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Updating the Vehicle Class Categories

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ABSTRACT

The use of "generic vehicle data" gained wide user acceptance with the introduction of the CRASH3 computer program in 1981. The categories were broadened for use in EDVAP in 1984. However, the categories have not been updated since 1984, and the data relied upon by vehicle safety researchers has become stale. This paper updates the vehicle class categories, as well as broadens the categories to provide a more useful set of generic vehicles for a newer vehicle population mix, which now includes mini-vans, small pickups and multi-purpose vehicles. The paper describes the methods used for establishing the categories, calculating the individual vehicle parameters for each category and extending the categories to include three-dimensional vehicle parameters.

GOOD VEHICLE DATA are required for the accurate reconstruction and simulation of motor vehicle crashes. Safety researchers use reconstruction and simulation techniques to determine the cause(s) of individual crashes as well as in statistical studies. Historically, researchers have depended upon the use of "generic" vehicle data, that is, average, statistically derived values, for the required dimensional, inertial and structural parameters. The researcher assigned these values by choosing a *class category* according to the vehicle's wheelbase, as shown in Table 1. The reconstruction or simulation program would use the chosen category to assign the appropriate parameters from a built-in data table. The parameters loaded in the tables are also shown in Table 1.

* Numbers in brackets designated references found at the end of the paper.

HISTORY OF GENERIC DATA

The generic data shown in Table 1 were originally developed in 1981 for use in the CRASH3 computer program by CALSPAN under contract to NHTSA [1]*. In 1984, Table 1 was extended by Engineering Dynamics Corporation to include a generic on-highway truck. This extended table was used by EDVAP [2].

Use and Purpose

The generic data were originally derived from the statistical analysis of a number of vehicles. The generic data did not represent any specific vehicle, but provided a reasonable estimate for each parameter. Generic data were especially useful for statistical studies, where, because of the large population sample size, a lack of precision for any particular vehicle parameter would not lead to systematic error. Generic data also represented a good "starting point" for vehicle parameters used in the reconstruction and simulation of individual accidents.

Problems With Current Data

A qualitative review of the 1981-era vehicle population revealed a majority of vehicles were front engine, rear-wheel drive. While many smaller vehicles of that era used unibody construction, most of the intermediate and larger vehicles still used a frame. A similar review of the modern vehicle population revealed a large majority of vehicles were front engine, front-wheel drive; nearly all vehicles used unibody construction. In addition, modern safety research has resulted in design concepts which improved crush energy management.

A comparison between the 1981 and 1990's vehicle populations also revealed a difference in the types of vehicles on the road. For example, in 1981, there was one basic size for

TABLE 1. Vehicle Class Categories, Circa 1981

PARAMETER	CLASS CATEGORIES →								
	1	2	3	4	5	6	7 (Vans)	8/9	10 (Movable Bar.)
Wheelbase (in)	80.9-94.8	94.8-101.6	101.6-110.4	110.4-117.5	117.5-123.2	123.2-150	109-130	No Data for Category 8 (Pickups) or 9 (Front wheel drive) Select Category 1 - 6 According to Wheelbase	120.0
Track (in)	51.1	54.6	58.9	61.8	63.7	63.7	67.6		60.0
Length (in)	159.8	174.9	196.2	212.8	223.7	229.4	183.6		180.0
Width (in)	60.8	67.2	72.6	77.0	79.8	79.8	79.0		78.0
A (in)	45.1	46.3	51.3	54.7	58.1	60.1	48.5		54.0
B (in)	48.1	50.1	55.5	59.2	63.0	65.1	68.5		66.0
X_f (in)	76.0	83.3	89.8	98.8	101.8	104.2	75.6		84.0
X_r (in)	83.8	91.6	106.4	114.0	121.9	125.2	107.0		96.0
Rsq (in^2)	2006	2951	3324	3741	4040	4229	3713		4024
I_{zz} (lb-sec^2-in)	11434	23313	30514	41114	50864	58106	41586		41906
Weight (lb)*	2202	3053	3547	4247	4865	5309	4300		4000
$C_{alfa,f}$ (lb/deg)	94	131	152	182	209	228	209		1000
$C_{alfa,r}$ (lb/deg)	88	121	141	168	193	210	193		1000

LEGEND:
A = Distance from CG to front axle
B = Distance from CG to rear axle
X_f = Distance from CG to front of vehicle
X_r = Distance from CG to rear of vehicle
Rsq = Radius of gyration squared
I_{zz} = Yaw moment of inertia
C_{alfa} = Tire cornering stiffness
* Weight includes 300 lb occupant loading

NOTE: Fixed barriers (category 11) are assigned inertial properties (mass, yaw inertia) of 10^6. These values are not reassignable. The barrier's dimensions (100" by 100") can be reassigned, however.

pickups and vans. Now there are two (mini and full-sized). The popular multi-purpose vehicle (e.g., Chevrolet S-10 Blazer and Ford Explorer) did not even exist in 1981.

Another difference came not from the changes in vehicles, but from improvements in reconstruction and simulation models. Fully 3-dimensional models are now available [3] which require additional data (tire models, suspension models, drivetrain models, brake system models) not used by earlier 2-dimensional simulations.

For the reasons stated above, it became necessary to update the generic vehicle data categories.

