. Comparisons were based on whether the school buses stopped or ran the stop sign; the school buses' weight and power; transmission type; or the age of the school buses. The test statistic equations used are given below:

$$t = [(y_1 - y_2) - D_0] \ / \ [s_1^2 / n_1 + s_2^2 / n_2)]^{1/2} \tag{4-2}$$

and

$$df = (\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2})^2 \ / \ [\frac{(s_1^2/n_1)^2}{n_1 - 1} + \frac{(s_2^2/n_2)^2}{n_2 - 1}] \tag{4-3}$$

where: t = test statistic

df = degrees of freedom

n_1 = size of sample 1

y_1 = mean of sample 1

s_1^2 = variance of sample 1

y_2 = mean of sample 2

n_2 = size of sample 2

s_2^2 = variance of sample 2

D_0 = hypothesized difference between the means

In all of the statistical analysis tests, the value for D_0 was assumed 0. The confidence interval for all tests was 90%. The t-critical value ranged between 1.65 and 1.72, depending on the sample size.

A statistical analysis on the school bus speed data was performed to determine the 12.5 percentile school bus speeds at each individual station. The 100 and 200 m speeds for those buses running the stop sign were removed from the analysis because there were significant differences between these speeds and the speeds of the school buses that had come to a full stop. The procedure consisted of taking one speed out of the sample size "n" (at the particular testing station) and then placing it back into the sample. This was done "n" times to get one iteration. The speeds were averaged to get a mean speed for the iteration. This procedure ("bootstrapping the data", using software called "S-plus") was repeated 500 times with the individual school bus speeds at each testing station to get the 12.5 percentile speeds at each station.

RESULTS OF ANALYSIS

The school buses' average acceleration times, average speeds, and 12.5 percentile speeds are shown in Table 5.

TABLE 5 School Bus Average Acceleration Times and Speeds

	Distance (m)						
Averages	0m	18m	100m	200m	300m	400m	500m
Avg. travel time between stations (sec.)	5.1	8.9	7.6	6.3	5.6	5.2	
Avg. accumulated travel time (sec.)		5.1	14.0	21.6	27.9	33.4	38.7
Avg. speed (kph)	0	25.1	42.8	53.1	61.9	68.0	70.7
Avg. 12.5 percentile speed (kph)	0	22.2	38.9	46.6	56.6	64.3	67.1

Turning Acceleration

Figures 6-12 showed the scatter plots for right or left turn school bus speeds at each of the level terrain testing stations. Figure 6 showed the speeds at all six testing stations, while Figures 7-12 showed the speeds at each testing station individually. In these figures, the speeds were shifted to the left and the right of the actual x-coordinate of the testing stations. This was done so that the speeds of the automatic transmission school buses could be differentiated from the speeds of the standard transmission school buses.

The figures demonstrated two distinct patterns for the school buses tested. First, they showed that the school bus acceleration rate was decreasing from 0 m to 100 m. Second, they showed that from 100 m to 500 m, the acceleration pattern of the school buses was somewhat linear.

The figures showed that several of the automatic transmission school buses accelerated faster than the standard transmission school buses up to the 200 m station. At the 300 m, 400 m, and 500 m stations, though, the standard transmission school bus speeds were close to those of buses with the automatic transmissions.

Straight Acceleration

Figures 13-15 showed the Washburn straight-line data (Appendix E) superimposed on the turning school bus data from 0 to 100 m. The Washburn data is to the left of the data from the other turning school buses.

