RESEARCH INPUT FOR COMPUTER SIMULATION OF AUTOMOBILE COLLISIONS
VOLUME IV
STAGED COLLISION RECONSTRUCTIONS

DISCLAIMER

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. DOT HS 805 040	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Research Input for Computer Simulation of Automobile Collisions, Volume IV. Staged Collision Reconstructions.		5. Report Date DECEMBER 1978
		6. Performing Organization Code
7. Author(s) Ian S. Jones, A. S. Baum		8. Performing Organization Report No. ZQ-6057-V-6
9. Performing Organization Name and Address Calspan Corporation, Advanced Technology Center, P. O. Box 400, Buffalo, New York 14225		10. Work Unit No.
		11. Contract or Grant No. DOT-HS-7-01511
12. Sponsoring Agency Name and Address U. S. Department of Transportation, National Highway Traffic Safety Administration, Washington, D. C. 20590		13. Type of Report and Period Covered Final Report, June 1977 - December 1978
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

Volume IV of this document describes and evaluates computer reconstructions of the twelve staged collisions presented in Volumes II and III. Results of the CRASH II program were judged on their degree of correspondence with the measured impact speeds and changes in velocity. Reconstructions using the SMAC program were assessed on the basis of the accuracy of the predicted final rest positions, damage dimensions, and changes in velocity. On the whole, the results from both the reconstruction programs were satisfactory. Recommendations that are made include: 1) to update representative values of vehicle characteristics used in the CRASH II program, 2) to add a stationary vehicle option to the CRASH program, 3) to simulate hard points and corner effects in the SMAC program, and 4) to provide an option to input tire cornering stiffness time history data in order to simulate weight transfer effects.

17. Key Words Accident Reconstruction, Computer Simulation, Automobile Collisions, Crashworthiness		18. Distribution Statement Document is available to the public through the National Technical Information Service, Springfield, Virginia 22151	
19. Security Classif. (of this report) None	20. Security Classif. (of this page) None	21. No. of Pages 185	22. Price

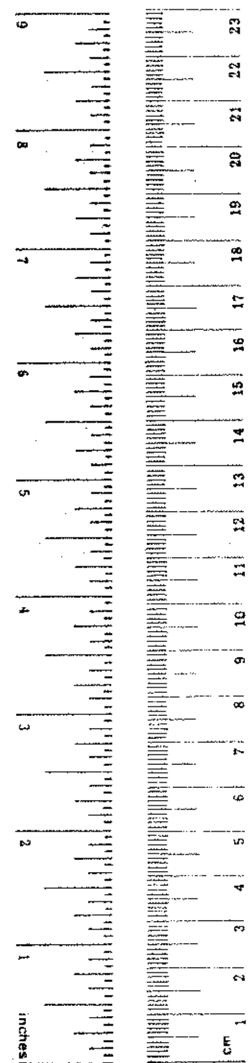
Form DOT F 1700.7 (8-69)

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

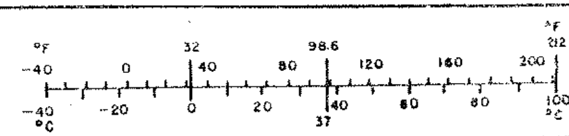
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



FOREWORD

This document summarizes the research achieved under Contract No. DOT-HS-7-01511, "Research Input for Computer Simulation of Automobile Collisions", with National Highway Traffic Safety Administration, U. S. Department of Transportation. Volume I summarizes previous existing experimental data from staged collisions and presents plans for future data needs. The experimental data generated in twelve staged collisions are reported in Volumes II and III of this document. Volume II contains the experimental test data for Test No. 1 through No. 5. Volume III contains the test data for Test No. 6 through No. 12. The reconstruction of these collisions, using the CRASH and SMAC simulation programs, is reported in Volume IV of this document.

The Contract Technical Manager for Phase II was Mr. Thomas Noga of the National Highway Traffic Safety Administration.

The opinions and findings expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

This report has been reviewed and approved by:

K. Hendershot

K. C. Hendershot, Head
Transportation Research Department

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES - Continued

Figure No.

LIST OF TABLES

1.0 INTRODUCTION

The objective of this program was to run twelve staged collisions and reconstruct them using the CRASH II and SMAC programs. This volume reports these reconstructions, compares the results with the measured data and discusses the shortcomings of the programs. The CRASH II reconstructions are presented and discussed in Section 2, the SMAC reconstructions in Section 3, and conclusions and recommendations in Section 4.

To aid in the reconstruction process, a minimum of ten high speed cameras were used to photograph each collision. Cameras were stationed on the ground at eye level and were located on portable towers as well. Two hand-held motion picture cameras (24 fps) were used to track each of the vehicles before, during, and after impact.

On-board instrumentation provided additional data which were used to assist in, and evaluate the accuracy of, the computer reconstructions. This volume deals almost exclusively with data collected by a triaxial (XYZ) accelerometer mounted on the vehicle's firewall, a linear stroke potentiometer attached to the vehicle steering linkage to measure the vehicle steer angle, and a rate gyroscope to obtain the vehicle yaw rate. Outputs from these instruments were recorded on 14 channel FM tape recorders. The analogue data recorded during the crash test were converted into digital form.

Plots of the digitized data were generated by a computer program, which also integrated the acceleration time histories* in order to obtain velocity (and displacement) time histories along each of the vehicle's three axes. Also from the time histories of the acceleration, the time at which separation occurred was estimated. It was defined to be the point at which both the involved vehicles' accelerations reapproached 0 g's. Table 1-1 presents the estimated contact durations for each of the twelve tests. It

*The integration algorithm is a combination of Simpson's and Newton's 3/8 methods.

TABLE 1-1

COLLISION CONTACT DURATION

Test No.	Contact Duration (Sec)	Test No.	Contact Duration (Sec)
1	.225	7	.200
2	.225	8	.200
3	.200	9	.200
4	.275	10	.200
5	.250	11	.225
6	.200	12	.225

should be noted that the separation point was not always obvious in collisions in which the two vehicles spun out together, e.g., Test 8.

The components of a vehicle's change in velocity (ΔV) were subsequently computed by subtracting the initial velocity at impact from the velocity at the time of separation. These are presented in Table 1-2.

It was discovered that the value of the separation velocity was contaminated by the effects of rotation of the vehicles between impact and separation. The data reduction software which computed the velocity time histories was originally developed in conjunction with prior research programs investigating vehicle crashworthiness. These studies primarily involved frontal collisions with barriers, and hence, very little, if any, rotation. Under these conditions, integrating the output of an accelerometer measuring acceleration along the, say, X-axis of the vehicle, gives one the vehicle's actual x-component of velocity, because the direction-cosine matrix (to be introduced below) essentially does not change throughout the collision and post crash trajectory. Unfortunately, modification of the sofware to account for the rotation was beyond the scope of this study.

In order to demonstrate the effect of the vehicle rotation, consider the two-dimensional vectors, $\vec{X}$, $\vec{Y}$ and $\vec{r}$, shown in Figure 1-1.

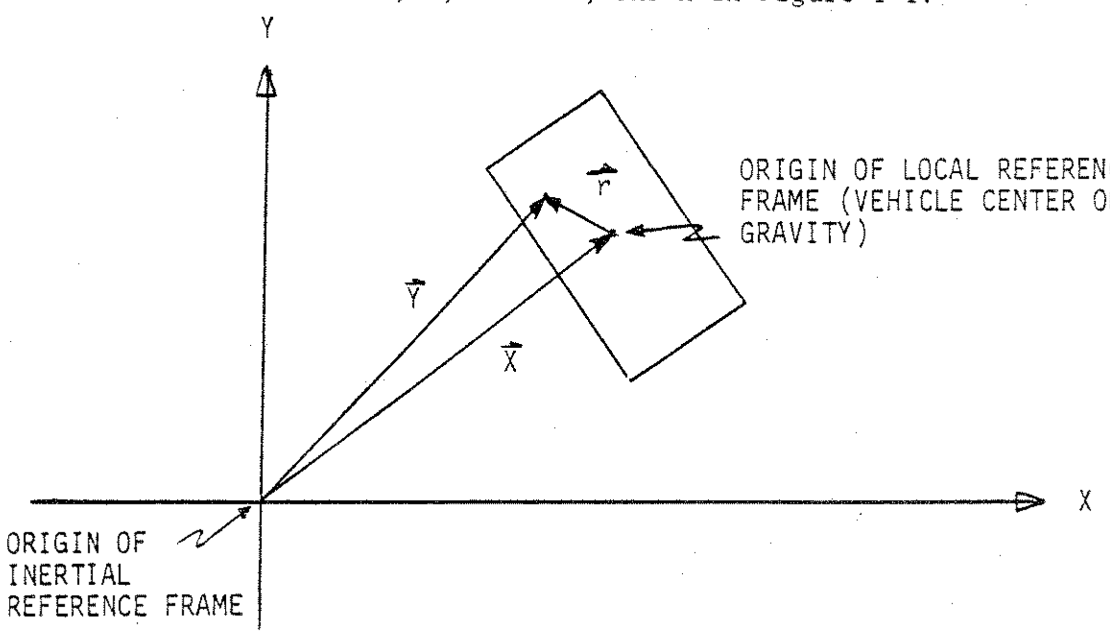


Figure 1-1 SCHEMATIC OF THE RELATION BETWEEN $\vec{X}$, $\vec{Y}$ AND $\vec{r}$

TABLE 1-2

VELOCITY CHANGE MEASURED AT FIREWALL

Test No.	Impact Configuration	Vehicle Size	~ΔV at Firewall ΔV	ΔVx	ΔVy
1	60° Front-to-Side	I	12.2	-10.6	6.0
		SC	15.6	-12.1	-9.8
2	60° Front-to-Side	I	19.6	-16.5	10.5
		SC	--	--	--
6	60° Front-to-Side	I	9.2	-8.5	3.0
		SC	11.9	-11.5	-3.2
7	60° Front-to-Side	I	12.0	-11.5	3.5
		SC	16.5	-14.1	-8.5
8	90° Front-to-Side	I	15.3	-12.7	8.6
		I	10.7	-7.2	-8.0
9	90° Front-to-Side	M	21.4	-17.7	12.0
		I	8.9	-5.0	-7.4
10	90° Front-to-Side	M	35.1	-27.3	22.0
		I	14.1	-8.8	-11.0
11	10° Offset Front-to-Front	SC	24.0	-24.0	0.8
		I	15.7	-15.6	2.0
12	10° Offset Front-to-Front	SC	40.1	-40.0	-2.2
		I	26.4	-26.0	4.8
3	10° Offset Front-to-Rear	I	9.5	-9.5	-0.4
		C	15.8	15.8	-0.2
4	10° Offset Front-to-Rear	I	18.7	-18.7	0.4
		SC	22.2	22.2	-2.8
5	10° Offset Front-to-Rear	I	16.3	-16.3	0.2
		M	25.1	25.0	-1.8

The location of point r in the inertial reference (denoted by $\vec{Y}$) can be given by the following matrix-vector equation:

$$\vec{Y} = \vec{X} + D^{-1}\vec{r} \tag{1}$$

where: $\vec{Y}$ - is a vector, whose components are in the inertial reference, from the inertial reference origin to point r

$\vec{X}$ - is a vector, whose components are in the inertial reference, from the inertial reference origin to the local reference origin (vehicle's center of gravity)

$\vec{r}$ - is a vector, whose components are in the local reference, from the local reference origin to point r

D - is the direction cosine matrix that relates the local reference system to the inertial frame

Differentiating Equation (1) with respect to time, the linear velocity of point r (in the inertial reference frame) is obtained.

$$\dot{\vec{Y}} = \dot{\vec{X}} + D^{-1}\vec{w}\otimes\vec{r} \tag{2}$$

where $\vec{w}$ - is a vector representing the angular velocity of the vehicle about its local axes

$\otimes$ - denotes the vector cross-product operation

The linear acceleration of the point r, in the inertial frame, can be obtained by differentiating Equation (2) to give

$$\ddot{\vec{Y}} = \ddot{\vec{X}} + D^{-1}\dot{\vec{w}}\otimes\vec{r} + D^{-1}\vec{w}\otimes(\vec{w}\otimes\vec{r}) \tag{3}$$

Equations (2) and (3) can be readily transformed into the local reference frame. Results of this transformation are shown for the linear velocity in Equation (4) and the linear acceleration in Equation (5).

$$D\,\dot{\vec{Y}} = D\,\dot{\vec{X}} + \vec{w} \otimes \vec{r} \tag{4}$$

$$D\,\ddot{\vec{Y}} = D\,\ddot{\vec{X}} + \dot{\vec{w}} \otimes \vec{r} + \vec{w} \otimes (\vec{w} \otimes \vec{r}) \tag{5}$$

The output of a triaxial accelerometer package located at point r, is represented by Equation (5). It should be obvious that, if the accelerometers are not placed at the local reference origin (vehicle center of gravity), the data obtained include a rotational effect, dependent not only on the magnitude of the offset, but also on the vehicle's angular velocity and angular acceleration.

Placing the accelerometer package at the local reference center of gravity does not entirely alleviate the problem of the need to account for rotation. Under the assumption that the accelerometer is at the center of gravity, Equations (4) and (5) become Equations (6) and (7), respectively.

$$D\,\dot{\vec{Y}} = D\,\dot{\vec{X}} \tag{6}$$

$$D\,\ddot{\vec{Y}} = D\,\ddot{\vec{X}} \tag{7}$$

The integration of Equation (7) with respect to time, without regard for the local reference's relation to the inertial frame, will result in Equation (6) only if the direction-cosine matrix remains constant over time, i.e., $\int_{t0}^{t1} D\,\ddot{\vec{X}}\,dt = D\int_{t0}^{t1} \ddot{\vec{X}}\,dt = D\,\dot{\vec{X}}$ if and only if D is a constant.

The software which reduced the raw accelerometer data from the staged collisions, unfortunately, is based on the assumption of a constant direction cosine matrix. Furthermore, it only calculates velocities and displacements for the position at which the accelerometer is located so that the behavior at other locations in the vehicle (particularly, the center of gravity) cannot be determined.

Neglecting the rotational effects obviously can introduce some error in the values of the velocity changes that are ultimately derived from the data. An examination of the ΔV's presented in Table 1-2 suggests, for instance, that linear momentum was not necessarily conserved during the impact, nor were the impacts necessarily co-linear. These are, however, artifacts caused by excluding the effects of rotation (and, in some cases, perhaps exacerbated by difficulties in precisely determining the time of separation). In an attempt to estimate the degree to which the data are affected, Table 1-3 has been compiled. It presents the change in heading angle between impact and separation (in order to estimate changes in the direction-cosine matrix), the angular velocity at separation, the maximum angular velocity, and the offset from the center of gravity of the accelerometer package; the latter three variables are useful in approximating the magnitude of the $\vec{w} \times \vec{r}$ term.

It would appear from Table 1-3, that the failure to consider changes in the D matrix may probably produce significant variations in only one case; specifically, the data for Vehicle 1 in Case 10, which rotated 55° between impact and separation. The cases in which significant error would likely be introduced by assuming that the change in velocity at the firewall was equivalent to that experienced at the center of gravity are: Test 2, Vehicle 1; Test 6, Vehicle 2; Test 7, Vehicle 2; and Vehicle 1 in Tests 8, 9, 10 and 12. The implications of the above discussion when evaluating the SMAC and CRASH II ΔV predictions will be considered on a case-by-case basis in Sections 2 and 3.

TABLE 1-3

FACTOR INFLUENCING MAGNITUDE OF EFFECTS OF ROTATION

Test No.	Vehicle No.	Change in Heading Angle (deg)	Maximum Angular Velocity (deg/sec)	Angular Velocity at Separation (deg/sec)	r_x (ft)	r_y (ft)
1	1	15	120	90	.57	-.74
	2	0	0	0	1.12	-.52
2	1	18	150	150	.70	-.80
	2	-9	-120	90	1.27	-.46
3	1	1	20	15	1.31	-.01
	2	0	0	0	.49	-.57
4	1	lost data	45	37	1.31	-.01
	2	lost data	30	30	.35	-.52
5	1	5	20	12	-1.32	-.03
	2	lost scale factor	90	70	.88	.33
6	1	5	45	30	.54	-.73
	2	20	210	180	2.53	-.37
7	1	12	65	30	.54	-.77
	2	22	210	192	2.48	-.38
8	1	15	135	114	.95	-.75
	2	0	18	18	.93	-.73
9	1	27	210	180	.88	-.74
	2	-10	-45	-45	1.21	-.56
10	1	55	300	300	.78	-.71
	2	-12	-90	-72	1.24	-.49
11	1	-5	-45	-30	1.61	1.02
	2	0	0	0	1.20	.23
12	1	-10	-90	-90	1.03	1.01
	2	-2	-60	-60	1.30	.16

2.0 DISCUSSION OF THE CRASH II RECONSTRUCTION RESULTS

Table 2-1 gives a summary of the CRASH II results showing impact configuration and vehicle size together with the measured and predicted values of impact speed and velocity change for each vehicle. Note that two predicted velocity changes are given. The first is that calculated using the spin out routine combined with the conservation of momentum routine for oblique type impacts or the spin out routine combined with the damage routine for axial type impacts; the second is the velocity change calculated using the damage only routine.

To aid interpretation of the results, rather than list the tests in numerical order, the tests have been grouped by impact configuration: Tests 1, 2, 6 and 7 were front-to-side impacts with the bullet car striking at a 60° angle with respect to the longitudinal axis of the struck car; Tests 8, 9 and 10 were front-to-side impacts with the bullet car striking at 90°; Tests 11 and 12 were front-to-front impacts with the vehicles offset and striking at a 10° angle; and Tests 3, 4 and 5 were front-to-rear impacts with the vehicles offset and striking at a 10° angle.

A cursory inspection of the table shows that on the whole there is good agreement between the CRASH II predictions and the measured values. Looking at impact speeds, the agreement is extremely good for the 60° front-side impacts and the 90° front-side impacts. The largest discrepancy being 3.7 mph for Vehicle 2 in Test 8. Larger discrepancies occur in the axial type impacts. These errors can be attributed to the DAMAGE subroutine underestimating the velocity changes that the vehicles undergo. For example, looking at the head-on impacts, although the agreement for Test 11 is good, for Test 12 the impact speed of Vehicle 1 is underestimated by 11.7 mph because the corresponding velocity change is also underestimated. Similar problems occur with the rear end impacts, Tests 3, 4 and 5. For all these tests, the impact speed of the striking vehicle is underestimated and that for the struck vehicle overestimated because the corresponding velocity changes are underestimated.

TABLE 2-1

SUMMARY OF CRASH RESULTS

Test No.		Vehicle Size	Measured Values Impact Speed	Measured Values ΔV	Crash Values Impact Speed	Crash Values ΔV_1	Crash Values ΔV_2
1	60° Front-to-Side	I	19.8	12.2	20.6	9.6	18.5
		S	19.8	15.6	20.4	14.4	27.7
2	60° Front-to-Side	I	31.5	19.6	29.6	20.6	19.3
		SC	31.5	--	33.3	30.9	29.0
6	60° Front-to-Side	I	21.5	9.2	24.9	12.4	12.7
		SC	21.5	11.9	20.5	20.4	20.9
7	60° Front-to-Side	I	29.1	12.0	26.2	11.6	16.3
		S	29.1	16.5	27.1	25.3	35.5
8	90° Front-to-Side	I	20.75	15.3	19.5	10.3	10.0
		I	20.75	10.7	24.5	9.5	9.5
9	90° Front-to-Side	M	21.2	21.4	23.2	24.2	19.1
		I	21.2	8.9	22.0	11.2	8.8
10	90° Front-to-Side	M	33.3	35.1	32.7	33.6	22.4
		I	33.3	14.1	31.5	15.9	10.9
11	10° Offset Front-to-Front	S	20.4	24.0	17.2	21.0	21.1
		I	20.4	15.7	18.0	13.2	13.2
12	10° Offset Front-to-Front	S	31.5	40.1	19.8	28.2	28.2
		I	31.5	26.4	30.2	20.0	19.6
3	10° Offset Front-to-Rear	I	21.2	9.5	15.2	3.1	3.1
		S	0.0	15.8	10.4	5.4	4.9
4	10° Offset Front-to-Rear	I	38.7	18.7	31.9	10.3	9.1
		S	0.0	22.2	4.9	13.0	14.1
5	10° Offset Front-to-Rear	I	39.7	16.3	33.8	8.1	8.1
		M	0.0	25.1	10.5	15.2	14.8

In summary, discrepancies between CRASH II predictions and measured values of impact speeds appear to be limited to head-on impacts at high speed (closing speeds of 60 mph) and to rear end impacts. It should be stressed that these are impact configurations for which there were limited data available when the stiffness coefficients were originally calculated for the damage analysis of the CRASH II program.* Updating these coefficients using the present data should, of course, improve the agreement.

2.1 Evaluation of the SPIN II Routine

Since the major discrepancies in impact speed stem from the damage analysis subroutine, it is instructive to compare the separation conditions predicted by the SPIN II routine with the measured values. This enables the effectiveness of the SPIN II routine to be evaluated independently. Table 2-2 gives a summary of the separation conditions for each test. Looking at the resultant velocities, the agreement is extremely good, generally within 5 mph with the exception of Test 2 which has a discrepancy of 6.7 mph for Vehicle 1, and Test 5, in which there is a difference of 6.5 mph for Vehicle 2. Both of these vehicles experienced a significant amount of rotation, the effects of which were neglected in the computation of the separation velocities.

The agreement is better (but not statistically significant) for the axial type collisions than for the oblique intersection type collisions which can be explained by the fact that the spin out trajectories in these cases are more nearly linear and the estimation of the velocity dissipated in the spin out correspondingly more accurate. This trend is more pronounced in the comparison of the velocity components; the average absolute deviation for the axial impacts differed significant from the oblique impacts ($t_{44} = 2.19$, $p \leq .05$). This again is explained by the fact that the trajectories in axial impacts are more linear, so that the lateral component of velocity is small and the estimated heading angle at separation less subject to error. To explain further, the velocity components are calculated by resolving the resultant velocity change using the vehicle's heading angle at separation.

---

*McHenry, R. R., "User's Manual for the CRASH Computer Program," Calspan Report No. ZQ-5708-V-3, January 1976.

TABLE 2-2

SUMMARY OF SEPARATION CONDITIONS
MEASURED VERSUS SPIN II PREDICTED VALUES

Test No.	Configuration	Vehicle 1 Separation Velocity						Vehicle 2 Separation Velocity					
		Measured			Predicted			Measured			Predicted		
		V	V_x	V_y	V	V_x	V_y	V	V_x	V_y	V	V_x	V_y
1	60° Front-Side	11.0	9.2	6.0	11.5	11.2	2.4	12.5	7.7	-9.8	14.6	10.3	-10.3
2	60° Front-Side	18.3	15.0	10.5	11.6	9.9	6.1	--	--	--	23.5	10.6	-21.0
6	60° Front-Side	13.3	13.0	3.0	12.9	12.7	2.3	10.5	10.0	-3.2	17.0	7.2	-15.4
7	60° Front-Side	17.9	17.6	3.5	15.3	15.0	3.2	17.2	15.0	-8.5	19.6	8.9	-17.5
8	90° Front-Side	11.8	8.0	8.6	14.3	12.3	7.3	15.7	13.6	-8.0	18.8	17.5	-6.9
9	90° Front-Side	12.5	3.5	12.0	9.9	1.1	9.8	17.8	16.2	-7.4	20.2	17.4	-10.2
10	90° Front-Side	22.8	6.0	22.0	20.0	6.1	19.0	26.9	24.5	-11.0	25.8	22.3	-13.0
11	Offset Head on	-3.7	-3.6	0.8	-3.8	-3.8	0.3	-5.2	4.8	2.0	4.8	4.8	0.2
12	Offset Head on	-8.7	-8.5	-2.2	-8.5	-8.3	-1.6	7.3	5.5	4.8	11.6	10.7	4.6
3	Offset Rear End	11.7	11.7	0.4	12.1	12.1	0.2	15.8	15.8	-0.2	15.5	15.3	-2.3
4	Offset Rear End	20.0	20.0	-0.4	23.3	22.8	4.9	22.4	22.2	-2.8	17.7	17.1	-4.4
5	Offset Rear End	23.4	23.4	0.2	25.7	25.7	0.0	25.1	25.0	-1.8	25.5	25.1	-4.5

This is estimated to be along the line joining the impact position with the rest or end-of-notation position, or in the case of curved trajectories, the tangent to the circle* at the impact position. Obviously, for near linear trajectories, which is usually the case for axial type impacts, any error in the heading angle is likely to be small. Conversely, in oblique type impacts, which tend to produce more complicated spin outs with large lateral and angular velocities, the likelihood of error must be higher.

During the course of the study, a problem was detected in the curved trajectory option in situations in which no end-of-rotation point was defined. In the three cases that were applicable, i.e., Tests 4, 9 and 10, the program calculated outlandish values for the separation velocities. This problem was circumvented by considering the curved trajectory as two straight line segments, one joining the point of impact to an end-of-rotation point and a second from end-of-rotation to the final rest position.

The source of this problem was traced to an error in the CRASH II program. The necessary changes to the source code are presented and discussed in Appendix I, but reconstructions reported herein did not utilize the corrected version of the program. It is notable, however, that the results obtained from the corrected curved trajectory routine were almost identical to the ones presented in this report.

2.2 Discussion of Individual Cases

A discussion of each case follows. For the convenience of the reader, a schematic diagram of each test configuration is given together with a table comparing predicted and measured data.

*The radius of the circle is estimated using the impact position, rest position and an intermediate point in the trajectory.

Test No. 1 - 60° Front-to-Side Impact - Chevrolet Chevelle Vs. Ford Pinto - Impact Speeds, 19.8/19.8 mph

Accident Schematic - Figure 2-1

The estimated impact speeds for both vehicles are in extremely close agreement; 20.6 mph versus 19.8 mph actual for Vehicle 1 and 20.4 mph versus 19.8 mph actual for Vehicle 2. The velocity changes predicted from the conservation of linear momentum are also in good agreement; for Vehicle 1, 9.6 mph versus 12.2 mph actual, and for Vehicle 2, 14.4 mph versus 15.6 mph actual. The velocity changes predicted from the vehicle damage are both grossly overestimated; for Vehicle 1, 18.5 mph versus 12.2 mph actual and 27.7 mph versus 15.6 mph actual for Vehicle 2. However, there was considerable corrosion on the Ford Pinto used in the test such that the stiffness of this vehicle was degraded. This means that the stiffness coefficients in the damage routine would be too high, which when combined with the damage profile (also more severe because of the degraded stiffness), results in an overestimate of the velocity change.

Looking at the separation velocities of each vehicle, both are slightly overestimated by SPIN II, 11.5 mph versus 11.0 mph for Vehicle 1 and 14.6 mph versus 12.5 mph for Vehicle 2. However, because of the relatively small amount of spin out, these velocities were very sensitive to quite small change in the impact and rest positions of the vehicles.

ACCIDENT SCHEMATIC

VEHICLES:

No. 1 - 1974 CHEVROLET CHEVELLE MALIBU
No. 2 - 1974 FORD PINTO

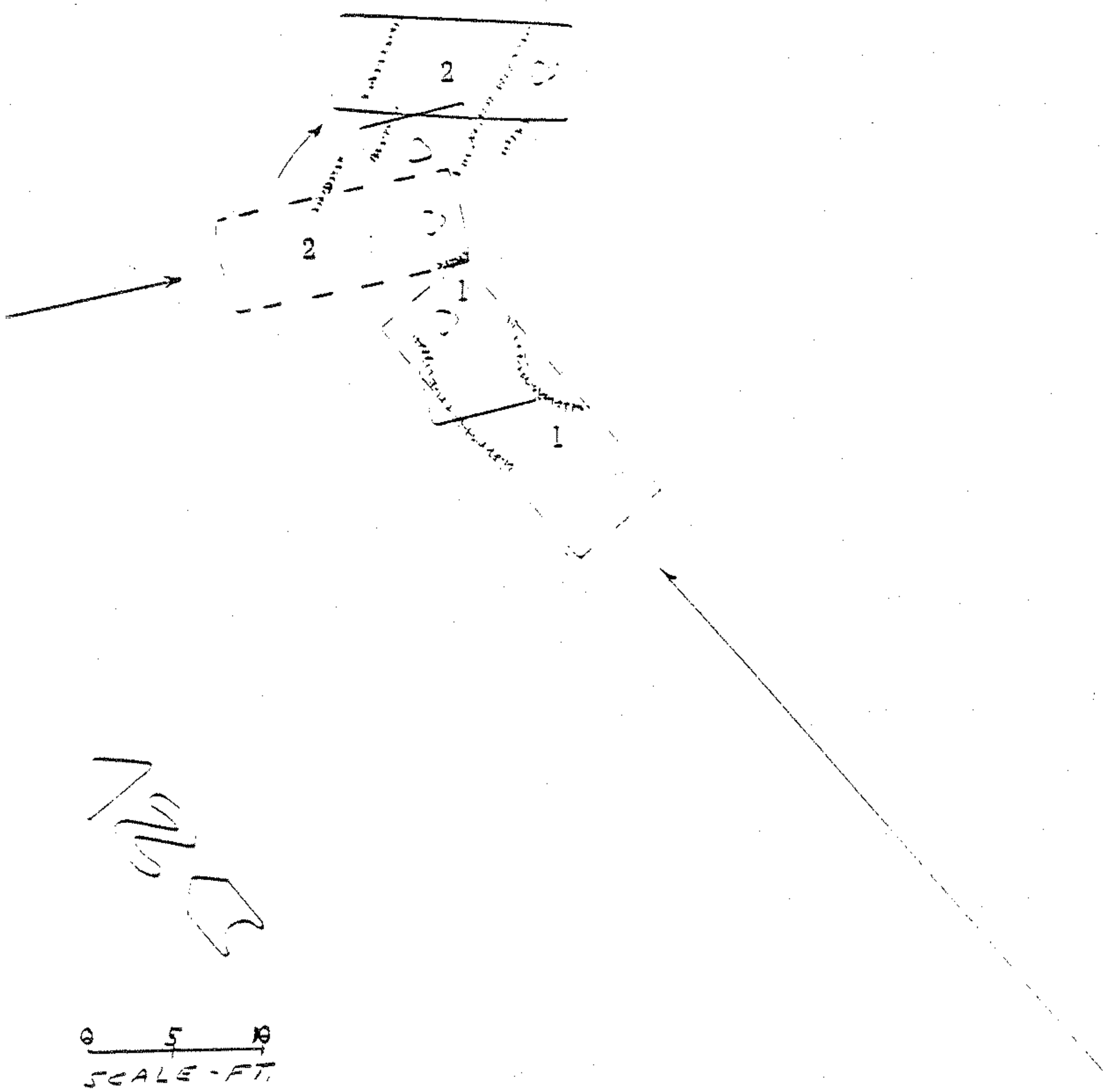


Figure 2-1 TEST NO. 1 - RICSAC ACCIDENT SCHEMATIC

SUMMARY FORM FOR STAGED COLLISION REPORTING

Comparison of Result

	MEASURED			SMAC			CRASH SPIN II		CRASH DAMAGE
	SPEED AT IMPACT	Δ V	VDI	SPEED AT IMPACT	Δ V	VDI	SPEED AT IMPACT	Δ V	Δ V
	MPH	MPH		MPH	MPH		MPH	MPH	MPH
VEHICLE #1	19.8	R 12.2 X -10.6 Y 6.0	11FZEW2	19.8	R 14.2 X Y	12FDEW3	20.6	R 9.6 X -9.3 Y 2.4	R 18.5 X -16.0 Y 9.3
VEHICLE #2	19.8	R 15.6 X -12.1 Y -9.8	01RDEW3	19.8	R 20.0 X Y	03RDEW3	20.4	R 14.4 X -10.1 Y -10.3	R 27.7 X -24.0 Y -13.9

Summary of Physical Evidence

	REST POSITIONS			IMPACT POSITIONS			END OF ROTATIONAL AND/OR LAT. SKID.				ROLLING RESISTANCE				TIRE PAVEMENT
	X'_{CR}	Y'_{CR}	ψ_R	X'_{CS}	Y'_{CS}	ψ_S	X'_{C1}	Y'_{C1}	ψ_1	ROT.	RF	LF	RR	LR	μ
	FT.	FT.	DEG.	FT.	FT.	DEG.	FT.	FT.	DEG.						
VEHICLE #1	-2.4	-1.0	-1.5	-10.8	1.0	-30.0	--	--	--	CW	.01	.01	.2	.2	-87
VEHICLE #2	7.5	2.5	105.0	0.0	-5.5	90.0	--	--	--	CW	.01	.01	.2	.2	

MEASURED DAMAGE DIMENSIONS

	WIDTH	DAMAGE EXTENT						MOMENT ARM		DIRECTION			
	L1	C11	C12	C13	C14	C15	C16	DI	RATIO	ANGI	VEH. SIZE	VEH. WGT.	REFERENCE
	IN.	IN.	IN.	IN.	IN.	IN.	IN.	IN.	RHOI	DEG.		LBS.	
VEHICLE #1	46.0	4.0	5.5	7.0	10.2	12.1	14.8	14.3	--	-30	I	4621	
VEHICLE #2	113.3	0.5	12.0	10.6	11.8	9.0	4.1	21.8	--	-30	S	3082	

COLLISION CONFIGURATION: 60° front-to-side impact

TEST IDENTIFICATION: RICSAC Test No. 1 - Chevrolet Chevelle Vs. Ford Pinto

Test No. 2 - 60° Front-to-Side Impact - Chevrolet Chevelle Vs. Ford Pinto - Impact Speeds, 31.5/31.5 mph

Accident Schematic - Figure 2-2

The estimated impact speeds are in good agreement; for Vehicle 1, 29.6 mph versus 31.5 mph actual and for Vehicle 2, 33.3 mph versus 31.5 mph actual. The velocity changes for Vehicle 1 agree closely, 20.6 mph from conservation of momentum and 19.3 mph from the damage analysis, versus 19.6 mph actual. Unfortunately, the accelerometer traces for Vehicle 2 were lost (due to malfunction of recording equipment) so that it is not possible to make a comparison for this vehicle. Suffice it to say that there is good agreement between the conservation of momentum and damage analysis ΔV's, although there is a small discrepancy in the components. This results from the heading angle used for resolution; in the damage analysis, it is assumed to be the line of maximum force whereas in the conservation of momentum calculation, it is the direction of spin out. Obviously, any difference between these two angles will be reflected in the components of the velocity change.

The separation velocity of Vehicle 1 was underestimated, 11.6 mph versus 18.3 mph actual. As mentioned previously, the SPIN II routine is particularly sensitive to the vehicle positions in estimating short spin out trajectories such that adjustment of the rest position would probably allow a better fit to be obtained. Furthermore, Vehicle 1 experienced a high (150 deg/sec) angular velocity for approximately 100 of the 225 msec. contact duration. The components of $\vec{r}$ (shown in Table 1-3) are such, that in combination with a clockwise rotation, the x-component of the separation velocity will decrease as will the y-component. This will improve the degree of correspondence between the actual and predicted separation velocities. At the same time, this has the effect of increasing the magnitude of ΔV_x and decreasing the magnitude of ΔV_y. As a result, the effect on the resultant velocity change should be minimal, thus preserving the good agreement reported above. Because the acceleration time histories for Vehicle 2 were not recorded, the actual separation velocities could not be calculated and, therefore, a comparison with the predicted values was not possible.

ACCIDENT SCHEMATIC

VEHICLES:

No. 1 - 1974 CHEVROLET CHEVELLE MALIBU
No. 2 - 1974 FORD PINTO

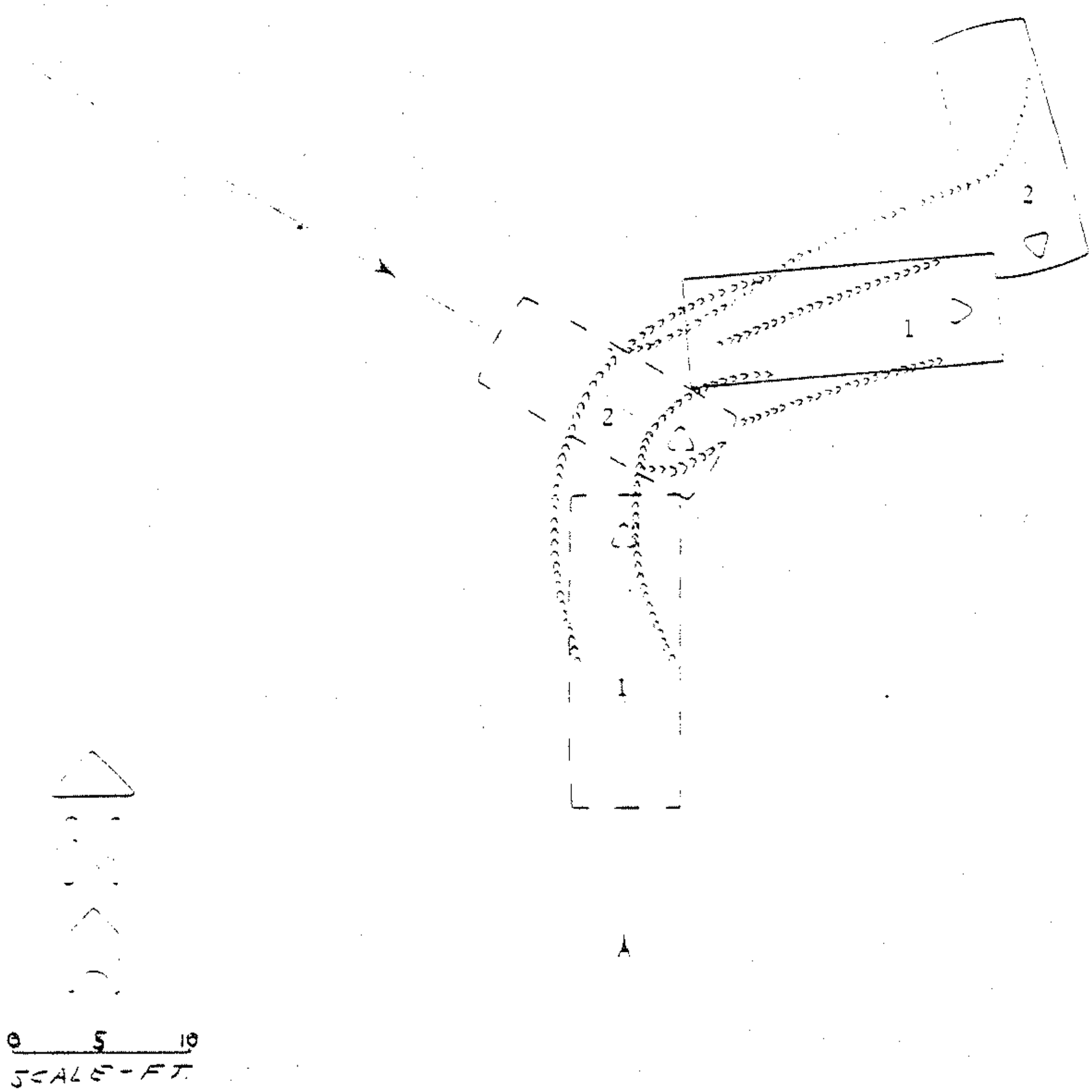


Figure 2-2 TEST NO. 2 - RICSAC ACCIDENT SCHEMATIC

SUMMARY FORM FOR STAGED COLLISION REPORTING

Comparison of Result

	MEASURED			SMAC			CRASH SPIN II		CRASH DAMAGE
	SPEED AT IMPACT (MPH)	Δ V (MPH)	VDI	SPEED AT IMPACT (MPH)	Δ V (MPH)	VDI	SPEED AT IMPACT (MPH)	Δ V (MPH)	Δ V (MPH)
VEHICLE #1	31.5	R 19.6 X -16.5 Y 10.5	11FDEW2	31.5	R 21.3 X Y	12FDEW3	29.6	R 20.6 X -19.7 Y 6.1	R 19.3 X -16.7 Y 9.7
VEHICLE #2	31.5	R -- X -- Y --	02RDEW4	31.5	R 31.7 X Y	02RYEW5	33.3	R 30.9 X -22.7 Y -21.0	R 29.0 X -14.5 Y -25.1

Summary of Physical Evidence

	REST POSITIONS			IMPACT POSITIONS			END OF ROTATIONAL AND/OR LAT. SKID.				ROLLING RESISTANCE				TIRE PAVEMENT
	X'_{CR}	Y'_{CR}	ψ_R	X'_{CS}	Y'_{CS}	ψ_S	X'_{C1}	Y'_{C1}	ψ_1						
	FT.	FT.	DEG.	FT.	FT.	DEG.	FT.	FT.	DEG.	ROT.	RF	LF	RR	LR	μ
VEHICLE #1	11.0	9.4	55.0	-11.2	8.5	-30.0	--	--	--	CW	.5	0.02	.2	.2	.87
VEHICLE #2	23.6	12.5	134.0	0.0	0.0	90.0	--	--	--	CW	.02	.02	.2	.2	

MEASURED DAMAGE DIMENSIONS

	WIDTH	DAMAGE EXTENT						MOMENT ARM		DIRECTION			
	L1	C11	C12	C13	C14	C15	C16	DI	RATIO	ANGI	VEH. SIZE	VEH. WGT.	REFERENCE
	IN.	IN.	IN.	IN.	IN.	IN.	IN.	IN.	RHOI	DEG.		LBS.	
VEHICLE #1	75.5	0.5	2.4	3.7	6.9	12.0	16.5	0.0	--	-30	I	4621	
VEHICLE #2	118.5	6.75	22.75	23.5	21.3	10.0	0.0	13.7	--	3-	S	3081	

COLLISION CONFIGURATION: 60° Front-to-side impact

TEST IDENTIFICATION: RICSAC Test No. 2 - 1974 Chevrolet Chevells Vs. 1974 Ford Pinto

Test No. 6 - Front-to-Side Impact - Chevrolet Chevelle Vs. VW Rabbit - Impact Speeds, 21.5/21.5 mph

Accident Schematic - Figure 2-3

The agreement for the predicted impact speeds is good, 24.9 mph versus 21.5 mph actual for Vehicle 1 and 20.5 mph versus 21.5 mph actual for Vehicle 2. There is also close agreement between the predicted ΔV's from the conservation of momentum calculation and the damage analysis for both vehicles. When compared to the actual ΔV values, there is good agreement for Vehicle 1, although there is a slight overestimate. A larger overestimation of the ΔV is evident for Vehicle 2, but some of this discrepancy is attributable to rotational effects. From Table 1-3, it can be seen that Vehicle 2 has a very large r_x in combination with high angular velocities. In fact, looking at the yaw rate time history presented in Volume II, it can be seen that Vehicle 2 experienced an angular velocity of at least 180 deg/sec for the last 80 msec (or 40%) of contact. Correcting for this rotation has the effect of drastically increasing the magnitude (but decreasing the value) of both the y-component of the separation velocity and ΔV. With an almost negligible change in the x-component (r_y is small), the result is a higher value in the actual resultant ΔV and resultant separation velocity. If the corrected ΔV for Vehicle 2 is still less than the CRASH II predictions, it implies, from the point of view of the damage analysis, that the stiffness coefficients are too high for these particular vehicle types and impact configuration.