UPDATING THE CATEGORIES

New vehicle class categories were developed to solve the above problems and limitations. The new categories included standard passenger cars as well as new vehicle types which reflect the current (and hopefully, future) vehicle population). Where necessary, new class categories were created for some vehicle types. Finally, data acquisition for all the new categories was extended to include the data necessary to execute 3-D reconstruction and simulation models. The specific procedures are described below.

Procedure

Developing the new vehicle class categories and related data involved the following procedures:

- Defining new vehicle types and categories
- Identifying the vehicles in each new category
- Identifying the required vehicle parameters
- Acquiring the data for each vehicle
- Calculating the generic (average) data for each category

Each of these steps is described below.

TABLE 2. New Vehicle Types

New Types	Previous Categories
Passenger Car	1-6, 9
Pickup	8
Van	7
Multi-purpose	N/A
Truck	12
Trailer	N/A
Dolly	N/A
Barrier	10,11

1. Define New Vehicle Types and Categories

Based on the current vehicle population, eight fundamental vehicle types were defined (see Table 2).

Passenger cars were defined as a traditional passenger vehicle and divided into five classes according to wheelbase. The wheelbase ranges adopted in the new categories (see Table 3-1) were the same as those used in the original categories.

In the original system, Class 8 was a single category devoted to pickups, regardless of their size. The new generation of pickups required a new *Pickup* vehicle type with two classes: *mini* (Class 1) and *full-size* (Class 2). See Table 3-2.

Like pickups, the original system also had a single category, Class 7, for vans. The new generation of mini-vans required a new *Van* vehicle type with two Classes: *mini* (Class 1) and *full-size* (Class 2). See Table 3-3.

In the original system, Class 9 was a single category devoted to front wheel drive vehicles. The current research suggested that drive axle (i.e., front or rear drive) was no longer a distinguishing feature, but that passenger car wheelbase was actually a fairly good predictor of drive axle (larger cars tend to be rear drive). Therefore, Class 9 was abandoned and the issue of drive axle was absorbed into the individual Passenger Car Class Categories.

Multi-purpose vehicles were not included in the prior system (these vehicles did not exist as a distinct species in 1981). A qualitative review of the current population of multi-purpose vehicles suggested an approach like that used for pickups and vans. Two new *Multi-purpose* classes were created: *mini* (Class 1) and *full-size* (Class 2). See Table 3-4.

New categories were created for on-highway Trucks. The new category included both straight trucks (i.e., those with load-hauling capability) and truck tractors (i.e., those which do not normally carry a load, but act as a tow vehicle with a connection for a trailer). Four classes for trucks were created according to wheelbase and the number of rear axles (single vs tandem), as shown in Figure 3-5.

A new category was also created for *Trailers*. Because of the wide variety of trailers, four classes were created based on a qualitative assessment of the on-highway population (see Table 3-6).

A new category was also created for *Dollys*, with two classes: *fixed* and *converter* (see Table 3-7). The inclusion of this new category will allow researchers to execute simulations involving multiple trailers.

The existing categories for movable and fixed SAE barriers (see Table 3-8) were included to allow crash test simulation.

TABLE 3-1. Passenger Car Class Categories.

Class	Wheelbase Range (in)
1	80.9 - 94.8
2	94.8 - 101.6
3	101.6 - 110.4
4	110.4 - 117.5
5	> 117.5

TABLE 3-2. Pickup Class Categories.

Class	Wheelbase Range (in)
1	< 114.0
2	≥114.0

TABLE 3-3. Van Class Categories.

Class	Wheelbase Range (in)
1	<115.4
2	≥115.4

TABLE 3-4. Multipurpose Vehicle Class Categories.

Class	Wheelbase Range (in)
1	< 104.5
2	≥104.5

TABLE 3-5. Truck Class Categories.

Class	Description	Wheelbase Range (in)
1	Single Axle	< 104.5
2	Single Axle	≥104.5
3	Tandem Axle	(*)
4	Tandem Axle	(*)

TABLE 3-6. Trailer Class Categories.

Class	Description	Wheelbase Range (in)
1	Utility	(*)
2	Mobile Home	(*)
3	Van, Single Axle	258 - 318
4	Van, Tandem Axle	383 - 484

TABLE 3-7. Dolly Class Categories.

Class	Description	Drawbar Length (in)
1	Fixed	60
2	Converter	60

TABLE 3-8. Barrier Class Categories.

Class	Description	Wheelbase (in)
1	Movable	120
2	Fixed	N/A

By necessity, the new system included two levels of hierarchy: Type and Class. This created a somewhat more complicated system than the original. This additional complexity was necessary in order to properly distinguish between vehicles, provide reasonable data for the current vehicle population, and provide researchers the required flexibility.

* Research in these categories is incomplete; results are not available.

2. Identify Vehicles In Each Category

The Market Data Book, published annually by the Automotive News [4] includes the annual US sales figures for passenger cars, pickups, vans and multi-purpose vehicles. The vehicles were divided into the newly established categories and ranked according to numbers sold. The top ten vehicles in each category were then identified for the years between 1983 and 1993. (see Table 4). These vehicles were selected for data acquisition.

Similar volume sales data were not found for vehicles in the Truck, Trailer and Dolly categories. In addition to the lack of sales data, the wide variety of vehicles found in each category made matters worse. As an initial approach, published research was used [5,6] to create typical vehicle data in these categories.

Data for the Barrier vehicle types were obtained directly from SAE J972 [7] for movable barriers and SAE J850 [8] for fixed barriers.