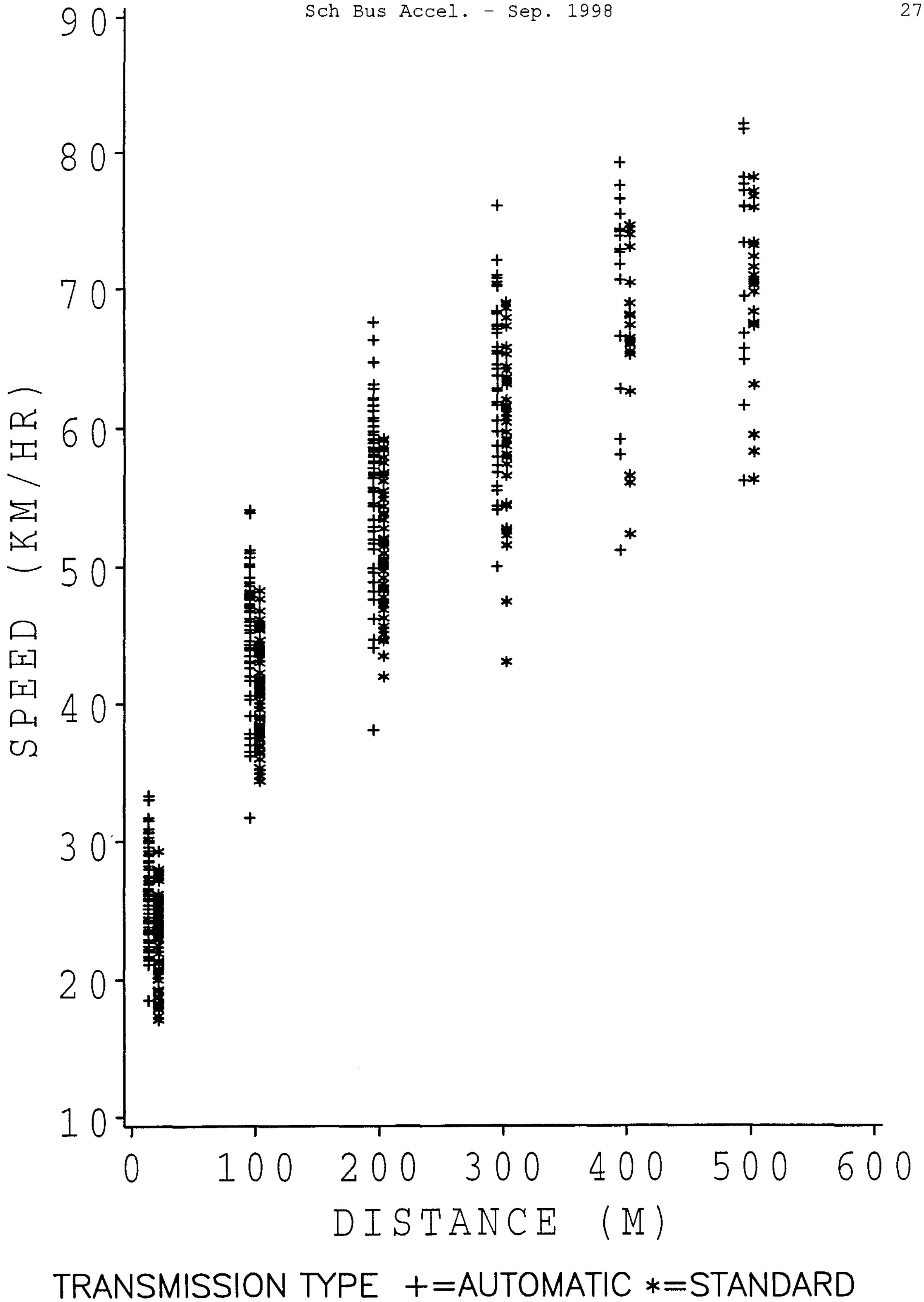


FIGURE 6 Scatter Plot of Turning Bus Speed and Distance

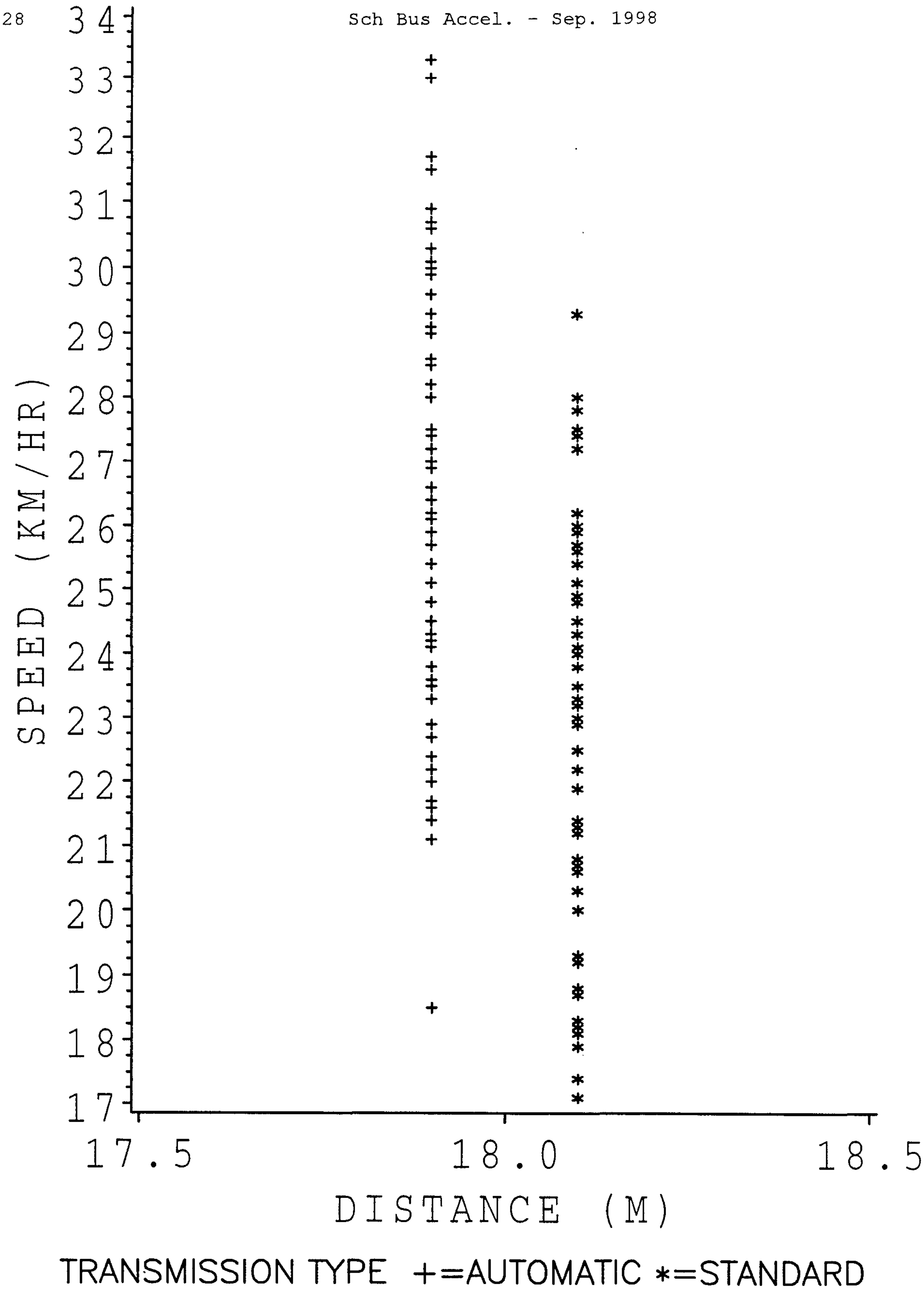


FIGURE 7 Scatter Plot of Turning Bus Speed and Distance at 18 m

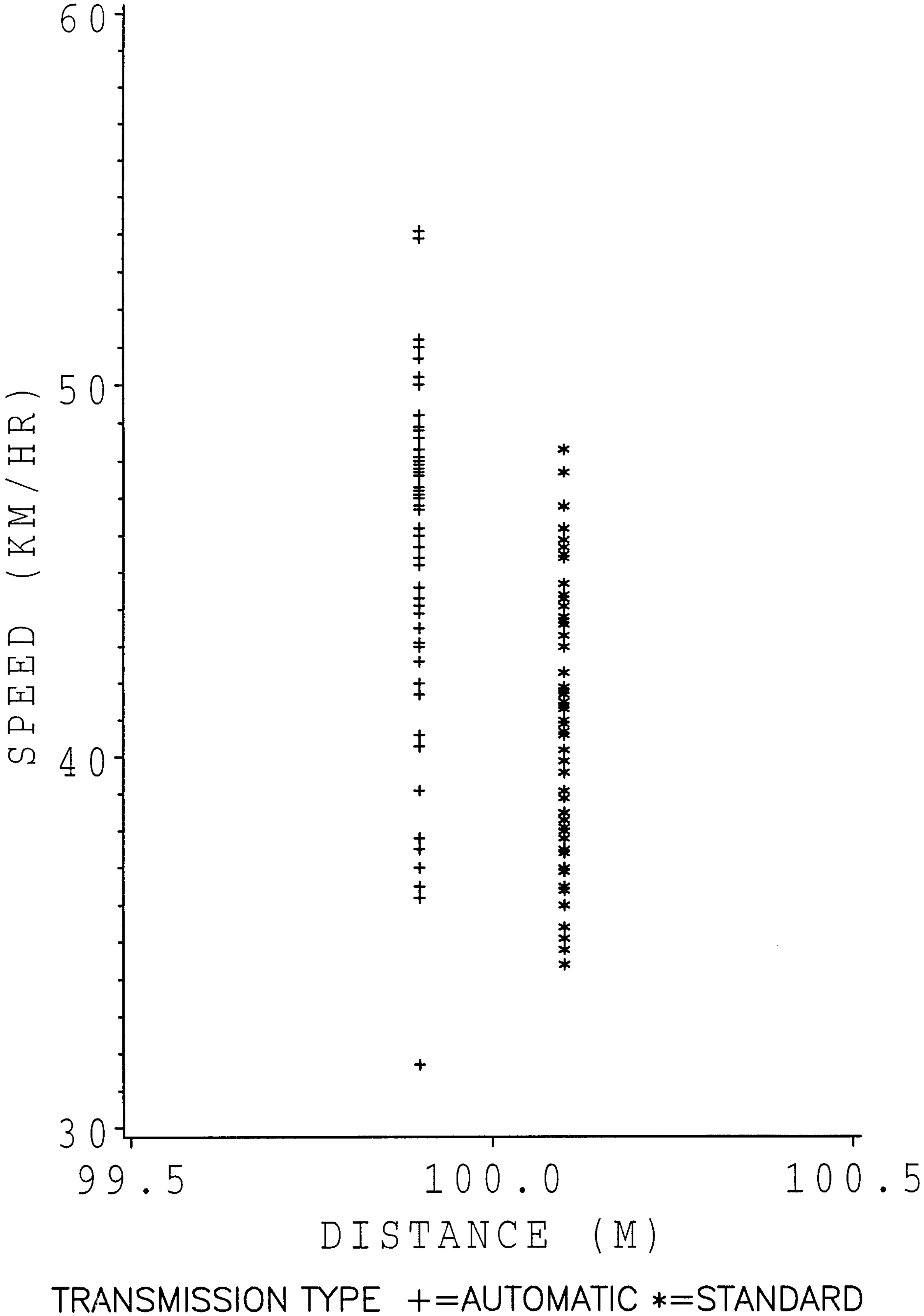


FIGURE 8 Scatter Plot of Turning Bus Speed and Distance at 100 m

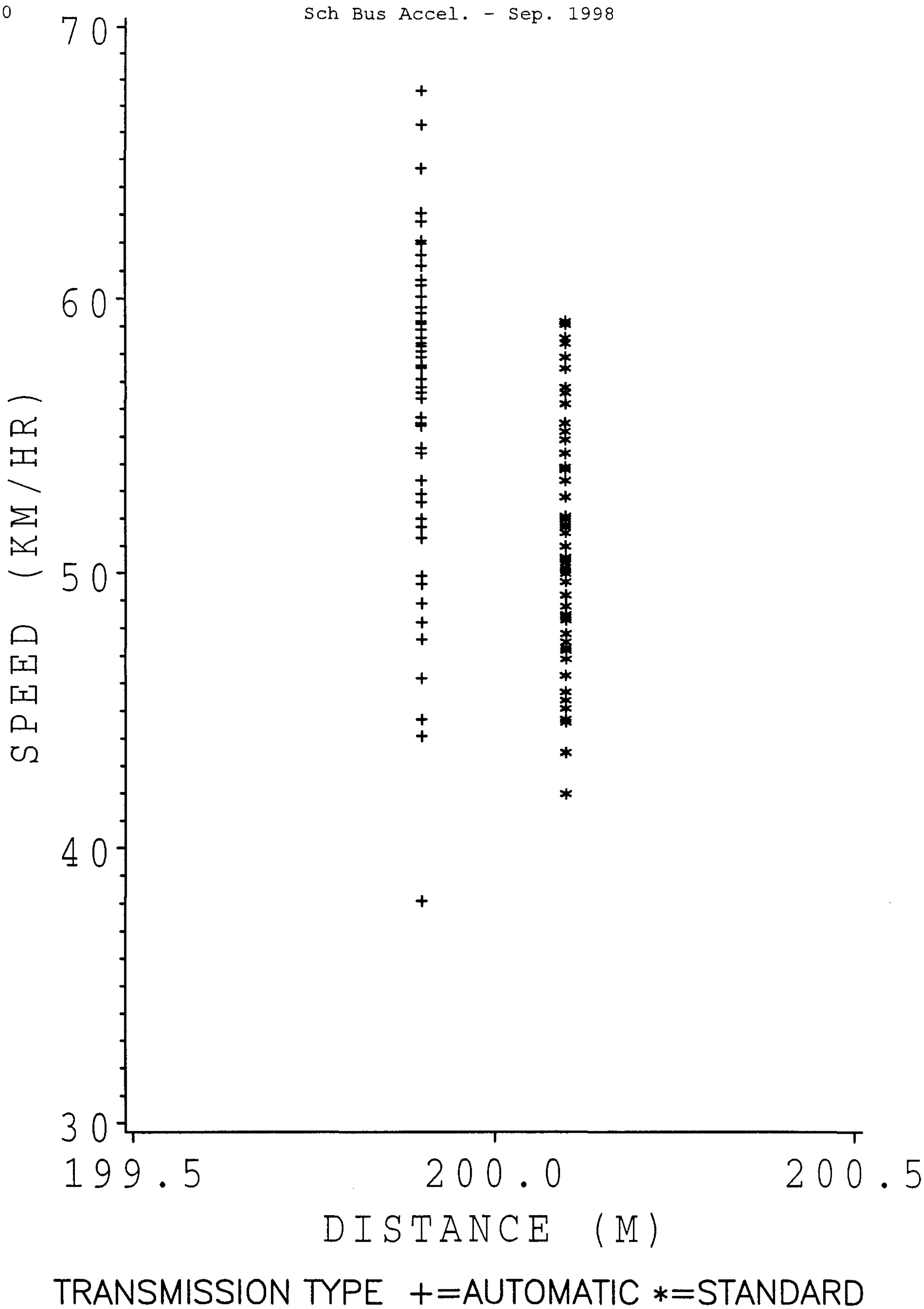


FIGURE 9 Scatter Plot of Turning Bus Speed and Distance at 200 m

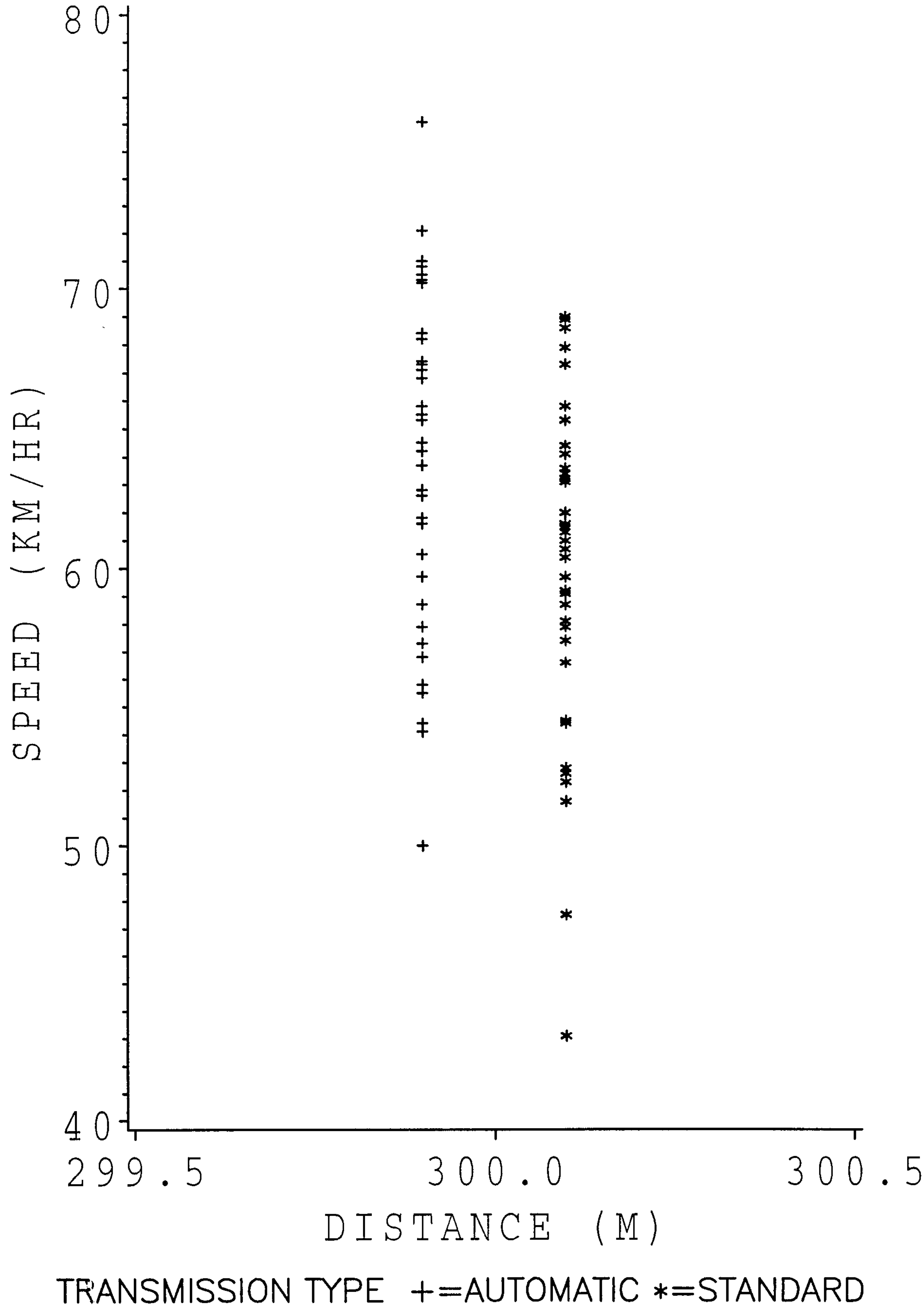


FIGURE 10 Scatter Plot of Turning Bus Speed and Distance at 300 m

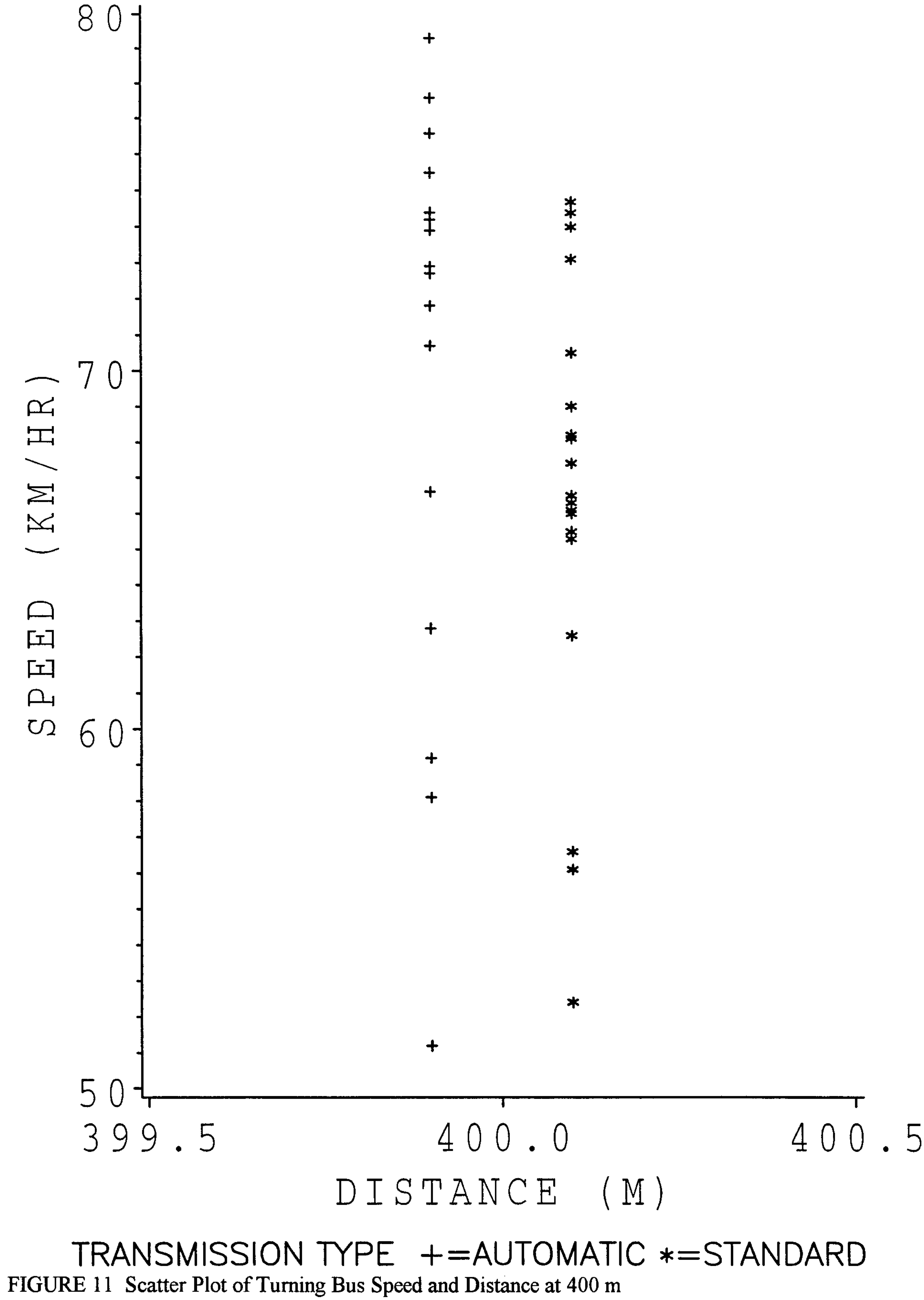


FIGURE 11 Scatter Plot of Turning Bus Speed and Distance at 400 m

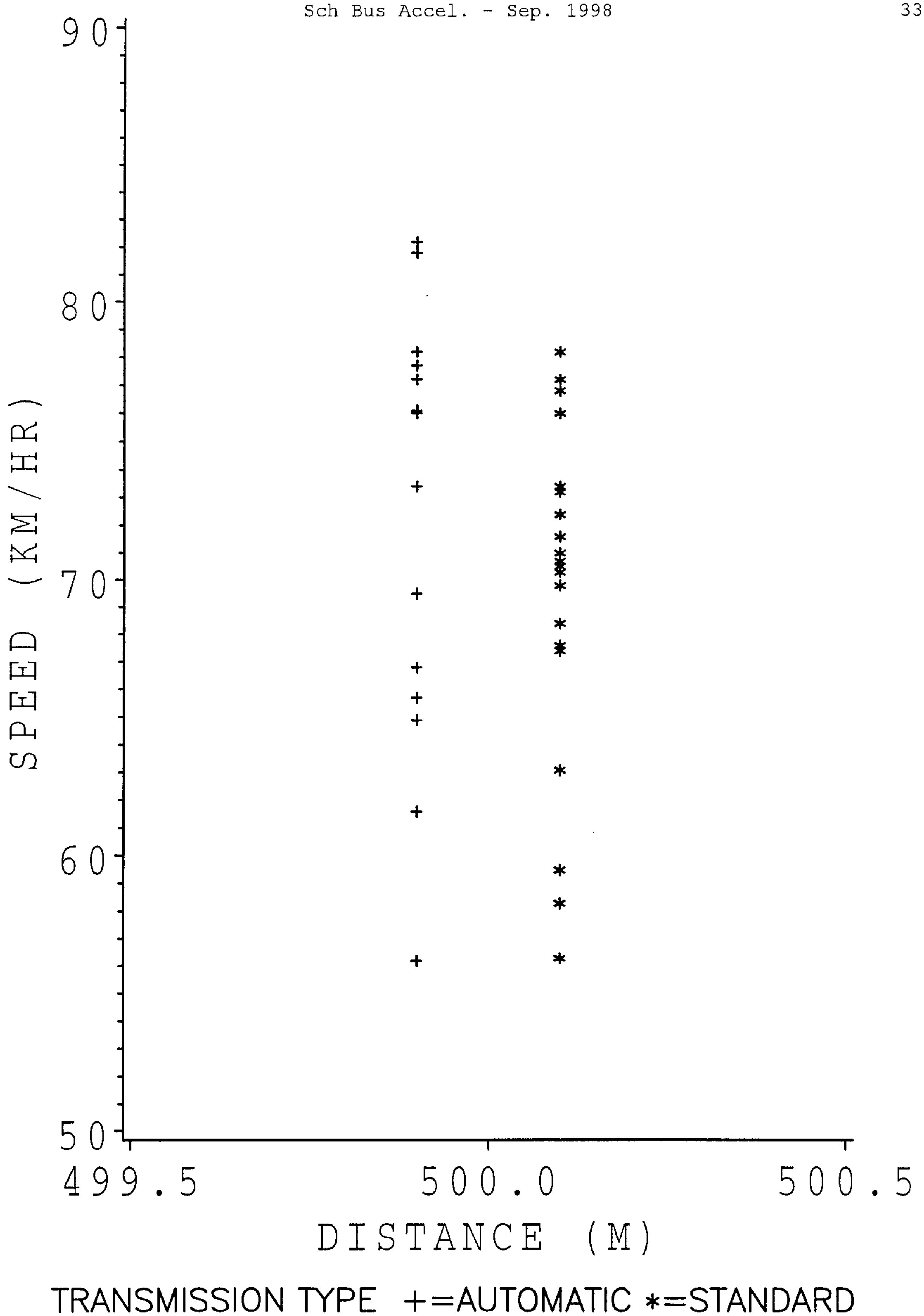


FIGURE 12 Scatter Plot of Turning Bus Speed and Distance at 500 m

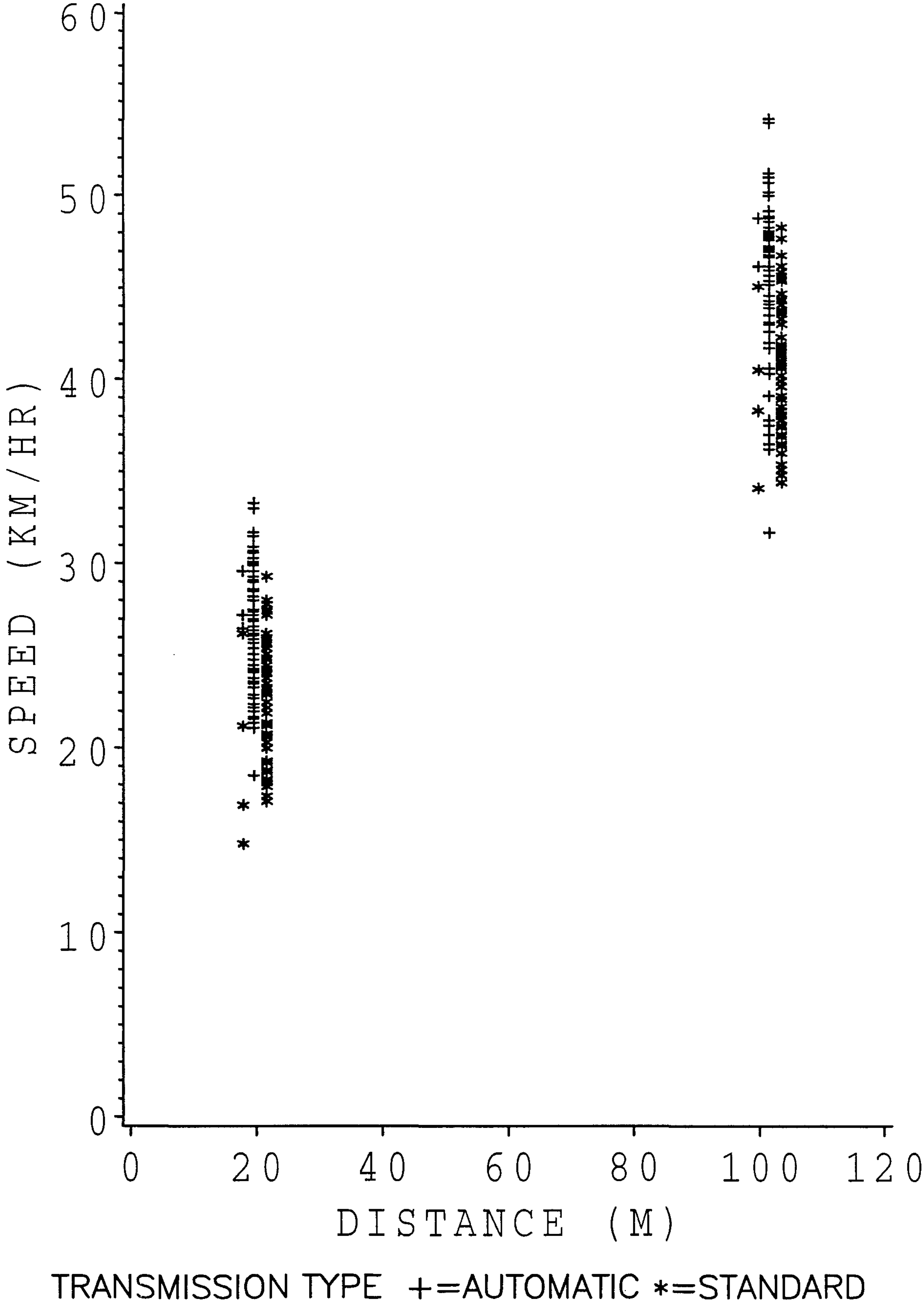


FIGURE 13 Scatter Plot of Washburn Straight-line Speed and Distance

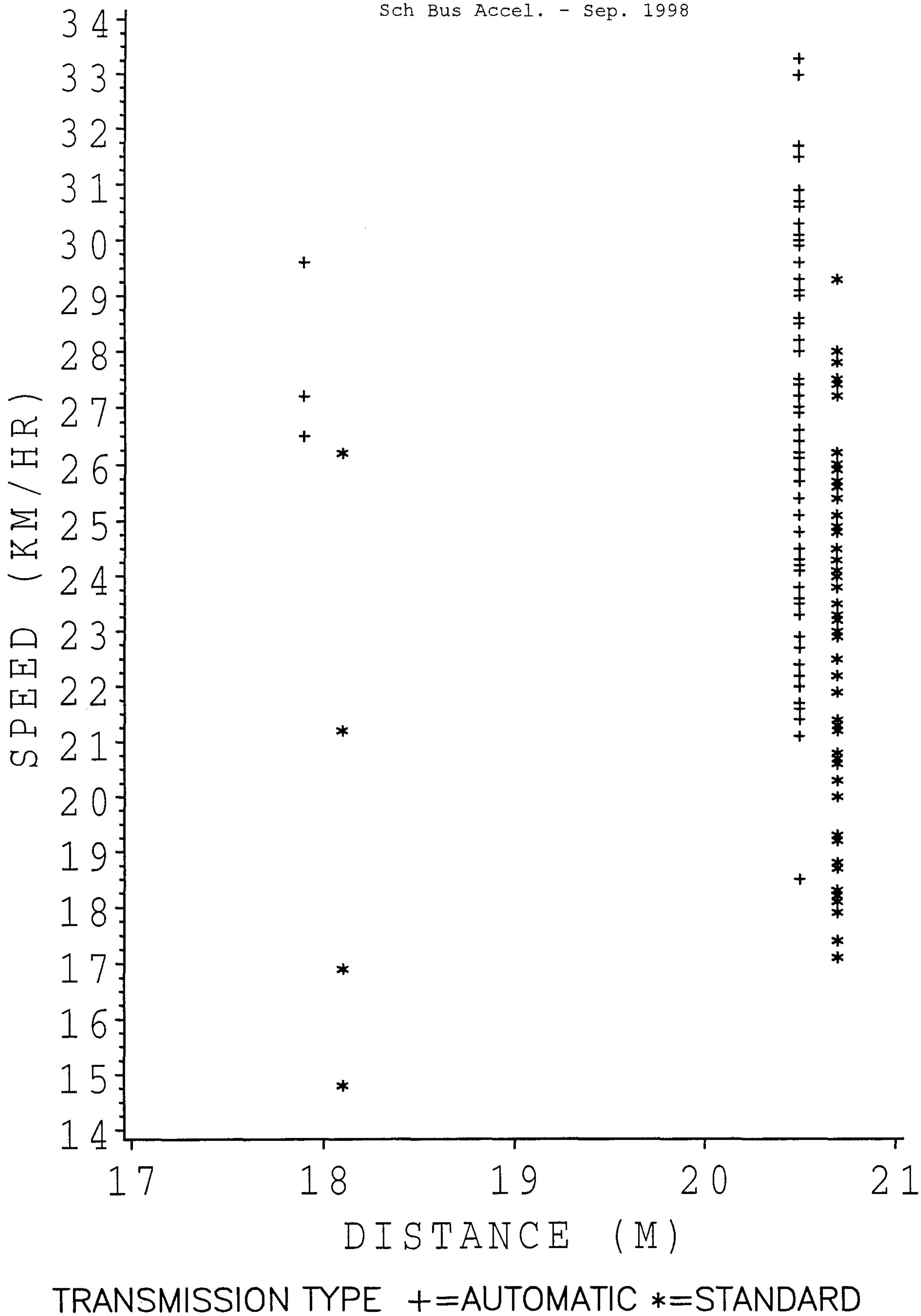


FIGURE 14 Scatter Plot of Washburn Straight-line Speed and Distance at 18 m

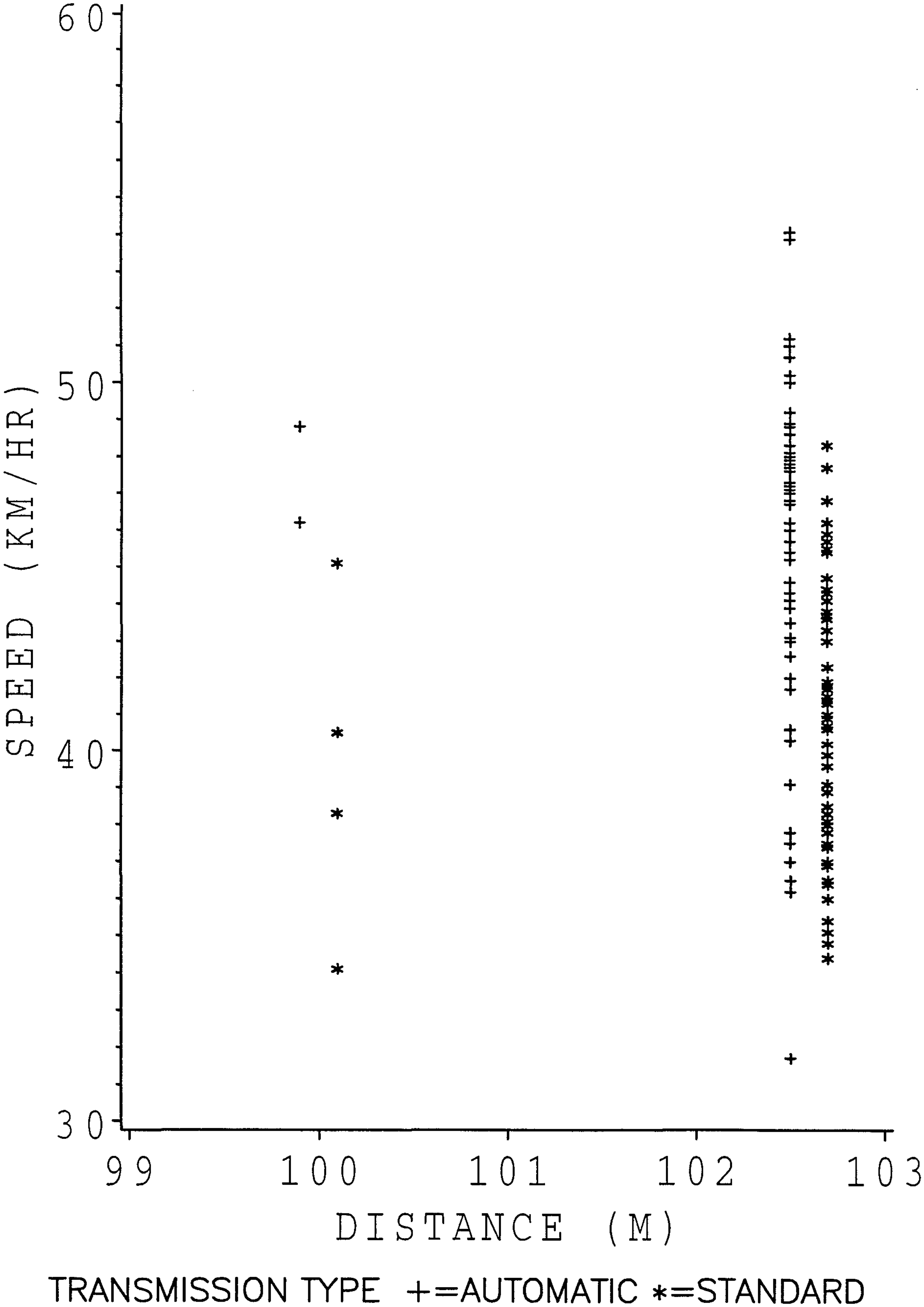


FIGURE 15 Scatter Plot of Washburn Straight-line Speed and Distance at 100 m

When comparing the straight and turning school buses, adjustments were made to calculate the actual distance that the turning school buses traveled to the first testing station at 18 m. It was assumed that the school bus began the right turn onto the highway from a position 3.048 m (10.0 ft) back from the edge of the road. Based on other research conducted, it was assumed that the turning radius of the school bus was 9.144 m (30.0 ft). It was also assumed that the bus made a 90° turn. After taking these assumptions into consideration, the distance traveled to the first station (18 m) was actually 20.6 m, or an extra 2.6 m above the nominal 18 m (Figure 16).