The separation velocity for Vehicle 1 is in close agreement, 12.9 mph versus 13.3 mph actual although the agreement for Vehicle 2 is not as good, 17.0 mph versus 10.5 mph actual. While this discrepancy will be lessened by including rotational effects in the determination of the separation velocity, much of it stems from the large lateral velocity that is predicted, -15.4 mph compared to -3.2 mph actual. This results from the fact that Vehicle 2 rotated approximately 20 degrees during impact, which the program includes as part of the spin out analysis, i.e., the program assumes that rotation during impact can be neglected such that the impact and separation positions are coincident. Significant amounts of rotation occurring during impact lead to an over-predition of the lateral velocity during spin out.

ACCIDENT SCHEMATIC

VEHICLES:

No. 1 - 1974 CHEVROLET MALIBU CLASSIC
No. 2 - 1975 VOLKSWAGEN RABBIT

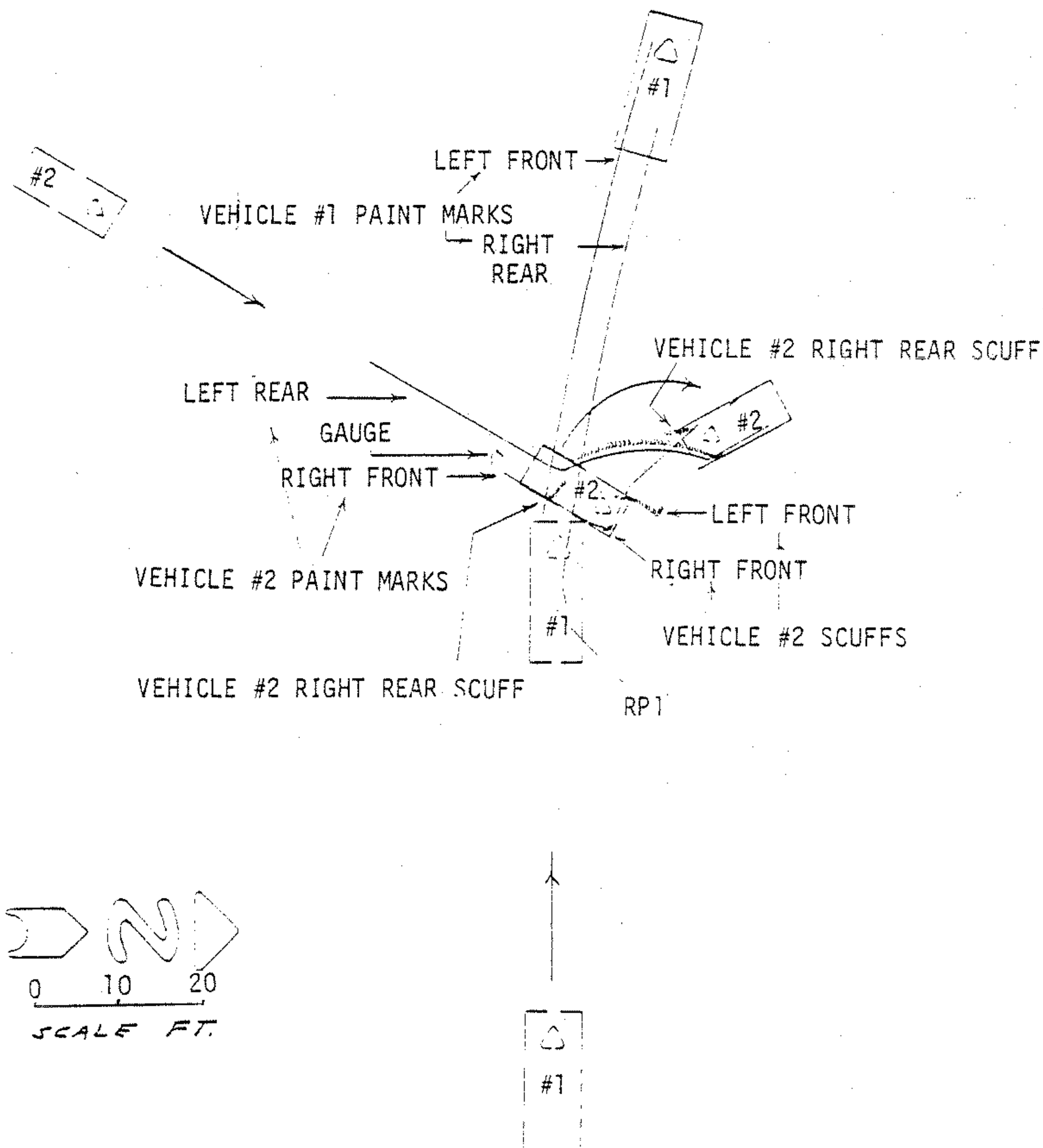


Figure 2-3 TEST NO. 6 - RICSAC ACCIDENT SCHEMATIC

SUMMARY FORM FOR STAGED COLLISION REPORTING

Comparison of Result

	MEASURED			SMAC			CRASH SPIN II		CRASH DAMAGE
	SPEED AT IMPACT	Δ V	VDI	SPEED AT IMPACT	Δ V	VDI	SPEED AT IMPACT	Δ V	Δ V
	MPH	MPH		MPH	MPH		MPH	MPH	MPH
VEHICLE #1	21.5	R 9.2 X -8.5 Y 3.0	11FZEW1	21.5	R 10.8 X Y	12FDEW3	24.9	R 12.4 X -12.2 Y 2.3	R 12.7 X -11.0 Y 6.4
VEHICLE #2	21.5	R 11.9 X -11.5 Y -3.2	02RDEW3	21.5	R 16.7 X Y	01RDEW5	20.5	R 20.4 X -13.3 Y -15.4	R 20.9 X -10.4 Y -18.1

Summary of Physical Evidence

	REST POSITIONS			IMPACT POSITIONS			END OF ROTATIONAL AND/OR LAT. SKID.				ROLLING RESISTANCE				TIRE PAVEMENT
	X'_{CR}	Y'_{CR}	ψ_R	X'_{CS}	Y'_{CS}	ψ_S	X'_{C1}	Y'_{C1}	ψ_1	ROT.	RF	LF	RR	LR	μ
	FT.	FT.	DEG.	FT.	FT.	DEG.	FT.	FT.	DEG.						
VEHICLE #1	60.0	11.0	15.0	0.0	0.0	0.0	--	--	--	CW	.01	.01	.2	.2	.87
VEHICLE #2	20.0	21.0	242.0	11.1	2.67	120	--	--	--	CW	.01	.01	.2	.2	

MEASURED DAMAGE DIMENSIONS

	WIDTH	DAMAGE EXTENT						MOMENT ARM		DIRECTION			
	L1	C11	C12	C13	C14	C15	C16	DI	RATIO	ANGI	VEH. SIZE	VEH. WGT. LBS.	REFERENCE
	IN.	IN.	IN.	IN.	IN.	IN.	IN.	IN.	RHOI	DEG.			
VEHICLE #1	54.5	0.5	0.5	1.25	1.5	1.75	2.25	9.75	--	-30	I	4300	
VEHICLE #2	77.0	4.0	12.0	17.8	19.3	17.0	8.25	-3.25	--	30	SC	2623	

COLLISION CONFIGURATION: 60° Front-to-side impact

TEST IDENTIFICATION: RICSAC Test No. 6 - Chevrolet Chevelle Vs. VW Rabbit

Test No. 7 - 60° Front-to-Side Impact - Chevrolet Chevelle Vs. VW Rabbit - Impact Speeds, 29.1/29.1 mph

Accident Schematic - Figure 2-4

The estimated impact speeds for both vehicles are slightly underestimated although both are within the 12 percent accuracy quoted for the program. The velocity change for Vehicle 1 from the conservation of momentum calculation agrees closely, 11.6 mph versus 12.0 mph actual, although the ΔV from the damage analysis, 16.3 mph, is an overestimate. The agreement for Vehicle 2 is not as good, 25.3 mph from conservation of momentum and 35.5 mph from the damage analysis versus 16.5 mph actual. As in Test 6, Vehicle 2 combined a large r_x component with a large angular velocity; the last 60 msec of contact produced angular velocities in excess of 180 deg/sec. Thus, the magnitude of the y-component of the separation velocity will increase, thereby increasing the magnitude of the ΔV's y-component. As before, a small change in the x-direction results in a larger resultant ΔV and separation velocity for Vehicle 2.

It is interesting to note that the velocity change of the struck vehicle is overestimated in both Tests 6 and 7. Since the same model vehicles were used in both tests, this is further evidence that the stiffness coefficient in the program is too high for these vehicles.

The separation velocities are in good agreement, 15.3 mph versus 16.5 mph actual for Vehicle 1 and, despite the rotational effects, 19.6 mph versus 17.2 mph actual for Vehicle 2. Note, however, that the lateral velocity component is again overestimated for Vehicle 2, which results from the significant amount of rotation (22 deg) that occurs during impact, i.e, this is assumed by the program to have occurred during the spin out phase.

ACCIDENT SCHEMATIC

VEHICLES:

No. 1 - 1974 CHEVROLET MALIBU
No. 2 - 1975 VOLKSWAGEN RABBIT

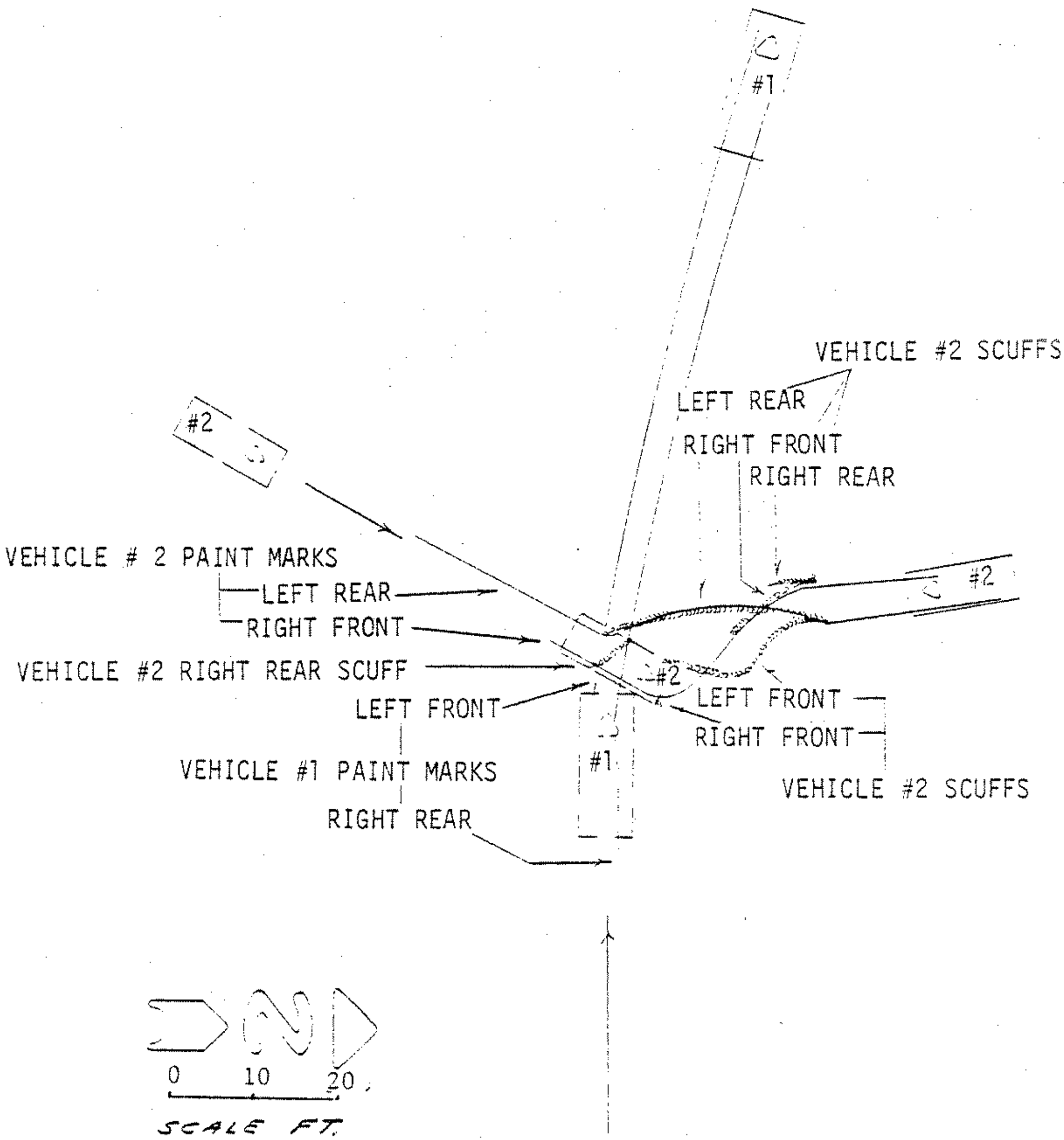


Figure 2-4 TEST NO. 7 - RICSAC ACCIDENT SCHEMATIC

SUMMARY FORM FOR STAGED COLLISION REPORTING

Comparison of Result

	MEASURED			SMAC			CRASH SPIN II		CRASH DAMAGE
	SPEED AT IMPACT	Δ V	VDI	SPEED AT IMPACT	Δ V	VDI	SPEED AT IMPACT	Δ V	Δ V
	MPH	MPH		MPH	MPH		MPH	MPH	MPH
VEHICLE #1	29.1	R 12.0 X -11.5 Y -3.5	11FDEW1	29.1	R 11.4 X Y	11FDEW2	26.2	R 11.6 X -11.1 Y -3.2	R 16.3 X -14.1 Y -8.2
VEHICLE #2	29.1	R 16.5 X -14.1 Y -8.5	02RDEW4	29.1	R 17.9 X Y	01RDEW4	27.1	R 25.3 X -18.2 Y -17.5	R 35.5 X -17.8 Y -30.8

Summary of Physical Evidence

	REST POSITIONS			IMPACT POSITIONS			END OF ROTATIONAL AND/OR LAT. SKID.				ROLLING RESISTANCE				TIRE PAVEMENT
	X'_{CR}	Y'_{CR}	ψ_R	X'_{CS}	Y'_{CS}	ψ_S	X'_{CI}	Y'_{CI}	ψ_I	ROT.	RF	LF	RR	LR	μ
	FT.	FT.	DEG.	FT.	FT.	DEG.	FT.	FT.	DEG.						
VEHICLE #1	84.5	18.2	16.5	0.0	0.0	0.0	--	--	--	CW	.01	.01	.2	.2	0.87
VEHICLE #2	22.9	41.4	262.0	10.7	3.45	120.0	22.0	30.0	250.0	CW	.01	.01	1.0	.2	

MEASURED DAMAGE DIMENSIONS

	WIDTH	DAMAGE EXTENT						MOMENT ARM		DIRECTION			
	L1	C11	C12	C13	C14	C15	C16	DI	RATIO	ANGI	VEH. SIZE	VEH. WGT.	REFERENCE
	IN.	IN.	IN.	IN.	IN.	IN.	IN.	IN.	RHOI	DEG.		LBS.	
VEHICLE #1	66.0	0.0	1.25	2.0	3.75	5.0	6.25	4.0	--	-30	I	3700	
VEHICLE #2	108.5	0.0	11.0	17.75	21.0	21.25	7.25	-8.5	--	30	S	1700	

COLLISION CONFIGURATION 60° Front-to-Side Impact

TEST IDENTIFICATION RICSAC Test No. 7 - Chevrolet Chevelle Vs. VW Rabbit

Test No. 8 - 90° Front-to-Side Impact - Chevrolet Chevelle Vs. Chevrolet Chevelle - Impact Speeds, 20.75/20.75 mph
Accident Schematic - Figure 2-5

The estimated impact speeds for both vehicles are in good agreement. Looking at the velocity changes calculated from the conservation of momentum, that for Vehicle 1 is considerably underestimated, 10.3 mph versus 15.3 mph actual; whereas that for Vehicle 2 is slightly underestimated, 9.8 mph versus 10.7 mph actual. This is consistent with an error in the estimation of the separation velocities 14.3 mph versus 11.8 mph actual for Vehicle 1 and 18.8 mph versus 15.7 mph actual for Vehicle 2. Correcting the change in velocity and the separation velocity of Vehicle 1 for the effects of rotation would tend to degrade the degree of agreement between the actual and predicted values. However, the magnitude of the change would be greatly reduced, as compared to Vehicle 2 in both Tests 6 and 7, since the r_x of Vehicle 1 in this test is only 0.95 feet (versus about 2.5 feet in the other two tests). It is worth noting that the spin out distances for this test were small such that the separation velocities are extremely sensitive to the measured impact and rest positions.

Looking at the velocity changes predicted from the damage analysis, it can be seen that Vehicle 1 is underestimated by about 5 mph, i.e., 10.0 mph versus 15.3 mph actual. Since this is the striking vehicle, this likely results from the fact that the program does not take the effect of energy absorbing bumpers into account. The velocity change for Vehicle 2 is in good agreement, 9.5 mph versus 10.7 mph actual.

ACCIDENT SCHEMATIC

VEHICLES:

No. 1 - 1974 CHEVROLET CHEVELLE
No. 2 - 1974 CHEVROLET CHEVELLE

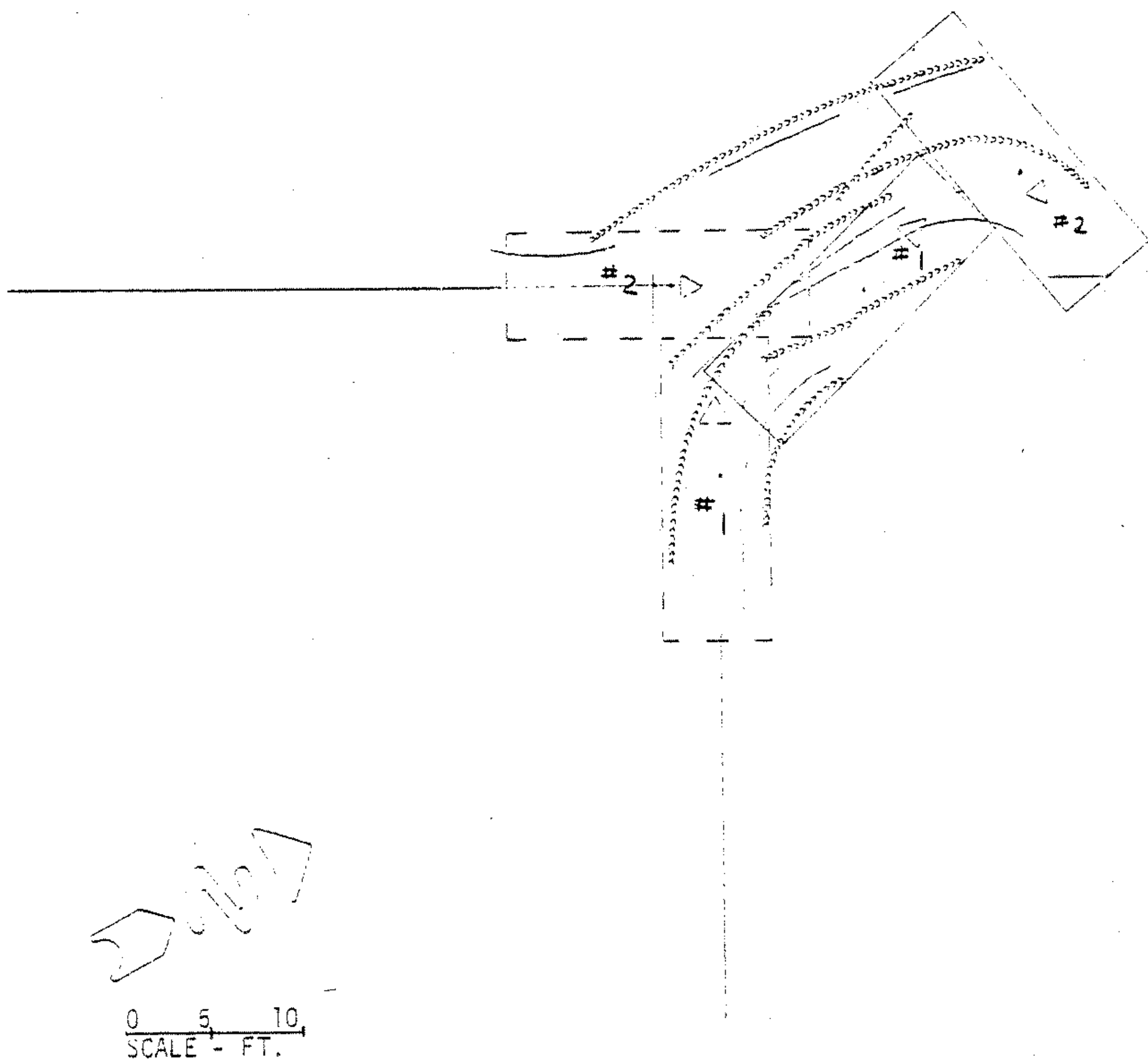


Figure 2-5 TEST NO. 8 - RICSAC ACCIDENT SCHEMATIC

SUMMARY FORM FOR STAGED COLLISION REPORTING

Comparison of Result

	MEASURED			SMAC			CRASH SPIN II		CRASH DAMAGE
	SPEED AT IMPACT	Δ V	VDI	SPEED AT IMPACT	Δ V	VDI	SPEED AT IMPACT	Δ V	Δ V
	MPH	MPH		MPH	MPH		MPH	MPH	MPH
VEHICLE #1	20.75	R 15.3 X -12.7 Y 8.6	12FDEW1	20.75	R 16.8 X Y	11FDEW2	19.5	R 10.3 X -7.2 Y 7.3	R 10.0 X -7.0 Y 7.1
VEHICLE #2	20.75	R 10.7 X -7.2 Y -8.0	03RYEW2	20.75	R 15.0 X Y	02RDEW3	24.5	R 9.8 X -6.9 Y -6.9	R 9.5 X -6.7 Y -6.7

Summary of Physical Evidence

	REST POSITIONS			IMPACT POSITIONS			END OF ROTATIONAL AND/OR LAT. SKID.				ROLLING RESISTANCE				TIRE PAVEMENT
	X'_{CR}	Y'_{CR}	ψ_R	X'_{CS}	Y'_{CS}	ψ_S	X'_{C1}	Y'_{C1}	ψ_1	ROT.	RF	LF	RR	LR	μ
	FT.	FT.	DEG.	FT.	FT.	DEG.	FT.	FT.	DEG.						
VEHICLE #1	-0.5	11.0	46.0	-10.9	3.2	0.0	--	--	--	CW	0.01	0.01	0.2	0.2	0.87
VEHICLE #2	6.5	21.0	141.0	0.0	1.9	90.0	--	--	--	CW	0.01	0.01	0.2	0.2	

MEASURED DAMAGE DIMENSIONS

	WIDTH	DAMAGE EXTENT						MOMENT ARM		DIRECTION			
	L1	C11	C12	C13	C14	C15	C16	DI	RATIO	ANGI	VEH. SIZE	VEH. WGT.	REFERENCE
	IN.	IN.	IN.	IN.	IN.	IN.	IN.	IN.	RHOI	DEG.		LBS.	
VEHICLE #1	73.0	2.7	3.6	--	--	--	--	0.0		-45	I	4479	
VEHICLE #2	84.5	6.2	8.3	9.2	5.9	4.4	0.8	15.0		45	I	4710	

COLLISION CONFIGURATION 90° Side-to-front impact, Chevrolet Chevelles

TEST IDENTIFICATION RICSAC Test No. 8

Test No. 9 - 90° Front-to-Side Impact - Honda Civic Vs. Ford Torino - Impact Speeds, 21.2/21.2 mph

Accident Schematic - Figure 2-6

The estimated impact speeds for both vehicles are in good agreement, 23.2 mph versus 21.2 mph actual for Vehicle 1 and 22.0 mph versus 21.2 mph actual for Vehicle 2. The velocity changes predicted from the conservation of linear momentum are also in good agreement, although slightly overestimated; for Vehicle 1, 24.2 mph versus 21.4 mph actual and for Vehicle 2, 11.2 mph versus 8.9 mph actual. The resultant velocity changes from the damage analysis also agree well, 19.1 mph versus 21.4 mph for Vehicle 1 and 8.8 mph versus 8.9 mph for Vehicle 2. The failure to consider the rotation of Vehicle 1 in determining the separation velocity did not appear to adversely affect the agreement between the actual and predicted values of ΔV. As demonstrated in Test 8, this is probably due to the fact that the components of the accelerometer offset vector, $\vec{r}$, are small, and the corrections, therefore, are also relatively small.

Looking at the separation velocities predicted by SPIN II, the agreement is good, for Vehicle 1, 9.9 mph versus 12.5 mph actual and for Vehicle 2. 20.2 mph versus 17.8 mph actual.

ACCIDENT SCHEMATIC

VEHICLES:

No. 1 - 1975 HONDA CIVIC
No. 2 - 1974 FORD TORINO

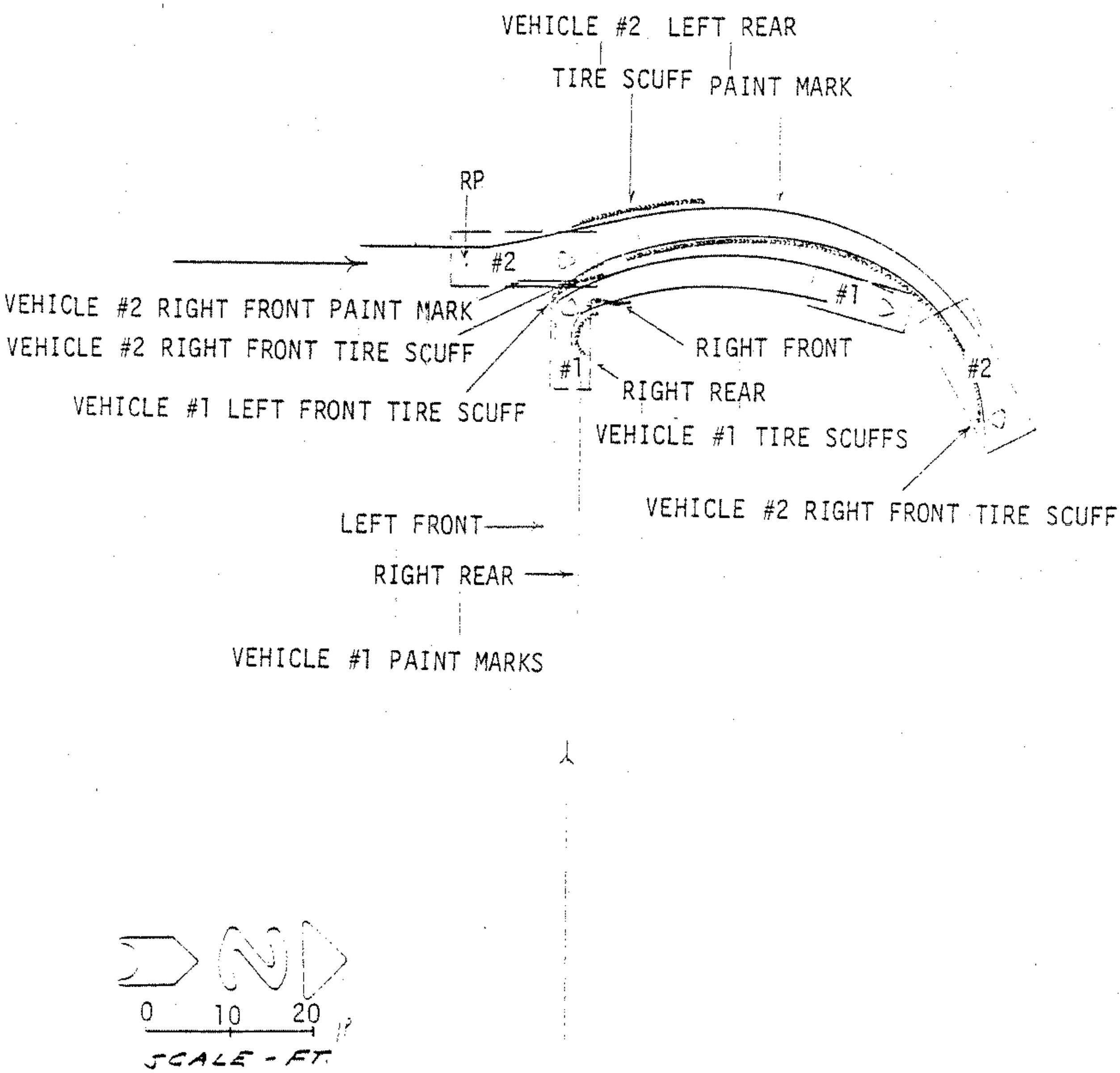


Figure 2-6 TEST NO. 9 - RICSAC ACCIDENT SCHEMATIC

SUMMARY FORM FOR STAGED COLLISION REPORTING

Comparison of Result

	MEASURED			SMAC			CRASH – SPIN II		CRASH – DAMAGE
	SPEED AT IMPACT	Δ V	VDI	SPEED AT IMPACT	Δ V	VDI	SPEED AT IMPACT	Δ V	Δ V
	MPH	MPH		MPH	MPH		MPH	MPH	MPH
VEHICLE #1	21.2	R 21.4 X -17.7 Y 12.0	11FDEW2	21.2	R 20.0 X Y	11LFEE2	23.2	R 24.2 X -22.1 Y 9.8	R 19.1 X -17.3 Y 8.1
VEHICLE #2	21.2	R 8.9 X -5.0 Y -7.4	02RFEW2 03RPEW1	21.2	R 8.7 X Y	02RYEW3	22.0	R 11.2 X -4.5 Y -10.2	R 8.8 X -3.72 Y -8.0

Summary of Physical Evidence

	REST POSITIONS			IMPACT POSITIONS			END OF ROTATIONAL AND/OR LAT. SKID.				ROLLING RESISTANCE				TIRE PAVEMENT
	X'_{CR}	Y'_{CR}	ψ_R	X'_{CS}	Y'_{CS}	ψ_S	X'_{C1}	Y'_{C1}	ψ_1	ROT.	RF	LF	RR	LR	μ
	FT.	FT.	DEG.	FT.	FT.	DEG.	FT.	FT.	DEG.						
VEHICLE #1	4.0	35.5	104.0	0.0	0.0	0.0	--	--	--	CW	0.2	0.2	0.01	0.01	0.87
VEHICLE #2	-5.0	49.5	152.0	8.53	-5.89	90.0	18.0	12.5	120.0	CW	0.1	0.01	0.2	0.2	

MEASURED DAMAGE DIMENSIONS

	WIDTH	DAMAGE EXTENT						MOMENT ARM		DIRECTION			
	L1	C11	C12	C13	C14	C15	C16	DT	RATIO	ANG1	VEH. SIZE	VEH. WGT. LBS.	REFERENCE
	IN.	IN.	IN.	IN.	IN.	IN.	IN.	IN.	RHOI	DEG.			
VEHICLE #1	49.75	5.0	5.75	12.5	7.5	7.5	9.5	1.63	--	25	MIN	2256	Source
VEHICLE #2	54.5	7.75	4.6	4.75	3.3	2.75	1.5	68.00	--	-65	INT	4900	

COLLISION CONFIGURATION 90° Front-to-side impact - Honda Civic Vs. Ford Torino

TEST IDENTIFICATION Test No. 9

Test No. 10 - 90° Front-to-Side Impact - Honda Civic Vs. Ford Torino - Impact Speeds, 33.3/33.3 mph

Accident Schematic - Figure 2-7

The estimated impact speeds are in good agreement for both vehicles, 32.7 mph versus 33.3 mph actual for Vehicle 1 and 31.5 mph versus 33.3 mph actual for Vehicle 2. The velocity changes predicted from the conservation of linear momentum are also in good agreement, 32.6 mph versus 35.1 mph actual for Vehicle 1 and 15.9 mph versus 14.1 mph actual for Vehicle 2. This result is somewhat surprising, since Vehicle 1 underwent the greatest angular velocity of all the vehicles involved in the staged collisions. However, the rotation and location of the accelerometer are such that the magnitude of ΔV_x will increase (due to a decrease in the separation velocity) and the magnitude of ΔV_y will decrease when the rotational effects are considered. The change in both components will be approximately equal, since the components of the $\vec{r}$ vector are similar. The effect on the resultant velocity change is shown in Equations (1) through (3).

$$\Delta V = \sqrt{(\Delta V_x - \delta_x)^2 + (\Delta V_y - \delta_y)^2} \quad (1)$$

where δ_x is the correction for correction to ΔV_x (ΔV_x is negative, so an an increase in its magnitude is caused by a negative correction term),

δ_y is the correction for rotation to ΔV_y

$$\Delta V = \sqrt{\Delta V_x^2 + \Delta V_y^2 + \delta_x^2 + \delta_y^2 - 2\Delta V_x \delta_x - 2\Delta V_y \delta_y} \quad (2)$$

In this case, in which $\delta_x \approx \delta_y$, $|\Delta V_x| \approx |\Delta V_y|$, and ΔV_x is opposite in sign from ΔV_y, Equation (2) can be simplified to:

$$\Delta V = \sqrt{\Delta V_x^2 + \Delta V_y^2 + \delta_x^2 + \delta_y^2} \quad (3)$$

As long as the $(\delta_x^2 + \delta_y^2)$ term is small relative to $(\Delta V_x^2 + \Delta V_y^2)$ the resultant velocity will not change appreciably, and for Test 10 the components of Vehicle 1's computed velocity change are large, i.e., -27.3 mph and 22.0 mph, thus explaining (and confirming) the high degree of correspondence between the predicted and actual resultant ΔV's.

The ΔV's predicted from the damage are underestimated at 22.4 mph for Vehicle 1 and 10.9 mph for Vehicle 2. This suggests that the structural stiffness coefficients in the program are underestimated for this particular vehicle-impact configuration. Note that the same trend was also present in Test 9, which had the same configuration and the same vehicles, i.e., a mini-size vehicle striking an intermediate size vehicle. This is the opposite trend to that exhibited in Tests 6 and 7, where the stiffness coefficients were too high for an intermediate striking a subcompact vehicle.

Looking at the separation velocities, the agreement is extremely good for Vehicle 2, 25.8 mph versus 26.9 mph actual. The agreement for Vehicle 1 is also good, but this may be an artifact of the failure to consider the vehicle's rotation during impact. Inclusion of this factor will decrease both components of the separation velocity, and therefore, the resultant separation velocity. While the magnitude of this change is not known, it is expected to be sufficient to cause the predicted value of the separation velocity to be an overestimate of the actual value. This is based on the fact that the Honda Civic is the smallest vehicle in its size category such that the representative dimensions and vehicle properties in the CRASH II program are probably overestimates.