3. Identify The Required Parameters

The 3-dimensional capability of new reconstruction and simulation models required a reassessment of the parameters to be documented for each category. The required parameters have been documented in previous research (see reference [9]).

The required parameters were divided into the following groups:

- General
- Dimensional
- Inertial Properties
- Stiffness Properties
- Suspension Properties
- Brake System Properties

The parameters are shown in Table 5.

4. Data Acquisition

The above data were obtained for each of the vehicles listed in Tables 4-1 through 4-4. The data were obtained from several sources, including the following:

- Direct Measurement
- AAMA Vehicle Sheets
- Published Research

The source of each parameter was documented. Once the data were obtained for each vehicle, the arithmetic averages and standard deviations were computed for each category.

TABLE 4-1. Top Ten In Sales For Each Passenger Car Class

Class 1 WB=80.9 - 94.8 in	**Class 2** WB=94.8 - 101.6	**Class 3** WB=101.6 - 110.4	**Class 4** WB=110.4 - 117.5	Class 5 WB > 117.5
Ford Escort	Chevrolet Cavalier	Ford Taurus	Buick LeSabre	Cadillac Fleetwood
Hyundai Excel	Ford Tempo	Pontiac Grand Am	Chevrolet Caprice	Buick Electra
Honda CRX	Chevrolet Camaro	Buick Regal	Ford Crown Victoria	Merceds SEL
Chevrolet Chevette	Ford Mustang	Chevrolet Lumina	Chrysler Fifth Avenue	(*)
Chevrolet Spectrum	Plymouth Reliant	Ford Thunderbird	Lincoln Town Car	
Toyota Tercel	Honda Civic	Toyota Camry	Jaguar XJ6	
Dodge Colt	Dodge Omni	Nissan Maxima	Lexus LS400	
Pontiac Fiero	Nissan Sentra	Dodge Dynasty	Mercedes S Class	
Mazda 323	Toyota Corolla	Honda Accord	Acura Legend	
Ford Festiva	Dodge Shadow	Plymouth Acclaim	Infinity Q45	

TABLE 4-2. Top Pickup Sales, 1983-1992

Class 1 WB < 114.0	Class 2 WB > 114.0
Chevrolet S-10	Chevrolet C/K Series
Ford Ranger	Ford F-Series
Dodge D-50	Dodge D/W
Toyota	Jeep J-10
Nissan	Toyota T-100
Jeep Commanche	(*)
Mazda	
Isuzu	

TABLE 4-3. Top Van Sales, 1983-1992

Class 1 WB < 115.4	Class 2 WB ≥ 115.4
Dodge Caravan	Chevrrolet Van
Chevrolet AstroVan	Ford Van
Ford AeroStar	Dodge Van
Chevrolet Lumina	(*)
Toyota Previa	
Mazda MPV	
Volkswagen Vanagon	
Toyota Van	
Nissan Van	

* These categories had fewer than 10 vehicles

TABLE 4-4. Top Multi-purpose Sales, 1983-1992

Class 1 WB < 104.5	**Class 2** WB > 104.5
Chevrolet S-10 Blazer	Ford Bronco
Jeep Cherokee	Chevrolet Suburban
Ford Bronco II	Chevrolet K-5 Blazer
Toyota 4-Runner	Ford Explorer
Geo Tracker	Dodge Ramcharger
Dodge Raider	Isuzu Trooper
Suzuki Samari	Toyota Land Cruiser
Jeep Wrangler	Isuzu Rodeo
Nissan Pathfinder	(*)

RESULTS

Research and inspection of each of the vehicles in each category resulted in the data shown in Table 6.

OBSERVATIONS

The data presented in Tables 6-1 through 6-4 represent statistical averages and standard deviation for each parameter. While the average value is generally the parameter of greatest interest, the standard deviation should also be scrutinized, for it represents an expected variation within the population. For example, the average front ride rate for a class 2 passenger car is 102 lb/in. However, researchers can be 95 percent confident true value for other vehicles in this class lies within +/- 10 lb/in of the average. This information is extremely valuable for cases when actual vehicle data are not available: By executing the reconstruction or simulation using the minimum and maximum within this range, researchers may assess the potential variation due to the estimated parameters.

Detailed tire data are omitted from the generic data. The reason for this omission lies in the practical fact that any detailed simulation requires a substantial amount of tire data, including longitudinal friction (mu vs slip), cornering and camber stiffness. A separate document, called "Generic Tire Data" is required.

Data for Truck, Trailer and Dolly categories were based on limited data, mostly from published literature. Additional data acquisition is required in these areas.

FUTURE WORK

To continue to be useful, the Generic Vehicle data must be updated annually.

Data for single-axle trucks, small trailers and dollys must be extended to include additional vehicles.

The development of a companion document, Generic Tire Data, is needed. However, test data are limited. All testing agencies are encouraged to publish known data in order to extend the body of knowledge in this area.

SUMMARY

1. The current research documented the need to update the vehicle categories to provide data sets for modern vehicles.

2. New vehicle types were define: passenger car, pickup, multi-purpose, van, trucks and truck tractors, trailers, dollys and movable and fixed barriers.

3. Updated parameters were provided for each vehicle type for use by the current generation of 2-D and 3-D reconstruction and simulation models.

4. The values presented in these table are directly usable by statistical researchers. However, the researcher studying an individual case should consider the standard deviation when applying these values.