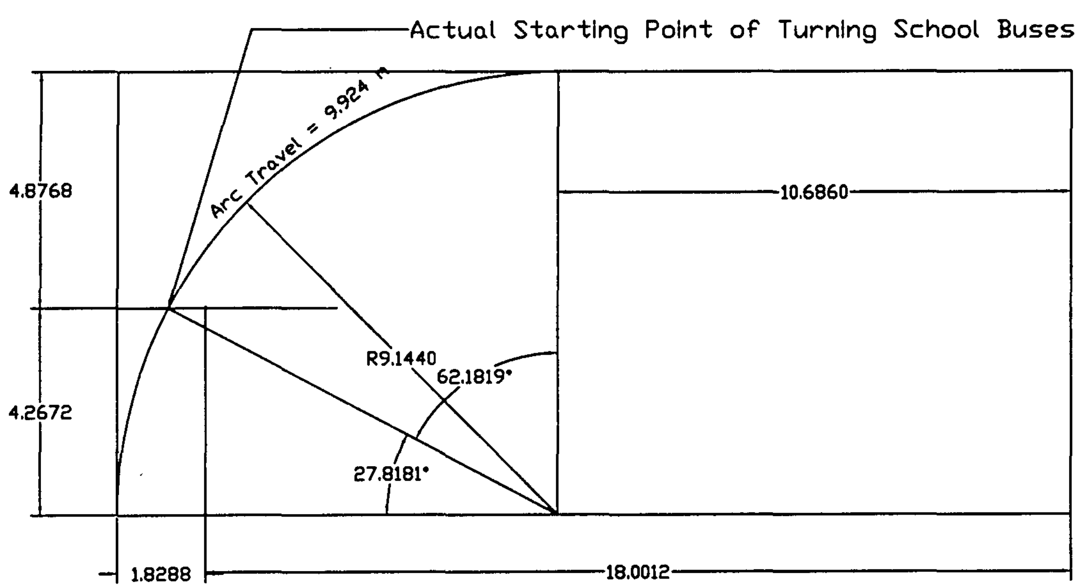
The figures showed that the straight-line acceleration school buses' speeds from Washburn were very similar to those of the turning school buses. Since the data did not suggest any great differences, it was assumed that the results of the straight-line and the turning tests could be used interchangeably for design purposes.

Circumference = pi * diameter

Arc Travel of School Bus = pi * 62.1819/360 *diameter
= 3.14 * 0.1727 * 18.288 m
= 9.924 m

Horizontal Travel = 10.6863 m
Total Travel Distance = 20.61 m

Delta = 20.61 m - 18 m = 2.61 m, or approximately 2.6 m



Note: All dimensions are in meters (m).

FIGURE 16 Diagram of Turning Arc Excess

Upgrade

Figure 4 showed the profile of Highway 71 where the buses were tested for upgrade acceleration. There were two sections of the upgrade. The first was 150 m south of the southern end of the bridge to the southern end of the bridge. This is where the grade changed from 0% to 2.95%. The second section was the constant 2.95% grade portion from the southern end of the bridge to the northern end of the bridge. This section was also 150 m long.

Appendix F showed the data collected for the upgrade acceleration tests at McDonald County. Only 4 school buses were tested (six data points), so no statistical information was generated from this test. The school buses maintained speeds ranging from 60 to 80 km/h while traveling up a 150 m long 2.95% upgrade. The observed school buses exhibited very little (if any) acceleration while traveling up this grade.

This observed school bus performance can be compared with the "speed loss which equals or exceeds 87.5% of all tractor-trailers and trucks" from the 1994 *Green Book*, Figure III-25(C) *(AASHTO, 1994)*. The *Green Book* figure showed the 12.5 percentile truck was decelerating from 85 to 80 km/h over a 3% grade (between 150 and 300 m of travel), with the speed not leveling out until the truck speed declined to 50 km/h. The small sample of observed school buses maintained speed on a 3% grade much better than the *Green Book* 12.5 percentile design truck did. The speeds of the 50 intercity buses on a 3.0% grade from the previously-mentioned California study *(Ching and Rooney)* were slightly higher than those of the small observed sample at McDonald County.

Stop vs. Run

Figure 17 showed the mean speeds of the stopped school buses compared with those that ran the stop sign. Up to the 300 m station, the school buses that ran the stop sign had higher speeds than the school buses that stopped. However, the average speeds of school buses that stopped were higher than the average speeds of school buses that ran the stop sign at the 400 m and 500 m stations.

The results of the statistical analysis of the stopped and running school buses are shown in Table 6. Since the statistical analysis showed significant differences between the mean speeds of the two groups at the 100 m and the 200 m stations, data from those school buses that ran the stop signs were deleted from the 100 and 200 m station columns during the subsequent "comparison tests".

Figure 18 showed the slowest, 12.5 percentile, and the average school bus speeds for the turning buses on level terrain, along with the passenger car and truck (300 lb/hp) acceleration curves from the 1994 *Green Book (AASHTO, 1994)*. The slope of the average speed plot between the 100 m and 500 m stations is almost a straight line. This again points out the school buses' tendency toward constant acceleration after passing 100 m station. Note that the 12.5 percentile school bus curve was very similar to the truck curve.

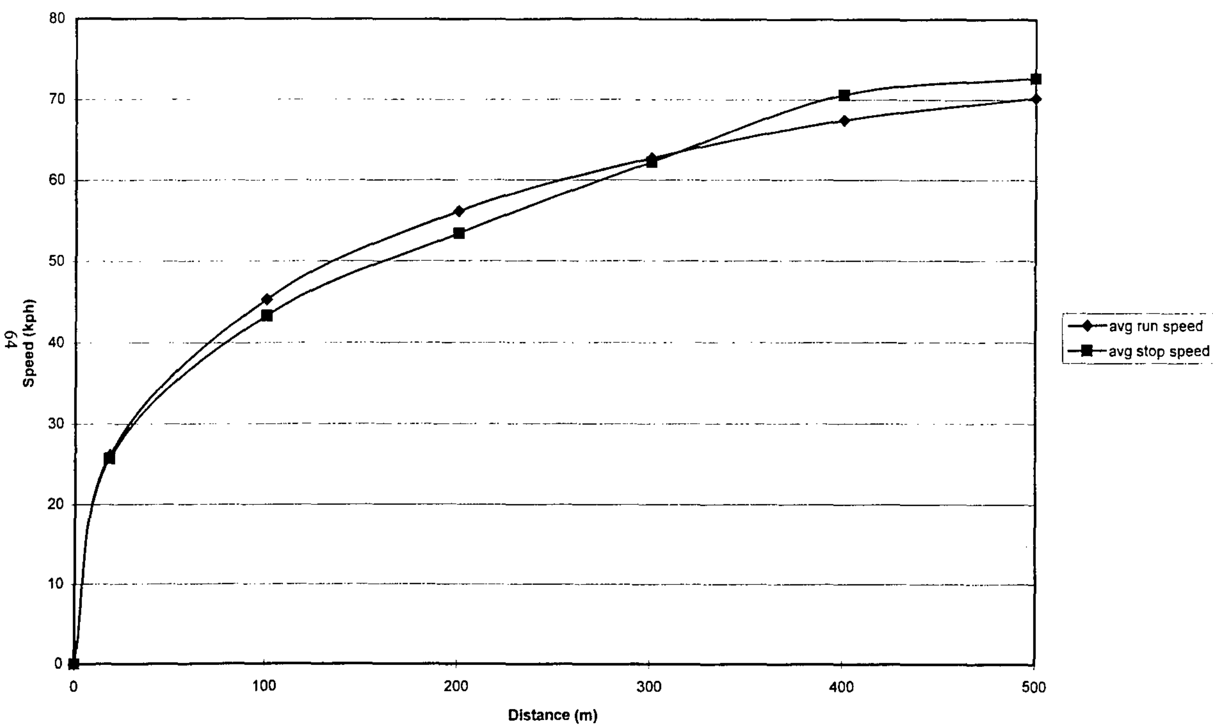


FIGURE 17 Mean Speeds for School Buses Stopping and Running the Stop Sign

TABLE 6 Analysis of Mean Speeds of Buses That Ran the Stop Sign and Those That Stopped

	Mean Speed (km/h)		Standard Deviation				
Distance (m)	Run	Stop	Run	Stop	n	t-stat	t-crit
18	26.1	25.7	3.13	3.36	125	0.59	1.67
100	45.3	43.3	4.54	4.57	82	1.89	1.68
200	56.1	53.4	5.45	5.81	81	2.06	1.68
300	62.7	62.2	8.41	4.87	65	0.26	1.69
400	67.4	70.6	8.94	6.32	27	1.05	1.72
500	70.2	72.7	8.22	6.14	28	0.91	1.71

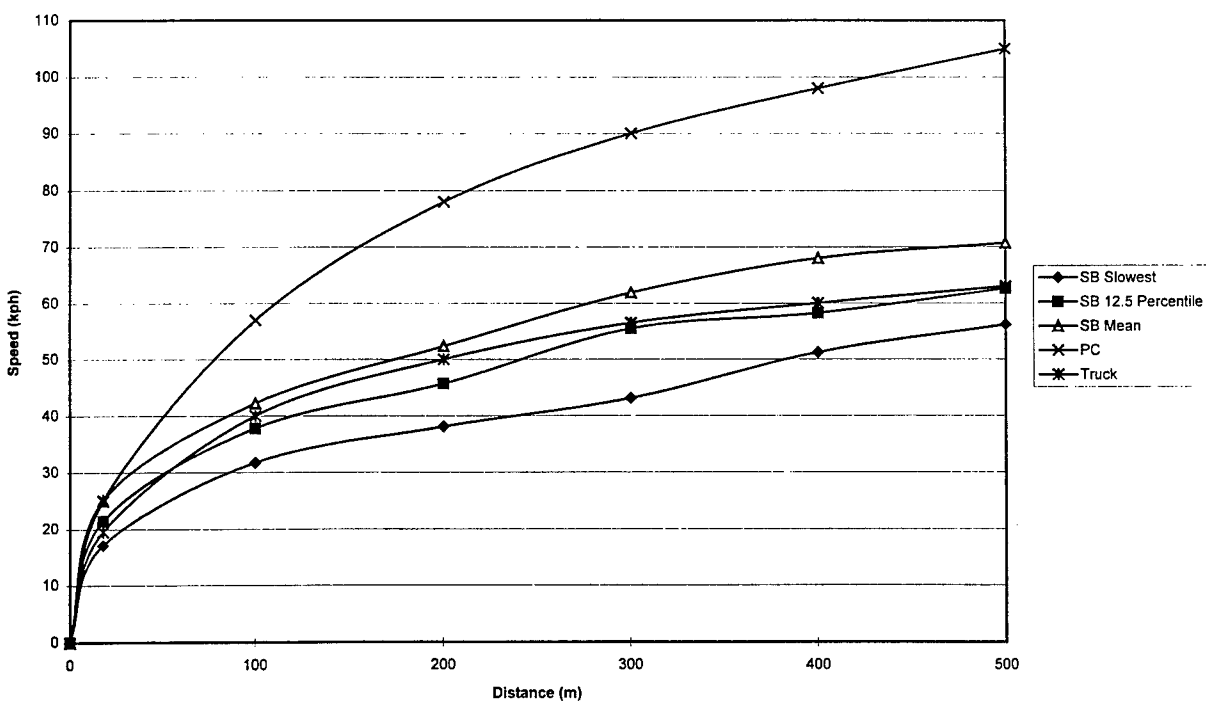


FIGURE 18 School Bus Speeds with PC and Truck Acceleration Curves

Figure 19 was based data in Appendix D under the column heading "Calculated Times from Speeds". The travel times between each pair of successive stations were added to derive the cumulative times for acceleration. Most of the individual times were calculated from data collected during the same day of testing. The travel times between the 200 m and 300 m stations were based on data from different days, since due to the limited number of classifiers that were available for field work, data was collected between the 18 and 200 m stations on different days than the data between the 300 and 500 m.

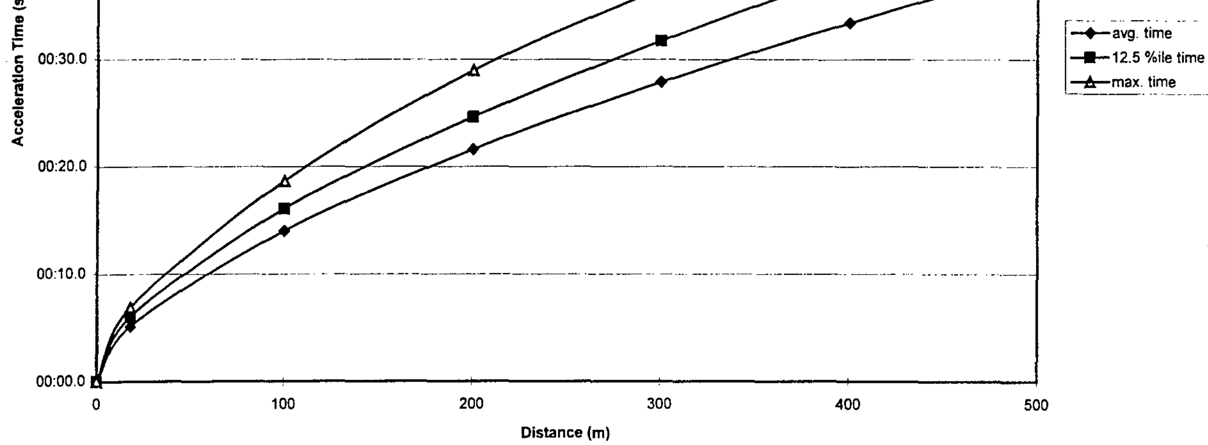


FIGURE 19 School Bus Acceleration Time Against Distance

Comparison Tests

The first statistical test compared the mean speeds of the school buses that ran the stop sign with those that did not. This test was performed first so if any of the test statistic (t-stat) values at the testing stations were found to be significantly different (t-stat > t-critical), then the speeds of school buses that ran the stop sign could be removed from the data at that station before conducting statistical analyses of the weight and power, transmission, and bus engine age.

Weight and Power

Figure 20 showed the mean speeds of those school buses in the top 1/3 and the bottom 1/3 wt/hp ratios. The differences between the mean speeds ranged from 2.3 km/h at the 18 m station to 5.6 km/h at the 200 m station. At every station, the mean speeds of the top 1/3 wt/hp ratio school buses were higher than the speeds of the bottom 1/3 wt/hp ratio school buses. The middle 1/3 wt/hp ratio mean school bus speeds fell between the top and bottom 1/3 wt/hp ratio school bus speeds except at the 300 m station. At the 300 m station, the middle 1/3 wt/hp mean speed was 62.5 km/h, which was lower than the bottom 1/3 wt/hp ratio speed of 63.1 km/h. It is not known why this occurred at this particular station.

The results of the statistical analysis of the mean school bus speeds for the top 1/3 and bottom 1/3 wt/hp ratios are shown in Table 7. The two weight/power groups at the 18 m, 100 m, and 200 m stations were found to have statistically significant differences between their mean speeds, while there were no statistically significant differences at the 300 m station. Data were not analyzed at the 400 and 500 m stations because the sample sizes at these stations were smaller.

Transmission

Figure 21 showed the mean speeds of the buses with standard and automatic transmissions. The differences in the mean speeds ranged from 3.0 km/h at the 18 m station to 4.2 km/h at the 100 m station. At every station, the mean speeds of the automatic transmission school buses were higher than the mean speeds of the standard transmission school buses.

Table 8 presents the comparison by transmission type. Significant differences between the mean speeds of the buses with standard and automatic transmissions were found at the 18 m, 100 m, 200 m, and 300 m stations. Data were not included for the 400 and 500 m stations due to the small sample sizes.

Age

Figure 22 showed the mean speeds of the oldest 1/3 and newest 1/3 school bus engine ages. The differences in the mean speeds ranged from 2.4 km/h at the 18 m station to 6.1 km/h at the 300 m station. At every station, the mean speeds of the newest 1/3 school bus engine ages were higher than the mean speeds of the lowest 1/3 school bus engine ages.

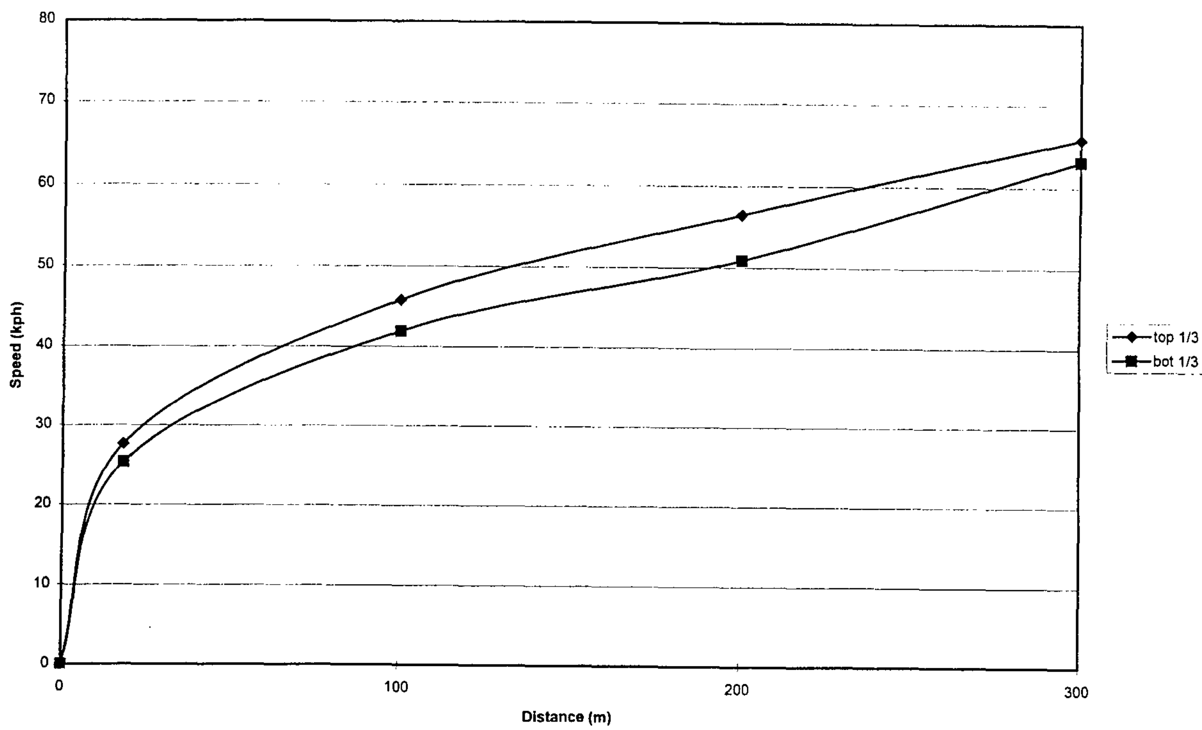


FIGURE 20 Mean School Bus Speeds for Top 1/3 and Bottom 1/3 Weight/Power Ratios

TABLE 7 Analysis of Mean Speeds for Top 1/3 and Bottom 1/3 Weight/Power Ratios

	Mean Speed (kph)		Standard Deviation				
Distance (m)	Top	Bot.	Top	Bot.	n	t-stat	t-crit
18	27.6	25.3	3.2	3.0	68	3.08	1.67
100	45.8	41.9	4.8	4.4	34	2.47	1.69
200	56.5	50.9	6.0	5.4	32	2.06	1.70
300	65.8	63.1	4.7	5.0	34	1.67	1.69

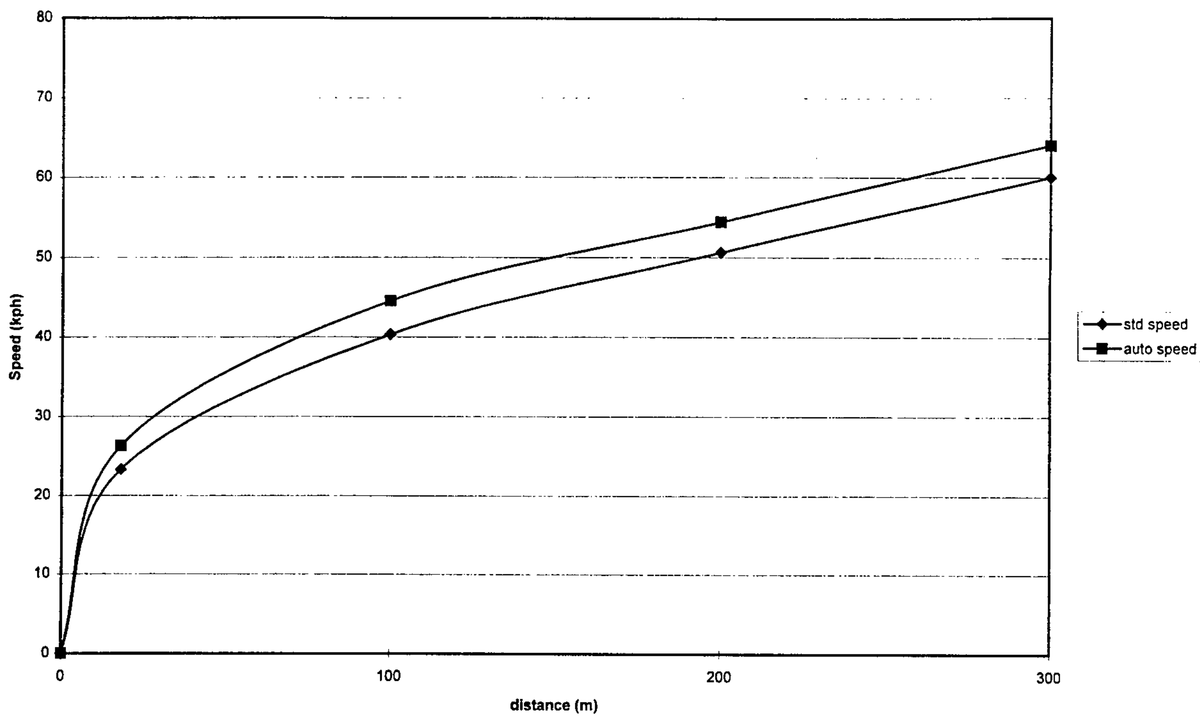


FIGURE 21 Mean School Bus Speeds for Standard and Automatic Transmissions

TABLE 8 Analysis of Mean Speeds for Standard and Automatic Transmissions

	Mean Speed (km/h)		Standard Deviation				
Distance (m)	Std	Auto	Std	Auto	n	t-stat	t-crit
18	23.3	26.3	2.9	3.1	171	6.64	1.65
100	40.3	44.5	3.3	4.5	103	5.33	1.66
200	50.6	54.4	3.8	6.1	102	3.72	1.67
300	60.0	64.0	5.7	6.1	77	2.96	1.67

Table 9 shows the statistical analysis of the mean school bus speeds for the oldest 1/3 and newest 1/3 engine ages. The two age groups at the 18 m, 100 m, 200 m, and 300 m stations were found to have statistically significant differences in the mean school bus speeds. Data from the 400 and 500 m stations were not analyzed because the sample sizes were smaller.