ACCIDENT SCHEMATIC

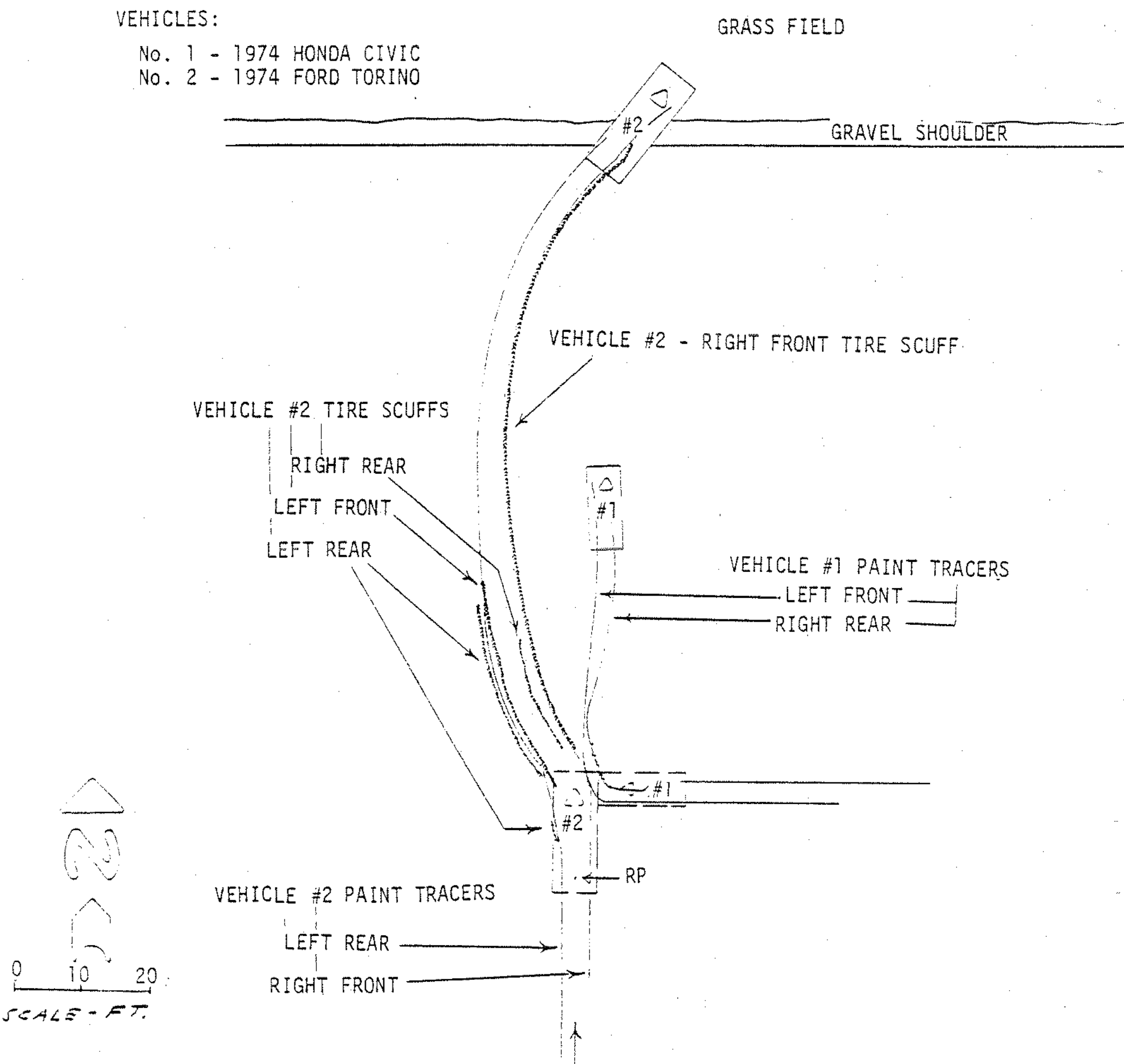


Figure 2-7 TEST NO. 10 - RICSAC ACCIDENT SCHEMATIC

SUMMARY FORM FOR STAGED COLLISION REPORTING

Comparison of Result

	MEASURED			SMAC			CRASH SPIN II		CRASH DAMAGE
	SPEED AT IMPACT	Δ V	VDI	SPEED AT IMPACT	Δ V	VDI	SPEED AT IMPACT	Δ V	Δ V
	MPH	MPH		MPH	MPH		MPH	MPH	MPH
VEHICLE #1	33.3	R 35.1 X -27.3 Y 22.0	10FDEW2	33.3	R 36.5 X Y	11LFEE3	32.7	R 32.6 X -26.5 Y 19.0	R 22.4 X -9.4 Y 20.3
VEHICLE #2	33.3	R 14.1 X -8.8 Y -11.0	01RFEW2	33.3	R 15.7 X Y	02RYEW3	31.5	R 15.9 X -9.3 Y -13.0	R 10.9 X -9.9 Y -4.6

Summary of Physical Evidence

	REST POSITIONS			IMPACT POSITIONS			END OF ROTATIONAL AND/OR LAT. SKID.				ROLLING RESISTANCE				TIRE PAVEMENT
	X'_{CR}	Y'_{CR}	ψ_R	X'_{CS}	Y'_{CS}	ψ_S	X'_{C1}	Y'_{C1}	ψ_1						
	FT.	FT.	DEG.	FT.	FT.	DEG.	FT.	FT.	DEG.	ROT.	RF	LF	RR	LR	μ
VEHICLE #1	5.0	43.0	87.0	0.0	0.0	0.0	5.0	25.0	90.0	CW	0.2	0.2	0.2	0.01	0.87
VEHICLE #2	0.0	99.5	128.5	8.5	-5.9	90.0	23.0	19.0	90.0	CW	0.1	0.1	0.01	0.2	

MEASURED DAMAGE DIMENSIONS

	WIDTH	DAMAGE EXTENT						MOMENT ARM		DIRECTION			
	L1	C11	C12	C13	C14	C15	C16	DI	RATIO	ANGI	VEH. SIZE	VEH. WGT.	REFERENCE
	IN.	IN.	IN.	IN.	IN.	IN.	IN.	IN.	RHOI	DEG.		LBS.	
VEHICLE #1	47.5	7.0	10.2	14.0	8.9	7.0	9.0	-2.75	--	-65	MIM	2306	--
VEHICLE #2	53.0	9.2	6.5	6.1	5.3	4.5	0.5	66.50	--	25	INT	4720	

COLLISION CONFIGURATION 90° Front-to-side impact

TEST IDENTIFICATION RICSAC Test No. 10 - Honda Civic Vs. Ford Torino

Test No. 11 - 10° Offset Front-to-Front Impact - Chevrolet Vega Vs. Ford Torino - Impact Speeds, 20.4/20.4 mph

Accident Schematic - Figure 2-8

The estimated impact speeds are in good agreement although slightly underestimated for both vehicles. The velocity changes agree closely, for Vehicle 1, 21.1 mph versus 24.0 mph actual and for Vehicle 2, 13.2 mph versus 15.7 mph actual. Not surprisingly then, the separation velocities are also in close agreement, -3.8 mph versus -3.7 mph actual for Vehicle 1 and 4.8 mph versus 5.2 mph actual for Vehicle 2.

ACCIDENT SCHEMATIC

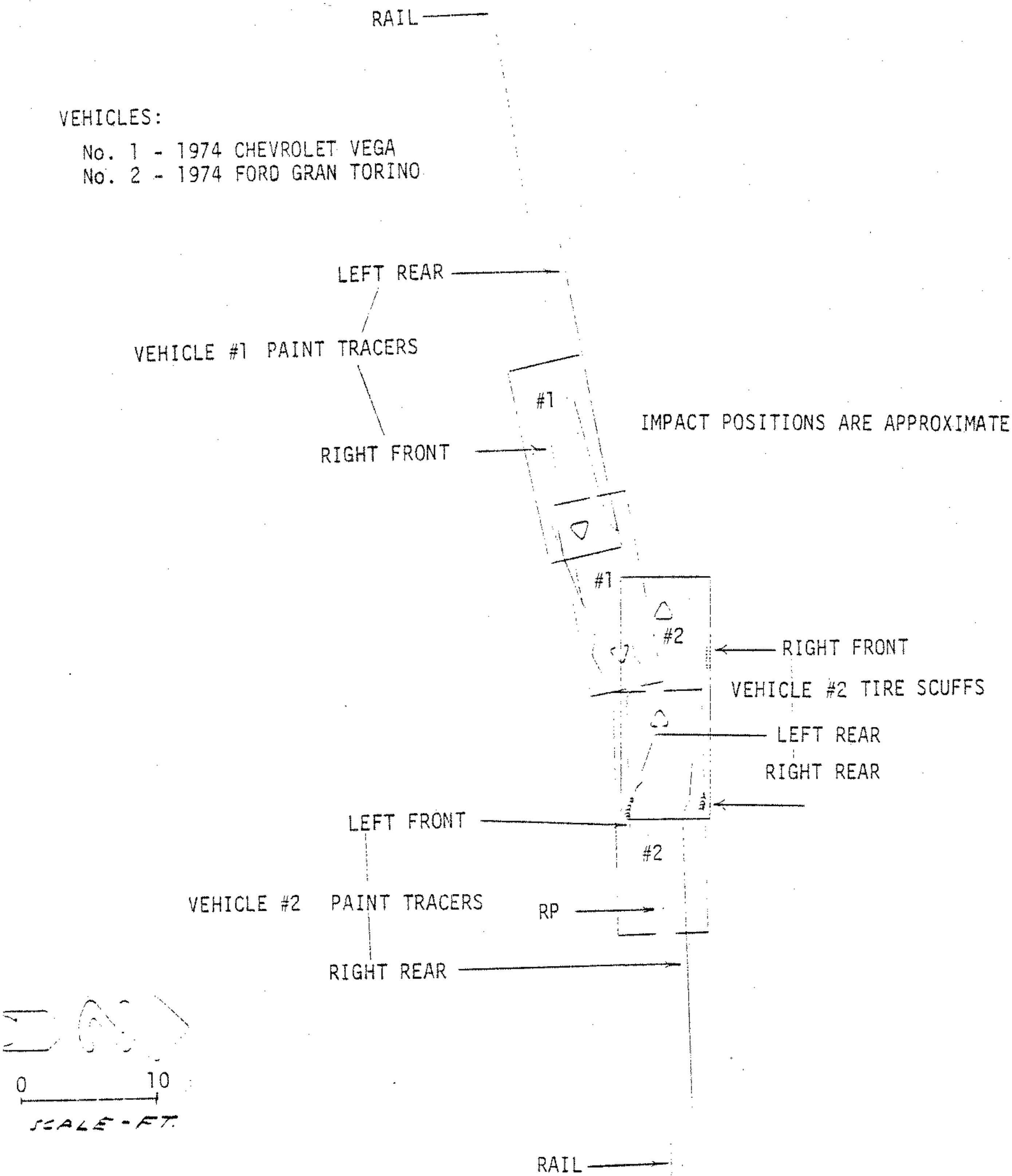


Figure 2-8 TEST NO. 11 - RICSAC ACCIDENT SCHEMATIC

SUMMARY FROM FOR STAGED COLLISION REPORTING

Comparison of Result

	MEASURED			SMAC			CRASH SPIN II		CRASH DAMAGE
	SPEED AT IMPACT	Δ V	VDI	SPEED AT IMPACT	Δ V	VDI	SPEED AT IMPACT	Δ V	Δ V
	MPH	MPH		MPH	MPH		MPH	MPH	MPH
VEHICLE #1	20.4	R 24.0 X -24.0 Y 0.8	12FYEW3	20.4	R 28.7 X Y	12FYEW3	17.2	R 21.0 X -21.0 Y 0.3	R 21.1 X -21.0 Y -1.8
VEHICLE #2	20.4	R 15.7 X -15.6 Y 2.0	12FYEW3	20.4	R 17.6 X Y	12FYEW2	18.0	R 13.2 X -13.2 Y 0.2	R 13.2 X -13.2 Y 1.2

Summary of Physical Evidence

	REST POSITIONS			IMPACT POSITIONS			END OF ROTATIONAL AND/OR LAT. SKID.				ROLLING RESISTANCE				TIRE PAVEMENT
	X'_{CR}	Y'_{CR}	ψ_R	X'_{CS}	Y'_{CS}	ψ_S	X'_{C1}	Y'_{C1}	ψ_1						
	FT.	FT.	DEG.	FT.	FT.	DEG.	FT.	FT.	DEG.	ROT.	RF	LF	RR	LR	μ
VEHICLE #1	25.6	-6.4	170.0	15.7	-4.0	171.0	--	--	--	CW	.01	.01	.1	.1	0.87
VEHICLE #2	8.6	0.4	0.0	0.0	0.0	0.0	--	--	--	CW	.01	.01	.2	.2	

MEASURED DAMAGE DIMENSIONS

	WIDTH	DAMAGE EXTENT						MOMENT ARM		DIRECTION			
	L1	C11	C12	C13	C14	C15	C16	DI	RATIO	ANGI	VEH. SIZE	VEH. WGT.	REFERENCE
	IN.	IN.	IN.	IN.	IN.	IN.	IN.	IN.	RHOI	DEG.		LBS.	
VEHICLE #1	32.5	22.0	20.2	18.5	16.8	15.0	12.5	-12.75	--	5	S	3041	
VEHICLE #2	32.26	29.5	26.25	23.0	18.7	14.3	11.0	-12.9	--	-5	I	4850	

COLLISION CONFIGURATION 10° Offset front-to-front

TEST IDENTIFICATION RICSAC Test No. 11 - Chevrolet Vega Vs. Ford Torino

Test No. 12 - 10° Offset Front-to-Front Impact - Chevrolet Vega Vs. Ford Torino - Impact Speeds, 31.5/31.5 mph

Accident Schematic - Figure 2-9

This test is identical in configuration to Test 11 except that the impact speeds are higher. The impact velocity for Vehicle 1 is considerably underestimated, 19.8 mph versus 31.5 mph actual. The separation velocity appears to be in good agreement, -8.5 mph versus -8.7 mph actual. However, this agreement may be degraded somewhat with the inclusion of rotational effects, which tend to decrease the magnitudes of both components of the separation velocity. Consequently, the magnitude of the resultant separation velocity will also be decreased; the amount of this change is not known, but it should not be sufficiently large to have any significant effect on the degree of correspondence with the predicted value of the separation velocity. The rotation would also tend to slightly decrease the measured velocity change of 40.1 mph. There is, however, little reason to believe that this correction would noticeably improve the agreement with the predicted ΔV of 28.2 mph.

The predicted impact velocity for Vehicle 2 is in good agreement, 30.2 mph versus 31.5 mph actual. Note, however, that this results from the errors in the velocity change and the separation velocity cancelling one another; the velocity change is underestimated at 20.0 mph versus 26.4 mph actual and the separation velocity overestimated at 11.6 mph versus 7.3 mph actual.

Since Test 11 used the same model vehicles and the agreement between the ΔV's was good, this suggests that vehicles colliding at higher closing speeds could present a higher structural stiffness. Obviously, to change the stiffness to improve the fit for this case would degrade the fit obtained for Test 11.

ACCIDENT SCHEMATIC

VEHICLES:

No. 1 - 1974 CHEVROLET VEGA
No. 2 - 1974 FORD TORINO

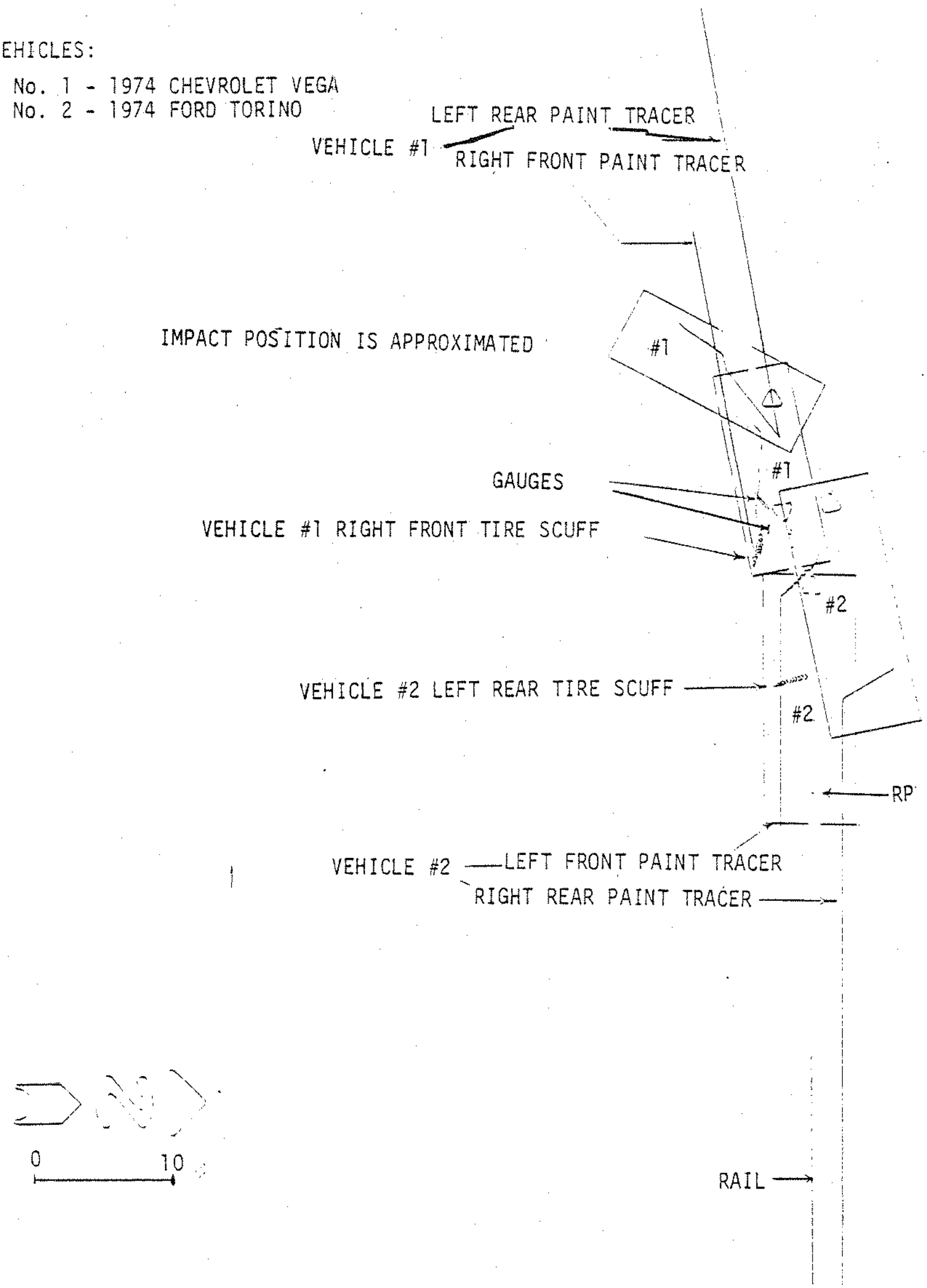


Figure 2-9 TEST NO. 12 - RICSAC ACCIDENT SCHEMATIC

SUMMARY FORM FOR STAGED COLLISION REPORTING

Comparison of Result

	MEASURED			SMAC			CRASH SPIN II		CRASH DAMAGE
	SPEED AT IMPACT	Δ V	VDI	SPEED AT IMPACT	Δ V	VDI	SPEED AT IMPACT	Δ V	Δ V
	MPH	MPH		MPH	MPH		MPH	MPH	MPH
VEHICLE #1	31.5	R 40.1 X -40.0 Y -2.2	12FDEW4	31.5	R 40.9 X Y	12FDEW4	19.8	R 28.2 X -28.1 Y -1.6	R 28.2 X -28.1 Y -2.5
VEHICLE #2	31.5	R 26.4 X -26.0 Y 4.8	12FYEW4	31.5	R 27.6 X Y	12LFEW3	30.2	R 20.0 X -19.5 Y 4.6	R 19.6 X -19.5 Y 1.7

Summary of Physical Evidence

	REST POSITIONS			IMPACT POSITIONS			END OF ROTATIONAL AND/OR LAT. SKID.				ROLLING RESISTANCE				TIRE PAVEMENT
	X'_{CR}	Y'_{CR}	ψ_R	X'_{CS}	Y'_{CS}	ψ_S	X'_{C1}	Y'_{C1}	ψ_1	ROT.	RF	LF	RR	LR	μ
	FT.	FT.	DEG.	FT.	FT.	DEG.	FT.	FT.	DEG.						
VEHICLE #1	22.3	-5.5	118.0	15.7	-4.0	171.0	--	--	--	CW	.01	0.01	.2	.2	0.87
VEHICLE #2	6.8	2.6	-12.0	0.0	0.0	0.0	--	--	--	CW	.01	0.01	.2	.2	

MEASURED DAMAGE DIMENSIONS

	WIDTH	DAMAGE EXTENT						MOMENT ARM		DIRECTION			
	L1	C11	C12	C13	C14	C15	C16	DI	RATIO	ANGI	VEH. SIZE	VEH. WGT. LBS.	REFERENCE
	IN.	IN.	IN.	IN.	IN.	IN.	IN.	IN.	RHOI	DEG.			
VEHICLE #1	32.0	38.6	34.6	29.5	26.0	19.6	14.25	+2.75		5	SC	3130	
VEHICLE #2	28.25	39.5	33.0	28.75	23.75	19.2	15.0	-10.6		-5	I	4512	

COLLISION CONFIGURATION 10° Offset - front-to-front

TEST IDENTIFICATION RICSAC Test No. 12 - Chevrolet Vega Vs. Ford Torino

Test Nos. 3, 4 and 5 - 10° Offset Front-to-Rear Impacts
Accident Schematics - Figures 2-10, 2-11 & 2-12

The results of these tests are discussed jointly since they all suffer from the same deficiency. It can be seen from Table 2-1 that the predicted impact speeds do not agree closely with the actual values. Table 2-2 shows that the separation velocities predicted by SPIN II are in extremely close agreement for all three tests so that the source of error lies in the estimation of the velocity change. Since these are axial type impact configurations, the velocity changes are estimated using the damage analysis. In every case, the velocity change is severely underestimated as can be seen from the summary table below. This must stem from the fact that the test vehicles were all fitted with 5 mph energy absorbing bumpers which are not taken into account in the stiffness coefficients in the CRASH II program.

Test	Velocity Change; Vehicle 1		Velocity Change; Vehicle 2	
No.	Actual (mph)	Predicted (mph)	Actual (mph)	Predicted (mph)
3	9.5	3.1	15.8	5.4
4	18.7	10.3	22.2	13.0
5	16.3	8.1	25.1	15.2

This means that the stiffness coefficients used to calculate the energy absorbed in rear end impacts are too low. Adding 5 mph to each ΔV improves the agreement, although the ΔV's are still underestimates which leads to the conclusion that vehicles with 5 mph energy absorbing bumpers are also stiffer than earlier models without.

ACCIDENT SCHEMATIC

VEHICLES:

No. 1 - 1974 FORD TORINO
No. 2 - 1974 FORD PINTO

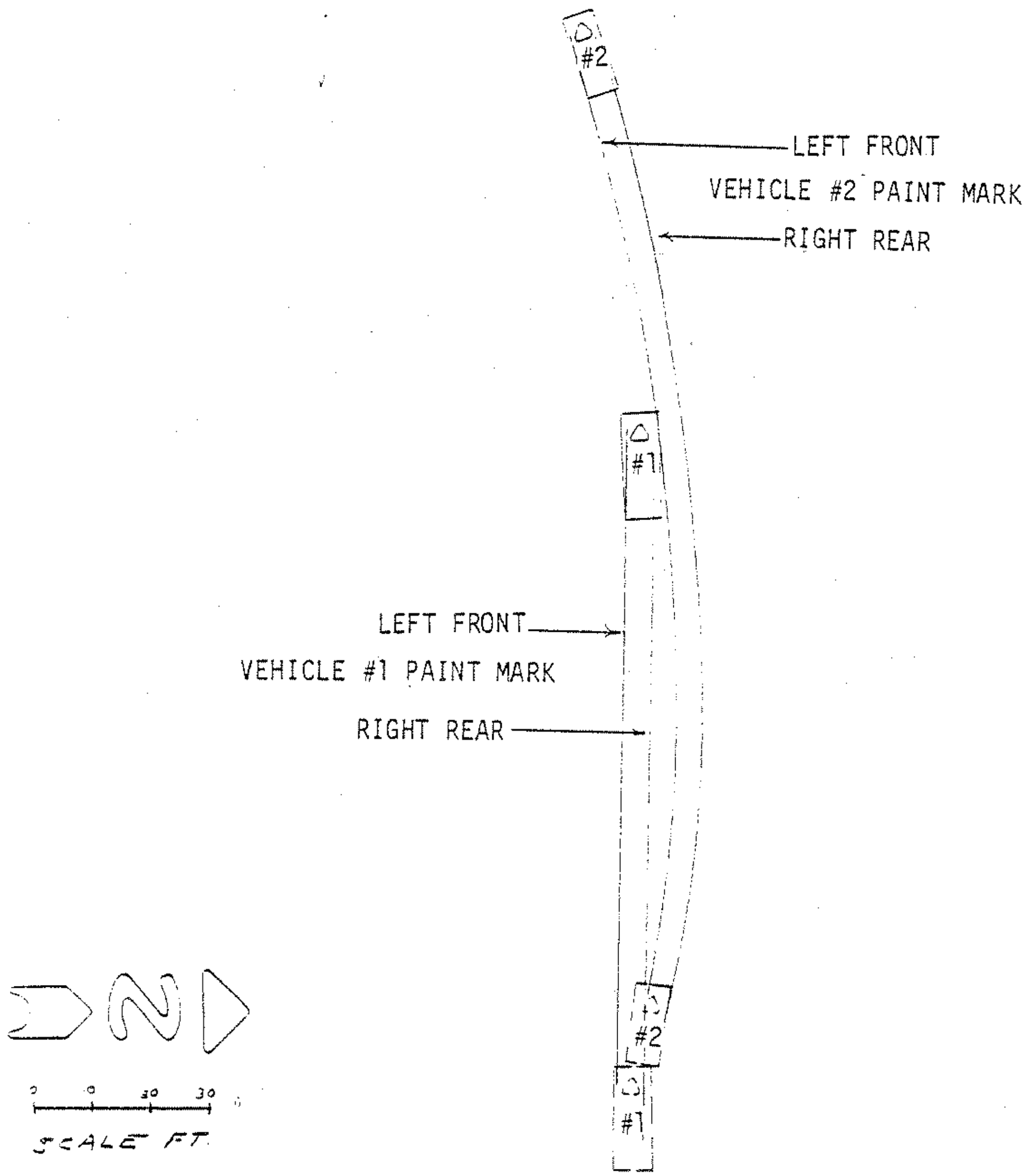


Figure 2-10 TEST NO. 3 - RICSAC ACCIDENT SCHEMATIC

ACCIDENT SCHEMATIC

VEHICLES:

No. 1 - 1974 FORD TORINO
No. 2 - 1974 FORD PINTO

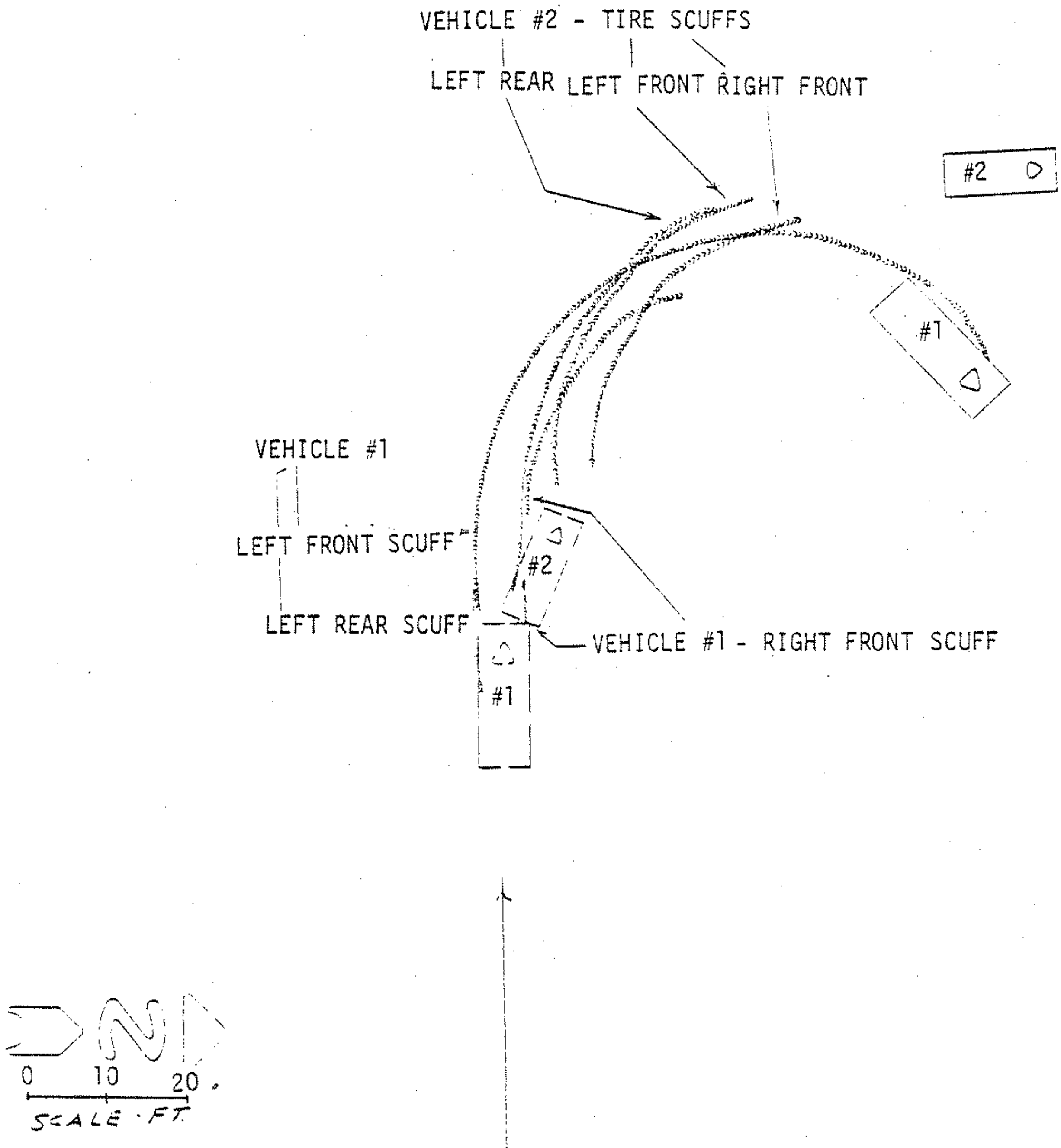


Figure 2-11 TEST NO. 4 - RICSAC ACCIDENT SCHEMATIC

ACCIDENT SCHEMATIC

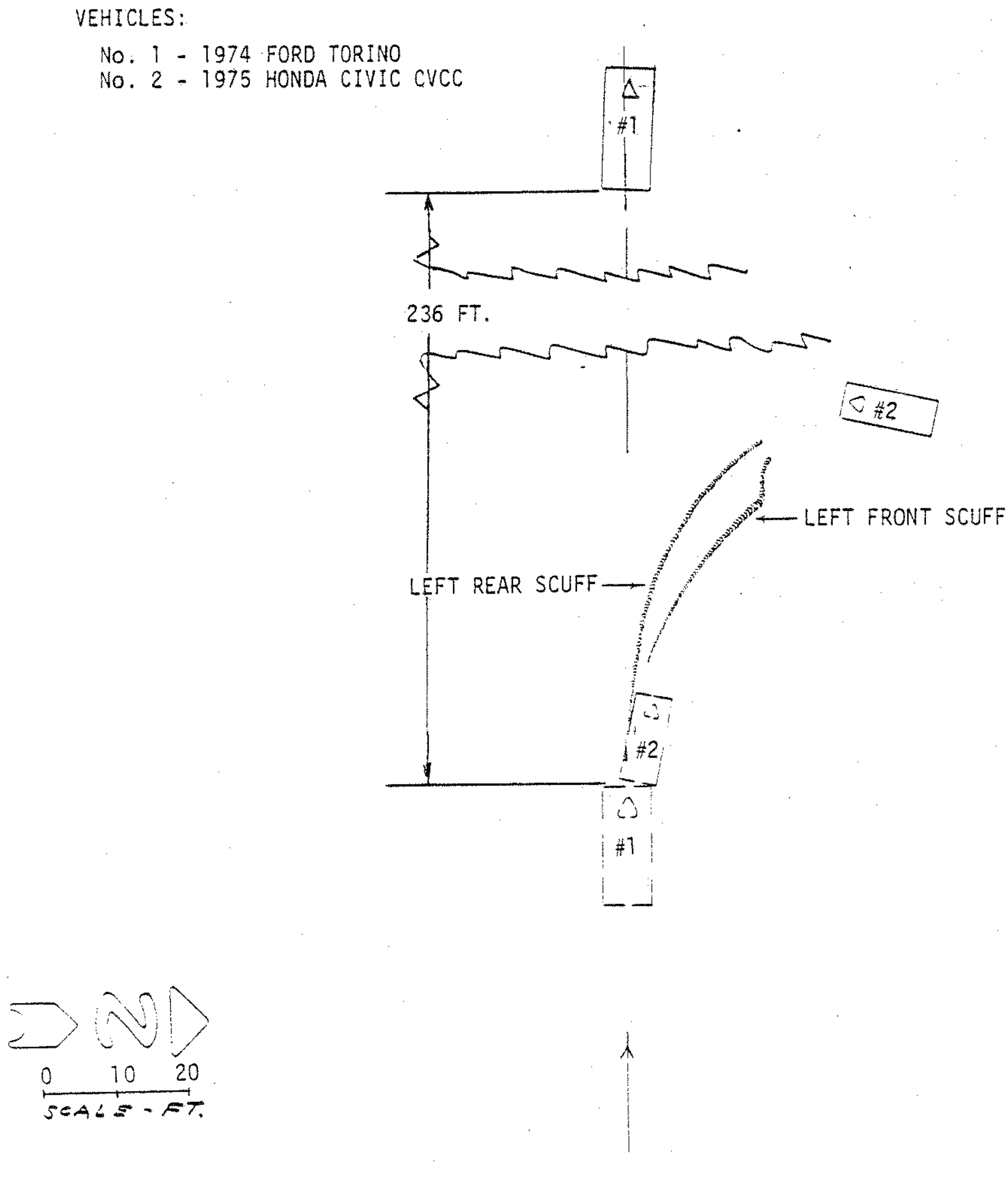


Figure 2-12 TEST NO. 5 - RICSAC ACCIDENT SCHEMATIC

SUMMARY FORM FOR STAGES COLLISION REPORTING

Comparison of Result

	MEASURED			SMAC			CRASH SPIN II		CRASH DAMAGE
	SPEED AT IMPACT	Δ V	VDI	SPEED AT IMPACT	Δ V	VDI	SPEED AT IMPACT	Δ V	Δ V
	MPH	MPH		MPH	MPH		MPH	MPH	MPH
VEHICLE #1	21.2	R 9.5 X -9.5 Y -0.4	12FZEW1	21.2	R 9.6 X Y	12FZEW2	15.2	R 3.1 X -3.1 Y 0.2	R 3.1 X -3.1 Y 0.0
VEHICLE #2	0.0	R 15.8 X 15.8 Y -0.2	06BZEW1	0.0	R 15.6 X Y	06BYEW2	10.4	R 5.4 X 4.9 Y -2.3	R 4.9 X 4.9 Y -0.9

Summary of Physical Evidence

	REST POSITIONS			IMPACT POSITIONS			END OF ROTATIONAL AND/OR LAT. SKID				ROLLING RESISTANCE				TIRE PAVEMENT
	X'_{CR}	Y'_{CR}	ψ_R	X'_{CS}	Y'_{CS}	ψ_S	X'_{C1}	Y'_{C1}	ψ_1						μ
	FT.	FT.	DEG.	FT.	FT.	DEG.	FT.	FT.	DEG.	ROT.	RF	LF	RR	LR	
VEHICLE #1	111.4	2.0	-4.0	0.0	0.0	0.0	--	--	--	N(CW)	.01	.01	.09	.09	0.87
VEHICLE #2	181.5	-6.4	-19.0	15.0	2.2	10.0	--	--	--	N(CW)	.01	.01	.1	.1	

MEASURED DAMAGE DIMENSIONS

	WIDTH	DAMAGE EXTENT						MOMENT ARM		DIRECTION			
	L1	C11	C12	C13	C14	C15	C16	DI	RATIO	ANGI	VEH. SIZE	VEH. WGT.	REFERENCE
	IN.	IN.	IN.	IN.	IN.	IN.	IN.	IN.	RHOI	DEG.		LBS.	
VEHICLE #1	30.0	2.0	2.00	1.50	1.75	2.0	2.25	22.00	--	0.0	I	4949	
VEHICLE #2	30.0	6.5	6.75	5.75	5.0	3.75	3.00	5.0	--	170.0	S	3120	

COLLISION CONFIGURATION 10° Offset front-to-rear impact

TEST IDENTIFICATION RICSAC Test No. 3 - Ford Torino Vs. Ford Pinto

SUMMARY FORM FOR STAGED COLLISION REPORTING

Comparison of Result

	MEASURED			SMAC			CRASH: SPIN II		CRASH: DAMAGE
	SPEED AT IMPACT (MPH)	Δ V (MPH)	VDI	SPEED AT IMPACT (MPH)	Δ V (MPH)	VDI	SPEED AT IMPACT (MPH)	Δ V (MPH)	Δ V (MPH)
VEHICLE #1	38.7	R 18.7 X -18.7 Y 0.4	12FZEW3		R 16.7 X Y	12RFEW2	31.9	R 10.3 X -9.1 Y 4.9	R 9.1 X -9.1 Y 0.0
VEHICLE #2	0.0	R 22.2 X 22.2 Y -2.8	05BYEW5		R 26.2 X Y	06BDEW4	4.9	R 13.0 X 12.2 Y -4.4	R 14.1 X 12.2 Y -7.1

Summary of Physical Evidence

	REST POSITIONS			IMPACT POSITIONS			END OF ROTATIONAL AND/OR LAT. SKID.				ROLLING RESISTANCE				TIRE PAVEMENT
	X'_{CR}	Y'_{CR}	ψ_R	X'_{CS}	Y'_{CS}	ψ_S	X'_{C1}	Y'_{C1}	ψ_1	ROT.	RF	LF	RR	LR	μ
	FT.	FT.	DEG.	FT.	FT.	DEG.	FT.	FT.	DEG.						
VEHICLE #1	42.8	54.5	137.5	0.0	0.0	1.0	20.0	5.0	10.0	CW	0.01	0.01	0.2	0.2	0.87
VEHICLE #2	63.9	62.5	88.0	16.4	3.4	10.0	35.0	2.0	10.0	CW	0.01	0.01	0.2	0.2	

MEASURED DAMAGE DIMENSIONS

	WIDTH	DAMAGE EXTENT						MOMENT ARM		DIRECTION			
	L1	C11	C12	C13	C14	C15	C16	DI	RATIO	ANGL	VEH. SIZE	VEH. WGT.	REFERENCE
	IN.	IN.	IN.	IN.	IN.	IN.	IN.	IN.	RHOI	DEG.		LBS.	
VEHICLE #1	41.5	6.3	7.8	9.8	12.5	14.8	18.3	16.1	--	0	I	4980	
VEHICLE #2	41.8	36.0	31.8	29.0	24.0	19.5	14.8	-9.1	--	170	S	3190	

COLLISION CONFIGURATION 10° Offset - front-to-rear

TEST IDENTIFICATION RICSAC - Test No. 4 - Ford Torino Vs. Ford Pinto

SUMMARY FORM FOR STAGED COLLISION REPORTING

Comparison of Result

	MEASURED			SMAC			CRASH: SPIN II		CRASH: DAMAGE
	SPEED AT IMPACT (MPH)	Δ V (MPH)	VDI	SPEED AT IMPACT (MPH)	Δ V (MPH)	VDI	SPEED AT IMPACT (MPH)	Δ V* (MPH)	Δ V (MPH)
VEHICLE #1	39.7	R 16.3 X -16.3 Y 0.2	12FZEW1		R 15.1 X Y	12RFEW2	33.8	R 8.1 X -8.1 Y 0.0	R 8.1 X -8.1 Y 0.0
VEHICLE #2	0.0	R 25.1 X 25.0 Y -1.8	05BDEW8		R 26.8 X Y	06BYEW5	10.5	R 15.2 X 14.5 Y -4.5	R 14.8 X 14.5 Y -2.6

Summary of Physical Evidence

	REST POSITIONS			IMPACT POSITIONS			END OF ROTATIONAL AND/OR LAT. SKID.				ROLLING RESISTANCE				TIRE PAVEMENT
	X'_{CR}	Y'_{CR}	ψ_R	X'_{CS}	Y'_{CS}	ψ_S	X'_{C1}	Y'_{C1}	ψ_1	ROT.	RF	LF	RR	LR	μ
	FT.	FT.	DEG.	FT.	FT.	DEG.	FT.	FT.	DEG.						
VEHICLE #1	241.6	0.0	3.0	0.0	0.0	0.0	--	--	--		.01	.01	.2	.2	0.87
VEHICLE #2	56.9	39.0	282.0	14.9	3.4	10.0	55.0	23.0	260.0	CW	.2	.2	.01	1.0	

MEASURED DAMAGE DIMENSIONS

	WIDTH	DAMAGE EXTENT						MOMENT ARM		DIRECTION			
	L1	C11	C12	C13	C14	C15	C16	DI	RATIO	ANGI	VEH. SIZE	VEH. WGT. LBS.	REFERENCE
	IN.	IN.	IN.	IN.	IN.	IN.	IN.	IN.	RHOI	DEG.			
VEHICLE #1	33.5	1.4	1.4	2.0	2.1	2.3	2.9	20.3	--	0.0	I	4600	RICSAC
VEHICLE #2	53.0	36.0	36.5	31.5	23.0	13.3	6.0	-1.6	--	170.0	M	2530	

COLLISION CONFIGURATION: 10° Offset - front-to-rear

TEST IDENTIFICATION: RICSAC Test No. 5 - Ford Torino Vs. Honda Civic

*Trajectory and Damage.