REFERENCES

1. Noga, T., Oppenheim, T., "CRASH3 User's Guide and Technical Manual", NHTSA, DOT HS-805 732 US Department of Transportation, Washington, DC, 1982.

2. *EDVAP User's Manual,* Engineering Dynamics Corporation, 1984 - 1996, Beaverton, OR.

TABLE 5. Parameters Documented For Each Vehicle

General	
	Number Of Axles
	Drive Axle(s)
	Drag, Aerodynamic Coefficient
	Drag, Velocity Coefficient
	Drag, Constant
Dimensions	
	CG to Front
	CG to Back
	CG to Sides
	CG Height
Inertias	
	Total Mass
	Sprung Roll Inertia
	Sprung Pitch Inertia
	Sprung Yaw Inertia
Stiffness (Front, Sides and Back)	
	A
	B
	K_V
Suspension (Front and Rear)	
	Type
	Wheel Ride Rate
	Wheel Damping Rate
	CG to Suspension, x-distance
	CG to Wheels, y-distance
	CG to Wheels, z-distance
	Tire Cornering Stiffness
	Tire Radius
	Inter-dual Spacing
	Inter-tandem Distance
	CG to Roll Center
	Lateral Spring Spacing
	Auxiliary Roll Stiffness
	Caster
	Camber
	Toe-in
	Steer Axis Inclination Angle
	Steering Gear Ratio
	Inter-tandem Dimension
Brakes (Front and Rear)	
	Master Cylinder Pressure Ratio
	Brake Torque Ratio, Front
	Brake Torque Ratio, Rear