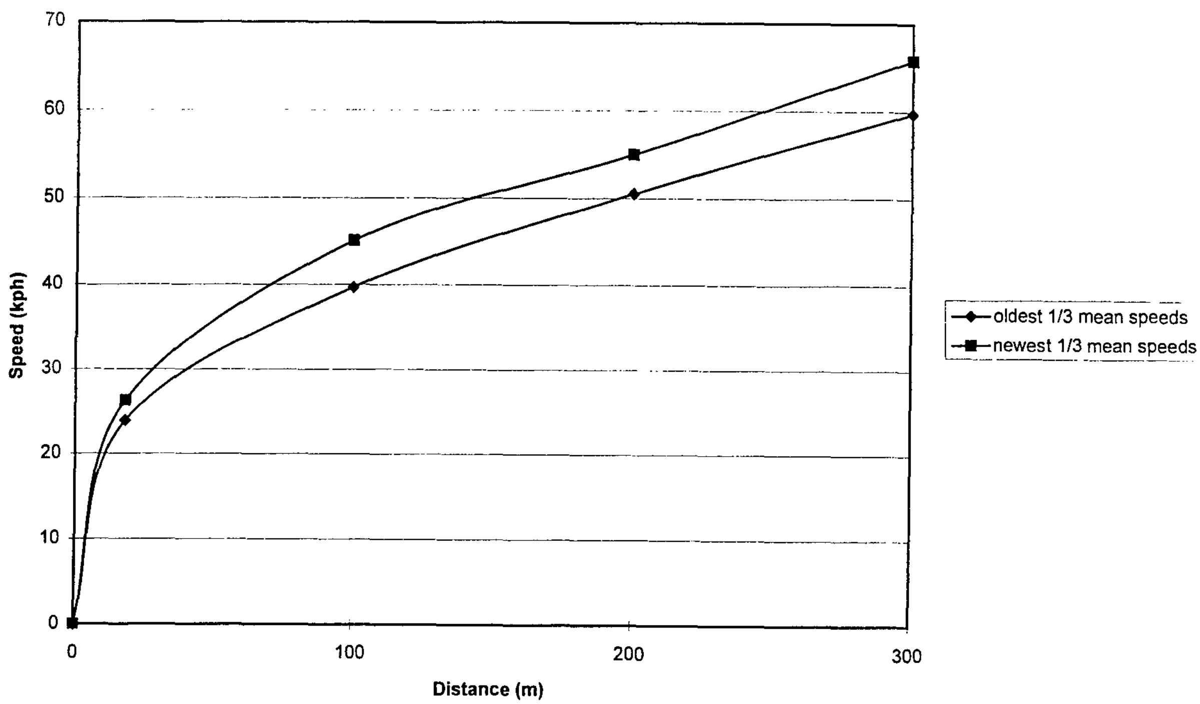


FIGURE 22 Mean School Bus Speeds for the Oldest 1/3 and Newest 1/3 Engines

TABLE 9 Analysis of Mean Speeds of School Buses for the Oldest 1/3 and Newest 1/3 Engines

	Mean Speed (km/h)		Standard Deviation				
Distance (m)	Old	New	Old	New	n	t-stat	t-crit
18	23.9	26.3	2.8	3.1	114	4.28	1.66
100	39.7	45.1	2.9	3.8	68	6.48	1.67
200	50.5	55.0	3.7	5.7	68	3.86	1.67
300	59.7	65.8	5.7	4.8	52	4.21	1.68

12.5 Percentile School Bus Speeds, Distances, and Travel Times

The 12.5 percentile school bus speeds were determined by performing a "bootstrapping" procedure. The procedure consisted of taking one speed out of the sample size "n" (at the particular testing station) and then placing it back into the sample. This was done "n" times to get one iteration. The speeds were averaged to get a mean speed for the iteration. This procedure was repeated 500 times at each testing station to get the 12.5 percentile speeds at each station. Table 10 listed the 12.5 percentile speeds for the mean school bus speeds at common confidence intervals.

TABLE 10 Statistical Analysis of 12.5 Percentile School Bus Speeds

	12.5 Percentile Speed Confidence Interval						
Distance (m)	2.5%	5.0%	10.0%	50.0%	90.0%	95.0%	97.5%
18	21.10	21.14	21.44	22.20	22.91	23.00	23.18
100	37.80	37.80	37.80	38.90	40.20	40.20	40.53
200	45.07	45.10	45.70	46.83	48.40	48.61	48.90
300	54.40	54.40	55.50	56.60	58.10	58.76	59.10
400	56.60	56.60	58.23	65.88	68.89	69.40	70.41
500	59.50	59.50	62.60	67.39	69.80	70.03	70.70

The lower 10% confidence interval speeds were selected for design purposes. The values were analyzed to determine a "best fit curve" that best represented these speed values. With x as distance (m) and y as speed (km/h), the equation generated for this curve was:

$$\ln y = 2.12994 + 0.324306 \ln x \qquad (4\text{-}4)$$

This equation was only valid for distances between 18 and 500 m. Table 11 showed the 12.5 percentile speeds (at the 10% confidence interval) generated from the speed data, the 12.5 percentile speeds (at the 10% confidence interval) calculated from equation 4-4, and the individual and cumulative acceleration times from the speeds calculated from equation 4-4. The school bus speeds and travel times furnished by North Carolina (Table 3) were "quicker" than these 12.5 percentile, 10% confidence interval values in Table 11.

Figure 23 showed the 12.5 percentile speed/time/distance information. These are the school bus acceleration times that should be used for calculating intersection sight distance values.

Figure 24 showed the speed/time/distance curves for the 12.5 percentile school buses compared with the PC, SU, and WB-15 design vehicle curves.

TABLE 11 School Bus 12.5 Percentile Speeds and Acceleration Times

School Bus	Distance (m) 0 m	18 m	100 m	200 m	300 m	400 m	500 m
12.5 %ile Speed @ 10% CI (kph)	0	21.4	37.8	45.7	55.5	58.2	62.6
12.5 %ile Speed per Eq 4-4 (kph)	0	21.5	37.5	46.9	53.5	58.7	63.1
Acceleration Time (sec)		6.0	10.0	8.5	7.2	6.4	5.9
Cumulative Accel. Time (sec)	0	6.0	16.1	24.6	31.8	38.2	44.1

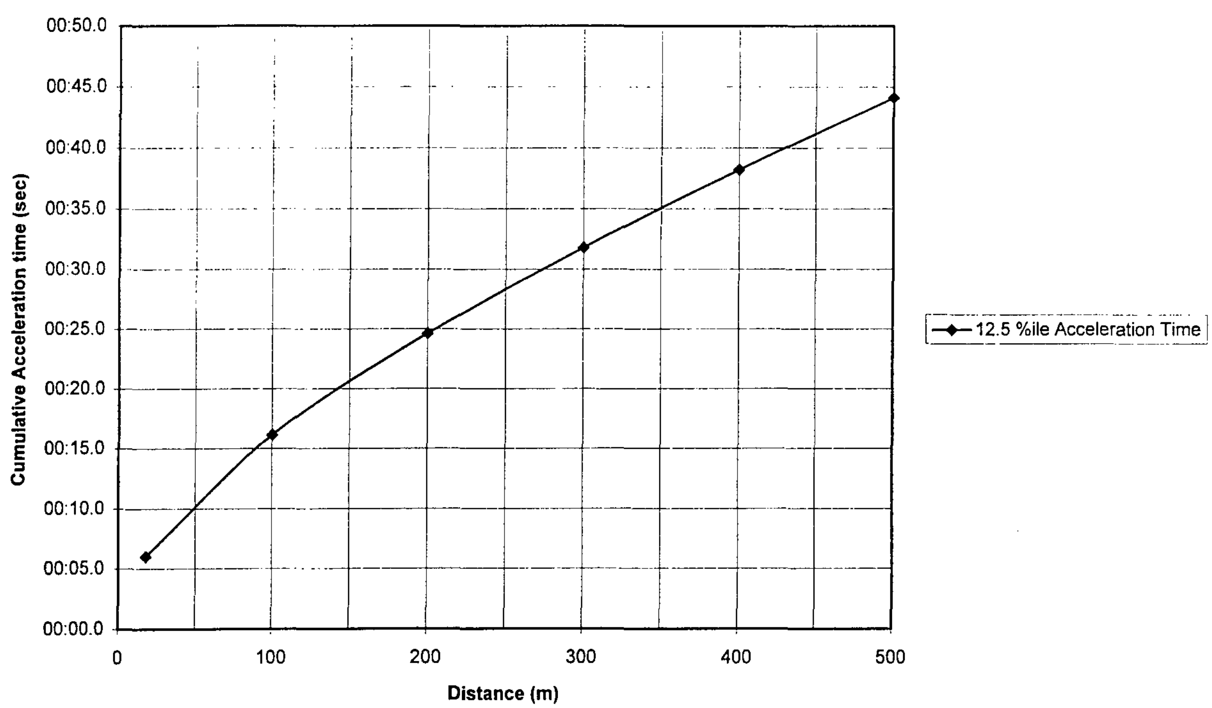


FIGURE 23 Final 12.5 Percentile School Bus Cumulative Acceleration Times

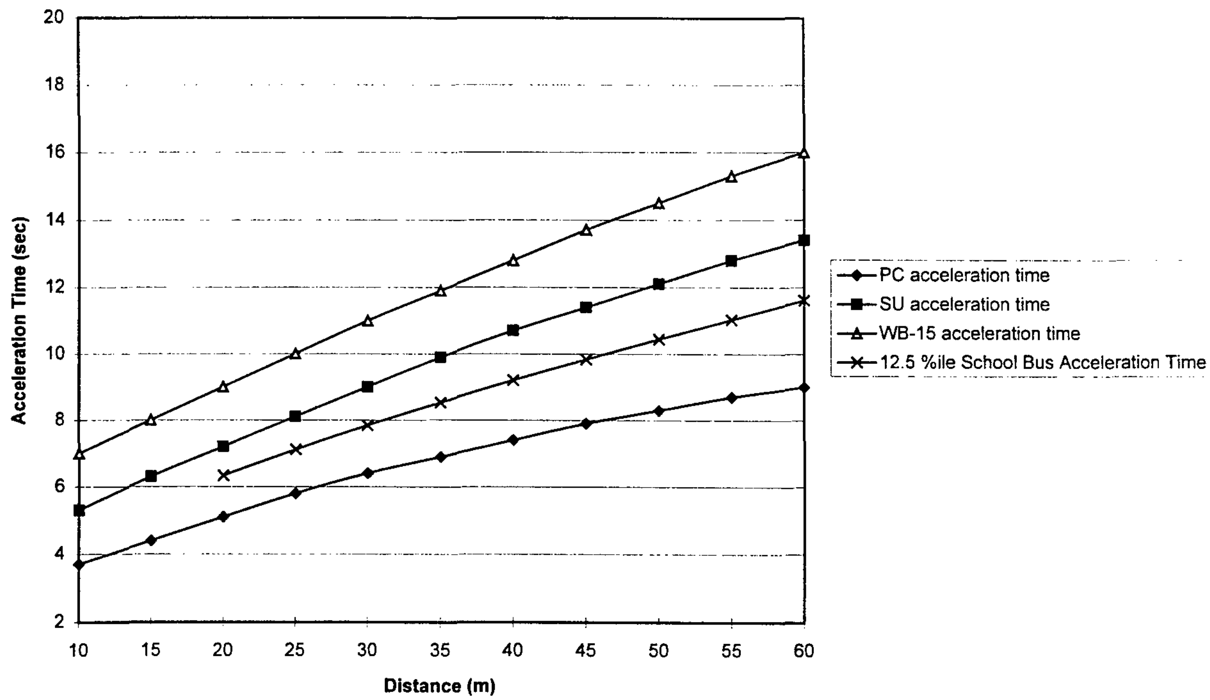


FIGURE 24 Cumulative Acceleration Times for PC, SU, WB-15, and 12.5 Percentile School Bus

A regression analysis was performed to fit a predictive curve between time and distance. With x as distance traveled from a stopped position (meters), the equation

$$y = 0.06\sqrt{x^2 + 612.46x} \qquad (4\text{-}5)$$

predicts y, the elapsed travel time (seconds) from the stopped position. This equation was constructed with data from up to 500 m from the stopped position, and had a R^2=0.99.

APPLYING THESE FINDINGS

The following two example problems illustrate the use of these findings.

Intersection Sight Distance Sample Calculation

Suppose a school bus needs to cross a 30 m wide highway. The speed limit on the highway is 90 km/h. How much intersection sight distance is needed along the highway?

The first step is to find the total distance S. The distance S is the sum of three distances; D, W, and L. In this case, D is assumed to be 3.0 m and L = 12.192 m *(CMSU)*. The given width-of-highway from near side to far edge, 30 m, equals W.

$$S = D + W + L = 3.0 \text{ m} + 30.0 \text{ m} + 12.192 \text{ m} = 45.192 \text{ m}$$

The next step is to find t_a from Figure 23 (using a distance of 45.192 m), which is approximately 9.9 seconds. Alternatively, the time required for the school bus to traverse the distance S could be calculated by means of Equation 4-5.

$$y = 0.06 \sqrt{x^2 + 612.46x}$$

With x = 45.192 m, y = 10.3 sec. The calculated value is slightly larger than the value found by reading the graph.

The last step is to calculate the needed intersection sight distance measured along the through highway. Using Equation 2-1:

$$d = 0.28 \, V (J + t_a) = 0.28 \, (90) \, (2.0 + 10.3) = 311 \text{ m}$$

The needed intersection sight distance for the school bus to cross the entire highway in one maneuver is 311 m.

Example Railroad Crossing Problem

Suppose a school bus has stopped at a railroad crossing. A train is approaching this crossing at 60 km/h. What is the distance up the railroad track for which if the train were any closer, the school bus driver may not see the oncoming train in time to get across (i.e., how much sight distance is needed)?

The length of the school bus, L, is equal to 12.2 m. The value for D, the clearance distance back from the railroad tracks, is assumed to be 4.5 m. The track width, W, of a single-line railroad is assumed to be 1.5 m. The distance traveled by the school bus while crossing the tracks is:

$$d_{SB} = L + 2D + W = 12.2 + 2*4.5 + 1.5 = 22.7 \text{ m}$$

This is analogous to the distance S for crossing the through highway.

Again, use Equation 4-5 to find the time needed by the school bus to travel that distance, 7.2 sec.

$$y = 0.06 \sqrt{x^2 + 612.46x}$$

The distance traveled by the train during this time is:

$$d_T = V_T * (J + t_a) = 60 \text{ kph} * (2.0 \text{ s} + 7.2 \text{ s}) = 16.67 \text{ m/s} * 9.2 \text{ s} = 153 \text{ m}$$

The needed sight distance along the railroad track for this particular situation is 153 m.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

Intersection sight distance is a significant parameter in the geometric design of streets and highways. Intersection sight distance design values are affected by the speed of the vehicle approaching on the through roadway, the side street vehicle's acceleration capability, and the type of maneuver (e.g., crossing, turning left, etc.) that the side street vehicle is performing.

In order to ascertain sight distance needs at intersections and at railroad grade crossings, research was conducted to determine the acceleration characteristics of school buses. Traffic classifiers and road tubes were used at seven testing sites to collect speed, time, and distance data for school buses as they accelerated from a stopped position at a side street or a railroad grade crossing. This data was collected at a distance up to 500 m from the initial stopped position. Most of the tests were conducted on level terrain.

Speed and time data were recorded for type C and type D full-size school buses. The total number of school bus speeds available at each station (Appendix D) were: 171 at 18 m, 129 at 100 m, 127 at 200 m, 77 at 300 m, 35 at 400 m, and 36 at 500 m. The measured speeds ranged between 17.1-33.3 kph at 18 m, 31.7-53.9 kph at 100 m, 38.1-67.6 kph at 200 m, 43.1-72.1 kph at 300 m, 51.2-79.3 kph at 400 m, and 56.2-82.2 kph at 500 m.

A number of analyses were performed. The data were first analyzed for any significant differences between the mean speeds of school buses that had come to a full stop before accelerating with those that ran the stop sign. There were significant differences at the 100 and 200 m stations, so the speed data for those running the stop were removed from the analysis before determining the 12.5 percentile speeds.

The mean school bus speeds for the top 1/3 and the bottom 1/3 weight/power ratios were compared. There were significant differences between the speeds at the 18, 100, and 200 m stations. The 300 m speeds showed no significant differences. Due to the smaller sample sizes, comparisons were not made at the 400 and 500 m stations. At each station, the top 1/3 wt/hp school bus speeds were higher than the bottom 1/3 wt/hp school bus speeds.

The mean speeds were compared for school buses having standard and automatic transmissions. There were significant differences at each of the stations (18-300 m; the 400 m and 500 m sample sizes were smaller). The automatic transmission school bus mean speeds were higher than the standard transmission school bus speeds at each of the testing stations.

The mean speeds of the school buses with the oldest 1/3 and newest 1/3 engines were compared. The speeds of buses with the newest 1/3 of the engines were significantly higher than those with the oldest 1/3 engines at each of the 18 to 300 m testing stations. Due to the smaller sample sizes, comparisons were not made at the 400 and 500 m stations.

The speed data were analyzed to estimate the 12.5 percentile school bus speeds. From these speeds, the lower 10th percentile confidence interval 12.5 percentile speeds were found. Finally, the research produced

1. an equation to estimate school bus speed achieved at a certain distance after accelerating from a stop;
2. a graph to estimate the time it takes a school bus to travel a certain distance after accelerating from a stop; and
3. an equation to estimate the time it takes a school bus to travel a certain distance after accelerating from a stop.

By combining the knowledge of how quickly a school bus can accelerate with assumed speeds of oncoming through street vehicles, the needed intersection sight distance can be calculated. Another application of the findings is analyzing departure sight distance at railroad grade crossings used by school buses.

REFERENCES

AASHTO. *A Policy on Geometric Design of Highways and Streets*. Washington, D. C., 1984

AASHTO. *A Policy on Geometric Design of Highways and Streets*. Washington, D. C., 1994.

Bhesania, Russi P. *Need For Adequate Intersection Sight Distance in Roadway Design*. ITE Journal, Vol. 58, No. 8, August 1988. pp 43-45.

Central Missouri State University. *1995 National Standards For School Buses.* The Twelfth National Conference on School Transportation. Warrensburg, Missouri, 1995. p 19.

