EDSMAC-IV input	Value	Source referenced in
Body overall length	431.3 in	This attachment
Body CG to front	187.66 in	This attachment
Body CG to Rear	-234.64 in	This attachment
Body Overall Width	90.5 in	This attachment
Total Weight	20,492lb	This attachment
Yaw Inertia	875,380in-sec^2 lb	This attachment
A Stiffness	1000 lb/in^2	See main body of report
B Stiffness	250 lb/in^2	See main body of report
Wheel Location X , Front Axle (Left side, pre-collision)	154.86 in	This attachment
Wheel Location X , Front Axle (Right side, pre-collision)	154.86 in	This attachment
Wheel Location X, front Axle (Left side, post -collision)	154.86 in	This attachment
Wheel Location X, front Axle (Right side, post-collision)	154.86 in	This attachment
Wheel Location X, second Axle (left side)	99.14 in	This attachment
Wheel Location X, Front Axle (Right side, pre-collision)	99.14 in	This attachment
Wheel Location X, front Axle (Left side, post -collision)	99.14 in	This attachment
Wheel Location X, Front Axle (Right side, pre-collision)	99.14 in	This attachment

Data Sources and Nomenclature for School Bus Calculations

Field measurements

W_r = Total weight on rear axle = 10,700lb

W_f = Total weight on front axle= 6,850lb

W_T = Total weight of vehicle = 17,550lb

Manufacture's data

X_{wb} = The wheel base (distance from the cg to the midpoint between axles 2 and 3)= 254"

FOH = Distance from front axle to furthest extent of front bumper = 33"

ROH = Distance from rear axle to rearmost point of truck = 144.5"

Definitions:

A = the longitudinal distance from the cg to the front axle

B = the longitudinal distance from the cg to the rear axle

Body overall length: The Body Overall Length in the EDSMAC-IV is defined as the distance from the rearmost point of the vehicle to the to the furthest point of the front bumper (see Diagram 1 of this attachment).

The overall length of 431.3 inches used in the simulation is based on data supplied by the manufacturer.

Wheel locations X (pre-collision)
The wheel location x is defined as the longitudinal distance from the cg to the wheel location. For the undamaged (pre-collision) bus these values are calculated
in the section entitled "Locating the Center of Gravity" which follows.

Wheel Location X (post collision)
The wheel locations relative to the cg were the same as for the undamaged vehicle.

Locating the Center of Gravity (cg)

Summing the moments about the front axle and solving:

$$\therefore A = \frac{W_R}{W_T} X_{wb} = \frac{10{,}700}{17{,}550} \cdot 254 = 154.86"$$

Summing the moments bout the rear axle and solving:

$$B = \frac{W_f}{W_T} X_{wb} = \frac{6850}{17{,}550} \bullet 254 = 99.14"$$

Therefore:
Wheel locations x for left and right tires (pre-collision) = A = 154.86 in
Wheel location x for second axle left and right side tires (both pre and post collision) =
=B = 99.14 in

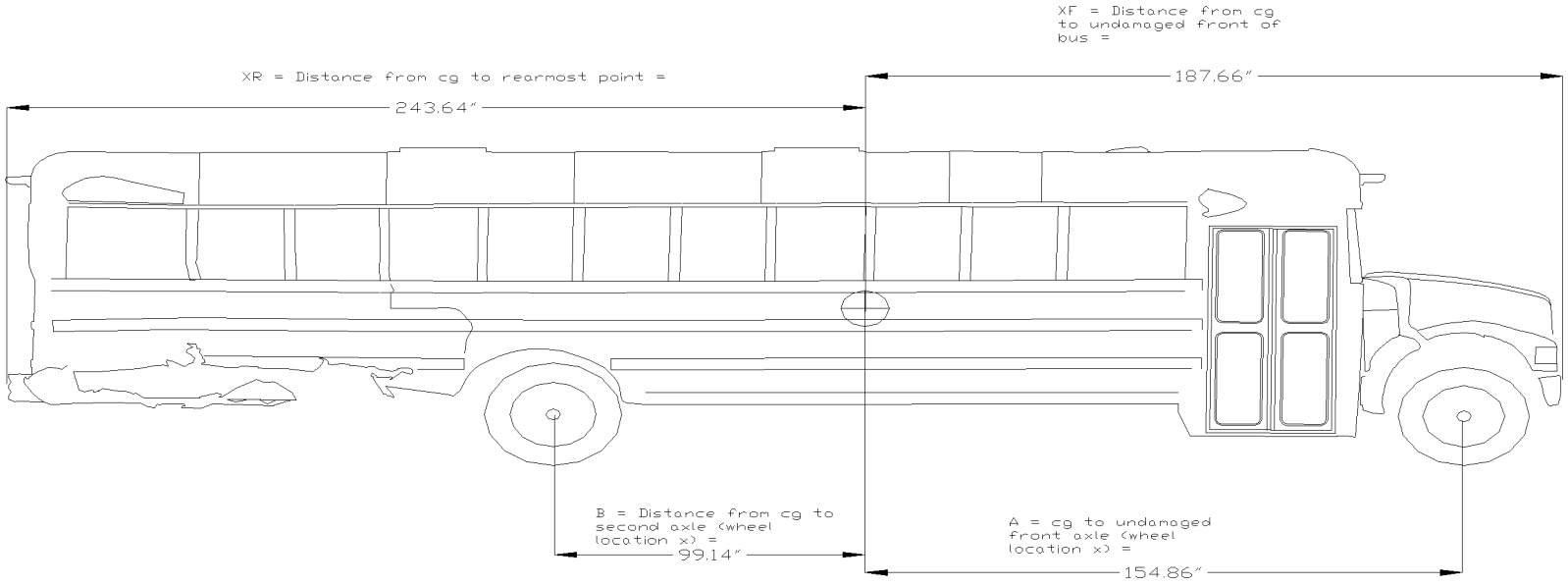
Body CG to rear and front of the bus (XF and XRB)