3.0 DISCUSSION OF THE SMAC RECONSTRUCTION RESULTS

Unlike the CRASH II program where the impact speeds, as well as velocity changes are predicted, the SMAC program requires the impact speeds to be specified as part of the input such that the predicted velocity changes, final rest positions, and damage profiles are the key elements with which to assess the reconstruction of a given case. By way of summary, Table 3-1 gives the SMAC predicted and actual velocity changes for each vehicle for each test. As an approximate means of comparing the damage profile, the predicted and actual values of the vehicle damage indices are also given. The table shows that the agreement between predicted and actual velocity changes is extremely good, the largest errors being, 4.7 mph for Vehicle 1 in case 11, 4.4 mph for Vehicle 2 in case 1, and 4.3 mph for Vehicle 2 in case 8. Note that none of these are vehicles which experienced significant rotation during impact. Similarly, the vehicle damage indices show no major discrepancies and, in general, are restricted to minor differences in the clock direction of force (columns 1 and 2) the specific horizontal area (column 3) and the extent of damage (column 7).

Summarizing the reconstruction task, in terms of obtaining a good fit to the measured data, the 60° front-to-side impacts were by far the most difficult configurations to reconstruct. This appears to result from the assumption in the SMAC program that the vehicle is an isotropic homogeneous body such that its stiffness is equal in all directions. In a 60° front-to-side impact the corner of the striking vehicle deforms radially producing deformation across the front and along the side of the vehicle. This has the effect that the onset of the collision interface on the struck vehicle is not steep enough (because, in effect, there is no corner on the striking vehicle to dig in) such that the deformation produced in the struck vehicle is too shallow. This makes it difficult to obtain an acceptable match of vehicle rest positions in these impact configurations. However, despite the limitation, it is important to note that the effect on the velocity change is extremely small, i.e., although matching the rest positions of the vehicles is very sensitive to the impact positions and indirectly to the development

TABLE 3-1

VELOCITY CHANGES AND VEHICLE DAMAGE INDICES PREDICTED BY SMAC COMPARED TO MEASURED VALUES

Test No.	Impact Configuration	Size	Impact Speed	Velocity Change Actual	Velocity Change SMAC	Error	Vehicle Damage Index Actual	Vehicle Damage Index SMAC
1	60° Front-to-Side	I	19.8	12.2	14.2	2.0	11FZEW2	12FDEW3
		S	19.8	15.6	20.0	4.4	01RDEW3	03RDEW3
2	60° Front-to-Side	I	31.5	19.6	21.3	1.7	11FDEW2	12FDEW3
		SC	31.5	--	31.7	-	02RDEW4	02RYEW5
6	60° Front-to-Side	I	21.5	9.2	10.8	1.6	11FZEW1	12FDEW3
		SC	21.5	11.9	16.7	4.8	02RDEW3	01RDEW5
7	60° Front-to-Side	I	29.1	12.0	11.3	-0.7	11FDEW1	12FDEW2
		SC	29.1	16.5	17.3	0.8	02RDEW4	02RDEW4
8	90° Front-to-Side	I	20.75	15.3	16.8	1.5	12FDEW1	11FDEW2
		I	20.75	10.7	15.0	4.3	03RYEW2	02RDEW2
9	90° Front-to-Side	M	21.2	21.4	20.0	-1.4	11FDEW2	11LFEE2
		I	21.2	8.9	8.7	-0.2	02RFEW2	02RYEW3
10	90° Front-to-Side	M	33.3	35.1	36.5	1.4	10FDEW2	11LFEE3
		I	33.3	14.1	15.7	1.6	01RFEW2	02RYEW3
11	10° Offset Front-to-Front	SC	20.4	24.0	28.7	4.7	12FYEW3	12FYEW3
		I	20.4	15.7	17.6	1.9	12FYEW3	12LFEW2
12	10° Offset Front-to-Front	SC	31.5	40.1	40.9	0.8	12FDEW4	12FDEW4
		I	31.5	26.4	27.6	1.2	12FYEW4	12LFEW3
3	10° Offset Front-to-Rear	I	21.2	9.5	9.6	0.1	12FEEW1	12FZEW2
		SC	0.0	15.8	15.6	-0.2	06BZEW1	06BYEW2
4	10° Offset Front-to-Rear	I	38.7	18.7	16.7	-2.0	12FZEW3	12RFEW2
		SC	0.0	22.2	26.2	4.0	05BYEW5	06BDEW4
5	10° Offset Front-to-Rear	I	39.7	16.3	15.1	-1.2	12FZEW1	12RFEW2
		M	0.0	25.1	26.8	1.7	05BDEW2	06BYEW5

of the correct collision interface the fine tuning that is required to produce such a match has only a small effect on the velocity changes that are predicted. Another limitation that was experienced with the SMAC program was in cases where vehicle roll or pitch was sufficient to unweight one or two of a vehicle's wheels. The SMAC program does not simulate weight transfer effects and assumes that the weight is equally distributed on either side of the vehicle such that the maximum tire force (whether side or circumferential) that the SMAC program will allow for any one side of the vehicle is $\mu\frac{W}{2}$. This means that even if the cornering stiffnesses and torques or one side of the vehicle are set to zero to simulate the airborne wheels, the forces on the two remaining wheels will not necessarily be realistic. Based on the films and recorded data of the front-to-side impacts, there does appear to be significant weight transfer effects in collisions between intermediate and subcompact vehicles, such that simulation of these effects would improve the utility of the program in reconstructing these impact configurations.

A discussion of the individual cases follows. Note that for each case, a summary table is provided giving the predicted and measured rest positions and velocity changes, a graphic display of the reconstruction and a figure showing the predicted and measured damage profiles. The input values used in each case are given in Appendix 3.

3.1 Discussion of Individual Cases

Test No. 1 - 60° Front-to-Side Impact - Chevrolet Chevelle Vs. Ford Pinto - Impact Speeds, 19.8/19.8 mph

	X_1 ft	Y_1 ft	ψ_1 deg	ΔV_1 mph	X_2 ft	Y_2 ft	ψ_2 deg	ΔV_2 mph
Actual	-1.0	5.4	-1.5	12.2	8.5	7.8	105	15.6
SMAC	-0.1	5.7	1.3	14.2	8.6	9.4	104	20.0

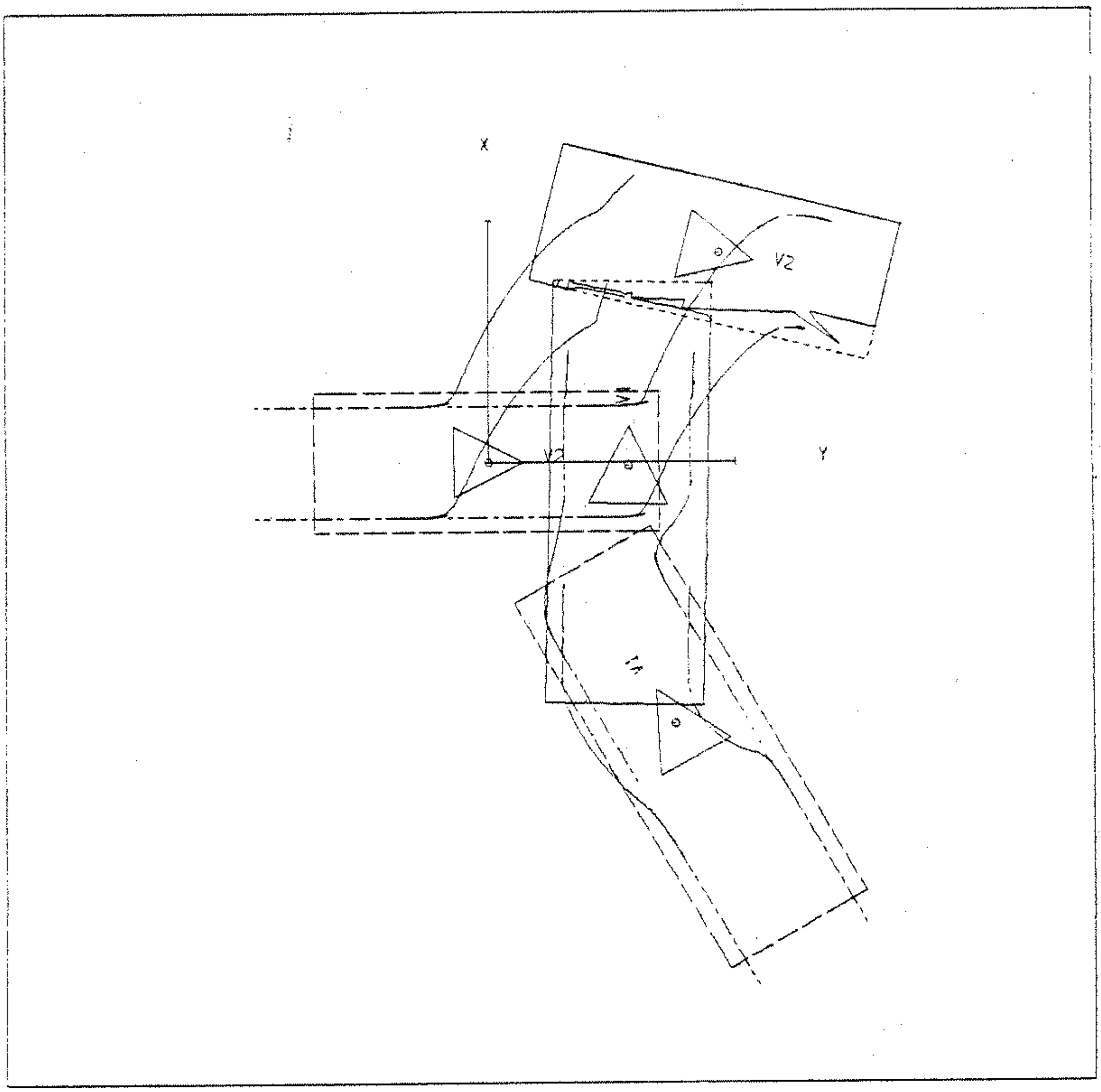
The match between the predicted and measured rest positions is extremely good, although the velocity changes (14.2 mph versus 12.2 mph actual and 20.0 mph versus 15.6 mph actual) are slightly overestimated, particularly for Vehicle 2 (the struck vehicle). This suggests that the engagement of the two vehicles was marginally too long. This is confirmed by looking at the predicted damage which is shown in Figure 3-2. The damage to Vehicle 1 is slightly overpredicted although it is worth noting that the Chevelle was fitted with a 5 mph energy absorbing bumper such that the actual structure was probably more elastic than the one simulated. The predicted damage to Vehicle 2 continues 66 inches to the rear of the car compared to 35 inches actual. However, the damage from 35 to 66 inches results from a secondary impact between the two vehicles which occurred in the simulation, which would have been prevented if the yaw velocity of Vehicle 1 had been marginally larger.

In achieving the match, twelve runs in all were made. The main problem was restricting the Y displacement (space fixed coordinates) of Vehicle 2. This was accomplished by increasing the intervehicle friction coefficient which had the effect of increasing the amount of engagement between the two vehicles and hence reducing the displacement of Vehicle 2. Perhaps surprisingly, the value used to obtain a match was 1.5 after successively increasing it from 0.55. The stiffnesses of the two vehicles were also varied to try and accomplish the same result, however, increasing Vehicle 1's stiffness to 60 lb/in^2 and reducing Vehicle 2's to 30 lb/in^2 produced too much damage to the struck vehicle and too much rotation.

GRAPHIC DISPLAY OF OUTPUTS OF ACCIDENT RECONSTRUCTION

COLLISION AND TRAJECTORY

★RICSAC TEST #1 ★



AXIS INTERVALS ARE 10. FEET

RECONSTRUCTED POSITIONS AND VELOCITIES AT IMPACT							DISPLAYED FINAL POSITIONS				VEHICLE	
	C.G. POSITION		HEADING				C.G. POSITION		HEADING		DAMAGE	
	XC1	YC1	PSI1	FWD	LATERAL	ANGULAR	XC1F	YC1F	PSI1F	REMARKS	INDICES	ΔV
	FT.	FT.	DEG.	MPH	MPH	DEG/SEC	FT.	FT.	DEG.			MPH
VEHICLE # 1	-10.8	7.6	-30.0	19.7	0.0	0.0	-0.1	5.7	1.3	VEHICLE AT REST	1 2 F D E W 3	14.2
VEHICLE # 2	0.0	0.0	90.0	19.2	0.0	0.0	8.6	9.4	104.0	VEHICLE AT REST	0 3 R D E W 3	20.0

Figure 3-1 GRAPHIC DISPLAY, TEST NO. 1

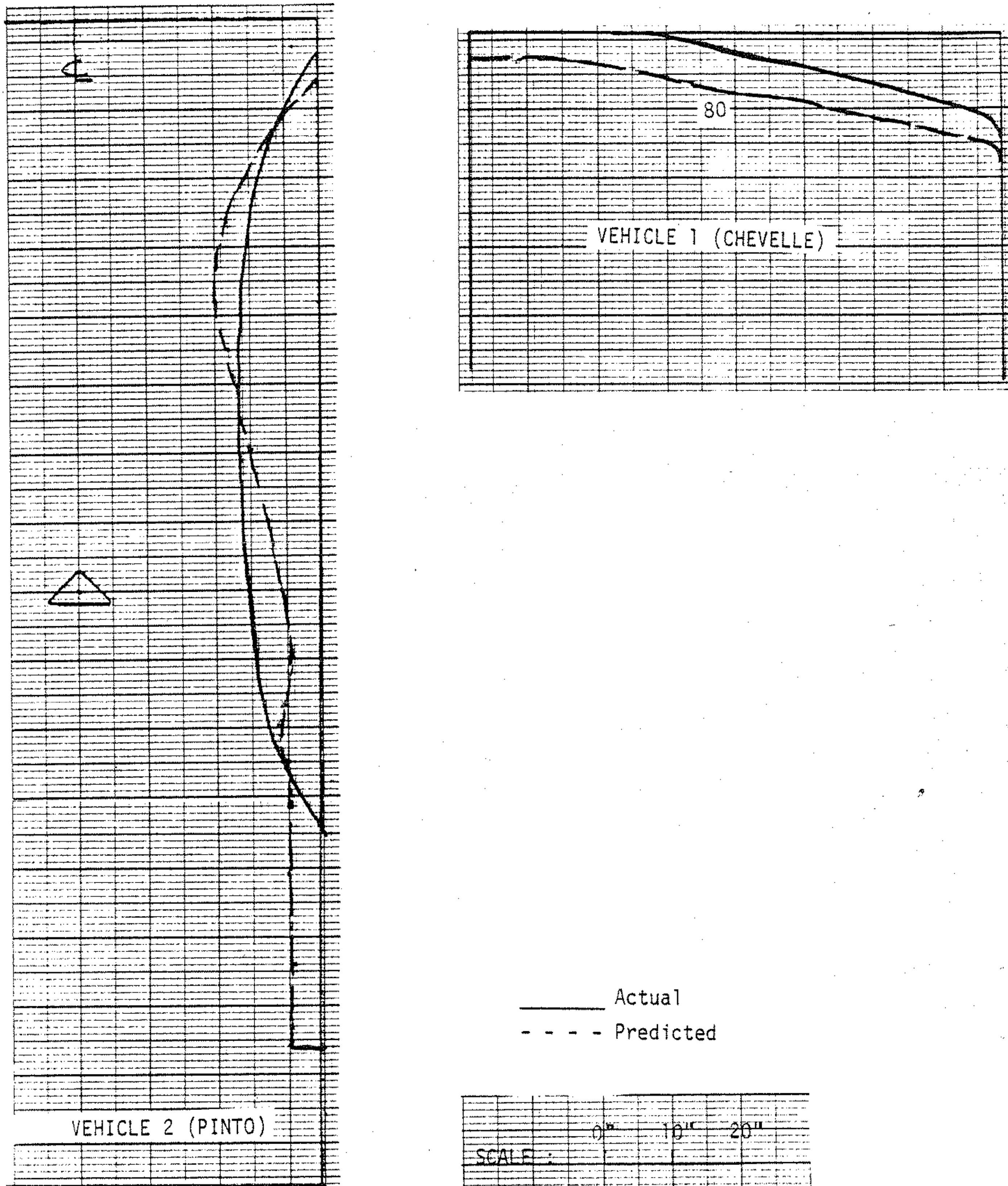


Figure 3-2 TEST NO. 1 - PREDICTED VERSUS ACTUAL DAMAGE

Test No. 2 - 60° Front-to-Side Impact - Chevrolet Chevelle Vs. Ford Pinto - Impact Speeds, 31.5/31.5 mph

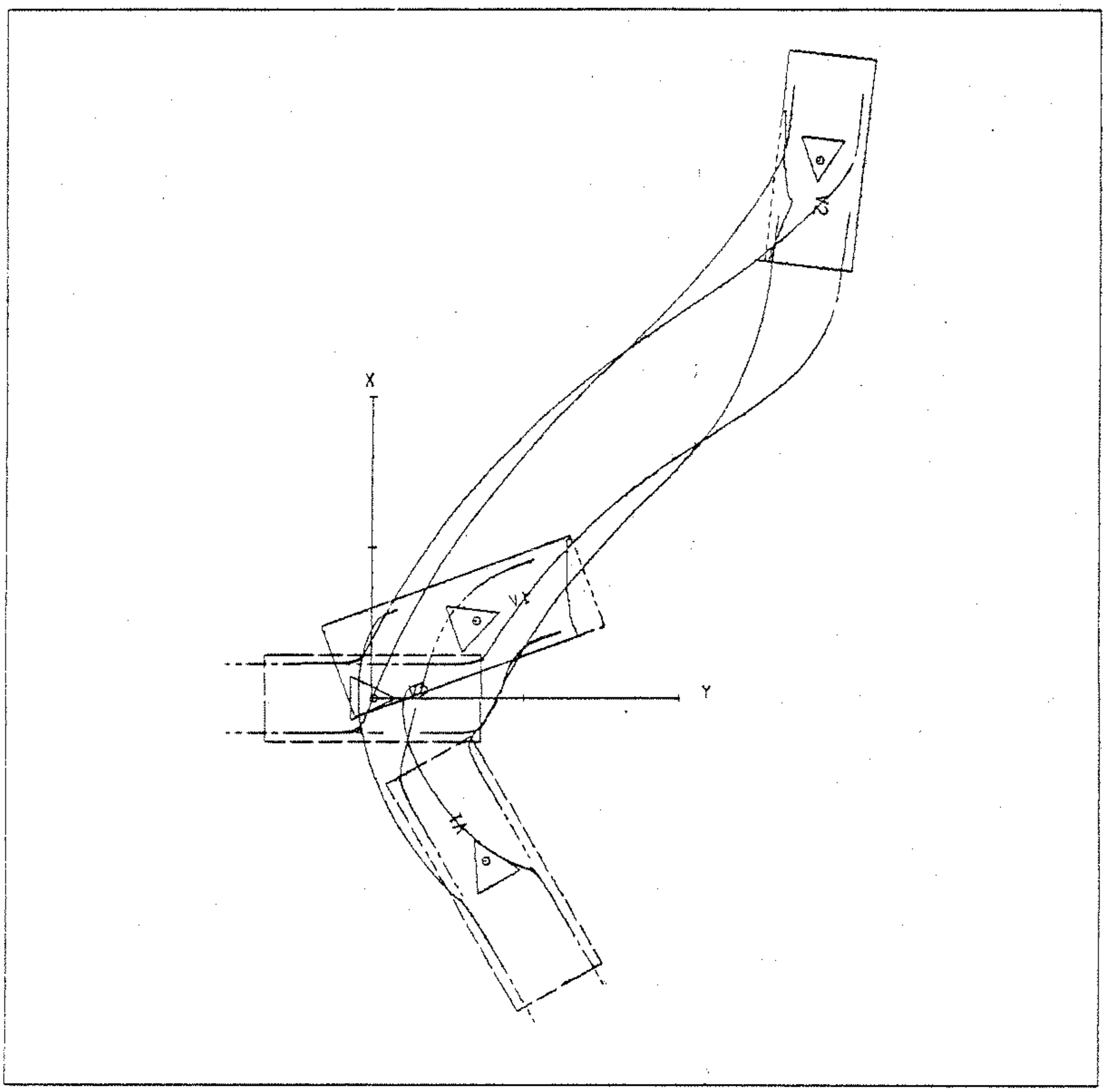
	Vehicle 1				Vehicle 2			
	X_1 ft	Y_1 ft	ψ_1 deg	ΔV_1 mph	X_2 ft	Y_2 ft	ψ_2 deg	ΔV_2 mph
Actual	11.0	9.4	55.0	19.6	23.6	12.5	134.0	--
SMAC Computed	5.1	6.9	69.8	21.5	35.7	29.3	186.6	31.2

This case proved extremely difficult to reconstruct. Analysis of the films showed that after the primary impact, a secondary impact occurred which had the effect of halting the rotation of Vehicle 2. This secondary impact is also evident in the schematic since the vehicles actually came to rest in contact with one another. Unfortunately, it was not possible within the time available to simulate the second impact; thus the rotation and displacement of Vehicle 2 are overestimated. The second impact appears not to occur because the damage to Vehicle 1 is overestimated such that the front of this vehicle clears the right front corner of Vehicle 2. The extent of engagement is probably correct because the predicted velocity change for this vehicle is in good agreement, 21.5 mph versus 19.6 mph actual. As discussed in the CRASH II results of this test, the inclusion of rotational effects would produce little change in the resultant value of ΔV. That for Vehicle 2 could not be compared since the velocity change was not recorded due to malfunction of the recording equipment.

The damage profiles are shown in Figure 3-4. As has already been stated, Vehicle 1's damage is overestimated although that for Vehicle 2 is underestimated. Looking at the actual damage to Vehicle 2, it is clear that the right front corner of Vehicle 1 pocketed just ahead of the right rear wheel of Vehicle 2. Unfortunately, this effect cannot be realistically simulated with the present version of SMAC.

GRAPHIC DISPLAY OF OUTPUTS OF ACCIDENT RECONSTRUCTION
COLLISION AND TRAJECTORY

★ RICSAC TEST #2 CHEVELLE-PINTO 31.5MPH ★



AXIS INTERVALS ARE 10. FEET

	RECONSTRUCTED POSITIONS AND VELOCITIES AT IMPACT						DISPLAYED FINAL POSITIONS				VEHICLE DAMAGE INDICES	ΔV
	C.G. POSITION		HEADING				C.G. POSITION		HEADING	REMARKS		
	XC1	YC1	PSI1	FWD	LATERAL	ANGULAR	XC1F	YC1F	PSI1F			
	FT.	FT.	DEG.	MPH	MPH	DEG/SEC	FT.	FT.	DEG.			MPH
VEHICLE # 1	-10.3	7.6	-29.9	31.5	-0.0	1.9	5.1	6.9	69.8	VEHICLE AT REST	1 1 F D E W 2	21.5
VEHICLE # 2	-0.0	0.1	90.1	31.2	-0.1	2.9	35.7	29.3	186.6	VEHICLE AT REST	0 3 R Y E W 3	31.2

Figure 3-3 GRAPHIC DISPLAY, TEST NO. 2

ZO-6057-V-6

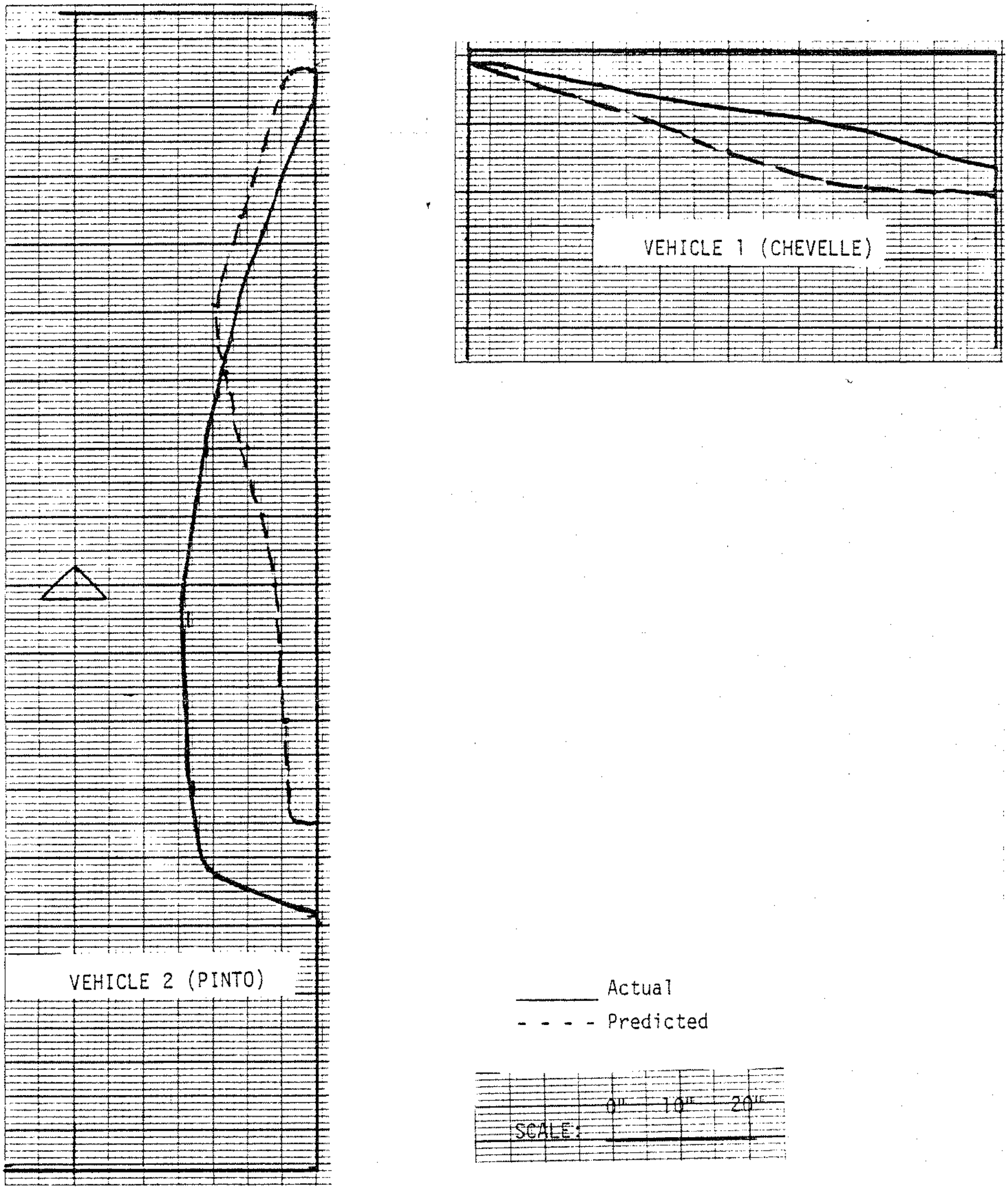


Figure 3-4 TEST NO. 2 - PREDICTED VERSUS ACTUAL DAMAGE

Test No. 6 - 60° Front-to-Side Impact - Chevrolet Chevelle Vs. VW Rabbit - Impact Speeds, 21.5/21.5 mph

	Vehicle 1				Vehicle 2			
	X_1 ft	Y_1 ft	ψ_1 deg	ΔV_1 mph	X_2 ft	Y_2 ft	ψ_2 deg	ΔV_1 mph
Actual	60.0	11.0	15.0	9.2	20.0	21.0	242.0	11.9
SMAC Computed	35.1	17.8	33.3	10.8	20.3	38.8	255.6	16.8

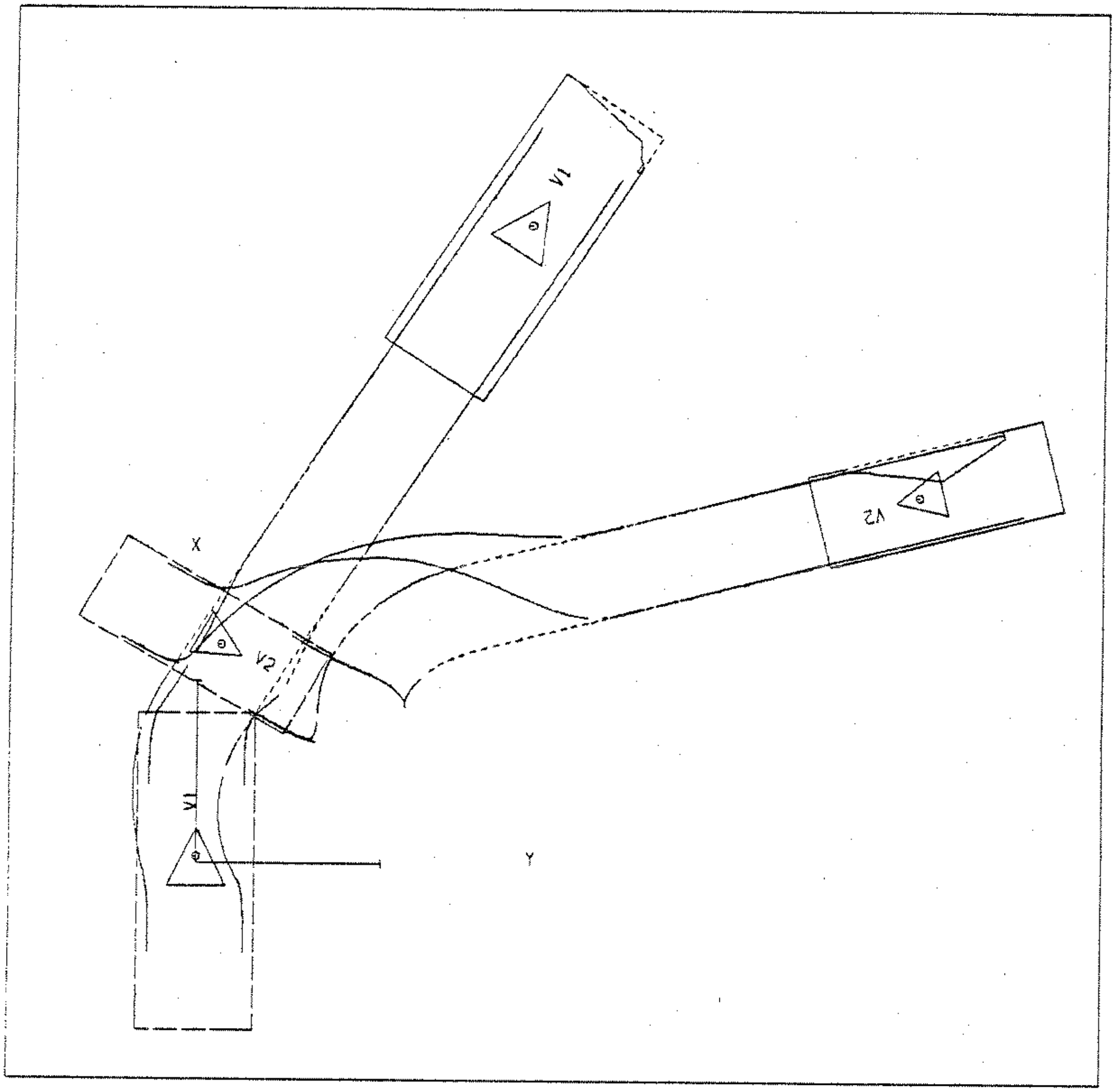
To obtain an acceptable reconstruction for this case proved to be very difficult. The problem was in producing a steep enough onset to the damage in Vehicle 2. This can be seen from Figure 3-6; the damage in the struck vehicle built up at a shallower angle than the actual damage. This has the effect of increasing the duration of the frictional force between the two vehicles and producing too much rotation in the striking vehicle, 33.3 degrees versus 15.0 degrees actual. However, if the point of impact is moved rearward to try and compensate, this produces too much rotation in Vehicle 2 and also insufficient lateral displacement. Thus, the extent of vehicle-to-vehicle engagement is probably correct. This is confirmed, in part, by the fact that the velocity change predicted for Vehicle 1 is in close agreement with the measured value, 10.8 mph versus 9.9 mph actual. While the correspondence is not nearly as striking for Vehicle 2, it should be remembered that in Section 2, it was shown that the computed value of Vehicle 2's ΔV was, in fact, a relatively large underestimate (because of the large r_x component) of the vehicle's actual velocity change. This should improve the agreement substantially and lend further support to the extent of vehicle engagement used in the simulation.

Note that the damage to Vehicle 1 is overpredicted paritally due to the effect of the 5 mph bumper but also due to the fact that the program neglects corner stiffness effects. It can be seen from the damage profile the simulation produces lateral deformation at the corner which does not occur in the actual test. If this type of deformation could be prevented by the introduction of corner stiffness effects, it would not only improve the damage match for the striking vehicle but should also increase the angle of damage onset in the struck vehicle.

GRAPHIC DISPLAY OF OUTPUTS OF ACCIDENT RECONSTRUCTION

COLLISION AND TRAJECTORY

*** TEST #6 CHEVELLE VS RABBIT ***



AXIS INTERVALS ARE 10. FEET

RECONSTRUCTED POSITIONS AND VELOCITIES AT IMPACT							DISPLAYED FINAL POSITIONS				VEHICLE DAMAGE INDICES	△V
	C.G. POSITION		HEADING				C.G. POSITION		HEADING	REMARKS		
	XC1	YC1	PSI1	FWD	LATERAL	ANGULAR	XC1F	YC1F	PSI1F			
	FT.	FT.	DEG.	MPH	MPH	DEG/SEC	FT.	FT.	DEG.			MPH
VEHICLE # 1	0.3	0.0	0.0	21.5	0.0	0.0	35.1	17.8	33.3	IN MOTION AT 4.0 SEC AFTER INITIAL CONTACT	1 2 F D E W 3	10.8
VEHICLE # 2	12.0	1.3	120.0	21.4	0.0	0.0	20.3	38.8	255.6	VEHICLE AT REST	0 1 R D E W 5	16.8

Figure 3-5 GRAPHIC DISPLAY, TEST NO. 6

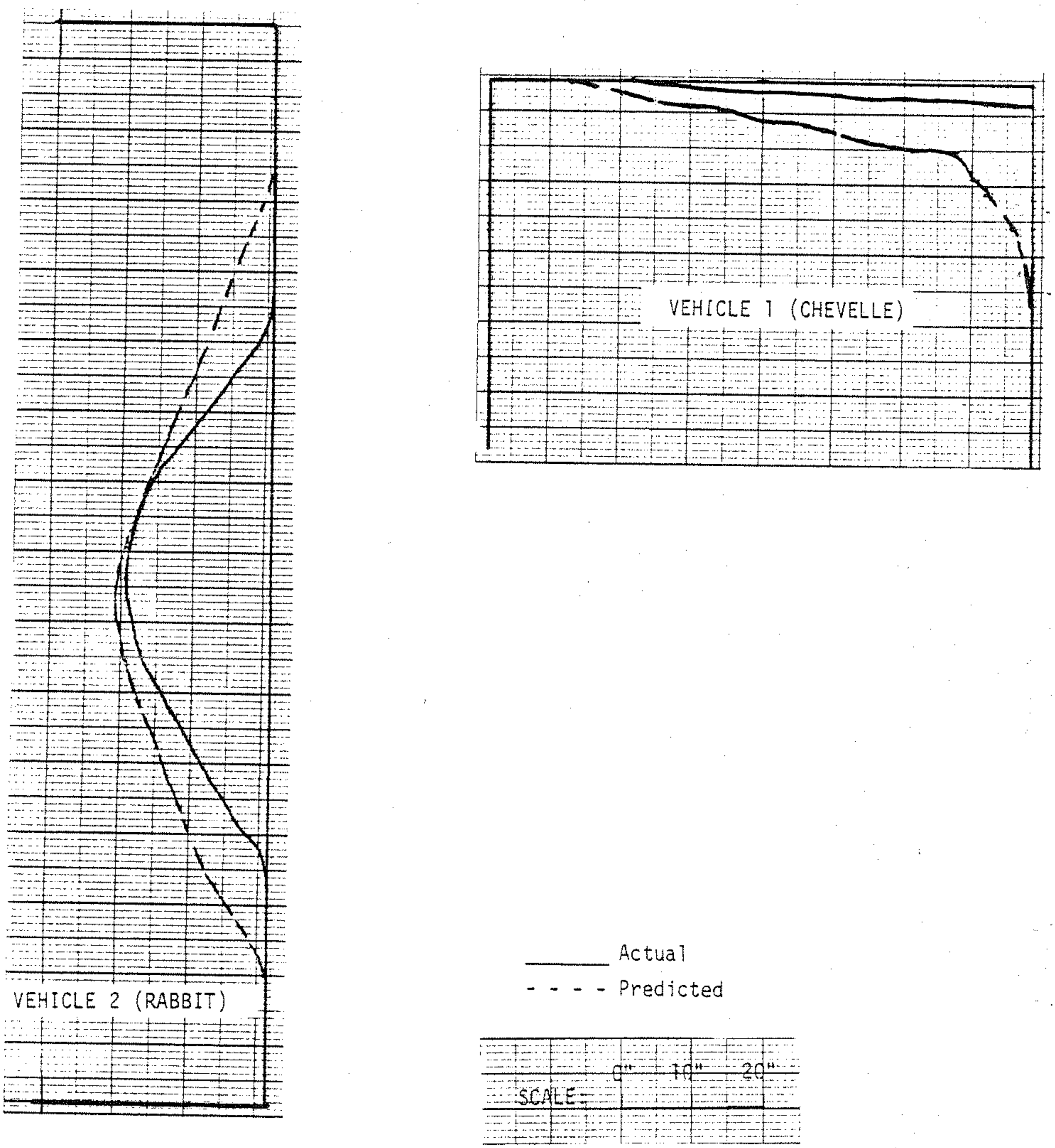


Figure 3-6 TEST NO. 6 - PREDICTED VERSUS ACTUAL DAMAGE

<u>Test No. 7</u> - 60° Front-to-Side Impact - Chevrolet Chevelle Vs. VW Rabbit - Impact Speeds, 29.1/29.1 mph

	Vehicle 1				Vehicle 2			
	X_1 ft	Y_1 ft	ψ_1 deg	ΔV_1 mph	X_2 ft	Y_2 ft	ψ_2 deg	ΔV_2 mph
Actual	84.5	18.2	16.5	12.0	22.9	41.4	262.0	16.5
SMAC Computed	76.1	18.8	16.4	11.3	5.5	49.3	299.5	17.3

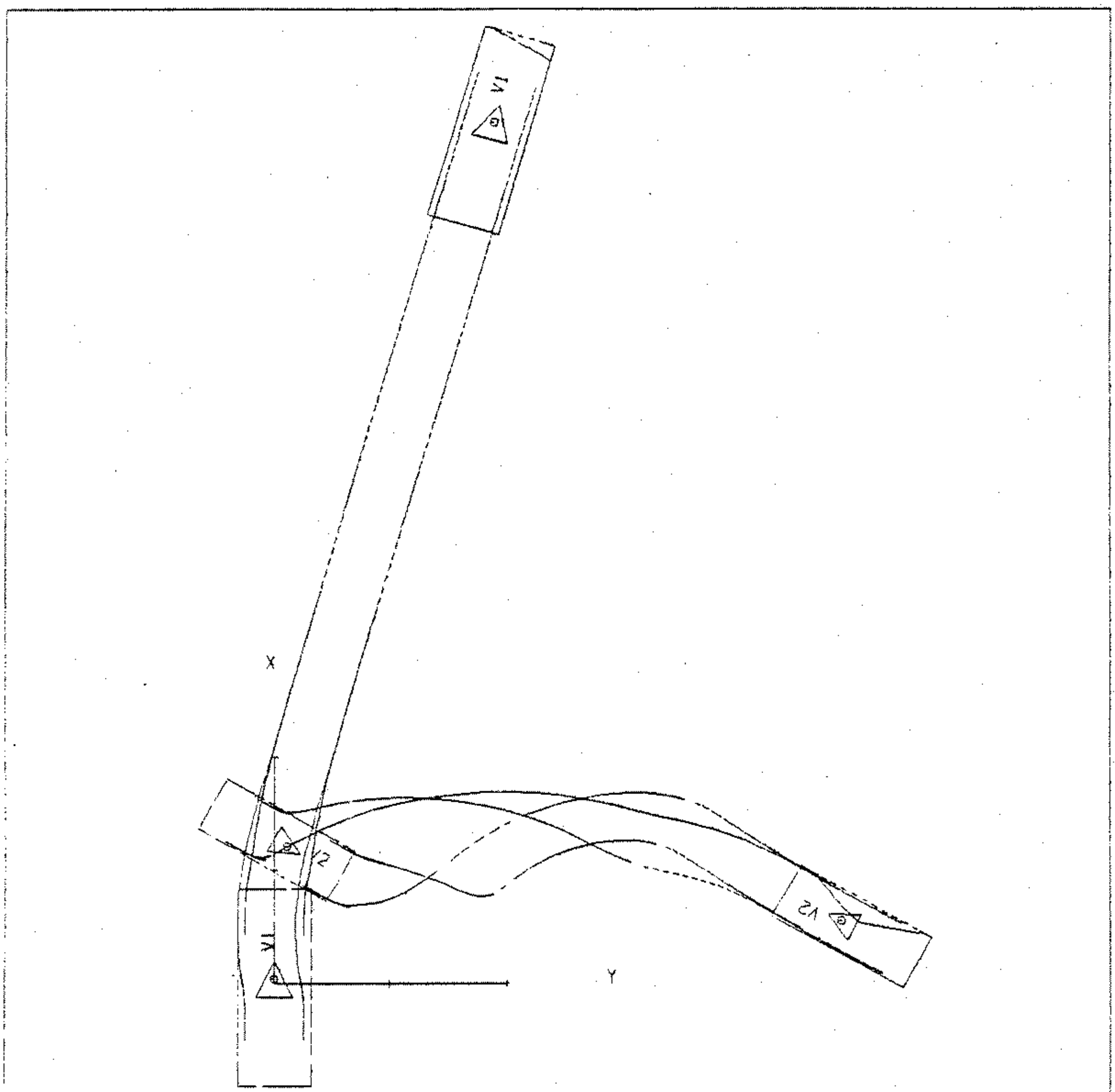
As for Case No. 6, reconstruction of this case was not straightforward. The main difficulty was in estimating appropriate values for the stiffness coefficients and the intervehicle friction coefficient. The rest positions of both vehicles were very sensitive to these parameters and to the positions of the vehicles at impact. The final values used for the stiffness coefficients were 70 and 50 lb/in^2 for Vehicles 1 and 2 respectively with an intervehicle friction coefficient of 0.3. It can be seen that for Vehicle 1 the agreement between predicted and measured rest positions is extremely close, although the agreement for Vehicle 2 is not as good, in that the rotation is overestimated by 30 degrees which also has the effect of reducing the X displacement. The velocity change for Vehicle 1 is slightly underestimated, 11.3 mph versus 12.0 mph actual. While it appears that the ΔV is overestimated for Vehicle 2, it should be noted, as discussed in the CRASH II results section, that the actual value that was obtained for the velocity change, may be lower than the actual ΔV at the center of gravity. Because of the large ΔV component coupled with relatively high angular velocities, the prediction of ΔV for Vehicle 2 may, in fact, be an underestimate as well.