Table 6-1. Generic Data For Passenger Cars

	Passenger Car									
	Class 1		Class 2		Class 3		Class 4		Class 5	
General										
Drive Axle	1		1		1		2		2	
Number Of Axles	2		2		2		2		2	
Drag Coefficient (in^2)	829.12	(33.35)	860.71	(20.77)	914.36	(39.50)	950.89	(38.62)	975.23	(40.54)
Drag Velocity (lb-sec/in)	0.01007	(0.0014)	0.01193	(0.0015)	0.0142	(0.0012)	0.01778	(0.0011)	0.01871	(0.0005)
Drag Const. (lb)	17.73	(2.47)	20.99	(2.66)	24.99	(2.04)	31.29	(2.01)	32.93	(0.90)
Exterior Dimensions										
CG To Front (in)	70.99	(8.34)	70.99	(13.77)	81.16	(14.43)	87.27	(23.82)	90.59	(3.67)
CG To Rear (in)	87.83	(8.94)	103.51	(9.42)	109.29	(16.59)	118.40	(22.11)	126.24	(2.54)
CG To Right (in)	32.40	(0.98)	33.85	(1.16)	34.75	(0.83)	36.98	(1.72)	37.22	(1.00)
CG To Left (in)	-32.40	(0.98)	-33.85	(1.16)	-34.75	(0.83)	-36.98	(1.72)	-37.22	(1.00)
CG To Ground (in)	20.60	(0.63)	21.00	(0.57)	22.05	(0.65)	22.38	(0.87)	22.48	(0.79)
Inertias										
Total Mass (lb-sec^2/in)	5.398	(0.75)	6.391	(0.81)	7.607	(0.62)	9.528	(0.61)	10.026	(0.27)
Sprung Inertia Roll (lb-sec^2-in)	2200	(330)	2300	(727)	3085	(467)	3822	(1140)	3834	(1109)
Sprung Inertia Pitch (lb-sec^2-in)	12383	(1843)	15845	(3726)	20001	(2429)	24980	(6043)	23985	(5861)
Sprung Inertia Yaw (lb-sec^2-in)	13489	(1870)	17286	(3198)	23989	(4198)	29294	(7339)	29279	(7360)
Stiffnesses										
Front										
A (lb/in)	180.25	(44.49)	184.69	(23.74)	206.64	(39.73)	215.40	(35.83)	288.73	(44.81)
B (lb/in^2)	72.11	(15.30)	65.38	(34.79)	69.97	(21.33)	66.70	(27.42)	113.45	(29.24)
Kv (lb/in^2)	95.27	(19.60)	84.51	(18.31)	93.40	(28.73)	87.73	(37.74)	147.56	(37.20)
Rear										
A (lb/in)	172.50	(27.34)	162.33	(19.29)	189.62	(34.69)	186.00	(3.27)	292.40	(109.16)
B (lb/in^2)	54.40	(17.05)	49.44	(25.39)	51.77	(19.79)	47.00	(1.63)	138.00	(104.00)
Kv (lb/in^2)	80.82	(23.98)	72.57	(14.57)	80.35	(30.10)	70.16	(4.63)	207.47	(155.62)
Sides										
A (lb/in)	88.25	(24.19)	100.00	(16.92)	95.75	(19.61)	137.00	n/a	137.00	n/a
B (lb/in^2)	59.75	(30.79)	66.20	(40.78)	77.75	(10.42)	95.00	n/a	95.00	n/a
Kv (lb/in^2)	88.92	(53.45)	84.06	(10.79)	97.45	(15.91)	119.12	n/a	119.12	n/a
Suspension										
Front										
Suspension Type	Independent		Independent		Independent		Independent		Independent	
Wheel Ride Rate (lb/in)	96.14	(16.38)	102.39	(10.00)	111.15	(21.51)	95.25	(5.97)	96.00	(2.16)
Wheel Damp Rate (lb-sec/in	9.90	(1.06)	9.23	(1.02)	8.69	(1.15)	7.02	(0.26)	6.86	(0.23)
CG To Suspension, x (in)	38.21	(6.26)	38.29	(3.23)	39.70	(4.23)	47.17	(3.78)	49.12	(1.40)
CG To Suspension, y (in)	27.55	(0.85)	28.31	(0.37)	29.36	(0.90)	29.94	(1.31)	30.01	(1.38)
CG To Suspension, z (in)	9.22	(0.63)	8.13	(0.57)	9.17	(0.65)	8.23	(0.87)	8.33	(0.79)
CG To Roll Center, (in)	23.04	(1.57)	20.32	(1.41)	22.93	(1.63)	20.56	(2.17)	20.81	(1.98)
Lateral Spring Spacing, (in	49.59	(1.54)	50.96	(0.66)	52.86	(1.61)	53.89	(2.35)	54.02	(2.49)
Aux Roll Stiffness (lb/rad)	17357	(537)	17836	(231)	21142	(645)	23890	(1043)	23947	(1102)
Caster (deg)	2.00	(1.25)	2.24	(1.12)	2.13	(0.92)	4.00	(2.58)	5.25	(3.18)
Camber (deg)	0.32	(0.31)	0.59	(0.68)	0.25	(0.43)	-0.04	(0.55)	0.25	(0.35)
Toe in (in)	0.02	(0.07)	0.09	(0.05)	0.07	(0.13)	0.07	(0.04)	0.08	(0.06)
Steer Axis Inclination (deg)	12.49	(2.03)	13.75	(0.81)	13.39	(2.40)	9.35	(4.07)	10.38	(0.38)
Steering Gear Ratio	19.19	(2.79)	19.10	(3.50)	16.62	(1.36)	16.93	(0.75)	17.67	(1.79)
Inter Tandem Dimension										
Rear										
Suspension Type	Independent		Independent		Independent		Solid		Solid	
Wheel Ride Rate (lb/in)	100.59	(19.81)	97.35	(21.10)	114.39	(34.29)	132.50	(20.16)	173.33	(9.43)
Wheel Damp Rate (lb-sec/in	7.99	(0.73)	7.01	(0.71)	6.93	(0.99)	6.96	(0.93)	7.64	(0.17)
CG To Suspension, x (in)	56.25	(6.35)	61.65	(3.24)	65.41	(14.76)	66.70	(21.94)	71.51	(1.51)
CG To Suspension, y (in)	27.30	(0.84)	28.66	(1.74)	28.92	(0.85)	30.92	(1.20)	30.00	(0.10)
CG To Suspension, z (in)	9.22	(0.63)	8.13	(0.57)	9.17	(0.65)	8.23	(0.87)	8.33	(0.79)
CG To Roll Center, (in)	13.83	(0.94)	12.19	(0.85)	13.76	(0.98)	12.34	(1.30)	12.49	(1.19)
Lateral Spring Spacing (in)	49.14	(1.51)	51.60	(3.14)	52.05	(1.54)	55.65	(2.17)	54.00	(0.18)
Aux Roll Stiffness (lb/rad)	0.00		0.00		0.00		0.00		0.00	
Caster (deg)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)
Camber (deg)	-0.55	(0.28)	-0.55	(0.20)	-0.42	(0.29)	-0.63	(0.13)	0.00	(0.00)
Toe in (in)	0.12	(0.08)	0.05	(0.09)	0.06	(0.07)	0.00	(0.00)	0.00	(0.00)
Steer Axis Inclination (deg)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)
Inter Tandem Dimension										
Brake System										
Master Cylinder Ratio (psi/lb)	13.69	(1.97)	15.16	(1.16)	17.56	(0.77)	14.49	(2.33)	18.50	n/a
Front Torque Ratio (in-lb/psi)	17.46	(2.64)	19.96	(5.73)	26.34	(4.28)	41.67	(0.78)	42.77	n/a
Rear Torque Ratio (in-lb/psi)	11.78	(2.77)	15.20	(5.12)	20.69	(3.44)	33.87	(0.05)	33.80	n/a