Ching, P.Y., and F.D. Rooney. *Truck Speeds on Grades in California*. California DOT, Sacramento, California, June 1979.

Fancher, P.S. *Vehicle Acceleration Characteristics Influencing Highway Design*, Appendix F. NCHRP Report No. 270, 1984, pp 146-169.

Gillespie, Thomas D. *Methods For Predicting Truck Speed Loss On Grades*. Transportation Research Institute, University of Michigan, Ann Arbor, Michigan, November 1985.

U.S. Bureau of the Census. *1977 Census of Transportation.* U.S. Department of Commerce, Washington, D. C., 1977.

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APPENDIX A -- Survey Sent to States

SURVEY OF GEOMETRIC DESIGN INFORMATION FOR "FULL-SIZE" SCHOOL BUSES
please respond with checkmarks or short answers

YES	NO	1. **Do you have any of the following** geometric data for "full-size" school bus design vehicles?
☐	☐	vehicle dimensions (body length, width, overall height, wheelbase, overhang, etc.)
☐	☐	inner and outer turning radius at either crawl or normal turning speeds
☐	☐	acceleration capabilities (time, speed, distance covered) when departing from a stopped position at an intersection, as would be used to determine intersection sight distance
☐	☐	acceleration capabilities (speed, distance vs. grade) for school buses going up grades
☐	☐	school bus braking distances
☐	☐	software to generate school bus vehicle turning paths

If you responded "yes" to software, please tell us the name of the software.

____

____

IF YOU HAVE ANY OF THE ABOVE GEOMETRIC DESIGN DATA FOR SCHOOL BUSES, PLEASE SEND ME A COPY OF IT

2. Do you use attributes (dimensions, turning path) of another design vehicle to "come close to" (i.e., as a surrogate for) an actual school bus?

- ☐ no
- ☐ yes, use AASHTO "Green Book" BUS vehicle when a school bus design vehicle is needed
- ☐ yes, use ... (please state what you use)

____

==

Your name ____________________ Title ______________

Your address ____

Phone number ______________ Fax number ______________

PLEASE MAIL YOUR SURVEY, WITH ANY ENCLOSURES, TO

J. L. Gattis
Mack-Blackwell Transportation Center
4190 Bell Engineering Center
Fayetteville, AR 72701

thank you for your help THE END

APPENDIX B School Bus Information Provided by the School District

District	Bus#	GVW (lb)	Trans	Year	Engine Size	HP Rating
Elkins	12	23,160	std	1980	366 cu in.	190
	8	23,660	std	84	366 cu in.	190
	11	27,800	auto	92		
	1	23,660	auto	81	366 cu in.	190
	4	27,800	auto	90		
Huntsville	15	19,000	std	88	366 cu in.	
	34	22,000	std	88	366 cu in.	
	39	22,000	std	90	366 cu in.	
	44	22,000	auto	90	8.2 L diesel	
	57	22,000	auto	95	175 Cat	175
	30	22,000	std	88	366 v/8 gas	
Greenwood	9	27,000	std	89	370 cu in gas	
	26	33,080	auto	95	230 cu in dsl	
	23	33,080	auto	96	230 cu in dsl	
	1	25,580	auto	89	366 cu in gas	
	2	28,000	auto	89	429 cu in gas	232
	11	26,500	std	87	370 cu in gas	
	22	26,500	std	87	370 cu in gas	
	28	33,080	auto	95	230 cu in dsl	
	29	33,080	auto	96	230 cu in dsl	
	17	25,580	auto	97	366 cu in gas	
	3	27,000	std	89	370 cu in gas	
	21	23,660	std	86	366 cu in gas	
McDnld Co.	45	27,800	auto	92	Cummins Turbo	190
	49	27,800	auto	95	Cummins Turbo	190
	37	27,080	std	89	8.2 L Cummins	150
	46	27,800	auto	94	Cummins Turbo	190
	1	28,000	std	89	8.2 L Cummins	150
	2	22,000	std	90	8.2 L Cummins	150
	41	27,080	std	88	8.2 L Cummins	150
	6	27,080	std	90	8.2 L Cummins	150
	32	27,500	std	91	7.3 L	155
	25	27,500	std	91	7.3 L	155
	51	27,960	auto	96	3116 Cat	185
	43	31,000	auto	93	466 cu in.	190
	3	27,080	std	88	8.2 L Cummins	150
	52	27,960	auto	96	3116 Cat	185
	50	27,800	auto	95	Cummins Turbo	190
	35	32,220	auto	91	Cummins Turbo	190
	27	27,500	std	91	7.3 L	155
	47	27,800	auto	95	Cummins Turbo	190
	48	27,800	auto	95	Cummins Turbo	190
	10	27,080	std	90	8.2 L Cummins	150
Alma	19	36,000	auto	92	3116 Cat	250
	2	34,000	auto	84	3208 Cat	210
	28	36,000	auto	92	3116 Cat	250
	10	34,000	auto	84	3208 Cat	210
	12	36,000	auto	88	3208 Cat	210
	14	36,000	auto	92	3116 Cat	250
	27	34,000	auto	81	3208 Cat	210
	21	36,000	auto	92	3116 Cat	250
	25	36,000	auto	92	3116 Cat	250

	7	34,000	auto	88	3208 Cat	210
	1	34,000	auto	86	3208 Cat	210
	17	34,000	auto	86	3208 Cat	210
	9	36,000	auto	92	3116 Cat	250
	24	36,000	auto	92	3116 Cat	250
	5	34,000	auto	84	3208 Cat	210
	26	24,000	std	79	366 cu in	225
	29	36,000	auto	92	3116 Cat	250
	8	34,000	auto	84	3208 Cat	210
	11	36,000	auto	92	3116 Cat	250
	18	36,000	auto	92	3116 Cat	250
	23	36,000	auto	92	3116 Cat	250
	6	36,000	auto	92	3116 Cat	250
	20	24,000	std	79	350 cu in	175
	15	24,000	std	80	350 cu in	175
Washburn	8	24,500	std	84	366 cu in	190
	11	25,580	std	88	366 cu in	190
	5	27,800	auto	91	6cyl	190
	2	25,000	std	86	366 cu in	190
	6	25,580	std	88	366 cu in	190
	18	29,800	auto	95	DT 466	
	20	29,800	auto	96	DT 466	
Waldron	31	23,960	std	90	366 cu in	190
	12	25,160	std	86	370 cu in	
	14	23,960	std	87	366 cu in	190
	15	28,000	auto	95		190
	47	26,500	auto	92		190
	21	26,500	auto	93		190
	1	23,160	std	83	366 cu in	190
	46	26,500	auto	92		190
	26	23,960	std	89	366 cu in	190
	16	28,000	auto	95		190
	18	26,500	auto	93		190
	9	25,160	std	85	366 cu in	190
	8	25,160	std	85	366 cu in	190
	17	28,960	auto	95		190
	19	26,500	auto	93		190
	29	23,960	std	90	366 cu in	190
	13	23,960	std	87	366 cu in	190
	39	27,060	std	81		165
	27	23,960	std	89	366 cu in	190
	4	25,160	std	84	366 cu in	190
	5	25,160	std	84	366 cu in	190
	30	23,960	std	90	366 cu in	190
	6	25,160	std	90	366 cu in	190
	48	26,500	auto	92		190
	28	23,960	std	89	366 cu in	190
	22	30,000	auto	93		190
	45	30,000	auto	91		190
	40	27,060	std	81		165
	20	23,960	std	87	366 cu in	190
	10	25,160	std	86	366 cu in	190
	44	27,800	auto	91		190

APPENDIX C
Raw Data Collected at Each Testing Site

				18 m					100 m	
	0-18m			Speed 1	time 1				Speed 1	time 1
	Times		Bus #	(km./hr.)					(km./hr.)	
Elkins		S	12	19.8	17:32.2		Elkins	12	42.5	17:42.2
2/17/97		S	8	18.5	18:13.2		2/17/97	8	36.2	18:25.1
15m		S	11	24.9	18:38.2		105.6m	11	49.2	18:46.7
		S	1	18.3	18:48.4			1	38.9	18:59.4
		S	4	22.2	19:07.6			4	38.6	19:18.0
Elkins	5.03	S	12	26.4	17:08.2					
2/18/97	5.08	S	8	23	17:13.9					
18m	5.01	S	11	24.9	17:39.2					
	5.26	S	1	18.8	17:46.8					
	5.55	S	4	21.2	18:05.9					
Elkins		DK								
2/25/97		DK								
		DK								
		DK								
		DK								
Elkins		DK	12	24.5	15:29.3		Elkins	12	38.9	15:37.3
2/27/97		DK	8	25.1	16:10.1		2/27/97	8	43.1	16:18.0
18m		DK	11	26.1	16:37.0		105.60m	11	44.7	16:43.9
		DK	4	22.7	17:05.4			4	38	17:13.5
		DK	1	24.3	17:10.3			1	41.4	17:17.7
Elkins	5.98	S	12	24.5	15:45.7					
3/3/97	4.13	S	8	24.1	15:52.9					
18m	5.2	S	11	23.8	16:00.7					
	4.97	R	4	22	16:07.4					
	6.63	S	1	21.4	16:21.6					
Elkins		DK								
3/4/97		DK								
		DK								
		DK								
		DK								
Huntsville		DK	15	23.8	26:49.0		Huntsville	15	38.1	26:55.3
3/7/97	4.34	S	34	17.9	29:28.2		3/7/97	34	38.1	29:35.2
15m	4.05	S	39	17.4	29:34.3		96m	39	32	29:43.1
	3.86	R	44	23.3	30:16.7			44	43.8	30:22.7
	3.94	R	57	26.7	31:00.3			57	47.2	31:05.4
	4.07	R	30	20	31:49.8			30	39.6	31:57.8
Huntsville	4.37	R	15	25.4	26:24.1			15	41.4	26:34.0
3/10/97	4.08	R	34	20.9	29:00.8			34	47.5	29:11.0
	4.31	R	39	21.4	29:10.8			39	42	29:21.1
	4.76	R	44	25.1	29:55.4			44	46.7	30:05.0
	4.4	R	57	22.7	30:39.4			57	48.3	30:49.2
	4.79	R	30	20.6	31:18.4			30	40.7	31:30.0
Huntsville		DK								
3/11/97		DK								
		DK								
		DK								
		DK								
		DK								
Huntsville		DK								
3/12/97		DK								
		DK								
		DK								
		DK								
		DK								

Huntsville		DK							Huntsville	15	38	24:08.4	
3/31/97		DK							3/31/97	**34	15.4	27:57.1	** #34 drove slow
		DK							96m	**39	23	28:07.5	for no reason and
		DK								44	42	28:46.5	kept #39 from
		DK								57	48.4	29:18.4	accelerating
		DK								30	44.4	29:47.8	
Huntsville		DK							Huntsville	15	43.3	25:55.3	
4/2/97		DK							4/2/97	34	39.9	27:52.4	
		DK							96m	39	37	28:01.8	
		DK								44	47.6	28:34.8	
		DK								57	47.2	29:32.5	
		DK								30	38.5	30:25.8	
Greenwood		DK	9	21.4	09:07.5				Greenwd	9	40.9	09:17.6	
3/17/97		DK	26	24.8	09:23.7				3/17/97	26	44.6	09:32.2	
18m		DK	23	24.8	09:35.5				100m	23	47.8	09:43.8	
		DK	1	24.5	09:44.4					1	46.7	09:53.0	
		DK	2	25.9	09:49.1					2	48.9	09:57.2	
		DK	11	23.3	09:56.6					11	44.3	10:06.0	
		DK	22	22.5	10:40.9					22	41.5	10:50.7	
		DK	28	22.9	10:51.7					28	43.1	11:00.7	
		DK	29	26.1	10:55.6					**29	48.8	11:03.6	<3sec. headway.
		DK	17	23.5	11:11.8					17	45.7	11:20.3	
		DK	3	29.3	11:15.1					3	39.1	11:24.0	
		DK	21	24.9	11:26.7					21	41.8	11:35.5	
Greenwood	4.2	S	9	22.9	08:17.4				Greenwd	9	38.5	08:25.7	
3/19/97	3.86	S	26	24.8	08:23.0				3/19/97	26	43.9	08:29.1	
18m	5.82	S	23	24.8	08:54.4				100m	23	47	09:01.0	
	5.93	S	1	25.7	09:05.9					1	47.3	09:12.3	
	3.61	S	2	26.9	09:10.9					2	48	09:17.2	
	4.91	S	11	22.9	09:17.5					11	38.3	09:25.1	
	5.46	S	22	23.5	09:32.1					22	38.9	09:39.1	
	4.59	R	28	23.8	09:38.4					28	43	09:45.5	
	6.21	S	29	24.5	09:49.7					29	46.2	09:56.4	
	4.02	R	17	28.2	09:53.0					**17	47	09:59.1	<3sec. headway.
	5.33	S	3	22.2	10:08.5					3	36.5	10:16.8	
	4.6	S	21	25.4	10:32.4					21	42.3	10:39.5	
McDnld		R	45	31.5	15:44.3				McDonld	45	50.2	15:51.4	
18m		R	49	27.2	15:48.4				3/20/97	49	50.7	15:55.0	
3/20/97		R	37	25.4	15:52.4				100m	37	46.8	16:00.3	
		R	46	26.2	15:59.5					46	50	16:07.2	
		R	1	25.1	16:02.7					1	44.4	16:11.3	
		R	27	25.7	16:11.1					27	43.3	16:19.0	
		R	**41			**Classifier combined				41	43.6	16:27.2	
		R	6			#41 and #6.				**6	45.7	16:29.0	<3sec. headway
		R	32	25.7	16:34.3					32	45.7	16:42.3	
		R	25	22.5	16:38.3					25	45.4	16:47.1	
		R	51	25.9	16:44.0					51	44.3	16:52.2	
		R	43	30.6	16:47.6					**43	48.3	16:55.2	<3sec. headway
		R	3	24.8	16:56.3					3	43.3	17:05.2	
		R	52	29.6	17:03.9					52	51.2	17:11.1	
		R	50	30.1	17:12.0					50	53.9	17:18.2	
		R	35	26.1	17:19.2					35	48.6	17:27.1	

McDonld		DK											
3/21/97		DK											
		DK											
		DK											
		DK											
		DK											
		DK											
		DK											
		DK											
		DK											
		DK											
		DK											
		DK											
		DK											
		DK											
		DK											
		DK											
McDonld	5.76	S	45	27.4	15:19.2				McDonld	45	48.3	15:24.2	
3/24/97	4.15	S	49	29.3	15:25.7				3/24/97	49	46.8	15:30.2	
18m	5.42	S	37	23	15:32.9				100m	37	48.3	15:39.1	
	4.94	S	46	29.3	15:39.4					46	50.2	15:45.0	
	4.32	S	1	25.6	15:45.5					1	41.4	15:52.4	
	4.41	S	34	30.1	15:52.1					34	47.6	15:57.7	
	4.94	S	27	27.5	15:59.7					27	44.7	16:06.2	
	5.04	S	41	27.2	16:07.5					41	40.2	16:14.1	
	5.28	S	6	23.3	16:15.8					6	43	16:22.2	
	5.24	S	32	24	16:28.3					32	44.3	16:34.7	
	4.53	S	25	27.8	16:35.1					25	45.9	16:41.5	
	5.43	S	51	30.9	16:43.3					51	51	16:48.4	
	4.78	S	43	31.7	16:50.3					43	50	16:55.4	
	4.54	S	3	28	16:57.0					3	45.5	17:03.0	
	6.88	S	52	29.6	17:07.8					52	48.1	17:13.3	
	4.27	S	50	33.3	17:14.2					50	54.1	17:18.2	
	5.7	S	35	30	17:21.8					35	50.2	17:27.3	
McDonld	5.54	S											
4/14/97	6.03	S											
18m	5.89	S											
	5.78	S											
	6.3	S											
	5.83	S											
	5.52	S											
	5.93	S											
	5.37	S											
	4.64	S											
	5.42	S											
	5.9	S											
	5.76	S											
	5.45	S											
	5.4	S											
	5.87	S											

Alma	5.36	S	19	26.6	18:26.4		Alma	19			Did not have time
4/7/97	6.11	S	2	24.1	18:34.6		4/7/97	2			to get this data
18m	4.56	S	28	30.1	18:40.8		100m	28	54.7	18:46.1	
	4.4	S	10	28.6	19:29.5			10	44.1	19:36.5	
	4.86	S	12	29.6	19:41.5			12	49.4	19:48.1	
	5.52	S	14	30.3	19:49.9			14	47.8	19:56.4	
	5.42	S	27	27	28:43.8			27	47.5	28:51.0	
	4.59	S	21	30.3	28:49.5			21	52.6	28:55.2	
	4.93	R	25	29.9	28:53.5			25	54.1	28:59.2	
	5.19	S	7	28.5	29:17.3			7	48.8	29:24.1	
	4.76	R	1	25.9	29:21.5			1	48	29:28.0	
	4.8	R	17	24.8	29:25.3			17	47.2	29:32.0	
	5.46	S	9	24.1	36:59.2			9	48.4	37:06.1	
	6.09	S	24	21.1	37:41.8			24	47.5	37:50.0	
	5.05	S	5	30.3	40:27.9			5	50.2	40:34.6	
	5.86	S	26	24.8	43:08.5			26	40.6	43:16.7	
	6.05	S	29	22.7	43:15.5			29	47.2	43:23.0	
	5.43	S	8	21.6	43:20.4			8	46.5	43:28.5	
	4.63	S	11	22.2	43:23.8			11	49.2	43:31.1	<3 sec. headway
	4.25	R	18	25.7	43:29.0			18	54.6	43:35.7	
	3.48	R	23	33	43:32.3			23	55.8	43:38.2	
Alma	5.8	S	19	27.2	18:45.5		Alma	19	49.7	18:53.1	
4/9/97	5.38	S	6	30.3	18:54.2		4/9/97	6	49.6	19:01.2	
18m	5.22	S	28	28	19:05.8		100m	28	46.8	19:13.0	
	4.54	S	10	28.2	19:14.0			10	49.1	19:22.5	
	4.89	S	12	27.5	19:19.1			12	48.9	19:27.7	
	4.67	R	14	33	19:22.5			14	51.3	19:29.1	<3 sec. headway
	4.91	S	27	25.4	27:47.7			27	43.8	27:57.0	
	5.78	S	21	28.2	28:08.4			21	50.9	28:16.7	
	4.99	S	25	29	28:33.9			25	55.5	28:41.7	
	4.7	S	7	29	28:42.5			7	49.6	28:51.0	
	5.4	S	1	26.4	28:58.7			1	45.2	29:07.7	
	5.25	S	17	22.9	29:06.4			17	46	29:15.9	
	4.23	S	9	30.1	36:12.0			9	47.2	36:19.2	
	5.68	S	24	29	36:40.3			24	50.5	36:48.4	
	4.91	R	15	28	42:07.5			15	45.4	42:15.2	
	5.06	S	26	23	42:39.5			26	40.2	42:49.4	
	6.26	S	29	24.3	42:55.2			29			Classifier missed this.
	4.37	S	20	24.5	42:57.8	<3 sec. headway		20	43.3	43:07.2	
	5.04	R	11	26.4	43:02.2			11	51.2	43:10.5	
	4.78	R	18	26.6	43:06.6			18	51.3	43:14.7	
	5.68	S	23	30.7	43:34.7			23	54.4	43:42.3	
Waldron	6.8	S	31	17.1	25:12.3		Waldron	31	40.6	25:21.8	
4/29/97	6.52	S	12	24.8	25:20.3		4/29/97	12	36.4	25:30.3	
18m	4.09	S	14	25.4	25:28.0		100m	14	39.6	25:36.2	
	5.49	S	15	24.5	25:35.4			15	46	25:43.2	
	5.73	S	47	21.7	25:46.4			47	37.8	25:55.8	
	4.91	S	21	26.2	25:56.8			21	36.2	26:04.9	
	5.37	S	1	23.2	26:21.9			1	41.8	26:31.0	
	5.26	S	46	27.2	26:27.6			46	47.3	26:35.0	
	4.39	S	26	23.3	26:33.6			26	41.7	26:43.0	
	4.67	S	16	23.8	26:41.0			16	41.7	26:49.5	
	5.69	S	18	26.2	26:49.2			18	49.2	26:56.7	
	5.37	S	9	25.1	26:57.6			9	43.8	27:05.0	
	5.72	S	8	18.3	27:07.6			8	38.9	27:17.5	
	5.95	S	17	29.1	27:17.3			17	44.1	27:25.0	
	5.23	S	19	27.2	27:29.2			19	45.4	27:36.0	
	5.54	S	29	25.9	27:35.2			29	44.1	27:43.9	
	4.61	S	13	24.1	27:39.8			13	39.9	27:49.0	
	4.47	R	39	23.2	27:53.1			39	36.5	28:01.1	
	4.51	R	27	27.4	28:07.3			27	45.9	28:15.1	
	5.01	R	4	24.3	28:14.4			4	38	28:23.7	
	4.83	S	5	20.6	28:20.2			5	35.1	28:30.6	
	6.11	S	30	20.8	28:25.9			30	39.6	28:35.8	
	5.2	S	6	20.6	28:35.7			6	38.9	28:45.3	
	5.11	S	48	24.8	28:42.3			48	42.6	28:50.3	
	5.32	S	28	26.2	28:55.4			28	46.2	29:03.9	
	5.94	S	22	21.7	29:03.6			22	40.6	29:12.8	