Looking at the damage profiles in Figure 3-8, that for Vehicle 1, the striking vehicle, is overestimated. This is, in part, due to the elastic effect of the 5 mph energy absorbing bumper which is not simulated and the lack of corner stiffening effects. The damage match for Vehicle 2 is extremely close which confirms that although the velocity changes are slightly underestimated, the engagement of the two vehicles as simulated is correct.

GRAPHIC DISPLAY OF OUTPUTS OF ACCIDENT RECONSTRUCTION

COLLISION AND TRAJECTORY

*** TEST #7 CHEVELLE VS RABBIT ***



AXIS INTERVALS ARE 10. FEET

RECONSTRUCTED POSITIONS AND VELOCITIES AT IMPACT							DISPLAYED FINAL POSITIONS				VEHICLE	
	C.G. POSITION		HEADING				C.G. POSITION		HEADING		DAMAGE	
	XC1	YC1	PSI1	FWD	LATERAL	ANGULAR	XC1F	YC1F	PSI1F	REMARKS	INDICES	ΔV
	FT.	FT.	DEG.	MPH	MPH	DEG/SEC	FT.	FT.	DEG.			MPH
VEHICLE # 1	0.4	0.0	0.0	29.1	0.0	0.0	76.1	18.8	16.4	IN MOTION AT 4.0 SEC AFTER INITIAL CONTACT	12FDEW2	11.3
VEHICLE # 2	12.1	1.1	120.0	29.1	0.0	-0.0	5.5	49.3	299.5	VEHICLE AT REST	02RDEW4	17.3

Figure 3-7 GRAPHIC DISPLAY, TEST NO. 7

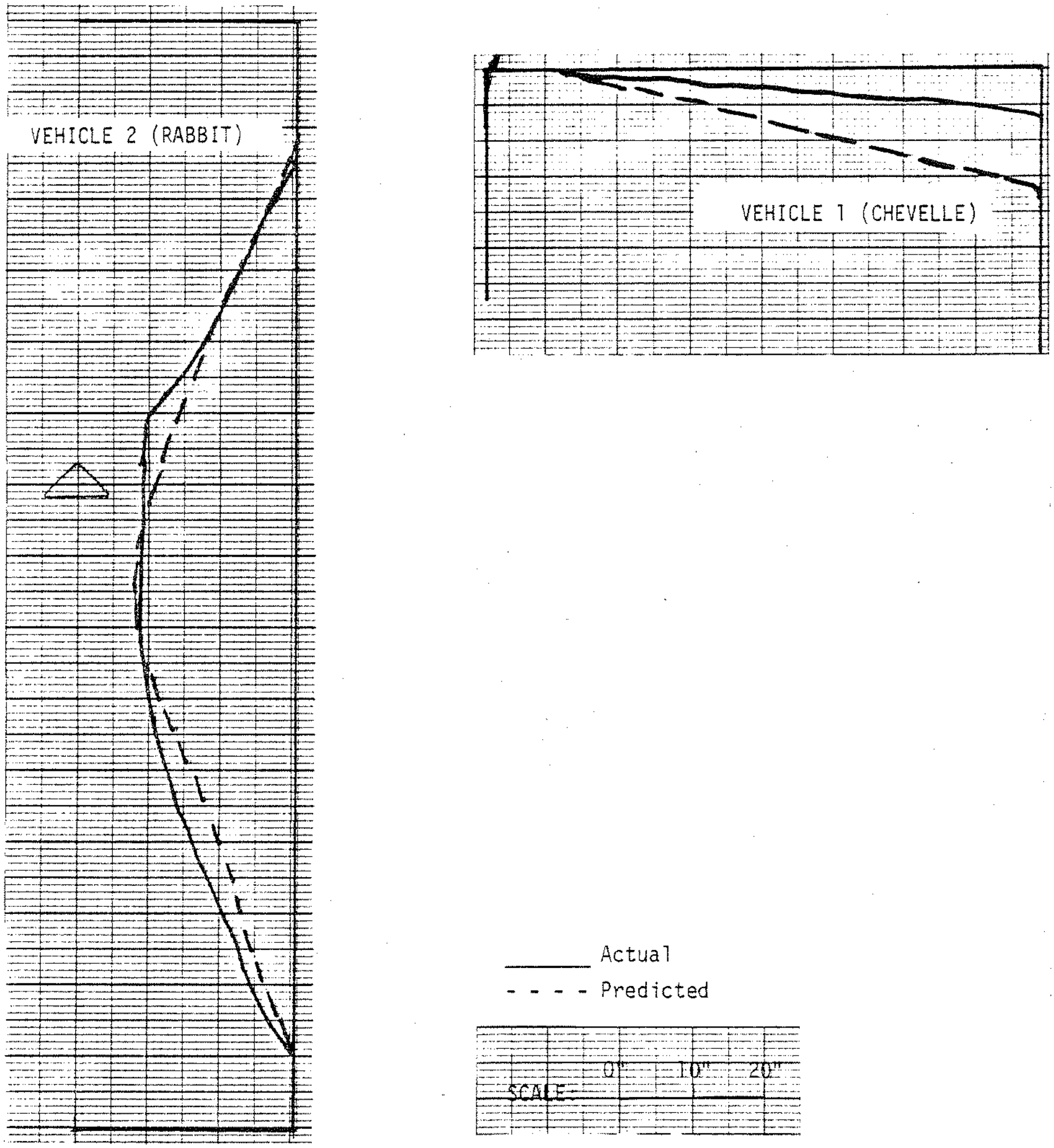


Figure 3-8 TEST NO. 7 - PREDICTED VERSUS ACTUAL DAMAGE

Test No. 8 - 90° Front-to-Side Impact - Chevrolet Chevelle Vs. Chevrolet Chevelle - Impact Speeds, 20.75/20.75 mph

	Vehicle 1				Vehicle 2			
	X_1 ft	Y_1 ft	ψ_1 deg	ΔV_1 mph	X_2 ft	Y_2 ft	ψ_2 deg	ΔV_2 mph
Actual	0.0	10.8	45.0	15.3	6.25	19.2	130.0	10.7
SMAC Computed	0.9	10.8	41.8	16.8	4.4	21.5	135.2	15.0

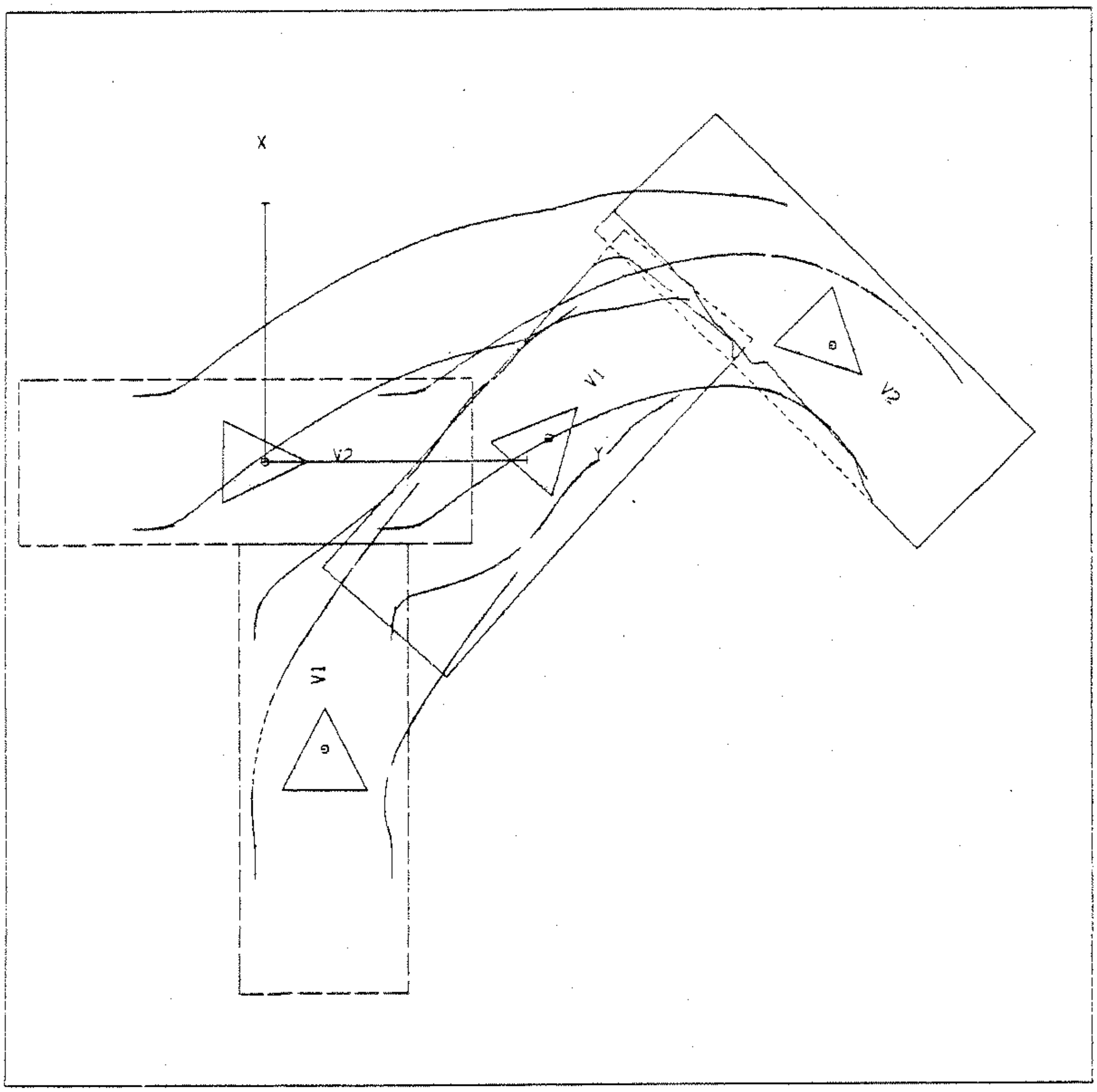
There is good agreement between the predicted and measured data, the only major discrepancies being in the velocity change for Vehicle 2 and its damage profile. Looking first at the damage profile, Figure 3-10, it can be seen that the SMAC reconstruction predicts damage which extends almost the entire length of Vehicle 2 (except for 30 inches in the front), whereas the actual damage occurred between the front wheel and "B" pillar. This difference can be attributed to the pocketing that occurred between the left front corner of Vehicle 1 and the "B" pillar of Vehicle 2, i.e., the "B" pillar presents a hard point on the side structure as the corner of the striking vehicle travels down the side of the car. This type of phenomenon cannot, at present, be simulated with the SMAC program since it is assumed that the vehicle is a uniform structure. To facilitate such a simulation would require the provision of hard points in the side structure and corner effects.

In achieving a satisfactory match to the measured data, the major input changes that had to be made were braking torques adjustments for both vehicles, and altering slightly the impact position, so that the initial contact occurred 30 inches rearward of Vehicle 2's right front corner. The intervehicle friction coefficient was also varied to try and improve the damage profile and simulate the pocketing that occurred. However, this appeared to have very little effect. This is perhaps surprising in that the 60 degree front-to-side impacts were quite sensitive to variation of the intervehicle friction coefficient.

GRAPHIC DISPLAY OF OUTPUTS OF ACCIDENT RECONSTRUCTION

COLLISION AND TRAJECTORY

TEST #8 MALIBU VS. MALIBU



AXIS INTERVALS ARE 10. FEET

RECONSTRUCTED POSITIONS AND VELOCITIES AT IMPACT							DISPLAYED FINAL POSITIONS				VEHICLE DAMAGE INDICES	ΔV
	C.G. POSITION		HEADING				C.G. POSITION		HEADING	REMARKS		
	XC1	YC1	PSI1	FWD	LATERAL	ANGULAR	XC1F	YC1F	PSI1F			
	FT.	FT.	DEG.	MPH	MPH	DEG/SEC	FT.	FT.	DEG.			MPH
VEHICLE # 1	-11.1	2.2	0.0	20.7	0.0	0.0	0.9	10.8	41.8	VEHICLE AT REST	11FDEW2	16.8
VEHICLE # 2	0.0	0.0	90.0	20.7	0.0	0.0	4.4	21.5	135.2	VEHICLE AT REST	02RDEW3	15.0

Figure 3-9 GRAPHIC DISPLAY, TEST NO. 8

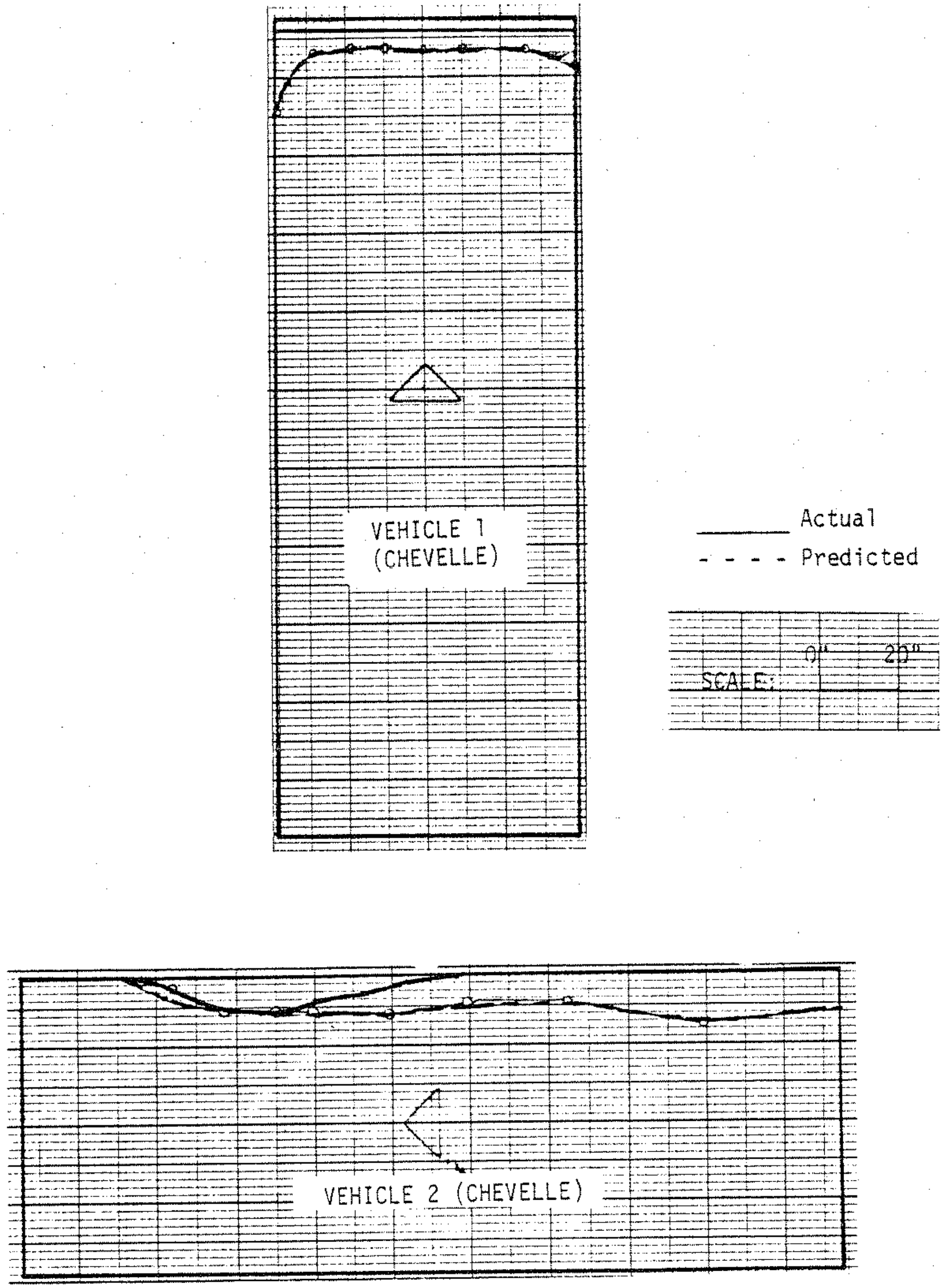


Figure 3-10 TEST NO. 8 - PREDICTED VERSUS ACTUAL DAMAGE

Test No. 9 - 90° Front-to-Side Impact - Honda Civic Vs. Ford Torino - Impact Speeds, 21.2/21.2 mph

	Vehicle 1				Vehicle 2			
	X_1 ft	Y_1 ft	ψ_1 deg	ΔV_1 mph	X_2 ft	Y_2 ft	ψ_2 deg	ΔV_2 mph
Actual	4.0	35.5	104.0	21.4	-5.0	49.5	152.0	8.9
SMAC Computed	6.6	31.7	98.6	20.0	-8.7	51.3	153.4	8.7

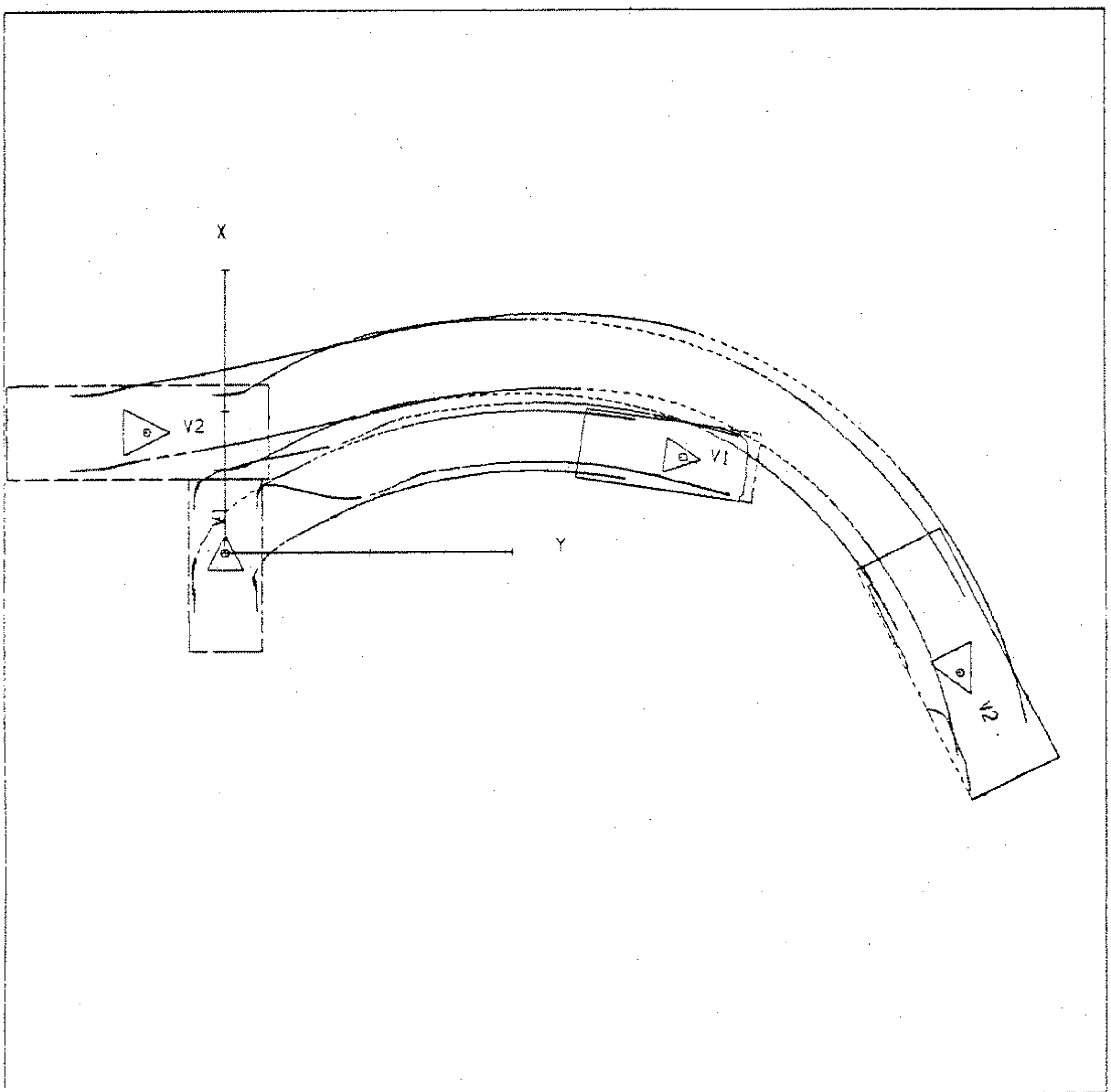
The agreement for this case is extremely good. The predicted and measured final rest positions and the velocity changes all are within an acceptable range. Looking at the damage profiles, Figure 3-12, that for Vehicle 1, the striking vehicle, agrees very closely although the damage for Vehicle 2 is slightly overestimated.

This case appeared to be particularly sensitive to brake and steer inputs, in fact, the majority of the input changes that were made during the reconstruction process were to steer angles and brake torques. The brake torques were adjusted to "fine tune" the spin out trajectories and changes in the steer angles were made primarily to smooth the effects of short duration spikes in the steering time-history plots.

GRAPHIC DISPLAY OF OUTPUTS OF ACCIDENT RECONSTRUCTION

COLLISION AND TRAJECTORY

*** TEST #9 HONDA VS TORINO 90 DEG FRONT/SIDE 21.2/21.2MPH



AXIS INTERVALS ARE 10. FEET

	RECONSTRUCTED POSITIONS AND VELOCITIES AT IMPACT						DISPLAYED FINAL POSITIONS				VEHICLE DAMAGE INDICES	
	C.G. POSITION		HEADING				C.G. POSITION		HEADING	REMARKS		ΔV
	XC1	YC1	PSI1	FWD	LATERAL	ANGULAR	XC1F	YC1F	PSI1F			
	FT.	FT.	DEG.	MPH	MPH	DEG/SEC	FT.	FT.	DEG.			MPH
VEHICLE # 1	0.0	0.0	0.0	21.2	0.0	0.0	6.6	31.7	98.6	VEHICLE AT REST	11LFEE2	20.0
VEHICLE # 2	8.5	-5.4	90.0	21.2	0.0	0.0	-8.7	51.3	153.4	IN MOTION AT 5.0 SEC AFTER INITIAL CONTACT	02RYEW3 02RZEW2	8.7 8.7

Figure 3-11 GRAPHIC DISPLAY, TEST NO. 9

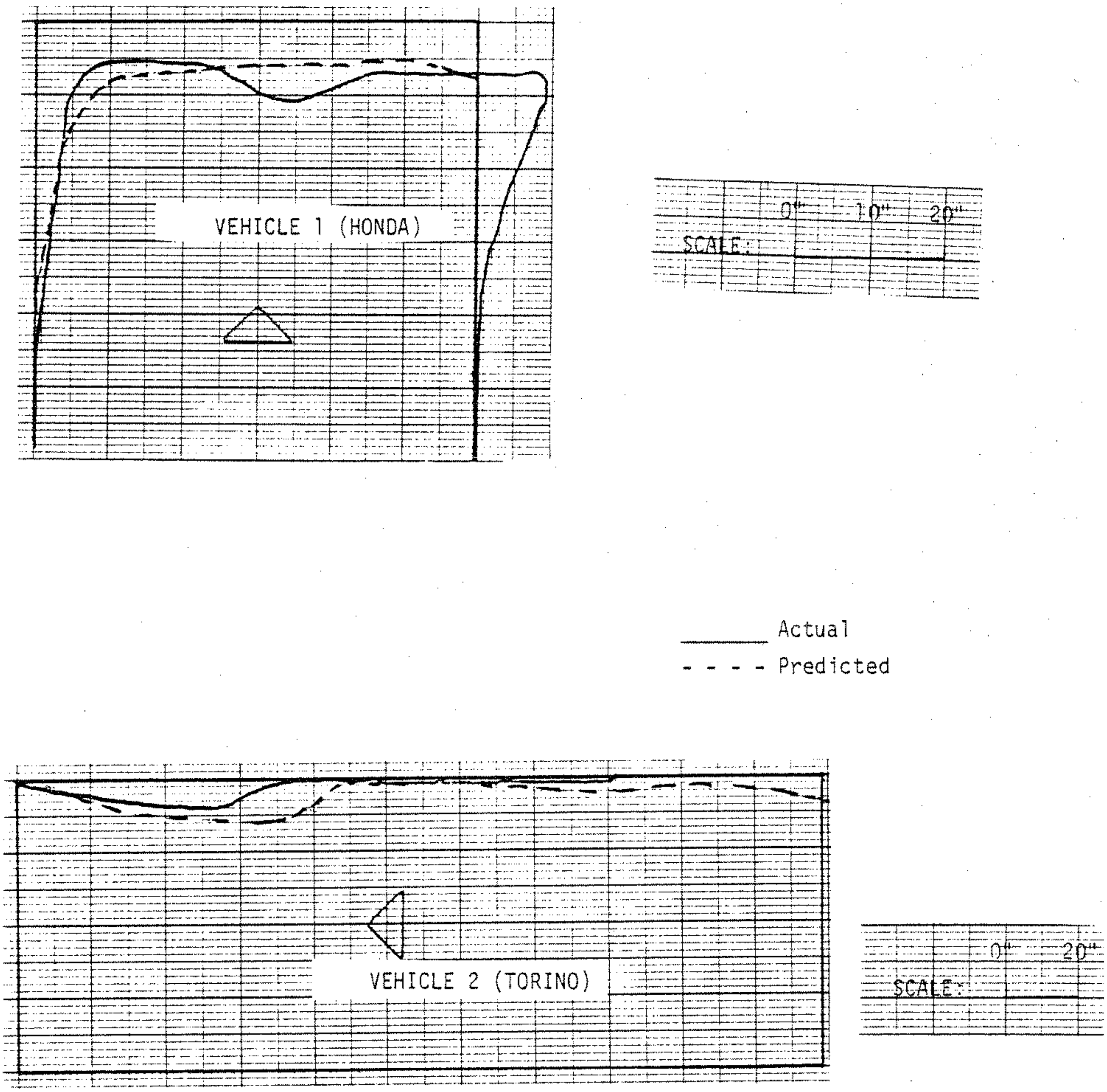


Figure 3-12 TEST NO. 9 - PREDICTED VERSUS ACTUAL DAMAGE

Test No. 10 - 90° Front-to-Side Impact - Honda Civic Vs. Ford Torino - Impact Speeds, 33.3/33.3 mph

	Vehicle 1				Vehicle 2			
	X_1 ft	Y_1 ft	ψ_1 deg	ΔV_1 mph	X_2 ft	Y_2 ft	ψ_2 deg	ΔV_2 mph
Actual	5.0	43.0	87.0	35.1	0.0	99.5	128.5	14.1
SMAC Computed	-1.5	43.4	99.8	36.5*	1.3	100.9	121.1	15.7

*Sum of two impacts

Although the agreement between predicted and measured rest positions is quite close, several factors compounded the reconstruction task; specifically:

- The right front tie rod was damaged during the impact such that the right front wheel was independent of the rest of the steering assembly; its steer angle had to be estimated from the films and through trial and error.

- Prior to coming to rest, Vehicle 2 mounted a metal transformer base and subsequently the cables connected to Vehicle 2 became fully extended, bringing the vehicle rapidly to a halt.

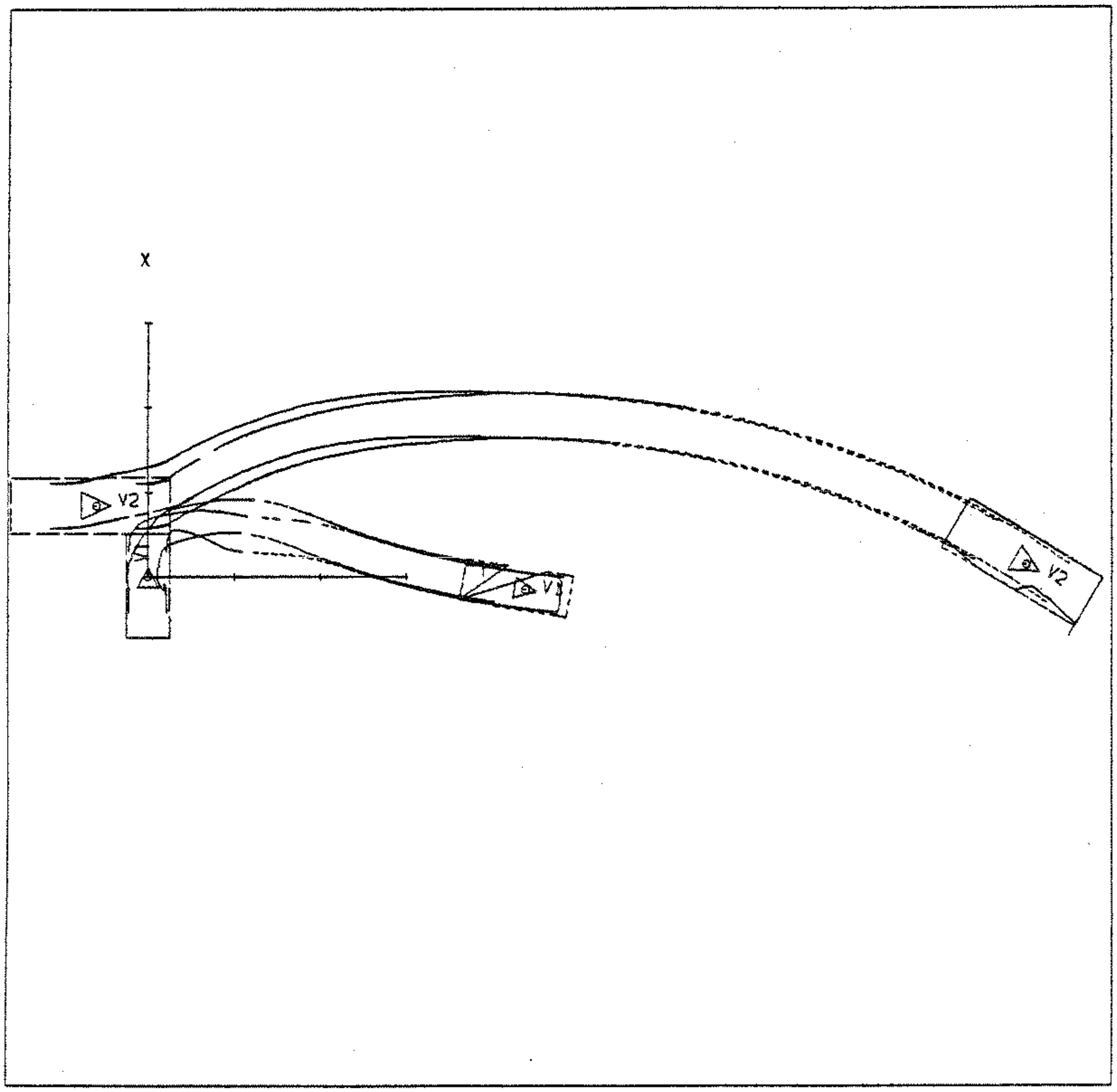
- A metal bar extending from the rear bumper of Vehicle 1 contacted the rear bumper of Vehicle 2 after the vehicles had separated from their second impact. This contact (on film) appeared to reduce Vehicle 1's angular velocity during spin out.

Once these compounding factors had been appreciated, the reconstruction process essentially entailed adjusting the braking torques and steer angles until acceptable rest positions were achieved. Looking at the vehicle damage, Figure 3-14, the predicted and measured profiles for Vehicle 1 are extremely close although, as in Test 9, that for Vehicle 2 is slightly overestimated.

GRAPHIC DISPLAY OF OUTPUTS OF ACCIDENT RECONSTRUCTION

COLLISION AND TRAJECTORY

*** TEST #10 HONDA VS TORINO 90 DEG FRONT/SIDE 33.3/33.3MPH



AXIS INTERVALS ARE 10. FEET

RECONSTRUCTED POSITIONS AND VELOCITIES AT IMPACT							DISPLAYED FINAL POSITIONS				VEHICLE DAMAGE INDICES	△V
	C.G. POSITION		HEADING				C.G. POSITION		HEADING	REMARKS		
	XC1	YC1	PSI1	FWD	LATERAL	ANGULAR	XC1F	YC1F	PSI1F			
	FT.	FT.	DEG.	MPH	MPH	DEG/SEC	FT.	FT.	DEG.			MPH
VEHICLE # 1	0.0	0.0	0.0	33.3	0.0	0.0	-1.5	43.4	99.8	VEHICLE AT REST	1 1 L F E E 3 0 8 L Z E W 3	29.7 6.8
VEHICLE # 2	8.4	-6.0	90.0	33.3	0.0	0.0	1.3	100.9	121.1	IN MOTION AT 3.9 SEC AFTER INITIAL CONTACT	0 2 R Y E W 3 0 2 R Z E W 3	15.7 15.7

Figure 3-13 GRAPHIC DISPLAY, TEST NO. 10

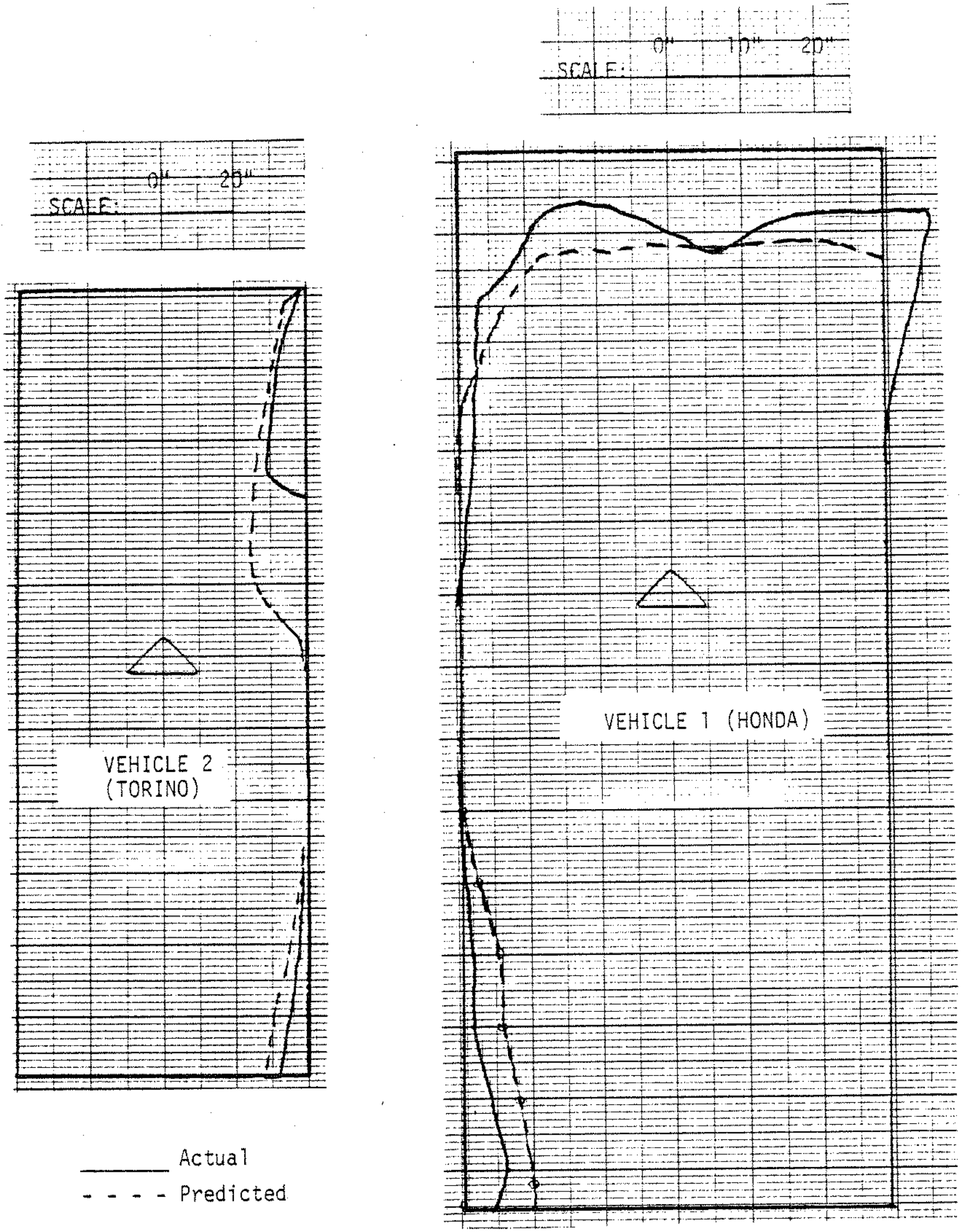


Figure 3-14 TEST NO. 10 - PREDICTED VERSUS ACTUAL DAMAGE

<u>Test No. 11</u> - 10° Offset Front-to-Front Impact - Chevrolet Vega Vs. Ford Torino - Impact Speeds, 20.4/20.4 mph

	Vehicle 1				Vehicle 2			
	X_1 ft	Y_1 ft	ψ_1 deg	ΔV_1 mph	X_2 ft	Y_2 ft	ψ_2 deg	ΔV_2 mph
Actual	25.6	-6.4	170.0	24.0	8.6	0.4	0.0	15.7
SMAC Computed	23.2	-7.4	167.1	28.7	6.9	0.7	0.3	17.6

The predicted and rest positions agree closely. However, the predicted velocity changes are slightly overestimated, 28.7 mph versus 24.0 mph actual for Vehicle 1 and 17.6 mph versus 15.7 mph actual for Vehicle 2.