Table 6-2. Generic Data For Pickups, Multi-purpose and Vans

	Pickup				Multi-Purpose				Van			
	Class 1		Class 2		Class 1		Class 2		Class 1		Class 2	
General												
Drive Axle	2		2		2		2		1		2	
Number Of Axles	2		2		2		2		2		2	
Drag Coefficient (in^2)	1340.11	(52.28)	1824.44	(50.83)	1182.87	(71.58)	1266.69	(99.79)	1300.16	(101.21)	1602.05	(34.62)
Drag Velocity (lb-sec/in)	0.01367	(0.0008)	0.0214	(0.0011)	0.01692	(0.0028)	0.02339	(0.0027)	0.01622	(0.0014)	0.02436	(0.0019)
Drag Const. (lb)	24.06	(1.48)	37.66	(2.01)	29.78	(4.95)	41.17	(4.82)	28.54	(2.39)	42.86	(3.33)
Exterior Dimensions												
CG To Front (in)	76.76	(2.37)	87.98	(2.29)	76.15	(4.69)	82.73	(15.89)	79.97	(5.87)	87.18	(1.58)
CG To Rear (in)	102.09	(6.30)	122.61	(2.77)	81.60	(11.58)	109.07	(14.77)	98.56	(8.03)	101.49	(11.27)
CG To Right (in)	32.54	(0.57)	38.71	(1.70)	32.98	(1.32)	37.23	(2.94)	35.91	(1.35)	39.88	(0.09)
CG To Left (in)	-32.54	(0.57)	-38.71	(1.70)	-32.98	(1.32)	-37.23	(2.94)	-35.91	(1.35)	-39.88	(0.09)
CG To Ground (in)	23.28	(1.00)	27.16	(1.00)	26.39	(1.51)	29.25	(1.73)	27.11	(1.12)	31.70	(1.60)
Inertias												
Total Mass (lb-sec^2/in)	7.324	(0.45)	11.465	(0.61)	9.069	(1.51)	12.535	(1.47)	8.691	(0.73)	13.050	(1.01)
Sprung Inertia Roll (lb-sec^2-in)	2427	(429)	5430	(448)	3134	(933)	6395	(1455)	5656	(938)	9134	n/a
Sprung Inertia Pitch (lb-sec^2-in)	17835	(2810)	40008	(5698)	19588	(6054)	38674	(10532)	24493	(2183)	47204	n/a
Sprung Inertia Yaw (lb-sec^2-in)	19979	(1700)	43081	(4563)	21998	(5989)	40949	(10256)	26474	(3335)	51035	(4215)
Stiffnesses												
Front												
A (lb/in)	266.08	(31.97)	219.60	(31.62)	266.08	(31.97)	219.60	(31.62)	309.00	(89.61)	358.75	(40.49)
B (lb/in^2)	108.92	(26.31)	68.40	(19.35)	108.92	(26.31)	68.40	(19.35)	135.00	(76.32)	154.75	(21.75)
Kv (lb/in^2)	140.59	(32.52)	89.10	(27.38)	140.59	(32.52)	89.10	(27.38)	170.35	(89.32)	199.74	(31.89)
Rear												
A (lb/in)	258.33	(47.54)	290.67	(48.65)	258.33	(47.54)	290.67	(48.65)	281.00	(41.82)	312.00	(75.76)
B (lb/in^2)	108.83	(39.23)	123.00	(41.58)	108.83	(39.23)	123.00	(41.58)	118.50	(35.27)	141.73	(61.79)
Kv (lb/in^2)	161.77	(57.53)	190.30	(65.21)	161.77	(57.53)	190.30	(65.21)	182.02	(54.88)	221.37	(98.80)
Sides												
A (lb/in)	103.00	(3.27)	78.00	n/a	103.00	(3.27)	78.00	n/a	96.00	(0.00)	137.00	n/a
B (lb/in^2)	92.00	(0.82)	40.00	n/a	92.00	(0.82)	40.00	n/a	78.00	(0.00)	95.00	n/a
Kv (lb/in^2)	110.55	(1.41)	48.65	n/a	110.55	(1.41)	48.65	n/a	97.00	(0.00)	119.12	n/a
Suspension												
Front												
Suspension Type	Independent		Independent		Solid		Solid		Independent		Independent	
Wheel Ride Rate (lb/in)	149.85	(11.90)	184.17	(6.74)	156.33	(14.56)	180.08	(11.03)	164.50	(44.60)	180.73	(4.44)
Wheel Damp Rate (lb-sec/in)	9.60	(0.88)	8.85	(0.23)	8.03	(0.32)	7.51	(0.36)	9.41	(1.50)	7.35	(0.34)
CG To Suspension, x (in)	47.46	(2.47)	54.26	(3.31)	47.72	(3.01)	55.12	(4.86)	44.88	(5.07)	59.78	(3.93)
CG To Suspension, y (in)	27.42	(0.51)	32.45	(0.74)	28.58	(0.54)	29.11	(1.56)	30.37	(1.23)	34.41	(0.29)
CG To Suspension, z (in)	10.41	(1.10)	13.01	(1.00)	12.23	(1.51)	15.10	(1.73)	13.14	(1.22)	17.55	(1.60)
CG To Roll Center, (in)	26.02	(2.74)	22.76	(1.75)	21.41	(2.65)	26.42	(3.03)	22.99	(2.14)	30.70	(2.80)
Lateral Spring Spacing, (in)	49.35	(0.92)	58.41	(1.33)	51.44	(0.98)	52.40	(2.81)	54.67	(2.21)	61.94	(0.52)
Aux Roll Stiffness (lb/rad)	19742	(366)	25895	(590)	20574	(391)	23228	(1244)	21870	(883)	27458	(231)
Caster (deg)	3.63	(2.34)	3.58	(2.67)	4.06	(2.55)	5.21	(3.49)	2.87	(1.97)	4.35	(2.76)
Camber (deg)	1.31	(1.27)	0.29	(0.53)	0.38	(0.67)	-0.13	(1.58)	0.30	(0.28)	-0.27	(0.52)
Toe in (in)	0.05	(0.18)	0.13	(0.07)	0.09	(0.07)	0.09	(0.06)	0.07	(0.05)	0.07	(0.08)
Steer Axis Inclination (deg)	5.00	(5.00)	0.00	(0.00)	13.60	(8.82)	9.50	(0.61)	12.40	(1.85)	0.00	(0.00)
Steering Gear Ratio	21.85	(2.35)	17.35	(0.95)	17.10	(0.85)	17.40	(0.90)	18.97	(1.57)	17.35	(0.95)
Inter Tandem Dimension	N/A		N/A		N/A		N/A		N/A		N/A	
Rear												
Suspension Type	Solid		Solid		Solid		Solid		Solid		Solid	
Wheel Ride Rate (lb/in)	128.00	(11.45)	157.33	(6.37)	134.22	(9.24)	145.48	(7.90)	146.12	(15.00)	158.00	(8.00)
Wheel Damp Rate (lb-sec/in)	7.96	(0.43)	6.84	(0.22)	7.33	(0.42)	6.92	(0.36)	7.62	(0.61)	6.57	(0.00)
CG To Suspension, x (in)	58.62	(3.76)	77.64	(2.97)	47.44	(5.96)	55.64	(3.29)	63.33	(6.44)	64.07	(10.42)
CG To Suspension, y (in)	27.25	(0.22)	31.26	(1.26)	28.39	(1.51)	28.94	(2.00)	30.14	(0.97)	30.30	(2.75)
CG To Suspension, z (in)	10.41	(1.10)	13.01	(1.00)	12.23	(1.51)	15.10	(1.73)	13.14	(1.22)	17.55	(1.60)
CG To Roll Center, (in)	11.45	(1.21)	14.31	(1.10)	13.46	(1.66)	16.69	(2.02)	14.45	(1.35)	19.30	(1.76)
Lateral Spring Spacing (in)	49.05	(0.40)	56.27	(2.27)	51.11	(2.71)	52.08	(3.59)	54.26	(1.74)	54.54	(4.95)
Aux Roll Stiffness (lb/rad)	0.00		0.00		0.00		0.00		0.00		0.00	
Caster (deg)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)
Camber (deg)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	-0.44	(0.38)	0.00	(0.00)
Toe in (in)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)
Steer Axis Inclination (deg)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)
Inter Tandem Dimension	N/A		N/A		N/A		N/A		N/A		N/A	
Brake System												
Master Cylinder Ratio (psi/lb)	11.13	(3.07)	15.99	(2.51)	21.50	n/a	15.99	(2.51)	18.04	(0.94)	15.99	(2.51)
Front Torque Ratio (in-lb/psi)	25.23	(0.06)	41.94	(0.83)	39.92	(14.89)	37.15	(11.55)	29.70	(9.09)	34.84	(0.83)
Rear Torque Ratio (in-lb/psi)	23.59	(0.27)	33.85	(0.05)	37.29	(14.05)	32.32	(10.23)	26.49	(8.79)	33.85	(0.05)