Waldron			31	17.9	24:38.4	Waldron	31	40.7	24:49.5	
4/30/97			45	18.5	25:03.0	4/30/97	45	31.7	25:16.4	
18m			14	20.6	25:10.5	100m	14	36.4	25:22.3	
			15	22.4	25:19.3		15	41.7	25:29.7	
			28	18.8	25:31.9		28	34.4	25:44.5	
			21	25.1	25:38.8		21	47.2	25:48.4	
			40	17.4	25:50.4		40	34.8	26:02.6	
			20	24.3	25:56.2		20	38.5	26:07.0	
			46	26.1	26:03.0		46	44.6	26:12.6	
			26	21.4	26:20.9		26	36.9	26:32.4	
			16	24.8	26:27.6		16	42	26:37.0	
			18	22.7	26:40.6		18	45.4	26:50.0	
			9	23.2	26:44.7		9	41.8	26:55.1	
			8	21.2	26:51.4		8	37.8	27:02.1	
			17	24.8	27:00.1		17	39.1	27:10.5	
			19	22.7	27:07.9		19	42	27:18.2	
			29	25.4	27:12.2		29	41	27:22.2	
			13	20.3	27:16.6		13	40.6	27:28.0	
			10	23.8	27:48.2		10	42.3	27:59.6	
			39	23.5	27:52.0		39	36	28:02.2	
			27	27.5	28:17.3		27	39.6	28:28.2	
			4	20	28:29.7		4	34.4	28:41.9	
			5	19.3	28:34.8		5	37.5	28:46.8	
			30	19.2	28:44.3		30	34.8	28:56.5	
			6	18.2	28:52.5		6	37	29:04.2	
			48	22.7	29:03.2		48	41.7	29:13.0	
			44	23.5	29:06.6		44	42	29:16.2	
			22	23.3	29:14.3		22	45.2	29:24.3	
Waldron	5.55	S	31							
5/21/97	4.36	S	45							
	5.1	S	14							
	5.73	S	15							
	5.26	S	47							
	5.63	S	21							
	5.7	R	40							
	4.3	S	20							
	4.84	S	46							
	5.27	S	26							
	5.27	S	16							
	4.4	S	18							
	4.73	S	9							
	4.83	R	8							
	5.44	S	17							
	5.68	S	19							
	5.1	R	29							
	5.38	R	13							
	5.47	S	10							
	5.25	S	39							
	5.45	S	27							
	4.8	S	4							
	5.78	S	5							
	6.51	S	30							
	4.71	S	11							
	5.46	S	48							
	4.25	S	44							
	4.48	S	22							
Washburn	6.1	S	8	16.9	17:26.4	Washburn	8	34.1	17:36.3	
5/16/97	6.3	S	11	14.8	17:58.0	5/16/97	11	38.3	18:08.5	
18m	4.5	S	5	29.6	18:10.4	100m	5	48.8	18:16.3	
RR XING	4.2	S	2	26.2	18:20.8		2	45.1	18:27.8	
	4.3	S	6	21.2	18:34.3		6	40.5	18:43.1	
	4	S	18	26.5	18:44.7		18	46.2	18:51.2	
	4.5	S	20	27.2	18:56.2		20			classifier error

*Elkins School Bus Measurements taken at 18 m, 105.60 m, 200 m, 300 m, 400 m, 500 m

Bus # 1 slowed to make a stop, that is why data is missing at the 300m, 400m, and 500m points.

*Huntsville School Bus Measurements taken at 15 m, 96 m, 205 m, 300 m, 385 m, 500 m.

Bus #30 second day data is missing at 300m, 400m, and 500m because bus stopped.

*Greenwood School Bus Measurements taken at 18 m, 100 m, 200 m.

*McDonald County School Bus Measurements taken at 18 m, 100 m, 200 m, 300 m, 400 m, 500 m.

Bus #s 32, 25, 51, 43, 3, 52, 50, and 35 slowed down around 300 m to turn right

*Alma data for 100m and 200m on 4/7/97 and 4/10/97 will be thrown out because the grade may have an influence on the school bus performance

*Waldron bus #4 slowed down to make a turn.

*Washburn data is for school buses stopping on the roadway before crossing RR tracks, ie. straight line acceleration test!

		200 m					300 m		
		Speed 1 (km./hr.)	time 1				Speed 1 (km./hr.)	time 1	
Elkins	12	58.6	17:25.2						
2/18/97	8	53.8	17:32.2						
200m	11	58.9	17:55.0						
	1	48.9	18:07.0						
	**4	47	18:25.0	**Bus slowed to make stop.					
					Elkins	12	58.6	16:19.5	
					2/25/97	8	60.7	16:27.1	
					300m	11	63.7	16:30.7	
						1	54.4	16:40.5	
						**4	33.3	17:09.3	**Bus stopped.
Elkins	12	53.4	15:53.5		Elkins	12	60.4	16:00.8	
3/4/97	8	50.4	16:12.4		3/4/97	8	58.1	16:19.0	
200m	11	48.2	16:20.2		300m	11	56.8	16:28.0	
	4	47.6	16:33.9			4	54.1	16:42.0	
	**1	44.4	16:49.3	**Bus slowed to stop.		**1	34.4	16:59.1	**Bus slowed to stop.
Huntsville	15	45.7	27:07.7						
3/7/97	34	53.3	29:47.0						
205m	39	41.4	29:56.7						
	44	56.6	30:33.7						
	57	60.8	31:16.0						
	30	50.9	32:09.3						
Huntsville	15	52	26:42.8						
3/10/97	34	54.1	29:20.4						
205m	39	51	29:29.2						
	44	58.1	30:12.9						
	57	61.3	30:56.5						
	30	47.2	31:38.7						
					Huntsville	15	63.4	27:01.8	
					3/11/97	34	59.7	29:49.7	
					300m	39	47.5	30:27.0	
						44	70.5	30:39.6	
						57	68.2	31:29.5	
						30	54.4	33:01.9	
					Huntsville	15	59.7	26:24.8	
					3/12/97	34	65.8	28:45.9	
					300m	39	52.3	29:09.9	
						44	50	29:28.8	
						57	67.3	30:40.3	
						**30	40.7	31:33.3	**Bus slowed to stop.

Huntsville	15	47.5	24:17.9		Huntsville	15	55.8	24:25.8	
3/31/97	**34	34.9	28:11.2	** #34 drove slow	3/31/97	**34	46.3	28:21.1	** #34 drove slow
205m	**39	38.6	28:19.7	for no reason and	300m	**39	43.3	28:29.4	for no reason and
	44	46.3	28:54.1	kept #39 from		44	48.4	29:03.5	kept #39 from
	57	61.8	29:25.2	accelerating		57	68.9	29:31.8	accelerating
	30	48.3	29:55.5			**30	39.9	30:04.7	**Slowed to stop.
Huntsville	15	55.5	26:03.1		Huntsville	**15	49.6	26:09.0	**Slowed for no
4/2/97	34	48.9	28:00.8		4/2/97	34	55.2	28:07.4	apparent reason
205m	39	47.8	28:10.9		300m	39	53.4	28:17.7	
	44	56.8	28:41.1			44	57.8	28:48.0	
	57	60.7	29:39.5			57	67.1	29:45.0	
	30	49.7	30:33.0			**30	43.5	30:41.5	**Slowed to stop.
Greenwd	9	49.2	09:26.1						
3/17/97	26	57.5	09:39.7						
200m	23	59.7	09:50.8						
	1	57.1	10:00.1						
	2	59.2	10:04.1						
	11	53.4	10:13.6						
	22	48.8	10:58.8						
	28	55.4	11:08.3						
	**29	56.6	11:10.7	<3sec. headway.					
	17	55.7	11:27.8						
	3	50	11:32.6						
	21	53.9	11:43.4						
Greenwd	9	50	08:35.6						
3/19/97	26	54.4	08:39.1						
200m	23	60.5	09:09.5						
	1	57.9	09:21.1						
	2	58.3	09:25.8						
	11	46.3	09:36.2						
	22	50	09:50.1						
	28	54.6	09:54.8						
	29	58.1	10:05.2						
	**17	57.3	10:08.0	<3sec. headway.					
	3	47.6	10:27.1						
	21	53.4	10:49.0						
McDonld	45	62	15:57.3						
3/20/97	49	64.7	16:01.5						
200m	37	59.1	16:06.7						
	46	62.8	16:13.0						
	1	59.2	16:17.7						
	27	50.2	16:27.1						
	41	55.5	16:34.8						
	**6	55	16:36.2	<3sec. headway					
	32	56.8	16:48.8						
	25	53.8	16:53.7						
	51	54.4	16:58.9						
	**43	54.4	17:01.5	<3sec. headway					
	3	56.2	17:11.7						
	52	59.5	17:17.1						
	50	67.6	17:24.2						
	35	58.6	17:33.0						

McDonld	45	70.3	15:55.7
3/21/97	49	70.8	16:01.0
300m	37	68.6	16:12.3
	46	72.1	16:16.6
	1	68.9	16:25.5
	34	67.4	16:31.4
	27	63.2	16:41.2
	41	63.2	16:50.9
	6	65.3	16:57.0
	32	60.7	17:09.7
	25	61.3	17:19.5
	51	61.8	17:25.5
	43	65.5	17:32.2
	3	64.4	17:40.6
	52	62.8	17:47.8
	50	68.4	17:50.9
	35	55.8	18:02.4

McDonld	45	58.4	15:33.7
3/24/97	49	61.2	15:39.3
200m	37	56.6	15:48.1
	46	61.2	15:53.2
	1	45.7	16:03.0
	34	58.1	16:06.4
	27	52	16:15.7
	41	52	16:24.1
	6	55.2	16:31.7
	32	53.4	16:44.1
	25	52.8	16:51.0
	51	62.1	16:56.8
	43	61.6	17:03.9
	3	58.4	17:11.9
	52	58.3	17:22.2
	50	66.3	17:26.9
	35	61.6	17:35.6

McDonld	45	67.4	15:33.6	
4/14/97	49	70.2	15:40.3	
300m	37	69	15:47.4	
	46	71	15:53.6	
	1	61	16:05.1	
	34	60	16:07.7	<3sec. headway
	27	63.6	16:17.4	
	41	59.2	16:26.9	
	6	67.9	16:30.5	
	32	63.1	16:44.5	
	25	62	16:49.9	
	51	64.5	16:55.1	
	43	71	17:00.8	
	3	64.1	17:08.7	
	52	76.1	17:16.6	
	35	67.1	17:26.5	

Alma	19			Did not
4/7/97	2			have
200m	28			time
	10			to get
	12			this
	14			data
	27	55.7	28:59.0	
	21	60.8	29:03.2	
	25	62.9	29:07.0	
	7	60.7	29:31.9	
	1	59.7	29:36.6	
	17	56.2	29:40.8	
	9	53.8	37:14.4	
	24	49.4	37:58.2	
	5	62	40:42.1	
	26	50.7	43:25.5	
	29	55.2	43:31.1	
	8	57.6	43:36.4	
	11	58.9	43:39.1	<3 sec. headway
	18	59.1	43:42.8	
	23	61.6	43:45.4	<3 sec. headway
Alma	19	57.5	18:59.0	
4/9/97	6	53.3	19:07.6	
200m	28	44.7	19:20.2	
	10	53.9	19:27.7	
	12	56.5	19:32.9	
	14	57.9	19:35.1	
	27	52	28:02.9	
	21	60.5	28:21.6	
	25	71.3	28:45.9	
	7	61	28:55.8	
	1	53.3	29:13.4	
	17	58.6	29:21.2	
	9	48.9	36:26.2	
	24	59.5	36:53.5	
	15	60	42:21.6	
	26	51	42:56.0	
	29	58.3	43:09.2	
	20	59.5	43:12.9	
	11	57.9	43:15.7	<3 sec. headway
	18	58.3	43:19.8	
	23	63.4	43:47.0	
Waldron	31	42	25:30.8	
4/29/97	12	43.5	25:39.6	
200m	14	52	25:45.5	
	15	56.6	25:51.1	
	47	46.2	26:04.9	
	21	44.1	26:14.8	
	1	53.9	26:39.4	
	46	56.8	26:42.7	
	26	51.5	26:51.7	
	16	49.9	26:58.0	
	18	63.1	27:03.7	
	9	51.8	27:14.3	
	8	47.2	27:26.5	
	17	44.7	27:33.6	
	19	48.9	27:45.0	
	29	57.5	27:51.7	
	13	50.1	27:58.0	
	39	50.2	28:11.0	
	27	47.8	28:24.5	
	4	49.2	28:32.6	
	5	45.1	28:40.2	
	30	48.4	28:44.8	
	6	48.3	28:53.9	
	48	49.9	28:58.8	
	28	57.9	29:11.3	
	22	52	29:21.1	

Waldron	31	49.2	24:57.7
4/30/97	45	38.1	25:27.2
200m	14	44.7	25:31.6
	15	51.7	25:37.9
	28	51.5	25:53.5
	21	52.9	25:56.0
	40	47.2	26:11.8
	20	51	26:15.7
	46	49.6	26:20.6
	26	50.5	26:41.3
	16	44.7	26:46.5
	18	55.5	26:58.4
	9	51.7	27:03.7
	8	47.3	27:11.7
	17	49.6	27:19.2
	19	53.4	27:26.5
	29	54.4	27:31.1
	13	48.3	27:36.5
	10	52.1	28:07.9
	39	47.5	28:12.0
	27	49.7	28:37.1
	4	48.8	28:51.0
	5	45.4	28:56.0
	30	44.6	29:05.8
	6	47.3	29:14.0
	48	52.6	29:22.0
	44	51.3	29:25.1
	22	59.1	29:31.8

Waldron	31	59.1	26:48.7	
5/21/97	45	57.3	26:56.8	
300m	14	59.2	27:06.0	
	15	57.9	27:17.9	
	47	66.8	27:22.2	
	21	64.2	27:32.9	
	40	51.6	27:47.5	
	20	67.3	28:00.3	
	46	60.5	28:13.0	
	26	58.7	28:19.9	
	16	55.5	28:51.0	
	18	61.6	28:57.2	
	9	61.5	29:05.9	
	8	57.9	29:08.0	<3sec. headway
	17	62.6	29:18.0	
	19	65.3	29:34.8	
	29	61.6	29:39.7	
	13	57.4	29:47.0	
	10	57.9	29:53.8	
	39	52.6	29:59.7	
	27	54.5	30:31.2	
	4	43.1	30:37.6	*slowed to turn
	5	56.6	30:47.8	
	30	52.8	30:57.4	
	11	53.3	31:08.3	
	48	59.7	31:14.2	
	44	58.7	31:18.3	
	22	65.8	31:23.3	

		400 m							500 m			
		Speed 1	time 1						Speed 1	time 1		
		(km./hr.)							(km./hr.)			
Elkins	**12	52.5	16:26.0	**Bus slowed down,no apparent reason.								
2/25/97	8	68.1	16:32.2									
400m	11	70.7	16:36.2									
	1	59.2	16:47.2									
	**4	37.3	17:40.0	**Bus leaving stop.								
Elkins	12	65.5	16:12.2				Elkins	12	71	16:16.3		
3/3/97	8	66.1	16:19.1				3/3/97	8	73.2	16:23.3		
400m	11	62.8	16:28.8				500m	11	66.8	16:32.3		
	4	58.1	16:37.2					4	61.6	16:42.0		
	**1	36.7	17:19.2	**Bus leaving stop.				**1	47.5	17:26.0	**Bus leaving stop.	
							Elkins	12	69.8	16:10.6		
							3/4/97	8	68.4	16:30.0		
							500m	11	65.7	16:38.5		
								4	64.9	16:53.0		
								**1	46.5	17:36.0	**Bus leaving stop.	
Huntsville	15	65	27:06.2				Huntsville	15	67.6	27:12.8		
3/11/97	34	65.7	29:54.2				3/11/97	34	70.3	30:00.7		
385m	39	51.8	30:32.2				500m	39	56.3	30:41.0		
	44	75.3	30:43.6					44	77.2	30:49.3		
	57	73.7	31:33.7					57	77.7	31:39.4		
	30	55.8	33:07.0					30	58.3	33:14.8		
Huntsville	15	65.3	26:29.2					15	70.5	26:34.1		
3/12/97	34	66.9	28:52.0					34	70.7	28:57.1		
385m	39	56.2	29:14.9					39	59.5	29:18.9		
	44	50.5	29:35.2					44	56.2	29:41.1		
	57	72.4	30:44.2					57	76	30:48.7		
	**30	23.7	32:16.0	**Bus slowed to stop.				30				

McDonld	45	76.6	16:00.0		McDonld	45	78.2	16:04.3	
3/21/97	49	74.4	16:05.6		3/21/97	**49	63.7	16:10.2	Bus slowed to avoid car
400m	37	74.7	16:16.0		500m	37	76.8	16:21.1	turning left in front of hi
	46	79.3	16:21.0			46	82.2	16:24.9	
	1	74.4	16:29.2			1	78.2	16:34.3	
	34	73.9	16:35.2			34	76	16:40.4	
	27	70.5	16:46.0			27	73.4	16:50.7	
	41	69	16:55.1			41	69.8	17:00.6	
	6	73.1	17:01.1			6	76	17:06.2	
	**32	55.5	17:15.3	**Buses 32-35 slowed		**32	30.9	17:22.7	**Buses 32-35 slowed
	**25	60.5	17:24.1	down to turn right.		**25	37.2	17:31.3	down to turn right.
	**51	57.1	17:31.2			**51	34.8	17:37.9	
	**43	61.3	17:37.4			**43	28.3	17:44.3	
	**3	65.8	17:45.7			**3	39.1	17:51.6	
	**52	59.9	17:53.0			**52	35.7	17:59.7	
	**50	57	17:55.0			**50	27.5	18:03.6	
	**35	56.2	18:08.2			**35	29.8	18:15.9	
McDonld	45	71.8	15:38.0		McDonld	45	76.1		
4/14/97	49	72.7	15:45.3		4/14/97	49	73.4		
400m	37	74	15:52.4		500m	37	77.2		
	46	77.6	15:58.4			46	81.8		
	1	66.5	16:10.0			1	67.4		
	34	66.6	16:13.2			34	69.5		
	27	68.2	16:22.0			27	71.6		
	41	62.6	16:32.9			41	63.1		
	6	70.5	16:35.9	<3sec. headway		6	72.4		
	**32	57.9	16:50.1			**32			
	**25	63.9	16:55.5			**25			
	**51	57.9	17:01.0			**51			
	**43	68.1	17:05.2			**43			
	**3	64.1	17:14.2			**3			
	**50	68.2	17:21.4			**50			
	**35	65.5	17:31.0			**35			
Waldron	31	63.6	26:55.9						
5/21/97	45	58.1	27:04.3						
400m	14	62.9	27:13.1						
	15	54.1	27:25.6						
	47	64.4	27:28.9						
	21	64.5	27:39.7						
	40	54.1	27:55.5						
	20	67.6	28:06.7						
	46	52.3	28:20.6						
	26	61.5	28:27.1						
	16	44.4	28:59.1						
	18	57.1	29:04.6						
	9	61.6	29:13.1						
	8	59.5	29:15.3	<3sec. headway					
	17	61.9	29:25.0						
	19	67.9	29:41.4						
	29	65.2	29:46.6						
	13	59.2	29:54.4						
	10	56.5	30:01.4						
	39	55.3	30:07.6						
	27	52.6	30:39.0						
	4			*slowed to turn					
	5	60.3	30:55.2						
	30	56.2	31:05.3						
	11	55.8	31:16.1						
	48	55.7	31:21.7						
	44	61.3	31:25.4						
	22	65.2	31:30.1						