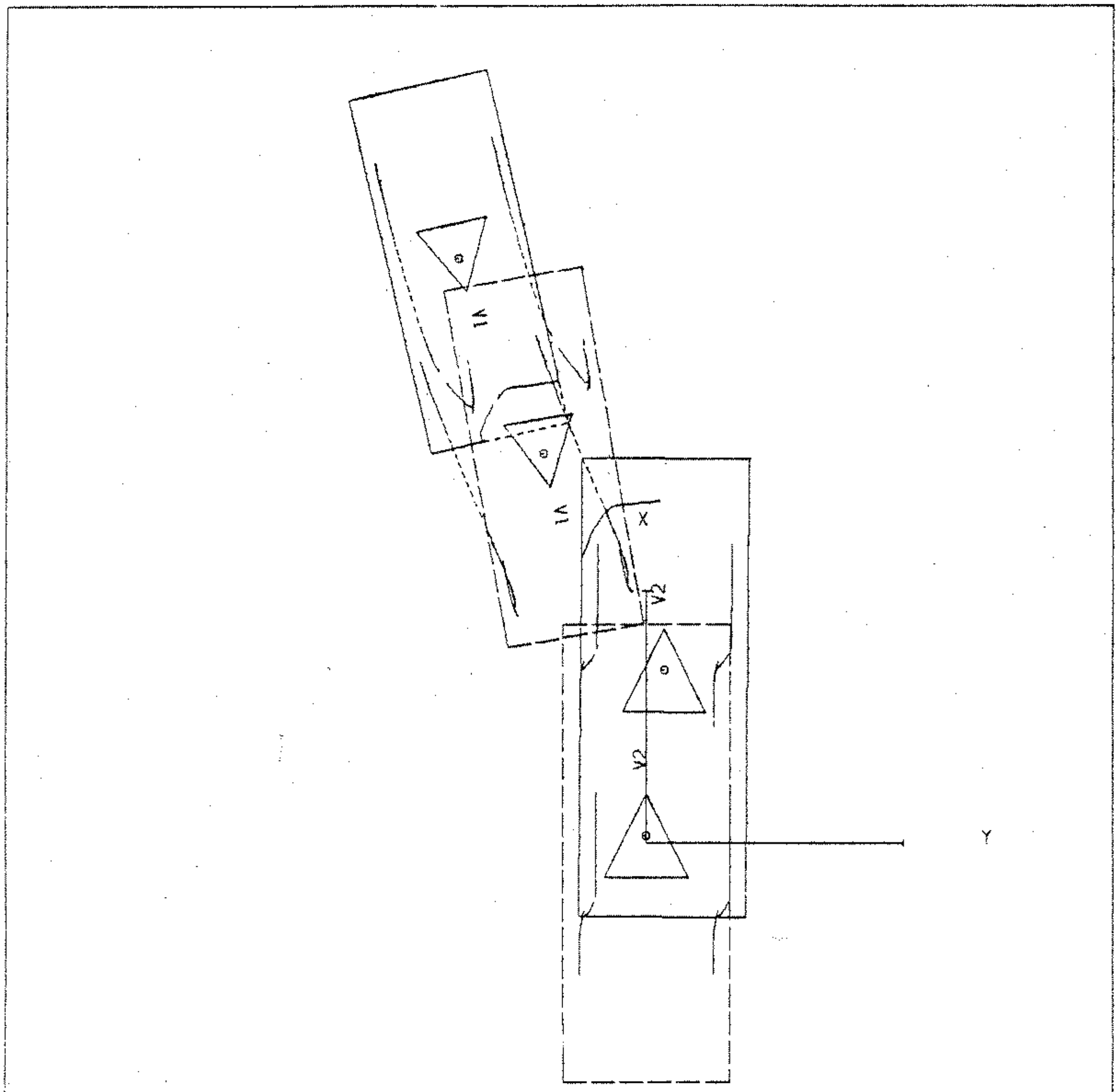
Looking at the damage profiles, Figure 3-16, the predicted extent is acceptable although the effect of the vehicle's bumper is not simulated. This has the effect of smoothing the deformation across the front of the car, whereas the homogenous isotropic body assumed in the program produces more localized effects.

In achieving an acceptable reconstruction, no real problems were encountered; the offset of the two vehicles had to be adjusted slightly to obtain the correct amount of rotation for Vehicle 1 and the stiffnesses of both vehicles increased from 50 to 60 lb/in^2 to match the damage.

GRAPHIC DISPLAY OF OUTPUTS OF ACCIDENT RECONSTRUCTION

COLLISION AND TRAJECTORY

*** TEST #11 VEGA VS TORINO OFFSET HEAD ON 20.4/20.4MPH



AXIS INTERVALS ARE 10. FEET

RECONSTRUCTED POSITIONS AND VELOCITIES AT IMPACT							DISPLAYED FINAL POSITIONS				VEHICLE DAMAGE INDICES	△V
	C.G. POSITION		HEADING				C.G. POSITION		HEADING	REMARKS		
	XC1	YC1	PSI1	FWD	LATERAL	ANGULAR	XC1F	YC1F	PSI1F			
	FT.	FT.	DEG.	MPH	MPH	DEG/SEC	FT.	FT.	DEG.			MPH
VEHICLE # 1	15.4	-4.1	170.0	20.4	0.0	0.0	23.2	-7.4	167.1	VEHICLE AT REST	1 2 F Y E W 3	28.7
VEHICLE # 2	0.3	0.0	0.0	20.4	0.0	0.0	6.9	0.7	0.3	VEHICLE AT REST	1 2 L F E W 2	17.6

Figure 3-15 GRAPHIC DISPLAY, TEST NO. 11

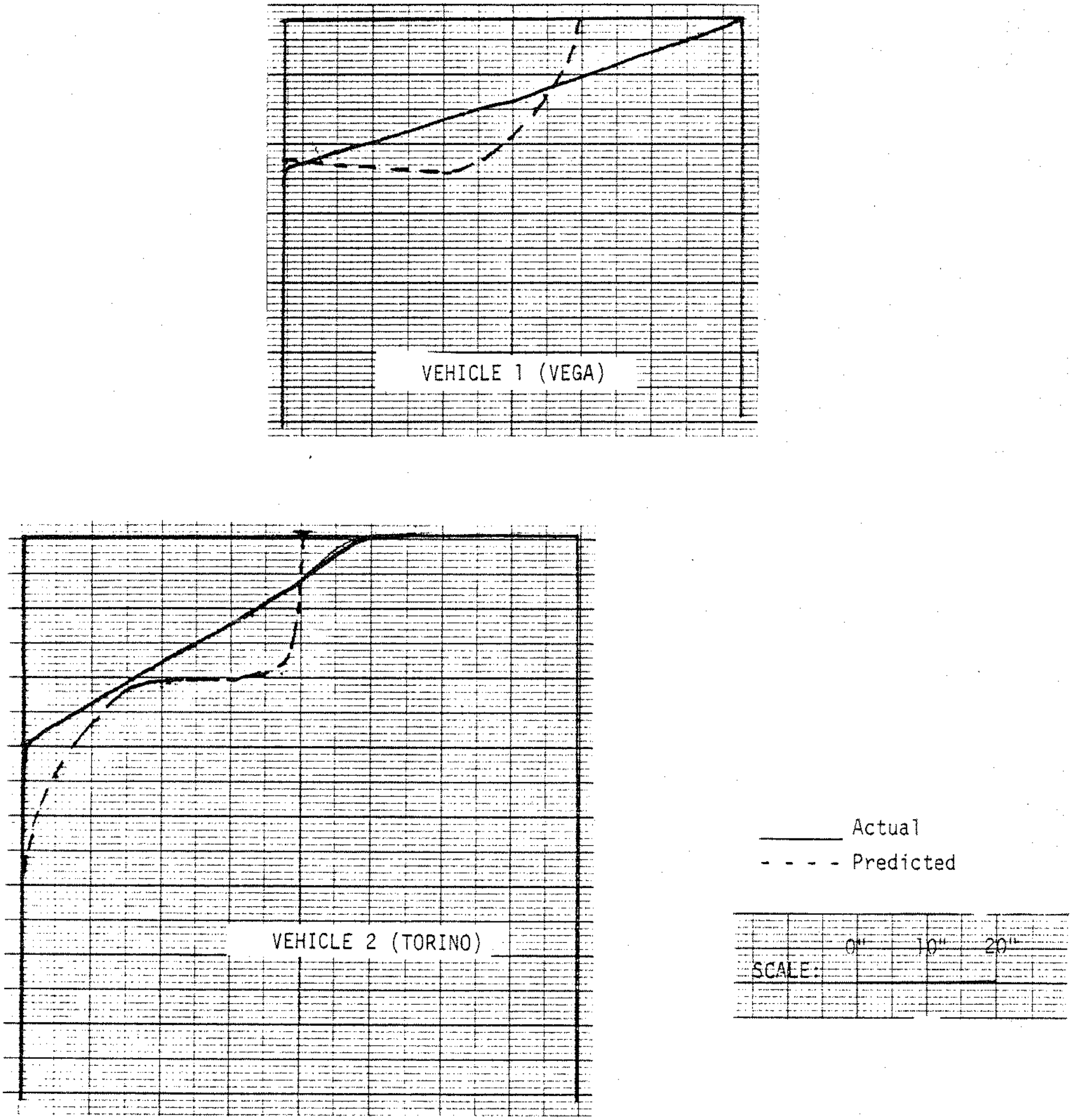


Figure 3-16 TEST NO. 11 - PREDICTED VERSUS ACTUAL DAMAGE

Test No. 12 - 10° Offset Front-to-Front Impact - Chevrolet Vega Vs. Ford Torino - Impact Speeds, 31.5/31.5 mph

	Vehicle 1				Vehicle 2			
	X_1 ft	Y_1 ft	ψ_1 deg	ΔV_1 mph	X_2 ft	Y_2 ft	ψ_2 deg	ΔV_2 mph
Actual	22.5	-5.4	122.0	40.1	6.8	2.6	-12.0	26.4
SMAC Computed	21.8	-6.5	148.7	40.9	8.8	1.6	-1.8	27.6

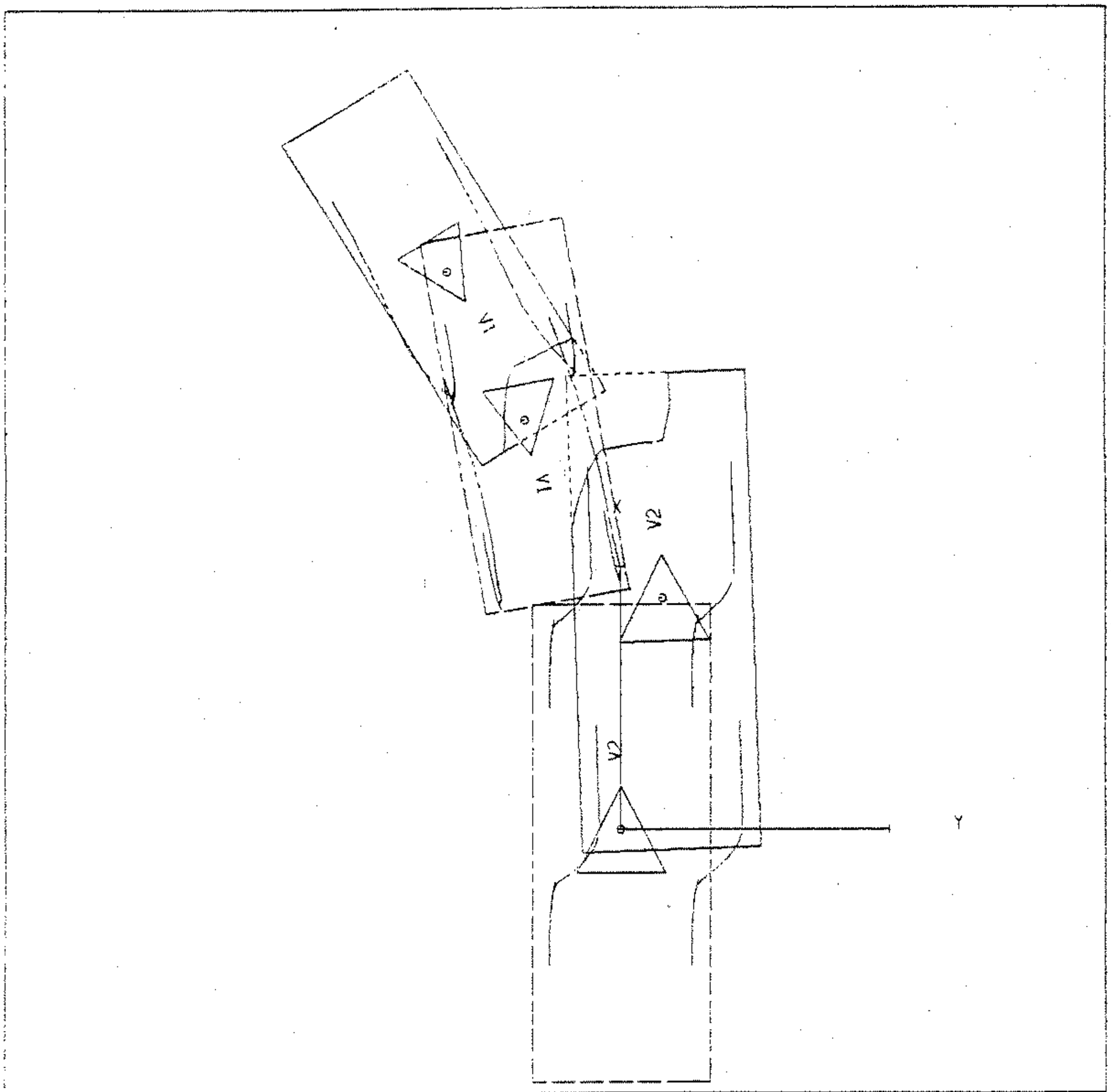
The match between predicted and measured rest positions is acceptable although the rotation of both vehicles is slightly underestimated. This is due to the fact both right side wheels of Vehicle 1 were airborne during most of the collision phase which will increase the amount of rotation of Vehicle 1. The predicted velocity changes are in good agreement, 40.9 mph versus 40.1 mph actual for Vehicle 1 and 27.6 mph versus 26.4 mph actual for Vehicle 2. The damage profiles, given in Figure 3-18 show that Vehicle 1 is in close agreement although Vehicle 2's damage is slightly overestimated.

Obtaining a match for this case was straightforward, minor adjustments were made to the overlap of the two vehicles, the braking increased on the left front wheel of Vehicle 1 (from 8 to 600 lbs) and the 12 degree steer angle introduced on Vehicle 2.

GRAPHIC DISPLAY OF OUTPUTS OF ACCIDENT RECONSTRUCTION

COLLISION AND TRAJECTORY

*** TEST #12 VEGA VS TORINO OFFSET HEAD ON 31.5/31.5MPH



AXIS INTERVALS ARE 10. FEET

RECONSTRUCTED POSITIONS AND VELOCITIES AT IMPACT							DISPLAYED FINAL POSITIONS				VEHICLE DAMAGE INDICES	
	C.G. POSITION		HEADING				C.G. POSITION		HEADING	REMARKS		
	XC1	YC1	PSI1	FWD	LATERAL	ANGULAR	XC1F	YC1F	PSI1F			ΔV
	FT.	FT.	DEG.	MPH	MPH	DEG/SEC	FT.	FT.	DEG.			MPH
VEHICLE # 1	15.6	-3.6	170.0	31.5	0.0	0.0	21.3	-6.5	148.7	VEHICLE AT REST	1 2 F D E W 4	40.9
VEHICLE # 2	0.0	0.0	0.0	31.5	0.0	0.0	8.8	1.6	-1.8	VEHICLE AT REST	1 2 L Y E W 6	27.6

Figure 3-17 GRAPHIC DISPLAY, TEST NO. 12

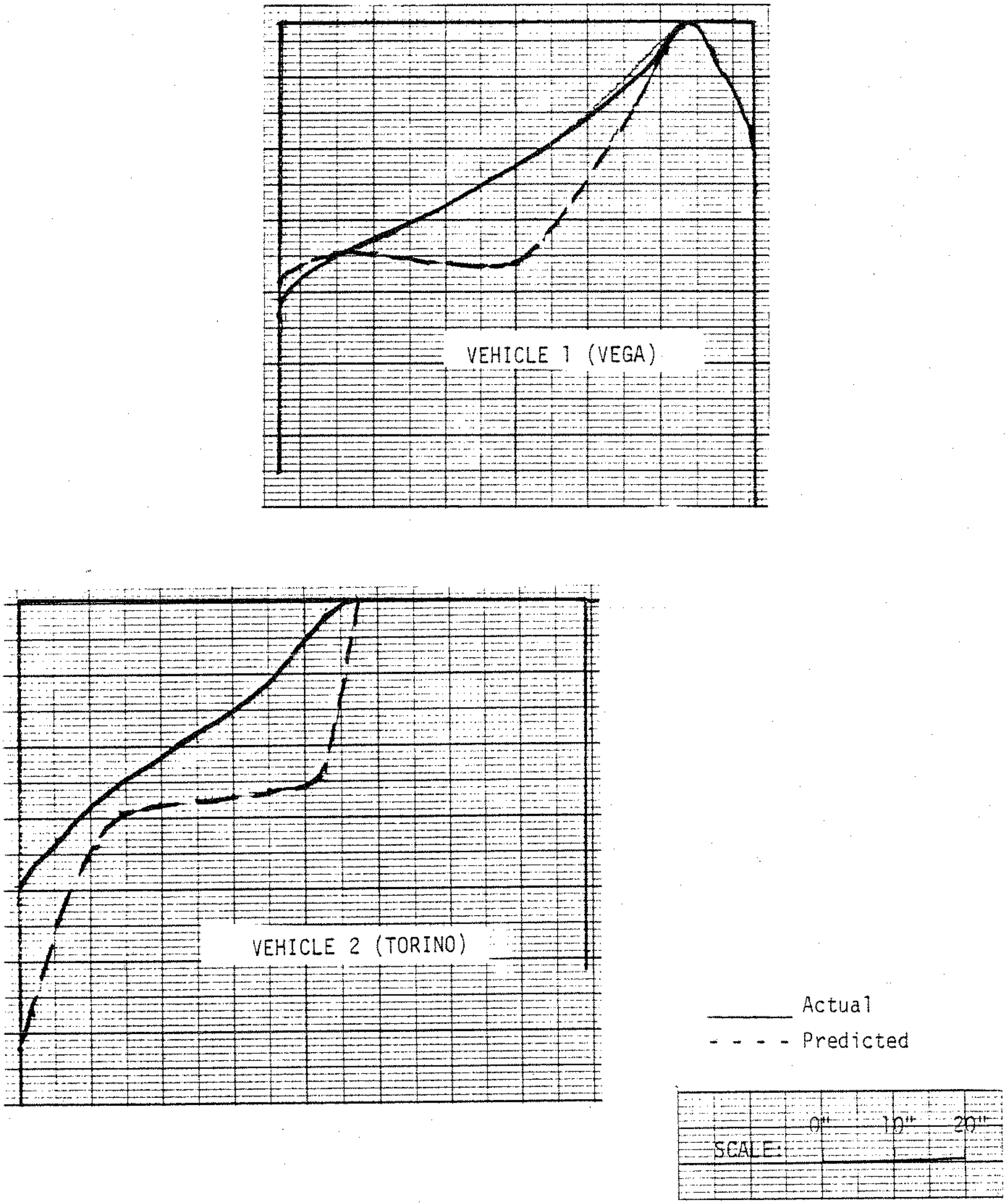


Figure 3-18 TEST NO. 12 - PREDICTED VERSUS ACTUAL DAMAGE

Test No. 3 - 10° Offset Front-to-Rear Impact - Ford Torino Vs. Ford Pinto - Impact Speeds, 21.1/0 mph

	Vehicle 1				Vehicle 1			
	X_1 ft	Y_1 ft	ψ_1 deg	ΔV_1 mph	X_2 ft	Y_2 ft	ψ_2 deg	ΔV_2 mph
Actual	111.4	2.0	-4.0	9.5	181.5	-6.3	-19.0	15.8
SMAC Computed	120.7	3.4	-4.7	9.6	188.7	-0.8	-22.2	15.6

The predicted and measured rest positions are in close agreement. The velocity changes are extremely close, 9.6 mph versus 9.5 mph actual for Vehicle 1 and 15.6 mph versus 15.8 mph actual for Vehicle 2.

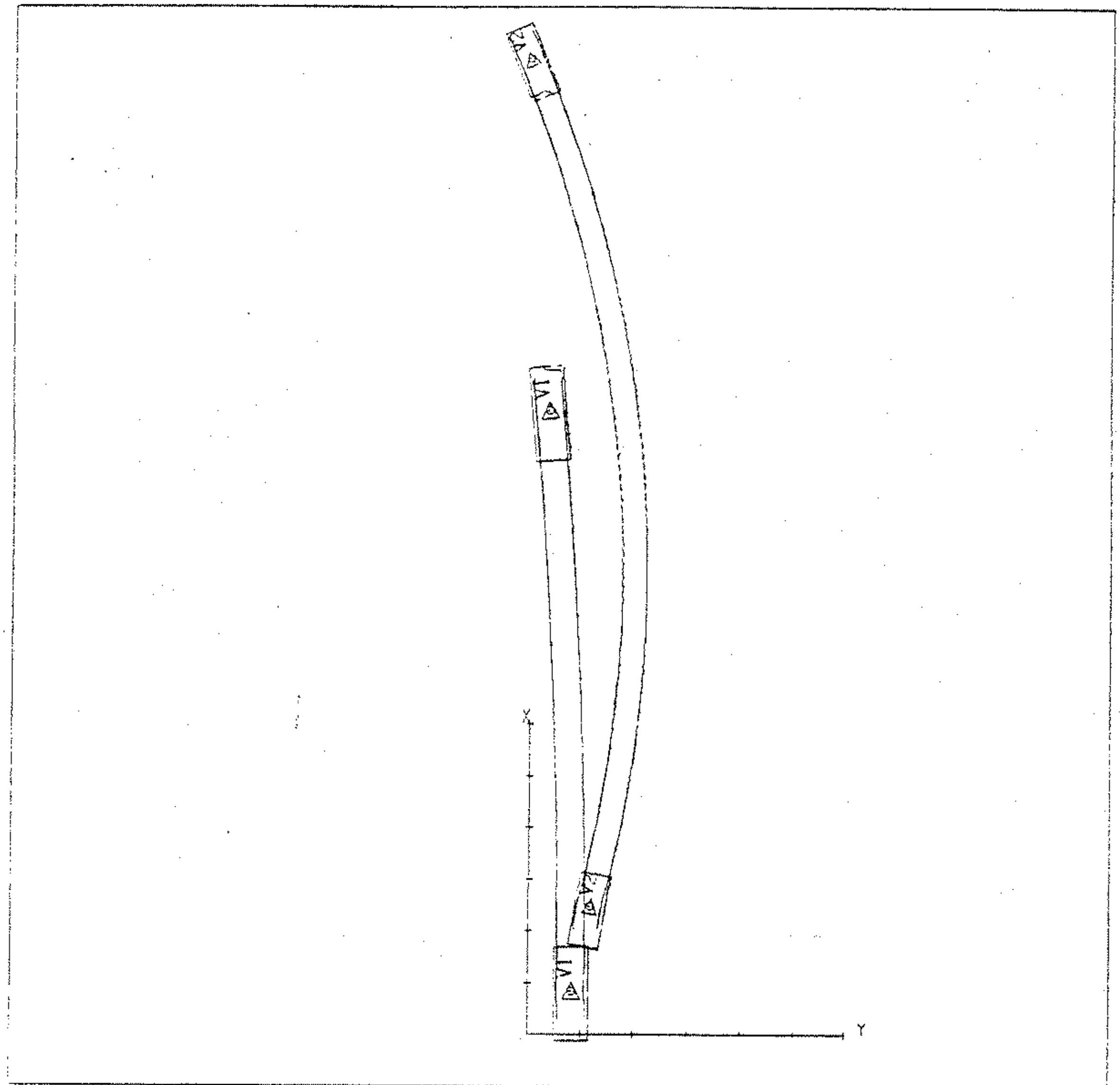
The damage for Vehicle 1, Figure 3-20, is overpredicted, however. The SMAC program does not simulate the elastic properties of the energy absorbing bumper which, according to the accident investigators report, had returned to the undeformed position. Similarly, the damage for Vehicle 2 is overpredicted mainly because of the energy absorbing bumper which again returned to its undeformed position following impact.

Adjustments that were made during the reconstruction to obtain a match with the measured data included: increasing the stiffness of both vehicles to 80 and 60 lb/in^2 for Vehicles 1 and 2, respectively, increasing the rolling resistances of both vehicles and adjusting the steer angles of both vehicles to obtain the desired amount of rotation.

GRAPHIC DISPLAY OF OUTPUTS OF ACCIDENT RECONSTRUCTION

COLLISION AND TRAJECTORY

★ RICSAC TEST #3 TORINO-PINTO 21.23MPH ★ RUN 15



AXIS INTERVALS ARE 10. FEET

	RECONSTRUCTED POSITIONS AND VELOCITIES AT IMPACT						DISPLAYED FINAL POSITIONS				VEHICLE DAMAGE INDICES	ΔV
	C.G. POSITION		HEADING				C.G. POSITION		HEADING			
	XC1	YC1	PSI1	FWD	LATERAL	ANGULAR	XC1F	YC1F	PSI1F	REMARKS		
	FT.	FT.	DEG.	MPH	MPH	DEG/SEC	FT.	FT.	DEG.			MPH
VEHICLE # 1	8.5	8.3	-0.0	21.2	-0.0	-0.1	120.7	3.4	-4.7	[illegible]EHICLE AT REST	12FZE[illegible]2	[illegible]6
VEHICLE # 2	34.7	11.9	10.0	0.0	0.0	0.0	188.7	-0.3	-22.2	VEHICLE AT REST	06BYEW2	15.6

Figure 3-19 GRAPHIC DISPLAY, TEST NO. 3

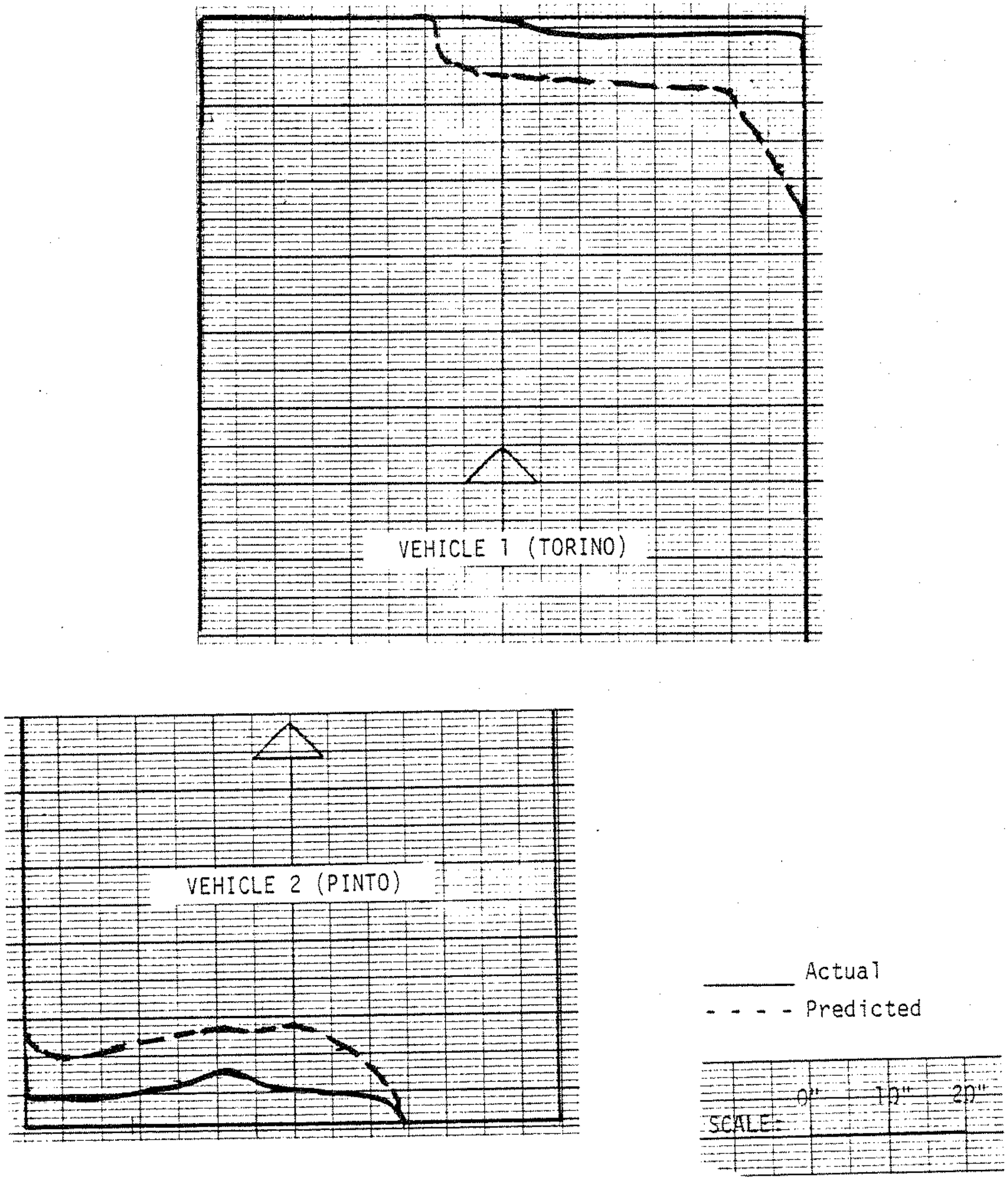


Figure 3-20 TEST NO. 3 - PREDICTED VERSUS ACTUAL DAMAGE

Test No. 4 - 10° Offset Front-to-Rear Impact - Ford Torino Vs. Ford Pinto - Impact Speeds, 38.7/0 mph

	Vehicle 1				Vehicle 2			
	X_1 ft	Y_1 ft	ψ_1 deg	ΔV_1 mph	X_2 ft	Y_2 ft	ψ_2 deg	ΔV_2 mph
Actual	42.8	54.5	137.5	18.7	63.9	62.5	88.0	22.2
SMAC Computed	40.5	55.3	127.1	16.7	73.7	66.5	69.7	26.2

The agreement between the predicted and rest positions is good, although the rotation of both vehicles is slightly underestimated. However, given the amount of rotation that both vehicles underwent and the length of their spin outs, the predicted rotations are very acceptable. The velocity changes are in good agreement, 16.7 mph versus 18.7 mph actual for Vehicle 1 and 26.2 mph versus 22.2 mph actual for Vehicle 2.

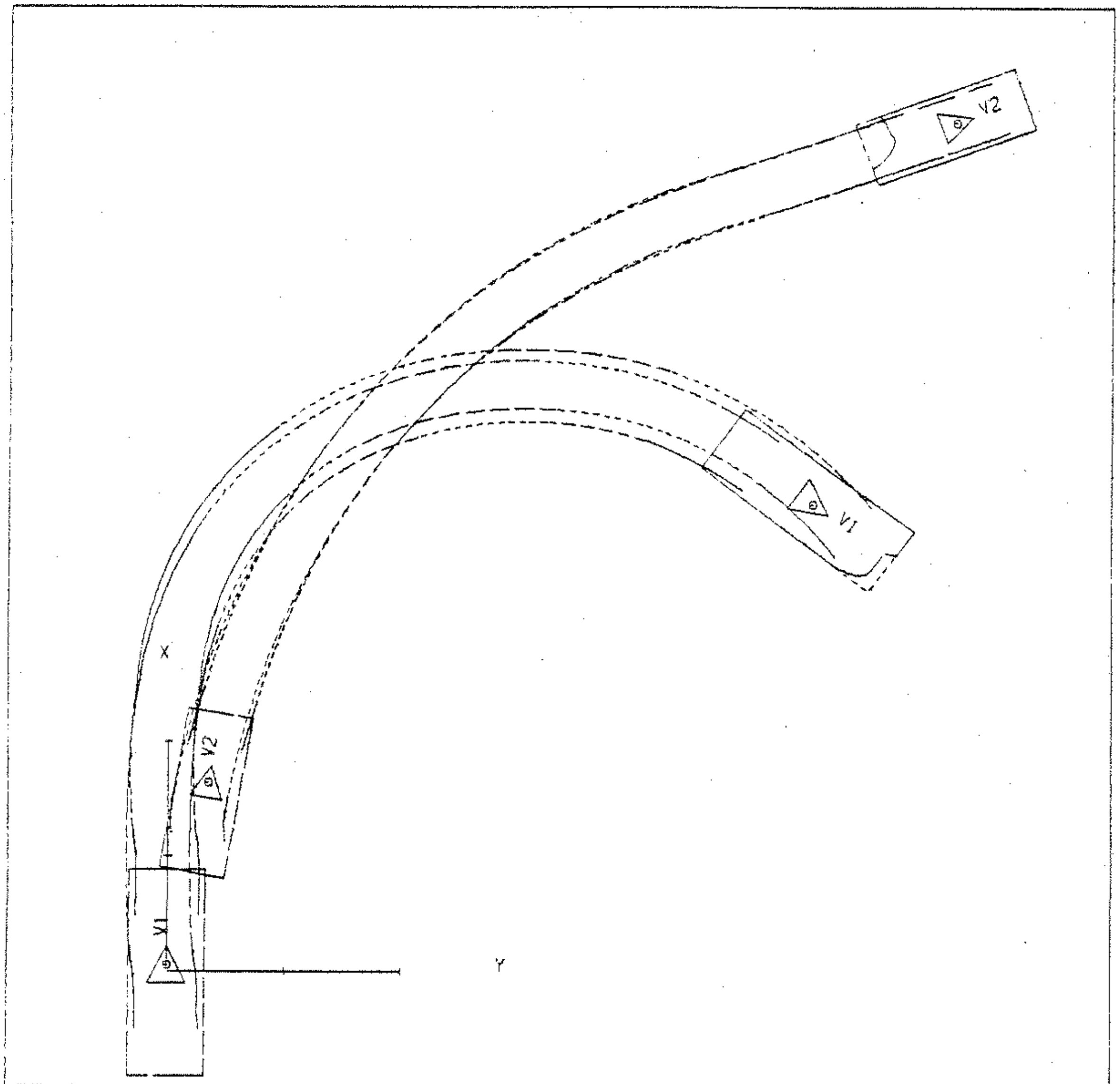
The predicted and measured damage profiles are given in Figure 3-22; for Vehicle 1 a good match is obtained apart from the smoothing effects produced by the bumper which does not appear in the simulation. The same limitation is true for Vehicle 2 in that the localized deformation produced at the edge of contact in the simulation does not appear in the actual damage because of the smoothing effect of the bumper.

In attaining an acceptable reconstruction, the stiffness of both vehicles had to be adjusted to obtain a good match of the damage. Final values used were 90 lb/in^2 for Vehicle 1 and 35 lb/in^2 for Vehicle 2. The brake and steer inputs to both vehicles were also adjusted to fine tune the spin out trajectories.

GRAPHIC DISPLAY OF OUTPUTS OF ACCIDENT RECONSTRUCTION

COLLISION AND TRAJECTORY

★ RICSAC TEST #4 TORINO-PINTO 38.7MPH ★



AXIS INTERVALS ARE 10. FEET

	RECONSTRUCTED POSITIONS AND VELOCITIES AT IMPACT						DISPLAYED FINAL POSITIONS				VEHICLE DAMAGE INDICES	ΔV
	C.G. POSITION		HEADING				C.G. POSITION		HEADING	REMARKS		
	XC1	YC1	PSI1	FWD	LATERAL	ANGULAR	XC1F	YC1F	PSI1F			
	FT.	FT.	DEG.	MPH	MPH	DEG/SEC	FT.	FT.	DEG.			MPH
VEHICLE # 1	0.6	-0.0	0.0	38.7	-0.0	0.0	40.6	55.1	126.6	IN MOTION AT 5.0 SEC AFTER INITIAL CONTACT	12RFEW2	16.9
VEHICLE # 2	15.4	3.4	10.0	0.0	0.0	0.0	73.8	67.0	69.6	VEHICLE AT REST	06BDEW4	26.3

Figure 3-21 GRAPHIC DISPLAY, TEST NO. 4

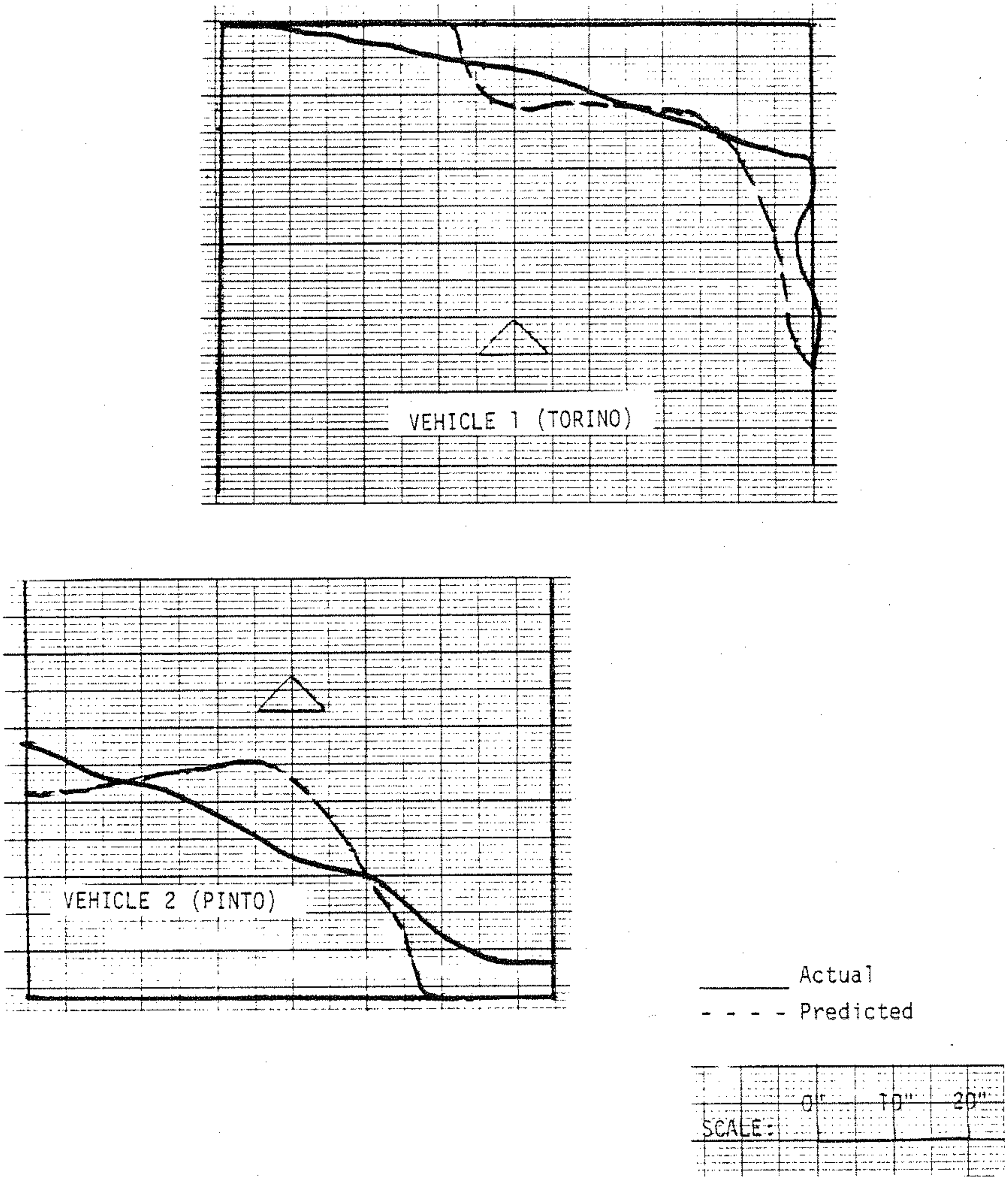


Figure 3-22 TEST NO. 4 - PREDICTED VERSUS ACTUAL DAMAGE

Test No. 5 - 10° Offset Front-to-Rear Impact - Ford Torino Vs. Honda Civic - Impact Speeds, 39.7/0 mph

	Vehicle 1				Vehicle 2			
	X_1 ft	Y_1 ft	ψ_1 deg	ΔV_1 mph	X_2 ft	Y_2 ft	ψ_2 deg	ΔV_2 mph
Actual	252.0	0.0	0.0	16.3	59.0	35.0	282.0	25.1
SMAC Computed	173.8	-22.3	-7.9	15.1	89.7	35.6	285.2	26.8

This case had a variety of complications which made the SMAC reconstruction difficult. The most significant of these problems was that both of the tires on the right side of Vehicle 2, the Honda, were off the ground for the majority of its rotation. This can be simulated by setting the braking torques and cornering stiffnesses for both of these tires to zero. However, the left side tires cannot be handled as easily. For instance, since the entire weight of the vehicle is supported by the two tires, the tire force (whether side or circumferential) that can be supported is μW, where W equals the weight of the vehicle and μ is the tire ground friction coefficient. The SMAC program, however, assumes that the weight is equally distributed among the four tires (except to correct for the position of the center of gravity); thus, the maximum tire force the SMAC program will allow for the left side of the vehicle (regardless of the input values) is $\mu\frac{W}{2}$.