Body Cg to front = XF = the distance from the front axle to the cg= A + FOH =
154.86 + 32.8"=187.66 "

Body CG to rear of vehicle =XR = the distance from the cg to the rearmost point of vehicle
= B + ROH= 243.64"

Figure 2- BUS CG Location

(Diagram not to scale)



Total Weight

The T*otal Weight* used in the simulation included an estimate of the total passenger weight (see section on passenger weight estimate which follows) as well as the total weight of the bus as measured by field investigators.

Total weight = wt of bus + the wt of occupants

17,550 lbs +2,942lbs = 20,492lbs

Passenger Weight Estimate

Based on the Survival Factors Group Factual Report, there were a total of 44 children and 9 adults (including the driver) aboard the bus when the collision occurred. Estimates of the child passengers weights given below are based on a 50 percentile data published in the *American Journal of Clinical Nutrition, vol 32, pages 607- 629, date1979*. The data takes into account both age and gender in its computations. The published data was from the National Center for Health Statistics (NCHS).
Data for adults was taken from the same source

2	six-year-old male passengers:	=	2 *46 = 92 lbs
16	seven year old male passengers	=	7*50 =350 lbs
8	eight year old male passengers	=	8*56 =448 lbs
18	seven year old female passengers	=	18*47 =846 lbs
44			1,736 lbs

3 adult males (including the driver)	=	3 *152= 456 lbs
6 adult females	=	6*125 = 750 lbs
9		1206 lbs

Total weight of passengers = 1,736lbs +1206lbs = 2942lbs

Yaw Inertia

The Yaw Inertia in EDSMAC-IV is the effective yaw moment of inertia about the cg of the bus. The Yaw Inertia for the simulation included the sum of the yaw moment of inertia of the bus about its cg (see next section) and yaw moment of inertia of the occupants about the cg (see attachment B of this report for calculation of occupants' moment of inertia).

Yaw Moment = Yaw moment of inertia of the bus + yaw moment of passengers

= 755,383 + 120,380

= 875,380 $lb\,\sec^2\,in$

Yaw Moments of Inertia of the Bus about its Center of Gravity

The yaw moment of inertia was estimated used the formula for the Thin Rod approximation.

Other estimates and published figures available to investigators for the yaw moment of inertia for the school buses and similar types of vehicles are summarized in Table 1 of this Attachment.

The Thin Rod Approximation was chosen over the other methods in the table for four reasons: 1) the basis for the published data summarized in the table was unclear, 2) the Thin Rod approximation gives approximately the same estimate as the PhaseIV formula for tractors so the differences between the two methods would be minor, 3) consistency, the Thin Rod approximation has been used in previous estimates made by the Safety Board, 4) the school bus body has a rectangular shape.

Yaw Moment of Inertia Estimates for the bus:

Thin Rod approximation

Formula: $I_{yy} = \frac{1}{12} \bullet m \bullet (OW^2 + OL^2)$

$$\therefore I_{yy} = \frac{1}{12} \bullet 45.4 \bullet ((96)^2 + 436.4^2) = 755{,}383.97.8 in * lb \bullet \sec^2$$

Yaw Moment of Inertia Estimates for the bus:(continued)

Phase IV method for estimating tractor yaw inertia

$$I_{zz} = \frac{1}{g}\left\{\left[WF + .4(WR)\right] * A1^2 + (WR)\left[1 - .4\right]A2^2\right\}$$

Where:

A1= A= Distance from cg to front of vehicle =154.86
A2= B = the distance from the cg to the rear of the bus = 99.14”
WF = W_f = the weight on the front axle = 6850lb
WR = W_r = the weight on the rear axle = 10,700lb

$$= \tfrac{1}{386.4}\left\{\left[6850 + .4 * 10700\right] * 154.86^2 + 10700(.6)99.14^2\right\}$$

$= 746{,}816.9 LB - SEC^2 - IN$

TABLE 1 – Summary of yaw moment of inertia estimates, and published data available for school buses and similar vehicles.

Calculations listed are given on previous pages

Formula Name	Source	Formula	I
Phase IV formula for tractors	University of Michigan	$I_{zz} = \frac{1}{g}\left\{\left[WF + .4(WR)\right] * A1^2 + (WR)\left[1 - .4\right]A2^2\right\}$	$746{,}816.9 LB - SEC^2 - IN$
Thin Rod Approximation		$I_{yy} = \frac{1}{12} \bullet m \bullet (OW^2 + OL^2)$	$755{,}383.97.8 in * lb \bullet \sec^2$
School bus[1]	See footnote		$1{,}019{,}490\, lb \sec^2 in$
Intercity bus [2]	See footnote		$1{,}105{,}500\, lb \sec^2 in$

[1] US Department of Transportation Report no. FHWA-RD-79-48. "Evaluation of Horizontal Curve Design", US Department of Transportation, Oct 1978

[2] US Department of Transportation Report No. DOT HS-802 141, "Effects of Tire Properties on Truck and Bus Handling," Volume 1, Dec 1978