Table 6-3. Generic Data For Trucks and Dollys

	Truck				Dolly	
	Class 1	Class 2	Class 3	Class 4	Class 1	Class 2
General						
Drive Axle			2,3	2,3	0	0
Number Of Axles			3	3	2	1
Drag Coefficient (in^2)					0.00	0.00
Drag Velocity (lb-sec/in)			0.01	0.01	0	0
Drag Const. (lb)			120.00	120.00	0.00	0.00
Exterior Dimensions						
CG To Front (in)			99.00	106.24	30.00	30.00
CG To Rear (in)			130.00	109.76	30.00	30.00
CG To Right (in)			48.00	48.00	24.00	24.00
CG To Left (in)			-48.00	-48.00	-24.00	-24.00
CG To Ground (in)						
Inerties						
Total Mass (lb-sec^2/in)			45.005	50.707	7.919	3.960
Sprung Inertia Roll (lb-sec^2-in)			36757	33852	1000	1000
Sprung Inertia Pitch (lb-sec^2-in)			1105493	120000	1000	1000
Sprung Inertia Yaw (lb-sec^2-in)			241479	120000	1000	1000
Stiffnesses						
Front						
A (lb/in)			1000.00	1000.00	1000.00	1000.00
B (lb/in^2)			1000.00	1000.00	250.00	250.00
Kv (lb/in^2)			1000.00	1000.00	500.00	500.00
Rear						
A (lb/in)			1000.00	1000.00	1000.00	1000.00
B (lb/in^2)			1000.00	1000.00	250.00	250.00
Kv (lb/in^2)			1000.00	1000.00	500.00	500.00
Sides						
A (lb/in)			1000.00	1000.00	1000.00	1000.00
B (lb/in^2)			1000.00	1000.00	250.00	250.00
Kv (lb/in^2)			1000.00	1000.00	500.00	500.00
Suspension	Data Unavailable*	Data Unavailable*				
Front						
Suspension Type			Solid	Solid	Tandem	Solid
Wheel Ride Rate (lb/in)			1500.00	1012.50	7818.00	7818.00
Wheel Damp Rate (lb-sec/in)			5.00	15.00	5.00	5.00
CG To Suspension, x (in)			68.60	76.24	24.00	24.00
CG To Suspension, y (in)			39.75	40.25	35.60	35.60
CG To Suspension, z (in)			20.13	27.60	19.70	19.70
CG To Roll Center, (in)			20.13	23.35	10.40	10.40
Lateral Spring Spacing, (in)			36.00	32.00	38.00	38.00
Aux Roll Stiffness (lb/rad)			567228	2299183	2033427	2033427
Caster (deg)			-0.32	-0.32	0.00	0.00
Camber (deg)			0.00	0.00	0.00	0.00
Toe in (in)			0.13	0.13	0.25	0.25
Steer Axis Inclination (deg)			-0.22	-0.22	0.00	0.00
Steering Gear Ratio			28.00	28.00	0.00	0.00
Inter Tandem Dimension			N/A	N.A	51.50	N/A
Rear						
Suspension Type			Tandem	Tandem	Tandem	
Wheel Ride Rate (lb/in)			3880.00	4000.00	7818.00	
Wheel Damp Rate (lb-sec/in)			5.00	15.00	5.00	
CG To Suspension, x (in)			57.40	41.76	24.00	
CG To Suspension, y (in)			36.00	36.00	35.60	
CG To Suspension, z (in)			20.13	27.60	19.70	
CG To Roll Center, (in)			20.13	25.90	10.40	
Lateral Spring Spacing (in)			36.00	35.00	38.00	
Aux Roll Stiffness (lb/rad)			0.00	0.00	2033427	
Caster (deg)			0.00	0.00	0.00	
Camber (deg)			0.00	0.00	0.00	
Toe in (in)			0.13	0.13	0.25	
Steer Axis Inclination (deg)			0.00	0.00	0.00	
Inter Tandem Dimension			51.50	51.50	51.50	
Brake System						
Master Cylinder Ratio (psi/lb)			1.00	10.00	1.00	1.00
Front Torque Ratio (in-lb/psi)			1200.00	1000.00	1000.00	1000.00
Rear Torque Ratio (in-lb/psi)			2000.00	1500.00	1000.00	1000.00