Furthermore, the right side tires of Vehicle 2 are not off the ground throughout the entire spin out and once they return to the surface, their cornering stiffnesses are no longer zero. Since the SMAC program allows only one value to be input for the cornering stiffness for each tire, it is not possible to accurately simulate the situation.

Regarding Vehicle 1's trajectory, it should be noted that its umbilical cable became fully extended bringing it to a rapid halt at the end of its spin out.

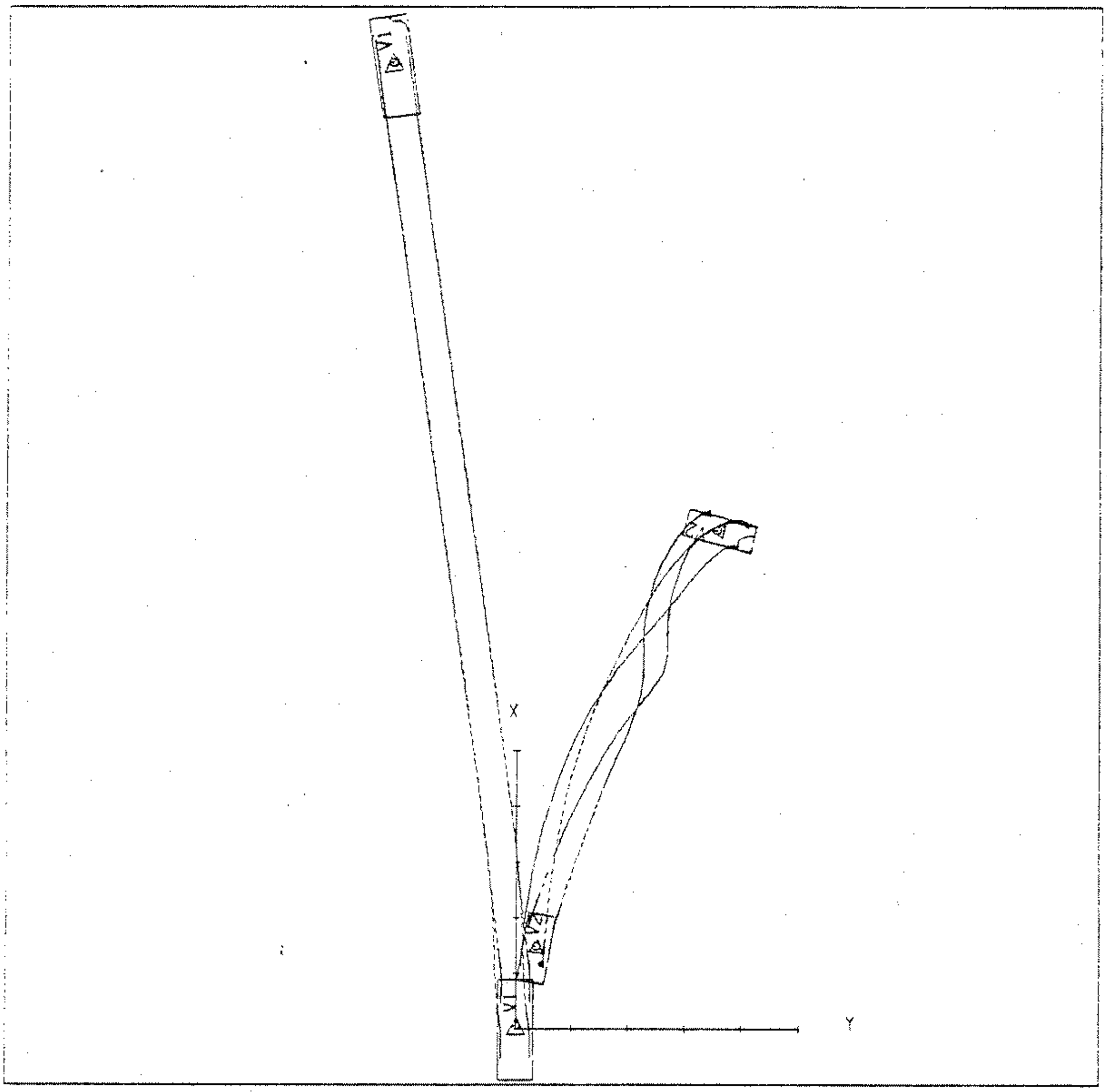
Because of these compounding factors, the final run was selected on the basis of its matching the velocity changes and the rotation of Vehicle 2. The match is surprisingly good. The X displacement of Vehicle 1 is slightly underestimated as is the spin out distance for Vehicle 2 although the latter could probably be improved by reducing its rolling resistance. The brake inputs used for Vehicle 2 were engine braking at 0.08 g, whereas 0.15 g has been used as an established value; however, whether this applies to a vehicle with automatic transmission without the engine running is open to argument.

The damage profiles are shown in Figure 3-24. That for Vehicle 1 is considerably overestimated due, in part, to the elastic recovery of the 5 mph energy absorbing bumper but also to the lack of any corner stiffening effects. Vehicle 2's damage is slightly underestimated but considering the severe damage that occurred to this vehicle is certainly acceptable.

GRAPHIC DISPLAY OF OUTPUTS OF ACCIDENT RECONSTRUCTION

COLLISION AND TRAJECTORY

★ RICSAC TEST #5 TORINO-HONDA 39.3MPH/0.0 ★



AXIS INTERVALS ARE 10. FEET

RECONSTRUCTED POSITIONS AND VELOCITIES AT IMPACT							DISPLAYED FINAL POSITIONS				VEHICLE DAMAGE INDICES	
	C.G. POSITION		HEADING				C.G. POSITION		HEADING			
	XC1	YC1	PSI1	FWD	LATERAL	ANGULAR	XC1F	YC1F	PSI1F	REMARKS		ΔV
	FT.	FT.	DEG.	MPH	MPH	DEG/SEC	FT.	FT.	DEG.			MPH
VEHICLE # 1	0.[illegible]	0.0	0.0	39.2	0.0	0.3	173.8	-22.3	-7.9	IN MOTION AT 6.0 SEC AFTER INITIAL CONTACT	1 2 R F E W 2	15.1
VEHICLE # 2	14.9	3.8	10.0	0.0	0.0	0.0	89.7	35.6	285.2	VEHICLE AT REST	0 6 B Y E W 5	26.8

Figure 3-23 GRAPHIC DISPLAY, TEST NO. 5

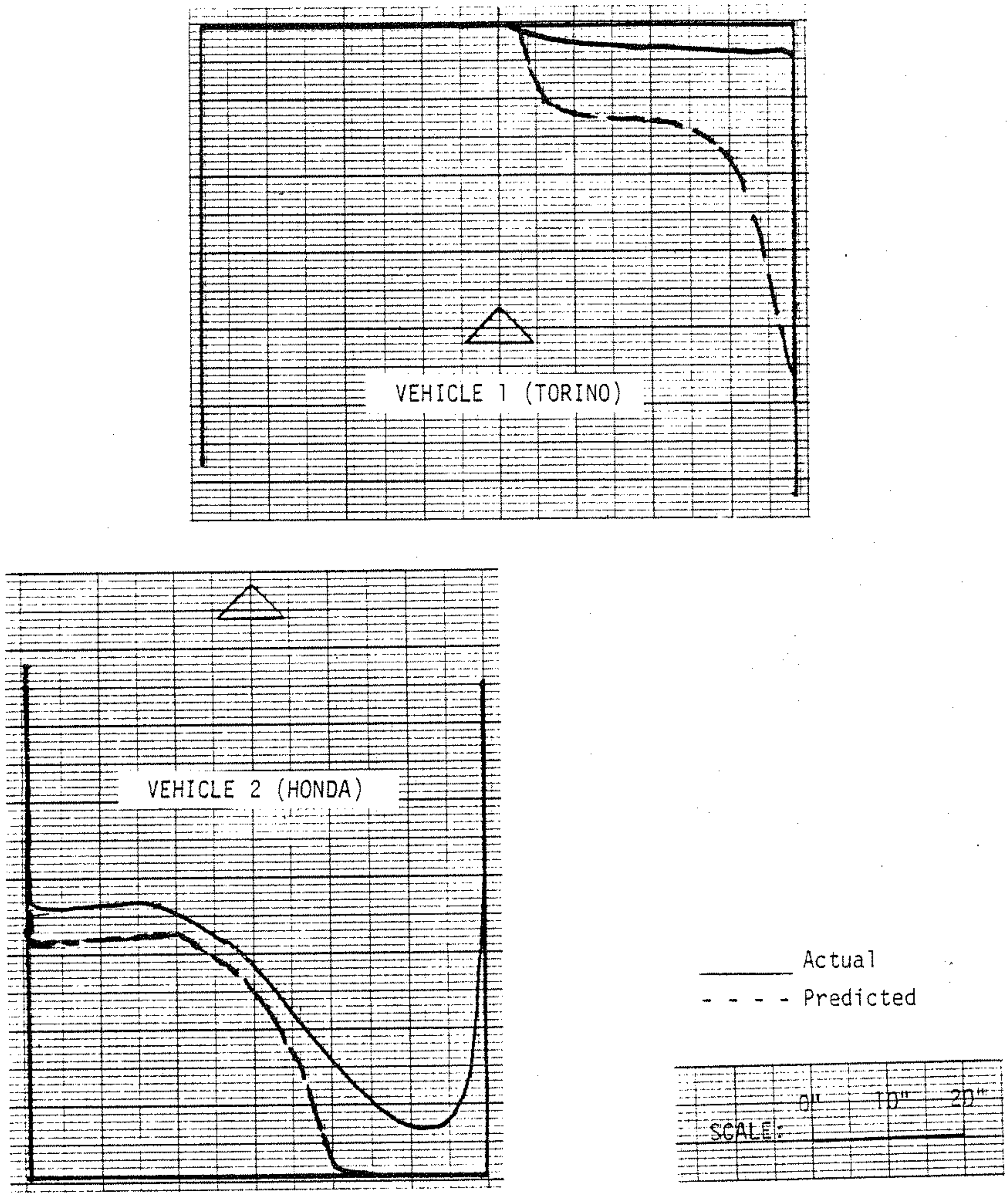


Figure 3-24 TEST NO. 5 - PREDICTED VERSUS ACTUAL DAMAGE

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 The CRASH Program

The major discrepancies in the CRASH results stemmed from the damage analysis subroutine and, in particular, the values used for the empirical stiffness coefficients for certain vehicle sizes and impact configurations. The velocity changes in the high level head-on impact (Test 12) were overestimated suggesting that the stiffness coefficients are too low for this particular impact/vehicle size configuration. The velocity changes for the corresponding low level test (No. 11) were also underestimated but to a lesser extent. A similar problem occurred with the rear end impacts, the velocity changes in all these tests and for all vehicles were severely underestimated, suggesting that the stiffness coefficients should be upgraded.

The SPIN II routine which calculates the separation velocities from the spin out trajectories was assessed separately. In general, the agreement between predicted and measured velocities was extremely good. The agreement was better for axial type collisions than for oblique or intersection type collisions. This is because spin out trajectories for axial type collisions are, in general, more nearly linear and the estimation of the velocity dissipated in the spin out correspondingly more accurate.

During the course of the reconstructions, an error in the SPIN II routine was discovered involving trajectories where the vehicle was tracking a curved path with no end of rotation point. For this situation, the separation velocities were grossly overestimated; a suggested correction to the problem is given in Appendix 1.

Recommendations

- Update the stiffness coefficients using the present data

- Include stationary vehicle option to minimize errors in damage analysis carrying over to the impact speed estimation.

4.2 The SMAC Program

One of the main problems experienced in evaluating the effectiveness of the SMAC program was the lack of knowledge that exists regarding appropriate values of certain input parameters for particular collision configurations and vehicle sizes. Because of this lack of certainity, it was difficult to determine in some cases whether the lack of success in matching the measured data was the result of inappropriate input values or a limitation of the program. For example, in the 60 degree front-to-side impact tests the inter-vehicle friction coefficient used in reconstructing Test 1 was 1.5, whereas that used for Case 7 was 0.3. The question arises whether this difference is the result of differences between the vehicles (Test 1 used a rather corroded Ford Pinto, whereas Test 7 used a VW Rabbit for the struck vehicle), or are there limitations in the program which are being compensated. An obvious way to resolve this dilemma would be to analyze the crash test data to determine input values for the indirect parameters in each test, i.e., the vehicle stiffness coefficient, intervehicle friction coefficients, coefficients of restitution, etc. This would mean that the input deck for each SMAC reconstruction was completely defined such that any deficiencies in the reconstruction could be attributed to limitations in the program. Ideally, this analysis should also include a film analysis of the overhead cameras to study the build-up of the collision interface to assess whether an isotropic homogenous body is an acceptable simulation of the vehicle structure.

Another limitation that was experienced in using the program was the lack of weight transfer effects. In a number of the staged collisions there were instances where one or more of the wheels on a particular vehicle became airborne. Since the program does not simulate these effects, this would automatically introduce some error in computing both the amount of translation and rotation of the vehicle.

Recommendations

- Include hard points and corner stiffness effects in the simulation of the vehicle structure.
- Include weight transfer effects.
- Modify reporting format so that output can be summarized in one or two pages.

4.3 Rotation Effects

The failure to include the effects of vehicle rotation into the determination of the separation velocities, and consequently, the changes in velocity, should detract little from the overall evaluation of the SMAC and CRASH II programs. Concerning the SMAC program, the ΔV's were just one of three measures of performance. The agreement between the predicted rest positions and damage profiles with those observed during the staged collisions, is, by itself, basis enough for believing the SMAC program to be a fairly accurate representation of the physical system being simulated. In those cases, in which rotation was not a significant factor, the ΔV comparisons lend additional support to such a hypothesis. Moreover, qualitative analysis of those vehicles undergoing significant rotation, indicated that the predicted ΔV's were certainly within a tolerable range of the true value of the velocity change.

The assessment of the CRASH II program is based entirely on the ΔV's and separation velocities. Again, the cases with little or no rotation provide ample evidence of CRASH's accuracy. Even in tests in which one of the vehicles experienced high angular velocities, the fact that close agreement was obtained for the other vehicle is significant. In the nonaxial collisions, where the rotational problems were encountered, the ΔV's for both the vehicles are not independent of one another; thus good agreement for one of the vehicles, reflects favorably on the accuracy of the other's reconstruction. Once again, the qualitative analyses on the cases with significant rotation enhances the accuracy judgments of the CRASH II results.

If one were sufficiently concerned about the accuracy of CRASH II and SMAC performance in those cases which had rotational problems, there are two possible courses of action, neither of which was explored during the course of the present study, due to time and financial constraints.

The first, and most obvious, solution is to reduce the raw acceleration data again, using software that takes into consideration the rotational effects. At Calspan, work on this type of software had been initiated, for the problem in three dimensions, but was discontinued due to difficulty in obtaining stable estimates of the angular motion because of biases in the accelerometers. Reducing the problem to two dimensions may alleviate some of the estimation difficulties, but, more importantly, the data collected for the staged collisions includes both yaw angle and yaw rate. If this information could be incorporated into the integration algorithms, the problem may be greatly simplified.

The other approach, which is only applicable to the present study, and would allow one to compare only the SMAC estimates of ΔV, involves altering the SMAC program to compute the velocities at the firewall as if any vehicle rotation had been disregarded. All the information necessary to accomplish this transformation is available at the end of the DAUX subroutine. The results could subsequently be compared directly to the experimental data.

APPENDIX I

CRASH II PROGRAM ERROR

CRASH II PROGRAM ERROR

In the course of this study, an error was found in the CRASH II program. The error occurred for spin outs in which a non-skidding vehicle had a curved trajectory with no end-of-rotation point defined. For these types of situations, i.e., where the vehicle is tracking, the program sets the end-of-rotation point equal to the separation point in preparation for the calculation of the error term in the trajectory simulation subroutine. This is appropriate since in comparing the predicted to actual end-of-rotation point, for a tracking vehicle, the separation point is the end of rotation.

The SPIN II routine, however, is coded so that it expects the end-of-rotation point to be equal to the final rest position. When it is not, the arc length of the spin-out is grossly overestimated, with the result that the separation velocities, that are subsequently calculated, are too large.

The program was changed in order to correct this error, although an exhaustive check of the new coding has not been done. The changes that were implemented are given below. In SUBROUTINE START2, after the COMMON block /CRASH/ insert:

```
COMMON/STTOSP/XEND,YEND
```

after 1500 IF(JCURVC1).EQ. 1)GO TO 1505

insert:
```
XEND = XCR1
YEND = YCR1
```

and after 1600 IF(JCURV(2). EQ. 1)GO TO 1605

insert:
```
XEND = XCR2
YEND = YCR2
```

Then in SUBROUTINE SPIN2, after the COMMON block /CRASH/ insert:

```
COMMON/STTOSP/XEND,YEND
```

in two places, and then immediately after label 310 and label 350,

replace: XC1P = XC1[1/2]*12 and YC1P = YC1[1/2]*12

with:
```
XC1P = XEND
YC1P = YEND
```

APPENDIX II

CRASH INPUT AND OUTPUT LISTINGS

```
 1. TITLE?
?TEST #1 CHEVELLE VS PINTO

 2. SIZE CATEGORIES?
?I S

 3. VDI, #1
?11FZEW2

 4. VDI, #2
?01RDEW3

 5. ACTUAL WEIGHTS? (Y OR N)
?Y

 6. WEIGHT #1
?4621

 7. WEIGHT #2
?3082

 8. REST & IMPACT? (Y OR N)
?Y

 9. REST COORDINATES?
?-2.4 -1, -1.5 7.5 2.5 105.

10. IMPACT COORDINATES?
?-10.8 1. -30. 0. -5.5 90.

11. SKIDDING OF # 1? (Y OR N)
?Y

12. SKIDDING STOP BEFORE REST? (Y OR N)
?N


14. CURVED PATH? (Y OR N)
?N

15. ROTATION DIRECTION #1?
?CW

17. MORE THAN 360 DEG? (Y OR N)
?N

18. SKIDDING OF # 2? (Y OR N)
?Y

19. SKIDDING STOP BEFORE REST? (Y OR N)
?N

21. CURVED PATH? (Y OR N)
?N

23. ROTATION DIRECTION # 2?
?CW

24. MORE THAN 360 DEG? (Y OR N)
?N

25. TIRE-GROUND FRICTION?
?.87
```

26. ROLLING RESISTANCE OPTION?(1 OR 2)
?1

27. ROLL. RESISTANCES, INDIV. WHEELS # 1
?.01 .01 .2 .2

28. ROLL. RESISTANCES, INDIV. WHEELS # 2
?.01 .01 .2 .2

31. TRAJECTORY SIMULATION? (Y OR N)
?N

37. DAMAGE DIMENSIONS? (Y OR N)
?Y

41. END DAMAGE WIDTH #1
?40.

42. END DAMAGE DEPTH #1
?4. 5.5 7. 10.2 12.1 14.8

43. END DAMAGE MIDPOINT OFFSET #1
?14.3

44. SIDE DAMAGE WIDTH #2
?113.3

45. SIDE DAMAGE DEPTH #2
?.5 12. 10.8 11.8 9. 4.1

46. SIDE DAMAGE MIDPOINT OFFSET #2
?21.8

52. FORCE DIRECTIONS (Y OR N)
?Y

53. PRINCIPAL FORCE ANGLE #1?
?-30.

54. PRINCIPAL FORCE ANGLE #2?
?30.

THANK YOU VERY MUCH

SUMMARY OF CRASH RESULTS

TEST #1 CHEVELLE VS PINTO

	VEHICLE # 1	VEHICLE # 2
SPEED CHANGE (TRAJ. ONLY)	9.6 MPH	14.4 MPH
	-14.4 DEG	45.5 DEG
SPEED CHANGE (DAMAGE ONLY)	18.5 MPH	27.7 MPH
	-30.0 DEG	30.0 DEG
IMPACT SPEED	20.6 MPH	20.4 MPH
ENERGY DISSIPATED BY DAMAGE	24652.4 FT-LB	169174.7 FT-LB
SPEED ALONG LINE THRU CGS	20.5 MPH	11.5 MPH
SPEED ORTHOG. TO CG LINE	1.5 MPH	-16.9 MPH
CLOSING VELOCITY	32.0 MPH	

SUMMARY OF CRASH RESULTS

TEST #1 CHEVELLE VS PINTO

VEHICLE # 1

IMPACT SPEED MPH	SPEED CHANGE MPH TOTAL	LONG.	LATERAL	BASIS OF RESULTS
20.6	9.6	-9.3	2.4	SPINOUT TRAJECTORIES AND CONSERVATION OF LINEAR MOMENTUM
				SPINOUT TRAJECTORIES AND DAMAGE
	18.5	-16.0	9.3	DAMAGE DATA ONLY

VEHICLE # 2

IMPACT SPEED MPH	SPEED CHANGE MPH TOTAL	LONG.	LATERAL	BASIS OF RESULTS
20.4	14.4	-10.1	-10.3	SPINOUT TRAJECTORIES AND CONSERVATION OF LINEAR MOMENTUM
				SPINOUT TRAJECTORIES AND DAMAGE
	27.7	-24.0	-13.9	DAMAGE DATA ONLY

SCENE INFORMATION

	VEHICLE # 1		VEHICLE # 2	
IMPACT X-POSITION	-11.58	FT.	-.00	FT.
IMPACT Y-POSITION	1.45	FT.	-6.40	FT.
IMPACT HEADING ANGLE	-30.00	DEG.	89.99	DEG.
REST X-POSITION	-2.40	FT.	7.50	FT.
REST Y-POSITION	-1.00	FT.	2.50	FT.
REST HEADING ANGLE	-1.50	DEG.	104.99	DEG.
DIRECTION OF ROTATION	CW		CW	
AMOUNT OF ROTATION	<360		<360	

COLLISION CONDITIONS

VEHICLE # 1			VEHICLE # 2		
XC10′	=	-11.6 FT.	XC20′	=	-.0 FT.
YC10′	=	1.5 FT.	YC20′	=	-6.4 FT.
PSI10	=	-30.0 DEGREES	PSI20	=	90.0 DEGREES
PSI1D0	=	0.0 DEG/SEC	PSI2D0	=	0.0 DEG/SEC
U10	=	20.6 MPH	U20	=	20.4 MPH
V10	=	0.0 MPH	V20	=	0.0 MPH

SEPARATION CONDITIONS

XCS1	=	-10.8 FT.	XCS2	=	0.0 FT.
YCS1	=	1.0 FT.	YCS2	=	-5.5 FT.
PSIS1	=	-30.0 DEG	PSIS2	=	90.0 DEG
US1	=	11.2 MPH	US2	=	10.3 MPH
VS1	=	2.4 MPH	VS2	=	-10.3 MPH
PSISD1	=	45.3 DEG/SEC	PSISD2	=	23.4 DEG/SEC

RELATIVE VELOCITY DATA

	VEHICLE # 1	VEHICLE # 2
SPEED CHANGE (TRAJ. ONLY)	9.6 MPH	14.4 MPH
	-14.4 DEG	45.5 DEG
SPEED CHANGE (DAMAGE ONLY)	18.5 MPH	27.7 MPH
	-30.0 DEG	30.0 DEG
IMPACT SPEED	20.6 MPH	20.4 MPH
ENERGY DISSIPATED BY DAMAGE	24652.4 FT-LB	109174.7 FT-LB
SPEED ALONG LINE THRU CGS	20.5 MPH	11.5 MPH
SPEED ORTHOG. TO CG LINE	1.5 MPH	-16.9 MPH
CLOSING VELOCITY	32.0 MPH	

SUMMARY OF DAMAGE DATA

(* INDICATES DEFAULT VALUE)

VEHICLE # 1		VEHICLE # 2	
TYPE----------	INTERMEDIATE	TYPE----------	SUBCOMPACT
WEIGHT-------	4621.0 LBS.	WEIGHT-------	3082.0 LBS.
VDI-----------	11FZEW2	VDI-----------	01RDEW3
L------------	46.0 IN.	L------------	113.3 IN.
C1-----------	4.0 IN.	C1-----------	.5 IN.
C2-----------	5.5 IN.	C2-----------	12.0 IN.
C3-----------	7.0 IN.	C3-----------	10.6 IN.
C4-----------	10.2 IN.	C4-----------	11.8 IN.
C5-----------	12.1 IN.	C5-----------	9.0 IN.
C6-----------	14.8 IN.	C6-----------	4.1 IN.
D------------	19.1 IN.	D------------	21.8 IN.
RHO----------	1.00 *	RHO----------	1.00 *
ANG----------	330.0 DEG.	ANG----------	30.0 DEG.

DIMENSIONS AND INERTIAL PROPERTIES

A1	=	54.7 INCHES	A2	=	46.3 INCHES
B1	=	59.2 INCHES	B2	=	50.1 INCHES
TR1	=	61.8 INCHES	TR2	=	54.6 INCHES
I1	=	44739.0 LB-SEC**2-IN	I2	=	23537.7 LB-SEC**2-IN
M1	=	11.959 LB-SEC**2/IN	M2	=	7.976 LB-SEC**2/IN
XF1	=	98.8 INCHES	XF2	=	83.3 INCHES
XR1	=	-114.0 INCHES	XR2	=	-91.6 INCHES
YS1	=	38.5 INCHES	YS2	=	33.6 INCHES

ROLLING RESISTANCE

VEHICLE # 1		VEHICLE # 2	
RF-----------	.01	RF-----------	.01
LF-----------	.01	LF-----------	.01
RR-----------	.20	RR-----------	.20
LR-----------	.20	LR-----------	.20
MU-----------	.87		

1. TITLE?
?TEST # 2 CHEVELLE VS PINTO

2. SIZE CATEGORIES?
?1 S

3. VDI, #1
?11FDEW2

4. VDI, #2
?02RDEW4

5. ACTUAL WEIGHTS? (Y OR N)
?Y

6. WEIGHT #1
?4021

7. WEIGHT #2
?3081

8. REST & IMPACT? (Y OR N)
?Y

9. REST COORDINATES?
?11. 9.4 55. 23.6 12.5 134.

10. IMPACT COORDINATES?
?-11.2 8.5 -30. 0. 0. 90.

11. SKIDDING OF # 1? (Y OR N)
?N

14. CURVED PATH? (Y OR N)
?N

16. ROTATION DIRECTION #1?
?CW

17. MORE THAN 360 DEG? (Y OR N)
?N

18. SKIDDING OF # 2? (Y OR N)
?Y

19. SKIDDING STOP BEFORE REST? (Y OR N)
?N

21. CURVED PATH? (Y OR N)
?N

23. ROTATION DIRECTION # 2?
?CW

24. MORE THAN 360 DEG? (Y OR N)
?N

25. TIRE-GROUND FRICTION?
?.67

26. ROLLING RESISTANCE OPTION?(1 OR 2)
?1

27. ROLL. RESISTANCES, INDIV. WHEELS # 1
?1. .02 .2 .2

28. ROLL. RESISTANCES, INDIV. WHEELS # 2
?.02 .02 1. 1.

31. TRAJECTORY SIMULATION? (Y OR N)
?N

37. DAMAGE DIMENSIONS? (Y OR N)
?Y

41. END DAMAGE WIDTH #1
?75.5

42. END DAMAGE DEPTH #1
?.5 2.4 3.7 6.9 12. 16.5

43. END DAMAGE MIDPOINT OFFSET #1
?0.

44. SIDE DAMAGE WIDTH #2
?116.5

45. SIDE DAMAGE DEPTH #2
?6.75 22.75 23.5 21.3 10. 0.

46. SIDE DAMAGE MIDPOINT OFFSET #2
?13.7

52. FORCE DIRECTIONS (Y OR N)
?N

SUMMARY OF CRASH RESULTS

TEST # 2 CHEVELLE VS PINTO

	VEHICLE # 1	VEHICLE # 2
SPEED CHANGE (TRAJ. ONLY)	20.6 MPH	30.9 MPH
	-17.2 DEG	42.8 DEG
SPEED CHANGE (DAMAGE ONLY)	19.3 MPH	29.0 MPH
	-30.0 DEG	60.0 DEG
IMPACT SPEED	29.6 MPH	33.3 MPH
ENERGY DISSIPATED BY DAMAGE	31832.5 FT-LB	169278.6 FT-LB
SPEED ALONG LINE THRU CGS	29.3 MPH	20.7 MPH
SPEED ORTHOG. TO CG LINE	4.4 MPH	-26.0 MPH
CLOSING VELOCITY	50.0 MPH	

SUMMARY OF CRASH RESULTS

TEST # 2 CHEVELLE VS PINTO

VEHICLE # 1

IMPACT SPEED MPH	SPEED CHANGE MPH TOTAL	LONG.	LATERAL	BASIS OF RESULTS
29.0	20.6	-19.7	6.1	SPINOUT TRAJECTORIES AND CONSERVATION OF LINEAR MOMENTUM
				SPINOUT TRAJECTORIES AND DAMAGE
	19.3	-16.7	9.7	DAMAGE DATA ONLY

VEHICLE # 2

IMPACT SPEED MPH	SPEED CHANGE MPH TOTAL	LONG.	LATERAL	BASIS OF RESULTS
33.3	30.9	-22.7	-21.0	SPINOUT TRAJECTORIES AND CONSERVATION OF LINEAR MOMENTUM
				SPINOUT TRAJECTORIES AND DAMAGE
	29.0	-14.5	-25.1	DAMAGE DATA ONLY

SUMMARY OF DAMAGE DATA (* INDICATES DEFAULT VALUE)

VEHICLE # 1			VEHICLE # 2		
TYPE----------	INTERMEDIATE		TYPE----------	SUBCOMPACT	
WEIGHT------	4621.0 LBS.		WEIGHT------	3081.0 LBS.	
VDI----------	11FDEW2		VDI----------	02RDEW4	
L------------	75.5 IN.		L------------	118.5 IN.	
C1-----------	.5 IN.		C1-----------	6.8 IN.	
C2-----------	2.4 IN.		C2-----------	22.8 IN.	
C3-----------	3.7 IN.		C3-----------	23.5 IN.	
C4-----------	6.9 IN.		C4-----------	21.3 IN.	
C5-----------	12.0 IN.		C5-----------	10.0 IN.	
C6-----------	16.5 IN.		C6-----------	0.0 IN.	
D------------	15.0 IN.		D------------	5.6 IN.	
RHO----------	1.00	*	RHO----------	1.00	*
ANG----------	330.0 DEG.	*	ANG----------	60.0 DEG.	*

DIMENSIONS AND INERTIAL PROPERTIES

A1	=	54.7 INCHES	A2	=	46.3 INCHES
B1	=	59.2 INCHES	B2	=	50.1 INCHES
TR1	=	61.8 INCHES	TR2	=	54.6 INCHES
I1	=	44739.0 LB-SEC**2-IN	I2	=	23530.1 LB-SEC**2-IN
M1	=	11.959 LB-SEC**2/IN	M2	=	7.974 LB-SEC**2/IN
XF1	=	98.8 INCHES	XF2	=	83.3 INCHES
XR1	=	-114.0 INCHES	XR2	=	-91.6 INCHES
YS1	=	38.5 INCHES	YS2	=	33.6 INCHES

ROLLING RESISTANCE

VEHICLE # 1		VEHICLE # 2	
RF-----------	.50	RF-----------	.02
LF-----------	.02	LF-----------	.02
RR-----------	.20	RR-----------	1.00
LR-----------	.20	LR-----------	1.00

MU----------- .87

SCENE INFORMATION

	VEHICLE # 1		VEHICLE # 2	
IMPACT X-POSITION	-11.62	FT.	-.00	FT.
IMPACT Y-POSITION	8.74	FT.	-.52	FT.
IMPACT HEADING ANGLE	-30.00	DEG.	89.99	DEG.
REST X-POSITION	11.00	FT.	23.60	FT.
REST Y-POSITION	9.40	FT.	12.50	FT.
REST HEADING ANGLE	54.99	DEG.	133.98	DEG.
END-OF-ROTATION X-POSITION	-11.62	FT.		
END-OF-ROTATION Y-POSITION	8.74	FT.		
END-OF-ROTATION HEADING ANGLE	-30.00	DEG.		
DIRECTION OF ROTATION	CW		CW	
AMOUNT OF ROTATION	<360		<360	

COLLISION CONDITIONS

VEHICLE # 1				VEHICLE # 2			
XC10'	=	-11.6	FT.	XC20'	=	-.0	FT.
YC10'	=	8.7	FT.	YC20'	=	-.5	FT.
PSI10	=	-30.0	DEGREES	PSI20	=	90.0	DEGREES
PSI1D0	=	0.0	DEG/SEC	PSI2D0	=	0.0	DEG/SEC
U10	=	29.6	MPH	U20	=	33.3	MPH
V10	=	0.0	MPH	V20	=	0.0	MPH

SEPARATION CONDITIONS

XCS1	=	-11.6	FT.	XCS2	=	-.0	FT.
YCS1	=	8.7	FT.	YCS2	=	-.5	FT.
PSIS1	=	-30.0	DEG	PSIS2	=	90.0	DEG
US1	=	9.9	MPH	US2	=	10.6	MPH
VS1	=	6.1	MPH	VS2	=	-21.0	MPH
PSISD1	=	0.0	DEG/SEC	PSISD2	=	45.0	DEG/SEC

RELATIVE VELOCITY DATA

	VEHICLE # 1		VEHICLE # 2	
SPEED CHANGE (TRAJ. ONLY)	20.6	MPH	30.9	MPH
	-17.2	DEG	42.8	DEG
SPEED CHANGE (DAMAGE ONLY)	19.3	MPH	29.0	MPH
	-30.0	DEG	60.0	DEG
IMPACT SPEED	29.6	MPH	33.3	MPH
ENERGY DISSIPATED BY DAMAGE	31832.5	FT-LB	169278.6	FT-LB
SPEED ALONG LINE THRU CGS	29.3	MPH	20.7	MPH
SPEED ORTHOG. TO CG LINE	4.4	MPH	-26.0	MPH
CLOSING VELOCITY	50.0	MPH		

```
  1. TITLE?
?TEST # 6

  2. SIZE CATEGORIES?
?1 3C

  3. VDI, #1
?11FZEW1

  4. VDI, #2
?02RDEW3

  5. ACTUAL WEIGHTS? (Y OR N)
?Y

  6. WEIGHT #1
?4500

  7. WEIGHT #2
?2525

  8. REST & IMPACT? (Y OR N)
?Y

  9. REST COORDINATES?
?65. 11. 15. 20. 21. 242.

 10. IMPACT COORDINATES?
?5. 0. 0. 11.1 2.67 120.

 11. SKIDDING OF # 1? (Y OR N)
?N

 14. CURVED PATH? (Y OR N)
?N

 16. ROTATION DIRECTION #1?
?CW

 17. MORE THAN 360 DEG? (Y OR N)
?N

 18. SKIDDING OF # 2? (Y OR N)
?Y

 19. SKIDDING STOP BEFORE REST? (Y OR N)
?N

 21. CURVED PATH? (Y OR N)
?N

 23. ROTATION DIRECTION # 2?
?CW

 24. MORE THAN 360 DEG? (Y OR N)
?N

 25. TIRE-GROUND FRICTION?
?.57
```

```
 26. ROLLING RESISTANCE OPTION?(1 OR 2)
?1

 27. ROLL. RESISTANCES, INDIV. WHEELS # 1
?.01 .01 .2 .2

 28. ROLL. RESISTANCES, INDIV. WHEELS # 2
?.01 .01 1. .2

 31. TRAJECTORY SIMULATION? (Y OR N)
?N

 37. DAMAGE DIMENSIONS? (Y OR N)
?Y

 41. END DAMAGE WIDTH #1
?54.5

 42. END DAMAGE DEPTH #1
?.5 .5 1.25 1.5 1.75 2.25

 43. END DAMAGE MIDPOINT OFFSET #1
?9.75

 44. SIDE DAMAGE WIDTH #2
?77.

 45. SIDE DAMAGE DEPTH #2
?4. 12. 17.8 19.3 17. 8.25

 46. SIDE DAMAGE MIDPOINT OFFSET #2
?-3.25

 52. FORCE DIRECTIONS (Y OR N)
?N


                         THANK YOU VERY MUCH


                      SUMMARY OF CRASH RESULTS

 TEST # 6

                                          VEHICLE # 1     VEHICLE # 2

 SPEED CHANGE (TRAJ. ONLY)                  12.4 MPH        20.4 MPH
                                           -10.8 DEG        49.2 DEG
 SPEED CHANGE (DAMAGE ONLY)                 12.7 MPH        20.9 MPH
                                           -30.0 DEG        60.0 DEG
 IMPACT SPEED                               24.9 MPH        20.5 MPH
 ENERGY DISSIPATED BY DAMAGE              5409.2 FT-LB   83328.5 FT-LB
 SPEED ALONG LINE THRU CGS                  24.5 MPH         7.0 MPH
 SPEED ORTHOG. TO CG LINE                   -4.3 MPH       -19.3 MPH
 CLOSING VELOCITY                           31.5 MPH
```

SUMMARY OF CRASH RESULTS

TEST # 6

VEHICLE # 1

IMPACT SPEED MPH	SPEED CHANGE MPH TOTAL	LONG.	LATERAL	BASIS OF RESULTS
24.9	12.4	-12.2	2.3	SPINOUT TRAJECTORIES AND CONSERVATION OF LINEAR MOMENTUM
				SPINOUT TRAJECTORIES AND DAMAGE
	12.7	-11.0	6.4	DAMAGE DATA ONLY

VEHICLE # 2

IMPACT SPEED MPH	SPEED CHANGE MPH TOTAL	LONG.	LATERAL	BASIS OF RESULTS
20.5	20.4	-13.3	-15.4	SPINOUT TRAJECTORIES AND CONSERVATION OF LINEAR MOMENTUM
				SPINOUT TRAJECTORIES AND DAMAGE
	20.9	-10.4	-18.1	DAMAGE DATA ONLY

SCENE INFORMATION

	VEHICLE # 1		VEHICLE # 2	
IMPACT X-POSITION	-.73	FT.	11.40	FT.
IMPACT Y-POSITION	0.00	FT.	2.15	FT.
IMPACT HEADING ANGLE	0.00	DEG.	119.99	DEG.
REST X-POSITION	60.00	FT.	20.00	FT.
REST Y-POSITION	11.00	FT.	21.00	FT.
REST HEADING ANGLE	15.00	DEG.	241.97	DEG.
END-OF-ROTATION X-POSITION	0.00	FT.		
END-OF-ROTATION Y-POSITION	0.00	FT.		
END-OF-ROTATION HEADING ANGLE	0.00	DEG.		
DIRECTION OF ROTATION	CW		CW	
AMOUNT OF ROTATION	<360		<360	

COLLISION CONDITIONS

VEHICLE # 1			VEHICLE # 2		
XC10'	=	-.7 FT.	XC20'	=	11.4 FT.
YC10'	=	0.0 FT.	YC20'	=	2.1 FT.
PSI10	=	0.0 DEGREES	PSI20	=	120.0 DEGREES
PSI1D0	=	0.0 DEG/SEC	PSI2D0	=	0.0 DEG/SEC
U10	=	24.9 MPH	U20	=	20.5 MPH
V10	=	0.0 MPH	V20	=	0.0 MPH