APPENDIX D

Most Complete Data Including the Information Provided by School Districts

BUS #	BUS ENGINE AGE	STD/ AUTO trans	bus wt (lbs)	student wt. (lbs)	Total Bus Weight (bus + stu. wt.) (lbs)	hP	WT/H	TIME 0-18 m 0-18m Times		Bus #	Raw Data at 18 m (km/hr)	REAL SPEED at 18 m (km/hr)	TIME 18-100 m CALC FROM SPEED		Bus #	Raw Data at 100 m (km/hr)	REAL SPEED at 100 m (km/hr)
E12	1980	std	23.160	7,710	30,870	190	162.5	5.98	Elkins	E12	24.5	24.5	00:09.4	Elkins	E12	38.9	38.1
E8	1984	std	23,660	8,070	31,730	190	167.0	4.13	2/27/97	E8	25.1	25.1	00:08.8	2/27/97	E8	43.1	41.9
E11	1992	auto	27,800	8.910	36,710			5.2	18m	E11	26.1	26.1	00:08.5	105.60m	E11	44.7	43.5
E4	1990	auto	27.800	9,750	37,550			4.97		E4	22.7	22.7	00:09.9		E4	38	37
E1	1981	auto	23.660	8.550	32,210	190	169.5	6.63		E1	24.3	24.3	00:09.1		E1	41.4	40.3
E12	1980	std	23,160	7,710	30,870	190	162.5		Elkins	E12	24.5	24.5		Elkins	E12	42.5	41.3
E8	1984	std	23,660	8,070	31,730	190	167.0		3/3/97	E8	24.1	24.1		2/17/97	E8	36.2	35.4
E11	1992	auto	27,800	8,910	36,710				18m	E11	23.8	23.8		105.6m	E11	49.2	47.6
E4	1990	auto	27,800	9,750	37,550					E4	22	22			E4	38.6	37.5
E1	1981	auto	23.660	8,550	32,210	190	169.5			E1	21.4	21.4			E1	38.9	37.8
H15	1988	std	19.000	3,750	22,750			5.24	Huntsvill	H15	25.4	26	00:08.7	Huntsville	H15	41.4	41.8
H34	1988	std	22.000	3,990	25,990			4.9	3/10/97	H34	20.9	21.9	00:08.5	3/10/97	H34	47.5	47.7
H39	1990	std	22.000	3,390	25,390			5.17	15m	H39	21.4	22.2	00:09.2	96m	H39	42	42.3
H44	1990	auto	22,000	3,630	25,630			5.71		H44	25.1	25.9	00:08.1		H44	46.7	47.1
H57	1995	auto	22.000	5,070	27,070	175	154.7	5.28		H57	22.7	23.6	00:08.2		H57	48.3	48.8
H30	1988	std	22.000	5,550	27,550			5.75		H30	20.6	21.3	00:09.5		H30	40.7	40.9
H15	1988	std	19,000	3,750	22,750				Huntsvill	H15	23.8	24.5		Huntsville	H15	43.3	43.7
H34	1988	std	22,000	3,990	25,990			5.21	3/7/97	H34	17.9	18.7		4/2/97	H34	39.9	40.2
H39	1990	std	22.000	3,390	25,390			4.86	15m	H39	17.4	18.1		96m	H39	37	37.4
H44	1990	auto	22,000	3,630	25,630			4.63		H44	23.3	24.2			H44	47.6	47.9
H57	1995	auto	22,000	5,070	27,070	175	154.7	4.73		H57	26.7	27.5			H57	47.2	47.7
H30	1988	std	22,000	5,550	27,550			4.88		H30	20	20.7			H30	38.5	38.9
G9	1989	std	27,000	6,150	33,150				Greenwo	G9	21.4	21.4	00:09.5	Greenwd	G9	40.9	40.9
G26	1995	auto	33,080	7,950	41,030				3/17/97	G26	24.8	24.8	00:08.5	3/17/97	G26	44.6	44.6
G23	1996	auto	33.080	7,950	41,030				18m	G23	24.8	24.8	00:08.1	100m	G23	47.8	47.8
G1	1989	auto	25,580	6,150	31,730					G1	24.5	24.5	00:08.3		G1	46.7	46.7
G2	1989	auto	28.000	5,550	33,550	232	144.6			G2	25.9	25.9	00:07.9		G2	48.9	48.9
G11	1987	std	26,500	6,150	32,650					G11	23.3	23.3	00:08.7		G11	44.3	44.3
G22	1987	std	26,500	6,750	33,250					G22	22.5	22.5	00:09.2		G22	41.5	41.5
G28	1995	auto	33.080	8,550	41,630					G28	22.9	22.9	00:08.9		G28	43.1	43.1
G17	1997	auto	25,580	6,150	31,730					G17	23.5	23.5	00:08.5		G17	45.7	45.7
G3	1989	std	27.000	6,150	33,150					G3	29.3	29.3	00:08.6		G3	39.1	39.1
G21	1986	std	23.660	6,150	29,810					G21	24.9	24.9	00:08.9		G21	41.8	41.8
G9	1989	std	27,000	6.150	33,150			4.2	Greenwo	G9	22.9	22.9	00:09.6	Greenwd	G9	38.5	38.5
G26	1995	auto	33.080	7,950	41,030			3.86	3/19/97	G26	24.8	24.8	00:08.6	3/19/97	G26	43.9	43.9
G23	1996	auto	33,080	7,950	41,030			5.82	18m	G23	24.8	24.8	00:08.2	100m	G23	47	47
G1	1989	auto	25.580	6,150	31,730			5.93		G1	25.7	25.7	00:08.1		G1	47.3	47.3
G2	1989	auto	28.000	5,550	33,550	232	144.6	3.61		G2	26.9	26.9	00:07.9		G2	48	48
G11	1987	std	26,500	6,150	32,650			4.91		G11	22.9	22.9	00:09.6		G11	38.3	38.3
G22	1987	std	26.500	6,750	33,250			5.46		G22	23.5	23.5	00:09.5		G22	38.9	38.9
G28	1995	auto	33,080	8,550	41,630			4.59		G28	23.8	23.8	00:08.8		G28	43	43
G29	1996	auto	33,080	7,950	41,030			6.21		G29	24.5	24.5	00:08.4		G29	46.2	46.2
G3	1989	auto	25,580	6,150	31,730			5.33		G3	22.2	22.2	00:10.1		G3	36.5	36.5
G21	1986	std	27,000	6,150	33,150			4.6		G21	25.4	25.4	00:08.7		G21	42.3	42.3
M45	1992	auto	27,800	1,950	29,750	190	156.6		McDnld	M45	31.5	31.5	00:07.2	McDonld	M45	50.2	50.2
M49	1995	auto	27,800	3,030	30,830	190	162.3		18m	M49	27.2	27.2	00:07.6	3/20/97	M49	50.7	50.7
M37	1989	std	27.080	1,350	28,430	150	189.5		3/20/97	M37	25.4	25.4	00:08.2	100m	M37	46.8	46.8
M46	1994	auto	27,800	3,750	31,550	190	166.1			M46	26.2	26.2	00:07.7		M46	50	50
M1	1989	std	28.000	3,750	31,750	150	211.7			M1	25.1	25.1	00:08.5		M1	44.4	44.4
M34	1991	auto	32,220	1,830	34,050	190	179.2			M34					M34		
M27	1991	std	27,500	1,590	29,090	155	187.7			M27	25.7	25.7	00:08.6		M27	43.3	43.3
M41	1988	std	27,080	750	27,830	150	185.5			M41					M41	43.6	43.6
M6	1990	std	27.080	1,350	28,430	150	189.5			M6					M6		
M32	1991	std	27,500	2,310	29,810	155	192.3			M32	25.7	25.7	00:08.3		M32	45.7	45.7
M25	1991	std	27,500	2,190	29,690	155	191.5			M25	22.5	22.5	00:08.7		M25	45.4	45.4
M51	1996	auto	27.960	1,350	29,310	185	158.4			M51	25.9	25.9	00:08.4		M51	44.3	44.3
M43	1993	auto	31,000	1,590	32,590	190	171.5			M43	30.6	30.6			M43		
M3	1988	std	27,080	1,830	28,910	150	192.7			M3	24.8	24.8	00:08.7		M3	43.3	43.3
M52	1996	auto	27.960	1,110	29,070	185	157.1			M52	29.6	29.6	00:07.3		M52	51.2	51.2
M50	1995	auto	27,800	1,350	29,150	190	153.4			M50	30.1	30.1	00:07.0		M50	53.9	53.9
M35	1991	auto	32.220	1,590	33,810	190	177.9			M35	26.1	26.1	00:07.9		M35	48.6	48.6
M45	1992	auto	27,800	1,950	29,750	190	156.6	5.76	McDonld	M45	27.4	27.4	00:07.8	McDonld	M45	48.3	48.3
M49	1995	auto	27,800	3,030	30,830	190	162.3	4.15	3/24/97	M49	29.3	29.3	00:07.8	3/24/97	M49	46.8	46.8
M37	1989	std	27,080	1,350	28,430	150	189.5	5.42	18m	M37	23	23	00:08.3	100m	M37	48.3	48.3
M46	1994	auto	27,800	3,750	31,550	190	166.1	4.94		M46	29.3	29.3	00:07.4		M46	50.2	50.2
M1	1989	std	28,000	3,750	31,750	150	211.7	4.32		M1	25.6	25.6	00:08.8		M1	41.4	41.4
M34	1991	auto	32,220	1,830	34,050	190	179.2	4.41		M34	30.1	30.1	00:07.6		M34	47.6	47.6
M27	1991	std	27,500	1,590	29,090	155	187.7	4.94		M27	27.5	27.5	00:08.2		M27	44.7	44.7
M41	1988	std	27,080	750	27,830	150	185.5	5.04		M41	27.2	27.2	00:08.8		M41	40.2	40.2
M6	1990	std	27.080	1,350	28,430	150	189.5	5.28		M6	23.3	23.3	00:08.9		M6	43	43
M32	1991	std	27,500	2,310	29,810	155	192.3	5.24		M32	24	24	00:08.6		M32	44.3	44.3
M25	1991	std	27,500	2,190	29,690	155	191.5	4.53		M25	27.8	27.8	00:08.0		M25	45.9	45.9
M51	1996	auto	27,960	1,350	29.310	185	158.4	5.43		M51	30.9	30.9	00:07.2		M51	51	51
M43	1993	auto	31,000	1,590	32,590	190	171.5	4.78		M43	31.7	31.7	00:07.2		M43	50	50
M3	1988	std	27,080	1,830	28,910	150	192.7	4.54		M3	28	28	00:08.0		M3	45.5	45.5
M52	1996	auto	27,960	1,110	29,070	185	157.1	6.88		M52	29.6	29.6	00:07.6		M52	48.1	48.1
M50	1995	auto	27,800	1,350	29,150	190	153.4	4.27		M50	33.3	33.3	00:06.8		M50	54.1	54.1
M35	1991	auto	32.220	1,590	33,810	190	177.9	5.7		M35	30	30	00:07.4		M35	50.2	50.2

A19	1992	auto	36,000	2,550	38,550	250	154.2	5.8	Alma	A19	27.2	27.2			Alma	A19		
A6	1992	auto	36,000	2,550	38,550	250	154.2	5.38	4/9/97	A6	30.3	30.3			4/9/97	A6		
A28	1992	auto	36,000	3,030	39,030	250	156.1	5.22	18m	A28	28	28			100m	A28		
A10	1984	auto	34,000	2,550	36,550	210	174.0	4.54		A10	28.2	28.2				A10		
A12	1988	auto	36,000	6,150	42,150	210	200.7	4.89		A12	27.5	27.5				A12		
A14	1992	auto	36,000	1,950	37,950	250	151.8	4.67		A14	33	33				A14		
A27	1981	auto	34,000	1,350	35,350	210	168.3	4.91		A27	25.4	25.4				A27		
A21	1992	auto	36,000	1,590	37,590	250	150.4	5.78		A21	28.2	28.2				A21		
A25	1992	auto	36,000	1,590	37,590	250	150.4	4.99		A25	29	29				A25		
A7	1988	auto	34,000	1,950	35,950	210	171.2	4.7		A7	29	29				A7		
A1	1986	auto	34,000	3,150	37,150	210	176.9	5.4		A1	26.4	26.4				A1		
A17	1986	auto	34,000	2,550	36,550	210	174.0	5.25		A17	22.9	22.9				A17		
A9	1992	auto	36,000	1,110	37,110	250	148.4	4.23		A9	30.1	30.1				A9		
A24	1992	auto	36,000	1,950	37,950	250	151.8	5.68		A24	29	29				A24		
A15	1980	std	24,000					4.91		A15	28	28				A15		
A26	1979	std	24,000	870	24,870	225	110.5	5.06		A26	23	23				A26		
A29	1992	auto	36,000	1,950	37,950	250	151.8	6.26		A29	24.3	24.3				A29		
A20	1979	std	24,000					4.37		A20	24.5	24.5				A20		
A11	1992	auto	36,000	2,310	38,310	250	153.2	5.04		A11	26.4	26.4				A11		
A18	1992	auto	36,000	1,950	37,950	250	151.8	4.78		A18	26.6	26.6				A18		
A23	1992	auto	36,000	1,950	37,950	250	151.8	5.68		A23	30.7	30.7				A23		
A19	1992	auto	36,000	2,550	38,550	250	154.2	5.36	Alma	A19	26.6	26.6			Alma	A19		
A2	1984	auto	34,000					6.11	4/7/97	A2	24.1	24.1			4/7/97	A2		
A28	1992	auto	36,000	3,030	39,030	250	156.1	4.56	18m	A28	30.1	30.1			100m	A28		
A10	1984	auto	34,000	2,550	36,550	210	174.0	4.4		A10	28.6	28.6				A10		
A12	1988	auto	36,000	6,150	42,150	210	200.7	4.86		A12	29.6	29.6				A12		
A14	1992	auto	36,000	1,950	37,950	250	151.8	5.52		A14	30.3	30.3				A14		
A27	1981	auto	34,000	1,350	35,350	210	168.3	5.42		A27	27	27				A27		
A21	1992	auto	36,000	1,590	37,590	250	150.4	4.59		A21	30.3	30.3				A21		
A25	1992	auto	36,000	1,590	37,590	250	150.4	4.93		A25	29.9	29.9				A25		
A7	1988	auto	34,000	1,950	35,950	210	171.2	5.19		A7	28.5	28.5				A7		
A1	1986	auto	34,000	3,150	37,150	210	176.9	4.76		A1	25.9	25.9				A1		
A17	1986	auto	34,000	2,550	36,550	210	174.0	4.8		A17	24.8	24.8				A17		
A9	1992	auto	36,000	1,110	37,110	250	148.4	5.46		A9	24.1	24.1				A9		
A24	1992	auto	36,000	1,950	37,950	250	151.8	6.09		A24	21.1	21.1				A24		
A5	1984	auto	34,000	2,910	36,910	210	175.8	5.05		A5	30.3	30.3				A5		
A26	1979	std	24,000	870	24,870	225	110.5	5.86		A26	24.8	24.8				A26		
A29	1992	auto	36,000	1,950	37,950	250	151.8	6.05		A29	22.7	22.7				A29		
A8	1984	auto	34,000					5.43		A8	21.6	21.6				A8		
A11	1992	auto	36,000	2,310	38,310	250	153.2	4.63		A11	22.2	22.2				A11		
A18	1992	auto	36,000	1,950	37,950	250	151.8	4.25		A18	25.7	25.7				A18		
A23	1992	auto	36,000	1,950	37,950	250	151.8	3.48		A23	33	33				A23		
W31	1990	std	23,960	6,150	30,110			6.8	Waldron	W31	17.1	17.1	00:10.2		Waldron	W31	40.6	40.6
W12	1986	std	25,160					6.52	4/29/97	W12	24.8	24.8	00:09.6		4/29/97	W12	36.4	36.4
W14	1987	std	23,960	6,150	30,110			4.09	18m	W14	25.4	25.4	00:09.1		100m	W14	39.6	39.6
W15	1995	auto	28,000	3,510	31,510	190	165.8	5.49		W15	24.5	24.5	00:08.4			W15	46	46
W47	1992	auto	26,500	3,990	30,490	190	160.5	5.73		W47	21.7	21.7	00:09.9			W47	37.8	37.8
W21	1993	auto	26,500	3,990	30,490	190	160.5	4.91		W21	26.2	26.2	00:09.5			W21	36.2	36.2
W1	1983	std	23,160					5.37		W1	23.2	23.2	00:09.1			W1	41.8	41.8
W46	1992	auto	26,500	2,670	29,170	190	153.5	5.26		W46	27.2	27.2	00:07.9			W46	47.3	47.3
W26	1989	std	23,960	4,830	28,790			4.39		W26	23.3	23.3	00:09.1			W26	41.7	41.7
W16	1995	auto	28,000	5,790	33,790	190	177.8	4.67		W16	23.8	23.8	00:09.0			W16	41.7	41.7
W18	1993	auto	26,500	4,710	31,210	190	164.3	5.69		W18	26.2	26.2	00:07.8			W18	49.2	49.2
W9	1985	std	25,160	4,950	30,110			5.37		W9	25.1	25.1	00:08.6			W9	43.8	43.8
W8	1985	std	25,160	5,070	30,230			5.72		W8	18.3	18.3	00:10.3			W8	38.9	38.9
W17	1995	auto	28,960	7,230	36,190	190	190.5	5.95		W17	29.1	29.1	00:08.1			W17	44.1	44.1
W19	1993	auto	26,500	6,270	32,770	190	172.5	5.23		W19	27.2	27.2	00:08.1			W19	45.4	45.4
W29	1990	std	23,960	6,750	30,710			5.54		W29	25.9	25.9	00:08.4			W29	44.1	44.1
W13	1987	std	23,960	4,950	28,910			4.61		W13	24.1	24.1	00:09.2			W13	39.9	39.9
W39	1981	std	27,060	4,830	31,890	165	193.3	4.47		W39	23.2	23.2	00:09.9			W39	36.5	36.5
W27	1989	std	23,960	3,270	27,230			4.51		W27	27.4	27.4	00:08.1			W27	45.9	45.9
W4	1984	std	25,160	5,550	30,710			5.01		W4	24.3	24.3	00:09.5			W4	38	38
W5	1984	std	25,160	6,870	32,030			4.83		W5	20.6	20.6	00:10.6			W5	35.1	35.1
W30	1990	std	23,960	6,510	30,470			6.11		W30	20.8	20.8	00:09.8			W30	39.6	39.6
W6	1990	std	25,160					5.2		W6	20.6	20.6	00:09.9			W6	38.9	38.9
W48	1992	auto	26,500	6,150	32,650	190	171.8	5.11		W48	24.8	24.8	00:08.8			W48	42.6	42.6
W28	1989	std	23,960					5.32		W28	26.2	26.2	00:08.2			W28	46.2	46.2
W22	1993	auto	30,000	6,150	36,150	190	190.3	5.94		W22	21.7	21.7	00:09.5			W22	40.6	40.6

W31	1990	std	23.960	6.150	30,110			5.55	Waldron	W31	17.9	17.9	00:10.1		Waldron	W31	40.7	40.7
W45	1991	auto	30,000	5,430	35,430	190	186.5	4.36	4/30/97	W45	18.5	18.5	00:11.8		4/30/97	W45	31.7	31.7
W14	1987	std	23,960	6,150	30,110			5.1	18m	W14	20.6	20.6	00:10.4		100m	W14	36.4	36.4
W15	1995	auto	28.000	3,510	31,510	190	165.8	5.73		W15	22.4	22.4	00:09.2			W15	41.7	41.7
W28	1989	std	23.960							W28	18.8	18.8	00:11.1			W28	34.4	34.4
W21	1993	auto	26.500	3,990	30,490	190	160.5	5.63		W21	25.1	25.1	00:08.2			W21	47.2	47.2
W40	1981	std	27,060	7,110	34,170	165	207.1	5.7		W40	17.4	17.4	00:11.3			W40	34.8	34.8
W20	1987	std	23.960	5.670	29,630			4.3		W20	24.3	24.3	00:09.4			W20	38.5	38.5
W46	1992	auto	26,500	2,670	29,170	190	153.5	4.84		W46	26.1	26.1	00:08.4			W46	44.6	44.6
W26	1989	std	23.960	4.830	28,790			5.27		W26	21.4	21.4	00:10.1			W26	36.9	36.9
W16	1995	auto	28,000	5,790	33,790	190	177.8	5.27		W16	24.8	24.8	00:08.8			W16	42	42
W18	1993	auto	26,500	4,710	31,210	190	164.3	4.4		W18	22.7	22.7	00:08.7			W18	45.4	45.4
W9	1985	std	25.160	4.950	30,110			4.73		W9	23.2	23.2	00:09.1			W9	41.8	41.8
W8	1985	std	25.160	5,070	30,230			4.83		W8	21.2	21.2	00:10.0			W8	37.8	37.8
W17	1995	auto	28.960	7,230	36.190	190	190.5	5.44		W17	24.8	24.8	00:09.2			W17	39.1	39.1
W19	1993	auto	26,500	6,270	32,770	190	172.5	5.68		W19	22.7	22.7	00:09.1			W19	42	42
W29	1990	std	23.960	6,870	30,830			5.1		W29	25.4	25.4	00:08.9			W29	41	41
W13	1987	std	23,960	4,950	28,910			5.38		W13	20.3	20.3	00:09.7			W13	40.6	40.6
W10	1986	std	25,160	5,790	30,950			5.47		W10	23.8	23.8	00:08.9			W10	42.3	42.3
W39	1981	std	27,060	4,830	31,890	165	193.3	5.25		W39	23.5	23.5	00:09.9			W39	36	36
W27	1989	std	23.960	3,270	27.230			5.45		W27	27.5	27.5	00:08.8			W27	39.6	39.6
W4	1984	std	25,160	5,670	30.830			4.8		W4	20	20	00:10.9			W4	34.4	34.4
W5	1984	std	25.160	6,870	32,030			5.78		W5	19.3	19.3	00:10.4			W5	37.5	37.5
W30	1990	std	23.960	6,510	30,470			6.51		W30	19.2	19.2	00:10.9			W30	34.8	34.8
W6	1990	std	25.160							W6	18.2	18.2	00:10.7			W6	37	37
W48	1992	auto	26,500	6,150	32,650	190	171.8	5.46		W48	22.7	22.7	00:09.2			W48	41.7	41.7
W44	1991	auto	27.800	5,670	33,470	190	176.2	4.25		W44	23.5	23.5	00:09.0			W44	42	42
W22	1993	auto	30,000	6,150	36,150	190	190.3	4.48		W22	23.3	23.3	00:08.6			W22	45.2	45.2