Table 6-4. Generic Data For Trailers and Barriers

	Trailer				Barrier	
	Class 1	Class 2	Class 3	Class 4	Class 1	Class 2
General	Data Unavailable*	Data Unavailable*				
Drive Axle			0	0	0	0
Number Of Axles			1	2	2	0
Drag Coefficient (in^2)					0.00	
Drag Velocity (lb-sec/in)			0.01	0.01	0	
Drag Const. (lb)			120.00	120.00	0.00	
Exterior Dimensions						
CG To Front (in)			194.55	318.96	84.00	50.00
CG To Rear (in)			183.45	142.04	78.00	50.00
CG To Right (in)			48.00	48.00	48.00	50.00
CG To Left (in)			48.00	48.00	-48.00	-50.00
CG To Ground (in)						
Inertias						
Total Mass (lb-sec^2/in)			40.813	29.670	10.352	1000000
Sprung Inertia Roll (lb-sec^2-in)			66224	66224	3252	1000000
Sprung Inertia Pitch (lb-sec^2-in)			542486	542486	41700	1000000
Sprung Inertia Yaw (lb-sec^2-in)			644483	644483	41700	1000000
Stiffnesses						
Front						
A (lb/in)			1000.00	1000.00	1000000	1000000
B (lb/in^2)			1000.00	1000.00	1000000	1000000
Kv (lb/in^2)			1000.00	1000.00	1000000	1000000
Rear						
A (lb/in)			1000.00	1000.00	0.00	0.00
B (lb/in^2)			1000.00	1000.00	0.00	0.00
Kv (lb/in^2)			1000.00	1000.00	0.00	0.00
Sides						
A (lb/in)			1000.00	1000.00	0.00	0.00
B (lb/in^2)			1000.00	1000.00	0.00	0.00
Kv (lb/in^2)			1000.00	1000.00	0.00	0.00
Suspension						
Front						
Suspension Type			Solid	Tandem	Solid	
Wheel Ride Rate (lb/in)			7818.00	7818.00	10000	
Wheel Damp Rate (lb-sec/in)			5.00	5.00	0.00	
CG To Suspension, x (in)			159.45	70.04	54.00	
CG To Suspension, y (in)			35.63	35.63	30.00	
CG To Suspension, z (in)			54.60	54.60	2.00	
CG To Roll Center, (in)			29.60	29.60	15.80	
Lateral Spring Spacing, (in)			38.00	38.00	48.00	
Aux Roll Stiffness (lb/rad)			2033427	2033427	100000	
Caster (deg)			0.00	0.00	0.00	
Camber (deg)			0.00	0.00	0.00	
Toe in (in)			0.13	0.13	0.13	
Steer Axis Inclination (deg)			0.00	0.00	0.00	
Steering Gear Ratio			0.00	0.00	0.00	
Inter Tandem Dimension			N/A	51.50	N/A	
Rear						
Suspension Type				Tandem	Solid	
Wheel Ride Rate (lb/in)				7818.00	10000.00	
Wheel Damp Rate (lb-sec/in)				5.00	0.00	
CG To Suspension, x (in)				118.04	54.00	
CG To Suspension, y (in)				35.63	30.00	
CG To Suspension, z (in)				54.60	2.00	
CG To Roll Center, (in)				29.60	15.80	
Lateral Spring Spacing (in)				38.00	48.00	
Aux Roll Stiffness (lb/rad)				2033427	100000	
Caster (deg)				0.00	0.00	
Camber (deg)				0.00	0.00	
Toe in (in)				0.13	0.00	
Steer Axis Inclination (deg)				0.00	0.00	
Inter Tandem Dimension				51.50	N/A	
Brake System						
Master Cylinder Ratio (psi/lb)			1.00	1.00	3.50	3.50
Front Torque Ratio (in-lb/psi)			1000.00	1000.00	1000.00	
Rear Torque Ratio (in-lb/psi)				1000.00	1000.00	

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