TIME 100-200 m CALC FROM SPEED		Bus #	Raw Data at 200 m (km/hr)	REAL SPEED at 200 m (km/hr)	TIME 200-300 m CALC FROM SPEED		Bus #	Raw Data at 300 m (km/hr)	REAL SPEED at 300 m (km/hr)
	Elkins	E12	53.4	53.4	00:06.3	Elkins	E12	60.4	60.4
	3/4/97	E8	50.4	50.4	00:06.6	3/4/97	E8	58.1	58.1
	200m	E11	48.2	48.2	00:06.9	300m	E11	56.8	56.8
		E4	47.6	47.6	00:07.1		E4	54.1	54.1
	Elkins	E12	58.6	58.6		Elkins			
	2/18/97	E8	53.8	53.8	00:06.3	2/25/97	E8	60.7	60.7
	200m	E11	58.9	58.9	00:05.9	300m	E11	63.7	63.7
		E1	48.9	48.9	00:07.0		E1	54.4	54.4
00:07.7	Huntsville	H15	52	51.5	00:06.3	Huntsville	H15	63.4	63.4
00:07.1	3/10/97	H34	54.1	53.8	00:06.3	3/11/97	H34	59.7	59.7
00:07.8	205m	H39	51	50.6	00:07.3	300m	H39	47.5	47.5
00:06.9		H44	58.1	57.6	00:05.6		H44	70.5	70.5
00:06.6		H57	61.3	60.7	00:05.6		H57	68.2	68.2
00:08.2		H30	47.2	46.9	00:07.1		H30	54.4	54.4
00:07.3	Huntsville	H15	55.5	54.9	00:06.3	Huntsville	H15	59.7	59.7
00:08.1	4/2/97	H34	48.9	48.5	00:06.3	3/12/97	H34	65.8	65.8
00:08.5	205m	H39	47.8	47.3	00:07.2	300m	H39	52.3	52.3
00:06.9		H44	56.8	56.4	00:06.8		H44	50	50
00:06.7		H57	60.7	60.1	00:05.7		H57	67.3	67.3
00:08.2		H30	49.7	49.2					
00:08.0	Greenwd	G9	49.2	49.2					
00:07.1	3/17/97	G26	57.5	57.5					
00:06.7	200m	G23	59.7	59.7					
00:06.9		G1	57.1	57.1					
00:06.7		G2	59.2	59.2					
00:07.4		G11	53.4	53.4					
00:08.0		G22	48.8	48.8					
00:07.3		G28	55.4	55.4					
00:07.1		G17	55.7	55.7					
00:08.1		G3	50	50					
00:07.5		G21	53.9	53.9					
00:08.1	Greenwd	G9	50	50					
00:07.3	3/19/97	G26	54.4	54.4					
00:06.7	200m	G23	60.5	60.5					
00:06.8		G1	57.9	57.9					
00:06.8		G2	58.3	58.3					
00:08.5		G11	46.3	46.3					
00:08.1		G22	50	50					
00:07.4		G28	54.6	54.6					
00:06.9		G29	58.1	58.1					
00:08.6		G3	47.6	47.6					
00:07.5		G21	53.4	53.4					
00:06.4	McDonld	M45	62	62	00:05.6	McDonld	M45	67.4	67.4
00:06.2	3/20/97	M49	64.7	64.7	00:05.3	4/14/97	M49	70.2	70.2
00:06.8	200m	M37	59.1	59.1	00:05.6	300m	M37	69	69
00:06.4		M46	62.8	62.8	00:05.4		M46	71	71
00:06.9		M1	59.2	59.2	00:06.0		M1	61	61
		M34					M34		
00:07.7		M27	50.2	50.2	00:06.3		M27	63.6	63.6
00:07.3		M41	55.5	55.5	00:06.3		M41	59.2	59.2
		M6					M6	67.9	67.9
00:07.0		M32	56.8	56.8	00:06.0		M32	63.1	63.1
00:07.3		M25	53.8	53.8	00:06.2		M25	62	62
00:07.3		M51	54.4	54.4	00:06.1		M51	64.5	64.5
		M43					M43	71	71
00:07.2		M3	56.2	56.2	00:06.0		M3	64.1	64.1
00:06.5		M52	59.5	59.5					
00:05.9		M50	67.6	67.6	00:05.0		M50	76.1	76.1
00:06.7		M35	58.6	58.6	00:05.7		M35	67.1	67.1

00:06.7	McDonld	M45	58.4	58.4	00:05.6	McDonld	M45	70.3	70.3
00:06.7	3/24/97	M49	61.2	61.2	00:05.5	3/21/97	M49	70.8	70.8
00:06.9	200m	M37	56.6	56.6	00:05.8	300m	M37	68.6	68.6
00:06.5		M46	61.2	61.2	00:05.4		M46	72.1	72.1
00:08.3		M1	45.7	45.7	00:06.3		M1	68.9	68.9
00:06.8		M34	58.1	58.1	00:05.7		M34	67.4	67.4
00:07.4		M27	52	52	00:06.2		M27	63.2	63.2
00:07.8		M41	52	52	00:06.2		M41	63.2	63.2
00:07.3		M6	55.2	55.2	00:06.0		M6	65.3	65.3
00:07.4		M32	53.4	53.4	00:06.3		M32	60.7	60.7
00:07.3		M25	52.8	52.8	00:06.3		M25	61.3	61.3
00:06.4		M51	62.1	62.1	00:05.8		M51	61.8	61.8
00:06.5		M43	61.6	61.6	00:05.7		M43	65.5	65.5
00:06.9		M3	58.4	58.4	00:05.9		M3	64.4	64.4
00:06.8		M52	58.3	58.3	00:05.9		M52	62.8	62.8
00:06.0		M50	66.3	66.3	00:05.3		M50	68.4	68.4
00:06.4		M35	61.6	61.6	00:06.1		M35	55.8	55.8
00:08.7	Waldron	W31	42	42	00:07.1	Waldron	W31	59.1	59.1
00:09.0	4/29/97	W12	43.5	43.5		5/21/97			
00:07.9	200m	W14	52	52	00:06.5	300m	W14	59.2	59.2
00:07.0		W15	56.6	56.6	00:06.3		W15	57.9	57.9
00:08.6		W47	46.2	46.2	00:06.4		W47	66.8	66.8
00:09.0		W21	44.1	44.1	00:06.6		W21	64.2	64.2
00:07.5		W1	53.9	53.9					
00:06.9		W46	56.8	56.8	00:06.1		W46	60.5	60.5
00:07.7		W26	51.5	51.5	00:06.5		W26	58.7	58.7
00:07.9		W16	49.9	49.9	00:06.8		W16	55.5	55.5
00:06.4		W18	63.1	63.1	00:05.8		W18	61.6	61.6
00:07.5		W9	51.8	51.8	00:06.4		W9	61.5	61.5
00:08.4		W8	47.2	47.2	00:06.9		W8	57.9	57.9
00:08.1		W17	44.7	44.7	00:06.7		W17	62.6	62.6
00:07.6		W19	48.9	48.9	00:06.3		W19	65.3	65.3
00:07.1		W29	57.5	57.5	00:06.0		W29	61.6	61.6
00:08.0		W13	50.1	50.1	00:06.7		W13	57.4	57.4
00:08.3		W39	50.2	50.2	00:07.0		W39	52.6	52.6
00:07.7		W27	47.8	47.8	00:07.0		W27	54.5	54.5
00:08.3		W4	49.2	49.2	00:07.8		W4	43.1	43.1
00:09.0		W5	45.1	45.1	00:07.1		W5	56.6	56.6
00:08.2		W30	48.4	48.4	00:07.1		W30	52.8	52.8
00:08.3		W6	48.3	48.3					
00:07.8		W48	49.9	49.9	00:06.6		W48	59.7	59.7
00:06.9		W28	57.9	57.9					
00:07.8		W22	52	52	00:06.1		W22	65.8	65.8
00:08.0	Waldron	W31	49.2	49.2					
00:10.3	4/30/97	W45	38.1	38.1	00:07.5		W45	57.3	57.3
00:08.9	200m	W14	44.7	44.7					
00:07.7		W15	51.7	51.7					
00:08.4		W28	51.5	51.5					
00:07.2		W21	52.9	52.9					
00:08.8		W40	47.2	47.2	00:07.3		W40	51.6	51.6
00:08.0		W20	51	51	00:06.1		W20	67.3	67.3
00:07.6		W46	49.6	49.6					
00:08.2		W26	50.5	50.5					
00:08.3		W16	44.7	44.7					
00:07.1		W18	55.5	55.5					
00:07.7		W9	51.7	51.7					
00:08.5		W8	47.3	47.3					
00:08.1		W17	49.6	49.6					
00:07.5		W19	53.4	53.4					
00:07.5		W29	54.4	54.4					
00:08.1		W13	48.3	48.3					
00:07.6		W10	52.1	52.1	00:06.5		W10	57.9	57.9
00:08.6		W39	47.5	47.5					
00:08.1		W27	49.7	49.7					
00:08.7		W4	48.8	48.8					
00:08.7		W5	45.4	45.4					
00:09.1		W30	44.6	44.6					
00:08.5		W6	47.3	47.3					
00:07.6		W48	52.6	52.6					
00:07.7		W44	51.3	51.3	00:06.5		W44	58.7	58.7
00:06.9		W22	59.1	59.1					

TIME			Raw	REAL	TIME				Raw	REAL
300-400 m			Data	SPEED	400-500 m				Data	SPEED
CALC			at 400 m	at 400 m	CALC				at 500 m	at 500 m
FROM		Bus #	(km/hr)	(km/hr)	FROM			Bus #	(km/hr)	(km/hr)
SPEED					SPEED					
00:05.7	Elkins	E12	65.5	65.5	00:05.3		Elkins	E12	71	71
00:05.8	3/3/97	E8	66.1	66.1	00:05.2		3/3/97	E8	73.2	73.2
00:06.0	400m	E11	62.8	62.8	00:05.6		500m	E11	66.8	66.8
00:06.4		E4	58.1	58.1	00:06.0			E4	61.6	61.6
	Elkins						Elkins	E12	69.8	69.8
00:05.6	2/25/97	E8	68.1	68.1	00:05.3		3/4/97	E8	68.4	68.4
00:05.4	400m	E11	70.7	70.7	00:05.3		500m	E11	65.7	65.7
								E4	64.9	64.9
00:06.3		E1	59.2	59.2						
00:05.6	Huntsville	H15	65	65.3	00:05.4		Huntsville	H15	67.6	67.6
00:05.7	3/11/97	H34	65.7	66.3	00:05.3		3/11/97	H34	70.3	70.3
00:07.2	385m	H39	51.8	52.4	00:06.6		500m	H39	56.3	56.3
00:04.9		H44	75.3	75.5	00:04.7			H44	77.2	77.2
00:05.1		H57	73.7	74.2	00:04.7			H57	77.7	77.7
00:06.5		H30	55.8	56.1	00:06.3			H30	58.3	58.3
00:05.7	Huntsville	H15	65.3	66	00:05.3		Huntsville	H15	70.5	70.5
00:05.4	3/12/97	H34	66.9	67.4	00:05.2		3/12/97	H34	70.7	70.7
00:06.6	385m	H39	56.2	56.6	00:06.2		500 m	H39	59.5	59.5
00:07.1		H44	50.5	51.2	00:06.7			H44	56.2	56.2
00:05.1		H57	72.4	72.9	00:04.8			H57	76	76
00:05.2	McDonld	M45	71.8	71.8	00:04.9		McDonld	M45	76.1	76.1
00:05.0	4/14/97	M49	72.7	72.7	00:04.9		4/14/97	M49	73.4	73.4
00:05.0	400m	M37	74	74	00:04.8		500m	M37	77.2	77.2
00:04.8		M46	77.6	77.6	00:04.5			M46	81.8	81.8
00:05.6		M1	66.5	66.5	00:05.4			M1	67.4	67.4
		M34	66.6	66.6	00:05.3			M34	69.5	69.5
00:05.5		M27	68.2	68.2	00:05.2			M27	71.6	71.6
00:05.9		M41	62.6	62.6	00:05.7			M41	63.1	63.1
								M6	72.4	72.4
00:04.9	McDonld	M45	76.6	76.6	00:04.7		McDonld	M45	78.2	78.2
00:05.0	3/21/97	M49	74.4	74.4			3/21/97	M49		
00:05.0	400m	M37	74.7	74.7	00:04.8		500m	M37	76.8	76.8
00:04.8		M46	79.3	79.3	00:04.5			M46	82.2	82.2
00:05.0		M1	74.4	74.4	00:04.7			M1	78.2	78.2
00:05.1		M34	73.9	73.9	00:04.8			M34	76	76
00:05.4		M27	70.5	70.5	00:05.0			M27	73.4	73.4
00:05.4		M41	69	69	00:05.2			M41	69.8	69.8
00:05.2		M6	73.1	73.1	00:04.8			M6	76	76

BUS #	BUS ENGIN AGE	STD/ AUTO trans	bus wt (lbs)	student wt (lbs)	bus + stu wt (lbs)	hP	WT/HP	TIME 0-18 m 0-18m Times		Bus #	Raw Data at 18 m (km/hr)	REAL SPEE at 18 (km/hr	TIME 18-100 m CALC FROM SPEED	Bus #	Raw Data at 100 (km/hr)	REAL SPEED at 100 m (km/hr)
WA5	1991	auto	27,800	5,550	33350	190	175.53	4.5	100m	WA5	29.6	29.6	00:07.5	WA5	48.8	48.8
WA18	1995	auto	29,800	6,150	35950			4		WA18	26.5	26.5	00:08.1	WA18	46.2	46.2
WA20	1996	auto	29,800	4,950	34750			4.5		WA20	27.2	27.2		WA20		
WA8	1984	std	24,500	3,750	28250			6.1	Washburn	WA8	16.9	16.9	00:11.6	WA8	34.1	34.1
WA11	1988	std	25,580	7,830	33410			6.3	5/16/97	WA11	14.8	14.8	00:11.1	WA11	38.3	38.3
WA2	1986	std	25,000	6,750	31750			4.2		WA2	26.2	26.2	00:08.3	WA2	45.1	45.1
WA6	1988	std	25,580	6,750	32330			4.3		WA6	21.2	21.2	00:09.6	WA6	40.5	40.5

Table 27

SCHOOL BUS CLIMBING DATA 8/1/97

BUS #	BUS ENGIN AGE	STD/ AUTO trans	bus wt. (lbs)	student wt. (lbs)	bus + stu. wt. (lbs)	hP	WT/HP		BUS #	150 M SOUTH OF SOUT END REAL SPEED (KPH)	CALC TIME 150 M S. TO S. END OF BRIDGE (SEC)		BUS #	SOUT END OF BRIDG REAL SPEED (KPH)	CALC TIME SOUTH END OF BRIDGE TO NORTH END OF BRIDGE			NORTH END OF BRIDGE REAL SPEED (KPH)
M32	1991	std	27,500	1,950	29,450	155	190	4/15	M32	56.2	00:08.9	4/15	M32	65.5	00:08.0	McDonld	M32	68.7
M44	1995	auto	27,800	1,590	29,390	190	154.7		M44	53.1	00:09.5		M44	60	00:08.8	4/15/97	M44	62.8
M47	1995	auto	27,800	1,350	29,150	190	153.4		M47	64.4	00:07.9		M47	72.4	00:07.2	N. End of	M47	76.8
M10	1990	std	27,080	1,830	28,910	150	192.7	4/18	M10	74.7	00:06.9	4/18	M10	81.6	00:06.6	McDonld	M10	82.3
M44	1995	auto	27,800	1,590	29,390	190	154.7		M44	55	00:09.3		M44	61.3	00:08.9	4/18/97	M44	59.5
M47	1995	auto	27,800	1,350	29,150	190	153.4		M47	63.2	00:07.9		M47	73.1	00:07.3	N. End of	M47	74.2

APPENDIX E
Washburn Straight-line Acceleration Data

		Washburn Data																		
								Time Data				Speed Data						Std vs. Auto data		
SCHOOL BUS STUDY																				
rev 7/17/97								0	18	100			0	18	100			0	18	100
							average	0	00:04.8	00:09.3		average	0	23.2	42.5		auto avg sp	0	27.7667	47.5
120 lbs per student							maxim	0	00:06.3	00:11.6		minimu	0	14.8	34.1		std avg spe	0	19.775	39.5
150 lbs for bus driver																				
							number of data p		7	5										
								TIME			Raw	REAL	TIME				Raw	REAL		
								0-18 m			Data	SPEED	18-100 m				Data	SPEED		
BUS	BUS	STD/			bus +						at 18 m	at 18 m	CALC				at 100 m	at 100 m		
#	ENGINE	AUTO	bus wt.	student	stu. wt.	hP	WT/HP	0-18m		Bus #	(km/hr)	(km/hr)	FROM			Bus #	(km/hr)	(km/hr)		
	AGE	trans	(lbs)	wt. (lbs)	(lbs)			Times					SPEED							
								7	number of data points				5	number of data points						
								4.84286	average time from 0 to 18 m				00:09.3	average time from 18 m to 100 m						
								23.2	average speed km/hr @ 18 m				42.5	average speed km/hr @ 100 m						
								6.3	maximum time from 0 to 18 m				00:11.6	maximum time from 18 m to 100 m						
								14.8	minimum speed @ 18m				34.1	minimum speed @ 100 m						
WA5	1991	auto	27,800	5,550	33350	190	175.5	4.5	100m	WA5	29.6	29.6	00:07.5			WA5	48.8	48.8		
WA18	1995	auto	29,800	6,150	35950			4		WA18	26.5	26.5	00:08.1			WA18	46.2	46.2		
WA20	1996	auto	29,800	4,950	34750			4.5		WA20	27.2	27.2				WA20				
WA8	1984	std	24,500	3,750	28250			6.1	Washburn	WA8	16.9	16.9	00:11.6			WA8	34.1	34.1		
WA11	1988	std	25,580	7,830	33410			6.3	5/16/97	WA11	14.8	14.8	00:11.1			WA11	38.3	38.3		
WA2	1986	std	25,000	6,750	31750			4.2		WA2	26.2	26.2	00:08.3			WA2	45.1	45.1		
WA6	1988	std	25,580	6,750	32330			4.3		WA6	21.2	21.2	00:09.6			WA6	40.5	40.5		

APPENDIX F
McDonald County Upgrade Acceleration Data

											CALC.					CALC.				
										150 M	TIME				SOUTH	TIME				NORTH
	SCHOOL BUS CLIMBING DATA				8/1/97					SOUTH	150 M S.				END	SOUTH				END
										OF SOUT	TO S. END				OF	END OF				OF
										END	OF				BRIDGE	BRIDGE				BRIDGE
BUS #	BUS	STD/	BUS WT	STUDENT	BUS +	HP	WT/HP		BUS #	REAL	BRIDGE			BUS #	REAL	TO NORTH				REAL
	ENGINE	AUTO	(LBS)	WT	STU. WT.					SPEED	(SEC)				SPEED	END OF				SPEED
	AGE	TRANS		(LBS)	(LBS)					(KPH)					(KPH)	BRIDGE				(KPH)
M32	1991	std	27,500	1,950	29,450	155	190	McDonld	M32	56.2	00:08.9		McDonld	M32	65.5	00:08.0		McDonld	M32	68.7
M44	1995	auto	27,800	1,590	29,390	190	154.7	4/15/97	M44	53.1	00:09.5		4/15/97	M44	60	00:08.8		4/15/97	M44	62.8
M47	1995	auto	27,800	1,350	29,150	190	153.4	150m Sou	M47	64.4	00:07.9		S. End of	M47	72.4	00:07.2		N. End of	M47	76.8
M10	1990	std	27,080	1,830	28,910	150	192.7	McDonld	M10	74.7	00:06.9		McDonld	M10	81.6	00:06.6		McDonld	M10	82.3
M44	1995	auto	27,800	1,590	29,390	190	154.7	4/18/97	M44	55	00:09.3		4/18/97	M44	61.3	00:08.9		4/18/97	M44	59.5
M47	1995	auto	27,800	1,350	29,150	190	153.4	150m Sou	M47	63.2	00:07.9		S. End of	M47	73.1	00:07.3		N. End of	M47	74.2