SEPARATION CONDITIONS

XCS1	=	0.0 FT.	XCS2	=	11.1 FT.
YCS1	=	0.0 FT.	YCS2	=	2.7 FT.
PSIS1	=	0.0 DEG	PSIS2	=	120.0 DEG
US1	=	12.7 MPH	US2	=	7.2 MPH
VS1	=	2.3 MPH	VS2	=	-15.4 MPH
PSISD1	=	0.0 DEG/SEC	PSISD2	=	137.6 DEG/SEC

RELATIVE VELOCITY DATA

	VEHICLE # 1	VEHICLE # 2
SPEED CHANGE (TRAJ. ONLY)	12.4 MPH	20.4 MPH
	-10.8 DEG	49.2 DEG
SPEED CHANGE (DAMAGE ONLY)	12.7 MPH	20.9 MPH
	-30.0 DEG	60.0 DEG
IMPACT SPEED	24.9 MPH	20.5 MPH
ENERGY DISSIPATED BY DAMAGE	5409.2 FT-LB	83328.5 FT-LB
SPEED ALONG LINE THRU CGS	24.5 MPH	7.0 MPH
SPEED ORTHOG. TO CG LINE	-4.3 MPH	-19.3 MPH
CLOSING VELOCITY	31.5 MPH	

SUMMARY OF DAMAGE DATA

(* INDICATES DEFAULT VALUE)

VEHICLE # 1			VEHICLE # 2		
TYPE	INTERMEDIATE		TYPE	SUBCOMPACT	
WEIGHT	4300.0 LBS.		WEIGHT	2623.0 LBS.	
VDI	11FZEW1		VDI	02RDEW3	
L	54.5 IN.		L	77.0 IN.	
C1	.5 IN.		C1	4.0 IN.	
C2	.5 IN.		C2	12.0 IN.	
C3	1.3 IN.		C3	17.6 IN.	
C4	1.5 IN.		C4	19.3 IN.	
C5	1.8 IN.		C5	17.0 IN.	
C6	2.3 IN.		C6	5.5 IN.	
D	16.4 IN.		D	-.5 IN.	
RHO	1.00	*	RHO	1.00	*
ANG	330.0 DEG.	*	ANG	60.0 DEG.	*

DIMENSIONS AND INERTIAL PROPERTIES

A1 =	54.7 INCHES	A2 =	46.3 INCHES
B1 =	59.2 INCHES	B2 =	50.1 INCHES
TR1 =	61.6 INCHES	TR2 =	54.6 INCHES
I1 =	41631.2 LB-SEC**2-IN	I2 =	20032.3 LB-SEC**2-IN
M1 =	11.128 LB-SEC**2/IN	M2 =	6.766 LB-SEC**2/IN
XF1 =	96.8 INCHES	XF2 =	63.3 INCHES
XR1 =	-114.0 INCHES	XR2 =	-91.6 INCHES
YS1 =	38.5 INCHES	YS2 =	33.5 INCHES

ROLLING RESISTANCE

VEHICLE # 1		VEHICLE # 2	
RF	.01	RF	.01
LF	.01	LF	.01
RR	.20	RR	1.00
LR	.20	LR	.20

MU	.87

1. TITLE?
?TEST # 7 CHEVELLE VS RABBIT

2. SIZE CATEGORIES?
?I S

3. VDI, #1
?11FDEW1

4. VDI, #2
?02RDEW4

5. ACTUAL WEIGHTS? (Y OR N)
?Y

6. WEIGHT #1
?3700.

7. WEIGHT #2
?1700.

8. REST & IMPACT? (Y OR N)
?Y

9. REST COORDINATES?
?84.5 18.2 16.5 22.9 41.4 262.

10. IMPACT COORDINATES?
?0. 0. 0. 10.7 3.45 120.

11. SKIDDING OF # 1? (Y OR N)
?N

14. CURVED PATH? (Y OR N)
?N

16. ROTATION DIRECTION #1?
?CW

17. MORE THAN 360 DEG? (Y OR N)
?N

18. SKIDDING OF # 2? (Y OR N)
?Y

19. SKIDDING STOP BEFORE REST? (Y OR N)
?Y

20. END OF SKIDDING COORDINATES?
?22. 30. 250.

21. CURVED PATH? (Y OR N)
?N

23. ROTATION DIRECTION # 2?
?CW

24. MORE THAN 360 DEG? (Y OR N)
?N

25. TIRE-GROUND FRICTION?
?.87

26. ROLLING RESISTANCE OPTION?(1 OR 2)
?1

27. ROLL. RESISTANCES, INDIV. WHEELS # 1
?.01 .01 .2 .2

28. ROLL. RESISTANCES, INDIV. WHEELS # 2
?.01 .01 1. .2

31. TRAJECTORY SIMULATION? (Y OR N)
?N

37. DAMAGE DIMENSIONS? (Y OR N)
?Y

41. END DAMAGE WIDTH #1
?60.

42. END DAMAGE DEPTH #1
?0. 1.25 2. 3.75 5. 6.25

43. END DAMAGE MIDPOINT OFFSET #1
?4.

44. SIDE DAMAGE WIDTH #2
?108.5

45. SIDE DAMAGE DEPTH #2
?.5 11. 17.75 21. 21.25 7.25

46. SIDE DAMAGE MIDPOINT OFFSET #2
?-8.5

52. FORCE DIRECTIONS (Y OR N)
?N

THANK YOU VERY MUCH

SUMMARY OF CRASH RESULTS

TEST # 7 CHEVELLE VS RABBIT

	VEHICLE # 1	VEHICLE # 2
SPEED CHANGE (TRAJ. ONLY)	11.6 MPH	25.3 MPH
	-16.2 DEG	43.8 DEG
SPEED CHANGE (DAMAGE ONLY)	16.3 MPH	35.5 MPH
	-30.0 DEG	60.0 DEG
IMPACT SPEED	26.2 MPH	27.1 MPH
ENERGY DISSIPATED BY DAMAGE	11494.3 FT-LB	131224.2 FT-LB
SPEED ALONG LINE THRU CGS	25.5 MPH	7.9 MPH
SPEED ORTHOG. TO CG LINE	-5.9 MPH	-26.0 MPH
CLOSING VELOCITY	33.4 MPH	

SUMMARY OF CRASH RESULTS

TEST # 7 CHEVELLE VS RABBIT

VEHICLE # 1

IMPACT SPEED MPH	SPEED CHANGE MPH TOTAL	LONG.	LATERAL	BASIS OF RESULTS
26.2	11.6	-11.1	3.2	SPINOUT TRAJECTORIES AND CONSERVATION OF LINEAR MOMENTUM
				SPINOUT TRAJECTORIES AND DAMAGE
/	16.3	-14.1	8.2	DAMAGE DATA ONLY

VEHICLE # 2

IMPACT SPEED MPH	SPEED CHANGE MPH TOTAL	LONG.	LATERAL	BASIS OF RESULTS
27.1	25.3	-18.2	-17.5	SPINOUT TRAJECTORIES AND CONSERVATION OF LINEAR MOMENTUM
				SPINOUT TRAJECTORIES AND DAMAGE
	35.5	-17.6	-30.6	DAMAGE DATA ONLY

SCENE INFORMATION

	VEHICLE # 1	VEHICLE # 2
IMPACT X-POSITION	-.77 FT.	11.10 FT.
IMPACT Y-POSITION	0.00 FT.	2.76 FT.
IMPACT HEADING ANGLE	0.00 DEG.	119.99 DEG.
REST X-POSITION	64.50 FT.	22.90 FT.
REST Y-POSITION	18.20 FT.	41.40 FT.
REST HEADING ANGLE	16.50 DEG.	261.97 DEG.
END-OF-ROTATION X-POSITION	0.00 FT.	22.00 FT.
END-OF-ROTATION Y-POSITION	0.00 FT.	30.00 FT.
END-OF-ROTATION HEADING ANGLE	0.00 DEG.	249.97 DEG.
DIRECTION OF ROTATION	CW	CW
AMOUNT OF ROTATION	<360	<360

COLLISION CONDITIONS

VEHICLE # 1			VEHICLE # 2		
XC10′	=	-.8 FT.	XC20′	=	11.1 FT.
YC10′	=	0.0 FT.	YC20′	=	2.8 FT.
PSI10	=	0.0 DEGREES	PSI20	=	120.0 DEGREES
PSI1D0	=	0.0 DEG/SEC	PSI2D0	=	0.0 DEG/SEC
U10	=	26.2 MPH	U20	=	27.1 MPH
V10	=	0.0 MPH	V20	=	0.0 MPH

SEPARATION CONDITIONS

XCS1	=	0.0 FT.	XCS2	=	10.7 FT.
YCS1	=	0.0 FT.	YCS2	=	3.5 FT.
PSIS1	=	0.0 DEG	PSIS2	=	120.0 DEG
US1	=	15.0 MPH	US2	=	8.9 MPH
VS1	=	3.2 MPH	VS2	=	-17.5 MPH
PSISD1	=	0.0 DEG/SEC	PSISD2	=	171.7 DEG/SEC

RELATIVE VELOCITY DATA

	VEHICLE # 1	VEHICLE # 2
SPEED CHANGE (TRAJ. ONLY)	11.6 MPH	25.3 MPH
	-16.2 DEG	43.8 DEG
SPEED CHANGE (DAMAGE ONLY)	16.3 MPH	35.5 MPH
	-30.0 DEG	60.0 DEG
IMPACT SPEED	26.2 MPH	27.1 MPH
ENERGY DISSIPATED BY DAMAGE	11494.3 FT-LB	131224.2 FT-LB
SPEED ALONG LINE THRU CGS	25.5 MPH	7.9 MPH
SPEED ORTHOG. TO CG LINE	-5.9 MPH	-26.0 MPH
CLOSING VELOCITY	33.4 MPH	

SUMMARY OF DAMAGE DATA (* INDICATES DEFAULT VALUE)

VEHICLE # 1			VEHICLE # 2		
TYPE---------	INTERMEDIATE		TYPE---------	SUBCOMPACT	
WEIGHT-------	3700.0 LBS.		WEIGHT-------	1700.0 LBS.	
VDI----------	11FDEW1		VDI----------	02RDEW4	
L------------	66.0 IN.		L------------	108.5 IN.	
C1-----------	0.0 IN.		C1-----------	.5 IN.	
C2-----------	1.3 IN.		C2-----------	11.0 IN.	
C3-----------	2.0 IN.		C3-----------	17.8 IN.	
C4-----------	3.8 IN.		C4-----------	21.0 IN.	
C5-----------	5.0 IN.		C5-----------	21.3 IN.	
C6-----------	6.3 IN.		C6-----------	7.3 IN.	
D------------	15.6 IN.		D------------	-1.5 IN.	
RHO----------	1.00	*	RHO----------	1.00	*
ANG----------	330.0 DEG.	*	ANG----------	60.0 DEG.	*

DIMENSIONS AND INERTIAL PROPERTIES

A1	=	54.7 INCHES	A2	=	46.3 INCHES
B1	=	59.2 INCHAS	B2	=	50.1 INCHES
TR1	=	61.8 INCHES	TR2	=	54.6 INCHES
I1	=	35822.2 LB-SEC**2-IN	I2	=	12983.2 LB-SEC**2-IN
M1	=	9.576 LB-SEC**2/IN	M2	=	4.400 LB-SEC**2/IN
XF1	=	98.8 INCHES	XF2	=	83.3 INCHES
XR1	=	-114.0 INCHES	XR2	=	-91.6 INCHES
YS1	=	38.5 INCHES	YS2	=	33.6 INCHES

ROLLING RESISTANCE

VEHICLE # 1		VEHICLE # 2	
RF-----------	.01	RF-----------	.01
LF-----------	.01	LF-----------	.01
RR-----------	.20	RR-----------	1.00
LR-----------	.20	LR-----------	.20

MU----------- .87

1. TITLE?
?TEST # 8 CHEVELLE VS CHEVELLE

2. SIZE CATEGORIES?
?1 1

3. VDI, #1
?12FDEW1

4. VDI, #2
?03RYEW2

5. ACTUAL WEIGHTS? (Y OR N)
?Y

6. WEIGHT #1
?4479

7. WEIGHT #2
?4710

8. REST & IMPACT? (Y OR N)
?Y

9. REST COORDINATES?
?-0.5 11. 46. 6.5 21. 141.

10. IMPACT COORDINATES?
?S

9. REST COORDINATES?
?-0.5 12. 46. 6.5 21. 141.

10. IMPACT COORDINATES?
?-10.9 3.2 0. 0. 1.9 90.

11. SKIDDING OF # 1? (Y OR N)
?Y

12. SKIDDING STOP BEFORE REST? (Y OR N)
?N

14. CURVED PATH? (Y OR N)
?N

16. ROTATION DIRECTION #1?
?CW

17. MORE THAN 360 DEG? (Y OR N)
?N

18. SKIDDING OF # 2? (Y OR N)
?Y

19. SKIDDING STOP BEFORE REST? (Y OR N)
?N

21. CURVED PATH? (Y OR N)
?N

23. ROTATION DIRECTION # 2?
?CW

24. MORE THAN 360 DEG? (Y OR N)
?N

25. TIRE-GROUND FRICTION?
?.87

26. ROLLING RESISTANCE OPTION? (1 OR 2)
?1

27. ROLL. RESISTANCES, INDIV. WHEELS # 1
?.01 .01 .2 .2

28. ROLL. RESISTANCES, INDIV. WHEELS # 2
?.01 .01 .2 .2

31. TRAJECTORY SIMULATION? (Y OR N)
?N

37. DAMAGE DIMENSIONS? (Y OR N)
?Y

41. END DAMAGE WIDTH #1
?73.

42. END DAMAGE DEPTH #1
?2.7 3.6

43. END DAMAGE MIDPOINT OFFSET #1
?0.

44. SIDE DAMAGE WIDTH #2
?84.5

45. SIDE DAMAGE DEPTH #2
?6.2 8.3 9.2 5.9 4.4 .8

46. SIDE DAMAGE MIDPOINT OFFSET #2
?15.

52. FORCE DIRECTIONS (Y OR N)
?Y

53. PRINCIPAL FORCE ANGLE #1?
?-45

54. PRINCIPAL FORCE ANGLE #2?
?45

SUMMARY OF CRASH RESULTS

TEST # 8 CHEVELLE VS CHEVELLE

	VEHICLE # 1	VEHICLE # 2
SPEED CHANGE (TRAJ. ONLY)	10.3 MPH	9.8 MPH
	-45.3 DEG	44.7 DEG
SPEED CHANGE (DAMAGE ONLY)	10.0 MPH	9.5 MPH
	-45.0 DEG	45.0 DEG
IMPACT SPEED	19.5 MPH	24.5 MPH
ENERGY DISSIPATED BY DAMAGE	18645.8 FT-LB	31217.2 FT-LB
SPEED ALONG LINE THRU CGS	19.2 MPH	4.3 MPH
SPEED ORTHOG. TO CG LINE	3.4 MPH	-24.1 MPH
CLOSING VELOCITY	23.4 MPH	

SUMMARY OF CRASH RESULTS

TEST # 8 CHEVELLE VS CHEVELLE

VEHICLE # 1

IMPACT SPEED MPH	SPEED CHANGE MPH			BASIS OF RESULTS
	TOTAL	LONG.	LATERAL	
19.5	10.3	-7.2	7.3	SPINOUT TRAJECTORIES AND CONSERVATION OF LINEAR MOMENTUM
				SPINOUT TRAJECTORIES AND DAMAGE
	10.0	-7.0	7.1	DAMAGE DATA ONLY

VEHICLE # 2

IMPACT SPEED MPH	SPEED CHANGE MPH			BASIS OF RESULTS
	TOTAL	LONG.	LATERAL	
24.5	9.8	-6.9	-6.9	SPINOUT TRAJECTORIES AND CONSERVATION OF LINEAR MOMENTUM
				SPINOUT TRAJECTORIES AND DAMAGE
	9.5	-6.7	-6.7	DAMAGE DATA ONLY

SCENE INFORMATION

	VEHICLE # 1		VEHICLE # 2	
IMPACT X-POSITION	-11.46	FT.	-.00	FT.
IMPACT Y-POSITION	3.20	FT.	1.17	FT.
IMPACT HEADING ANGLE	0.00	DEG.	89.99	DEG.
REST X-POSITION	-.50	FT.	0.50	FT.
REST Y-POSITION	11.00	FT.	21.00	FT.
REST HEADING ANGLE	45.99	DEG.	140.98	DEG.
DIRECTION OF ROTATION	CW		CW	
AMOUNT OF ROTATION	<360		<360	

COLLISION CONDITIONS

VEHICLE # 1			VEHICLE # 2		
XC10'	=	-11.5 FT.	XC20'	=	-.0 FT.
YC10'	=	3.2 FT.	YC20'	=	1.2 FT.
PSI10	=	0.0 DEGREES	PSI20	=	90.0 DEGREES
PSI1D0	=	0.0 DEG/SEC	PSI2D0	=	0.0 DEG/SEC
U10	=	19.5 MPH	U20	=	24.5 MPH
V10	=	0.0 MPH	V20	=	0.0 MPH

SEPARATION CONDITIONS

XCS1	=	-11.5 FT.	XCS2	=	-.0 FT.
YCS1	=	3.2 FT.	YCS2	=	1.2 FT.
PSIS1	=	0.0 DEG	PSIS2	=	90.0 DEG
US1	=	12.3 MPH	US2	=	17.5 MPH
VS1	=	7.3 MPH	VS2	=	-6.9 MPH
PSISD1	=	58.6 DEG/SEC	PSISD2	=	53.9 DEG/SEC

RELATIVE VELOCITY DATA

	VEHICLE # 1		VEHICLE # 2	
SPEED CHANGE (TRAJ. ONLY)	10.3	MPH	9.8	MPH
	-45.3	DEG	44.7	DEG
SPEED CHANGE (DAMAGE ONLY)	10.0	MPH	9.5	MPH
	-45.0	DEG	45.0	DEG
IMPACT SPEED	19.5	MPH	24.5	MPH
ENERGY DISSIPATED BY DAMAGE	18645.8	FT-LB	31217.2	FT-LB
SPEED ALONG LINE THRU CGS	19.2	MPH	4.3	MPH
SPEED ORTHOG. TO CG LINE	3.4	MPH	-24.1	MPH
CLOSING VELOCITY	23.4	MPH		

SUMMARY OF DAMAGE DATA (* INDICATES DEFAULT VALUE)

VEHICLE # 1		VEHICLE # 2	
TYPE----------	INTERMEDIATE	TYPE----------	INTERMEDIATE
WEIGHT-------	4479.0 LBS.	WEIGHT-------	4710.0 LBS.
VDI----------	12FDEW1	VDI----------	03RYEW2
L------------	73.0 IN.	L------------	84.5 IN.
C1-----------	2.7 IN.	C1-----------	6.2 IN.
C2-----------	3.6 IN.	C2-----------	8.3 IN.
C3-----------	0.0 IN.	C3-----------	9.2 IN.
C4-----------	0.0 IN.	C4-----------	5.9 IN.
C5-----------	0.0 IN.	C5-----------	4.4 IN.
C6-----------	0.0 IN.	C6-----------	.8 IN.
D------------	1.7 IN.	D------------	7.8 IN.
RHO----------	1.00 *	RHO----------	1.00 *
ANG----------	315.0 DEG.	ANG----------	45.0 DEG.

DIMENSIONS AND INERTIAL PROPERTIES

A1	= 54.7 INCHES	A2	= 54.7 INCHES
B1	= 59.2 INCHES	B2	= 59.2 INCHES
TR1	= 61.8 INCHES	TR2	= 61.8 INCHES
I1	= 43364.2 LB-SEC**2-IN	I2	= 45600.7 LB-SEC**2-IN
M1	= 11.592 LB-SEC**2/IN	M2	= 12.189 LB-SEC**2/IN
XF1	= 98.8 INCHES	XF2	= 98.8 INCHES
XR1	= -114.0 INCHES	XR2	= -114.0 INCHES
YS1	= 38.5 INCHES	YS2	= 38.5 INCHES

ROLLING RESISTANCE

VEHICLE # 1		VEHICLE # 2	
RF-----------	.01	RF-----------	.01
LF-----------	.01	LF-----------	.01
RR-----------	.20	RR-----------	.20
LR-----------	.20	LR-----------	.20

MU-------------- .87

ENTER TYPE OF CRASH RUN?
(COMPLETE,ABBREVIATED,RERUN,PRINT,BATCH,SMAC,OR END)
YE

1. TITLE?
?TEST # 9 HONDA VERSUS TORINO

2. SIZE CATEGORIES?
?M I

3. VDI, #1
?11FDEW2

4. VDI, #2
?02RFEW2

5. ACTUAL WEIGHTS? (Y OR N)
?Y

6. WEIGHT #1
?2256

7. WEIGHT #2
?4900

8. REST & IMPACT? (Y OR N)
?Y

9. REST COORDINATES?
?4. 35.5 104. -5. 49.5 152.

10. IMPACT COORDINATES?
?0. 0. 0. 6.53 -5.89 90.

11. SKIDDING OF # 1? (Y OR N)
?N

14. CURVED PATH? (Y OR N)
?N

16. ROTATION DIRECTION #1?
?CW

17. MORE THAN 360 DEG? (Y OR N)
?N

18. SKIDDING OF # 2? (Y OR N)
?Y

19. SKIDDING STOP BEFORE REST? (Y OR N)
?Y

20. END OF SKIDDING COORDINATES?
?16. 12.5 120.

21. CURVED PATH? (Y OR N)
?N

23. ROTATION DIRECTION # 2?
?CW

24. MORE THAN 360 DEG? (Y OR N)
?N

25. TIRE-GROUND FRICTION?
?.87

26. ROLLING RESISTANCE OPTION?(1 OR 2)
?1

27. ROLL. RESISTANCES, INDIV. WHEELS # 1
?.2 .2 .01 .01

28. ROLL. RESISTANCES, INDIV. WHEELS # 2
?.1 .01 .2 .2

31. TRAJECTORY SIMULATION? (Y OR N)
?N

37. DAMAGE DIMENSIONS? (Y OR N)
?Y

41. END DAMAGE WIDTH #1
?49.75

42. END DAMAGE DEPTH #1
?5. 5.75 12.5 7.5 7.5 9.5

43. END DAMAGE MIDPOINT OFFSET #1
?1.63

44. SIDE DAMAGE WIDTH #2
?54.5

45. SIDE DAMAGE DEPTH #2
?7.75 4.6 4.75 3.3 2.75 1.5

46. SIDE DAMAGE MIDPOINT OFFSET #2
?66.

52. FORCE DIRECTIONS (Y OR N)
?Y

53. PRINCIPAL FORCE ANGLE #1?
?-65.

54. PRINCIPAL FORCE ANGLE #2?
?25.

SUMMARY OF CRASH RESULTS

TEST # 9 HONDA VERSUS TORINO

	VEHICLE # 1	VEHICLE # 2
SPEED CHANGE (TRAJ. ONLY)	24.2 MPH	11.2 MPH
	-23.9 DEG	66.1 DEG
SPEED CHANGE (DAMAGE ONLY)	19.1 MPH	8.8 MPH
	-65.0 DEG	25.0 DEG
IMPACT SPEED	23.2 MPH	22.0 MPH
ENERGY DISSIPATED BY DAMAGE	68892.3 FT-LB	31370.4 FT-LB
SPEED ALONG LINE THRU CGS	18.9 MPH	12.8 MPH
SPEED ORTHOG. TO CG LINE	13.6 MPH	-17.8 MPH
CLOSING VELOCITY	31.7 MPH	

SUMMARY OF CRASH RESULTS

TEST # 9 HONDA VERSUS TORINO

VEHICLE # 1

IMPACT SPEED MPH	SPEED CHANGE MPH TOTAL	SPEED CHANGE MPH LONG.	SPEED CHANGE MPH LATERAL	BASIS OF RESULTS
23.2	24.2	-22.1	9.8	SPINOUT TRAJECTORIES AND CONSERVATION OF LINEAR MOMENTUM
				SPINOUT TRAJECTORIES AND DAMAGE
	19.1	-8.1	17.3	DAMAGE DATA ONLY

VEHICLE # 2

IMPACT SPEED MPH	SPEED CHANGE MPH TOTAL	SPEED CHANGE MPH LONG.	SPEED CHANGE MPH LATERAL	BASIS OF RESULTS
22.0	11.2	-4.5	-10.2	SPINOUT TRAJECTORIES AND CONSERVATION OF LINEAR MOMENTUM
				SPINOUT TRAJECTORIES AND DAMAGE
	8.8	-8.0	-3.7	DAMAGE DATA ONLY

SCENE INFORMATION

	VEHICLE # 1		VEHICLE # 2	
IMPACT X-POSITION	-1.02	FT.	8.53	FT.
IMPACT Y-POSITION	0.00	FT.	-6.80	FT.
IMPACT HEADING ANGLE	0.00	DEG.	89.99	DEG.
REST X-POSITION	4.00	FT.	-5.00	FT.
REST Y-POSITION	35.50	FT.	49.50	FT.
REST HEADING ANGLE	103.99	DEG.	151.98	DEG.
END-OF-ROTATION X-POSITION	0.00	FT.	18.00	FT.
END-OF-ROTATION Y-POSITION	0.00	FT.	12.50	FT.
END-OF-ROTATION HEADING ANGLE	0.00	DEG.	119.99	DEG.
DIRECTION OF ROTATION	CW		CW	
AMOUNT OF ROTATION	<360		<360	

COLLISION CONDITIONS

VEHICLE # 1			VEHICLE # 2		
XC10'	=	-1.0 FT.	XC20'	=	8.5 FT.
YC10'	=	0.0 FT.	YC20'	=	-6.9 FT.
PSI10	=	0.0 DEGREES	PSI20	=	90.0 DEGREES
PSI1D0	=	0.0 DEG/SEC	PSI2D0	=	0.0 DEG/SEC
U10	=	23.2 MPH	U20	=	22.0 MPH
V10	=	0.0 MPH	V20	=	0.0 MPH

SEPARATION CONDITIONS

XCS1	=	0.0 FT.	XCS2	=	8.5 FT.
YCS1	=	0.0 FT.	YCS2	=	-5.9 FT.
PSIS1	=	0.0 DEG	PSIS2	=	90.0 DEG
US1	=	1.1 MPH	US2	=	17.4 MPH
VS1	=	9.8 MPH	VS2	=	-10.2 MPH
PSISD1	=	0.0 DEG/SEC	PSISD2	=	54.7 DEG/SEC

RELATIVE VELOCITY DATA

	VEHICLE # 1	VEHICLE # 2
SPEED CHANGE (TRAJ. ONLY)	24.2 MPH	11.2 MPH
	-23.9 DEG	60.1 DEG
SPEED CHANGE (DAMAGE ONLY)	19.1 MPH	8.8 MPH
	-65.0 DEG	25.0 DEG
IMPACT SPEED	23.2 MPH	22.0 MPH
ENERGY DISSIPATED BY DAMAGE	68892.3 FT-LB	31370.4 FT-LB
SPEED ALONG LINE THRU CGS	18.9 MPH	12.8 MPH
SPEED ORTHOG. TO CG LINE	13.6 MPH	-17.8 MPH
CLOSING VELOCITY	31.7 MPH	

SUMMARY OF DAMAGE DATA (* INDICATES DEFAULT VALUE)

VEHICLE # 1			VEHICLE # 2		
TYPE----------	MINICAR		TYPE----------	INTERMEDIATE	
WEIGHT------	2250.0 LBS.		WEIGHT------	4900.0 LBS.	
VDI----------	11FDEW2		VDI----------	02RFEW2	
L----------	49.7 IN.		L----------	54.5 IN.	
C1----------	5.0 IN.		C1----------	7.8 IN.	
C2----------	5.8 IN.		C2----------	4.6 IN.	
C3----------	12.5 IN.		C3----------	4.8 IN.	
C4----------	7.5 IN.		C4----------	3.3 IN.	
C5----------	7.5 IN.		C5----------	2.8 IN.	
C6----------	9.5 IN.		C6----------	1.5 IN.	
D----------	2.9 IN.		D----------	62.4 IN.	
RHO----------	1.00	*	RHO----------	1.00	*
ANG----------	295.0 DEG.		ANG----------	25.0 DEG.	

DIMENSIONS AND INERTIAL PROPERTIES

A1	=	45.1 INCHES	A2	=	54.7 INCHES
B1	=	48.1 INCHES	B2	=	59.2 INCHES
TR1	=	51.1 INCHES	TR2	=	61.8 INCHES
I1	=	11712.0 LB-SEC**2-IN	I2	=	47440.2 LB-SEC**2-IN
M1	=	5.839 LB-SEC**2/IN	M2	=	12.681 LB-SEC**2/IN
XF1	=	76.0 INCHES	XF2	=	98.8 INCHES
XR1	=	-83.8 INCHES	XR2	=	-114.0 INCHES
YS1	=	30.4 INCHES	YS2	=	38.5 INCHES

ROLLING RESISTANCE

VEHICLE # 1		VEHICLE # 2	
RF----------	.20	RF----------	.10
LF----------	.20	LF----------	.01
RR----------	.01	RR----------	.20
LR----------	.01	LR----------	.20

MU---------- .87

1. TITLE?
?TEST # 10 HONDA VS TORINO

2. SIZE CATEGORIES?
?4 1

3. VDI, #1
?10FDEW2

4. VDI, #2
?01RFEW2

5. ACTUAL WEIGHTS? (Y OR N)
?Y

6. WEIGHT #1
?2300

7. WEIGHT #2
?4720

8. REST & IMPACT? (Y OR N)
?Y

9. REST COORDINATES?
?5. 43. 87. 0. 99.5 128.5

10. IMPACT COORDINATES?
?0. 0. 0. 8.5 -5.9 90.

11. SKIDDING OF # 1? (Y OR N)
?Y

12. SKIDDING STOP BEFORE REST? (Y OR N)
?Y

13. END OF SKIDDING COORDINATES?
?5. 25. 90.

14. CURVED PATH? (Y OR N)
?N

16. ROTATION DIRECTION #1?
?CW

17. MORE THAN 360 DEG? (Y OR N)
?N

18. SKIDDING OF # 2? (Y OR N)
?Y

19. SKIDDING STOP BEFORE REST? (Y OR N)
?Y

20. END OF SKIDDING COORDINATES?
?23. 19. 90.

```
21. CURVED PATH? (Y OR N)
?N

23. ROTATION DIRECTION # 2?
?CW

24. MORE THAN 360 DEG? (Y OR N)
?N

25. TIRE-GROUND FRICTION?
?.87

26. ROLLING RESISTANCE OPTION?(1 OR 2)
?1

27. ROLL. RESISTANCES, INDIV. WHEELS # 1
?.2 .2 .01 .01

28. ROLL. RESISTANCES, INDIV. WHEELS # 2
?.1 .01 .2 .2

31. TRAJECTORY SIMULATION? (Y OR N)
?N

37. DAMAGE DIMENSIONS? (Y OR N)
?Y

41. END DAMAGE WIDTH #1
?47.5

42. END DAMAGE DEPTH #1
?7. 10.2 14. 8.9 7. 9.

43. END DAMAGE MIDPOINT OFFSET #1
?-2.75

44. SIDE DAMAGE WIDTH #2
?53.

45. SIDE DAMAGE DEPTH #2
?9.2 6.5 6.1 5.3 4.5 .5

46. SIDE DAMAGE MIDPOINT OFFSET #2
?66.5

52. FORCE DIRECTIONS (Y OR N)
?Y

53. PRINCIPAL FORCE ANGLE #1?
?-55.

54. PRINCIPAL FORCE ANGLE #2?
?25.
```

SUMMARY OF CRASH RESULTS

TEST # 10 HONDA VS TORINO

	VEHICLE # 1	VEHICLE # 2
SPEED CHANGE (TRAJ. ONLY)	32.6 MPH	15.9 MPH
	-35.6 DEG	54.4 DEG
SPEED CHANGE (DAMAGE ONLY)	22.4 MPH	10.9 MPH
	-65.0 DEG	25.0 DEG
IMPACT SPEED	32.7 MPH	31.5 MPH
ENERGY DISSIPATED BY DAMAGE	88023.1 FT-LB	44972.8 FT-LB
SPEED ALONG LINE THRU CGS	26.4 MPH	18.6 MPH
SPEED ORTHOG. TO CG LINE	19.2 MPH	-25.5 MPH
CLOSING VELOCITY	45.0 MPH	

SUMMARY OF CRASH RESULTS

TEST # 10 HONDA VS TORINO

VEHICLE # 1

IMPACT SPEED MPH	SPEED CHANGE MPH TOTAL	LONG.	LATERAL	BASIS OF RESULTS
32.7	32.0	-26.5	19.0	SPINOUT TRAJECTORIES AND CONSERVATION OF LINEAR MOMENTUM
				SPINOUT TRAJECTORIES AND DAMAGE
	22.4	-9.4	20.3	DAMAGE DATA ONLY

VEHICLE # 2

IMPACT SPEED MPH	SPEED CHANGE MPH TOTAL	LONG.	LATERAL	BASIS OF RESULTS
31.5	15.9	-9.3	-13.0	SPINOUT TRAJECTORIES AND CONSERVATION OF LINEAR MOMENTUM
				SPINOUT TRAJECTORIES AND DAMAGE
	10.9	-9.9	-4.6	DAMAGE DATA ONLY

SCENE INFORMATION

	VEHICLE # 1		VEHICLE # 2	
IMPACT X-POSITION	-1.20	FT.	8.50	FT.
IMPACT Y-POSITION	0.00	FT.	-7.00	FT.
IMPACT HEADING ANGLE	0.00	DEG.	89.99	DEG.
REST X-POSITION	5.00	FT.	0.00	FT.
REST Y-POSITION	43.00	FT.	99.50	FT.
REST HEADING ANGLE	86.99	DEG.	128.49	DEG.
END-OF-ROTATION X-POSITION	5.00	FT.	23.00	FT.
END-OF-ROTATION Y-POSITION	25.00	FT.	19.00	FT.
END-OF-ROTATION HEADING ANGLE	89.99	DEG.	89.99	DEG.
DIRECTION OF ROTATION	CW		CW	
AMOUNT OF ROTATION	<360		<360	

COLLISION CONDITIONS

VEHICLE # 1			VEHICLE # 2		
XC10'	=	-1.2 FT.	XC20'	=	8.5 FT.
YC10'	=	0.0 FT.	YC20'	=	-7.1 FT.
PSI10	=	0.0 DEGREES	PSI20	=	90.0 DEGREES
PSI1D0	=	0.0 DEG/SEC	PSI2D0	=	0.0 DEG/SEC
U10	=	32.7 MPH	U20	=	31.5 MPH
V10	=	0.0 MPH	V20	=	0.0 MPH

SEPARATION CONDITIONS

XCS1	=	0.0 FT.	XCS2	=	8.5 FT.
YCS1	=	0.0 FT.	YCS2	=	-5.9 FT.
PSIS1	=	0.0 DEG	PSIS2	=	90.0 DEG
US1	=	6.1 MPH	US2	=	22.3 MPH
VS1	=	19.0 MPH	VS2	=	-13.0 MPH
PSISD1	=	116.0 DEG/SEC	PSISD2	=	0.0 DEG/SEC

RELATIVE VELOCITY DATA

	VEHICLE # 1	VEHICLE # 2
SPEED CHANGE (TRAJ. ONLY)	32.6 MPH	15.9 MPH
	-35.6 DEG	54.4 DEG
SPEED CHANGE (DAMAGE ONLY)	22.4 MPH	10.9 MPH
	-65.0 DEG	25.0 DEG
IMPACT SPEED	32.7 MPH	31.5 MPH
ENERGY DISSIPATED BY DAMAGE	88023.1 FT-LB	44972.8 FT-LB
SPEED ALONG LINE THRU CGS	26.4 MPH	18.6 MPH
SPEED ORTHOG. TO CG LINE	19.2 MPH	-25.5 MPH
CLOSING VELOCITY	45.0 MPH	

SUMMARY OF DAMAGE DATA (* INDICATES DEFAULT VALUE)

VEHICLE # 1		VEHICLE # 2	
TYPE---------	MINICAR	TYPE---------	INTERMEDIATE
WEIGHT-------	2306.0 LBS.	WEIGHT-------	4720.0 LBS.
VDI----------	10FDEW2	VDI----------	01RFEW2
L------------	47.5 IN.	L------------	53.0 IN.
C1-----------	7.0 IN.	C1-----------	9.2 IN.
C2-----------	10.2 IN.	C2-----------	6.5 IN.
C3-----------	14.0 IN.	C3-----------	6.1 IN.
C4-----------	8.9 IN.	C4-----------	5.3 IN.
C5-----------	7.0 IN.	C5-----------	4.5 IN.
C6-----------	9.0 IN.	C6-----------	.5 IN.
D------------	-3.8 IN.	D------------	61.5 IN.
RHO----------	1.00 *	RHO----------	1.00 *
ANG----------	295.0 DEG.	ANG----------	25.0 DEG.

DIMENSIONS AND INERTIAL PROPERTIES

A1	=	45.1 INCHES	A2	=	54.7 INCHES
B1	=	48.1 INCHES	B2	=	59.2 INCHES
TR1	=	51.1 INCHES	TR2	=	61.8 INCHES
I1	=	11971.6 LB-SEC**2-IN	I2	=	45697.5 LB-SEC**2-IN
M1	=	5.968 LB-SEC**2/IN	M2	=	12.215 LB-SEC**2/IN
XF1	=	76.0 INCHES	XF2	=	98.8 INCHES
XR1	=	-83.8 INCHES	XR2	=	-114.0 INCHES
YS1	=	30.4 INCHES	YS2	=	38.5 INCHES

ROLLING RESISTANCE

VEHICLE # 1		VEHICLE # 2	
RF-----------	.20	RF-----------	.10
LF-----------	.20	LF-----------	.01
RR-----------	.01	RR-----------	.20
LR-----------	.01	LR-----------	.20

MU----------- .87

```
1. TITLE?
?TEST #11 VEGA VS TORINO

2. SIZE CATEGORIES?
?5X   I

3. VDI, #1
?12FYEN3

4. VDI, #2
?12FYEN3

5. ACTUAL WEIGHTS? (Y OR N)
?Y

6. WEIGHT #1
?3041

7. WEIGHT #2
?4850

8. REST & IMPACT? (Y OR N)
?Y

9. REST COORDINATES?
?25.6 -6.4 170. 8.6 0.4 0.0

10. IMPACT COORDINATES?
?15.7 -4. 171. 0. 0. 0.

11. SKIDDING OF # 1? (Y OR N)
?N

14. CURVED PATH? (Y OR N)
?N

16. ROTATION DIRECTION #1?
?CW

17. MORE THAN 360 DEG? (Y OR N)
?N

18. SKIDDING OF # 2? (Y OR N)
?N

21. CURVED PATH? (Y OR N)
?N

23. ROTATION DIRECTION # 2?
?N

25. TIRE-GROUND FRICTION?
?.87

26. ROLLING RESISTANCE OPTION?(1 OR 2)
?1

27. ROLL. RESISTANCES, INDIV. WHEELS # 1
?.01 .01 .1 .1
```

```
28. ROLL. RESISTANCES, INDIV. WHEELS # 2
?.01 .01 .2 .2

31. TRAJECTORY SIMULATION? (Y OR N)
?N

37. DAMAGE DIMENSIONS? (Y OR N)
?Y

41. END DAMAGE WIDTH #1
?32.5

42. END DAMAGE DEPTH #1
?22. 20.2 18.5 16.8 15. 12.5

43. END DAMAGE MIDPOINT OFFSET #1
?-12.75

47. END DAMAGE WIDTH #2
?32.26

48. END DAMAGE DEPTH #2
?29.5 26.25 23. 18.7 14.3 11.

49. END DAMAGE MIDPOINT OFFSET #2
?-12.9

52. FORCE DIRECTIONS (Y OR N)
?Y

53. PRINCIPAL FORCE ANGLE #1?
?5.

54. PRINCIPAL FORCE ANGLE #2?
?-5.
```

SUMMARY OF CRASH RESULTS

TEST #11 VEGA VS TORINO

	VEHICLE # 1	VEHICLE # 2
SPEED CHANGE (TRAJ. + DAMAGE)	21.0 MPH	13.2 MPH
	-.8 DEG	-.9 DEG
SPEED CHANGE (DAMAGE ONLY)	21.1 MPH	13.2 MPH
	5.0 DEG	-5.0 DEG
IMPACT SPEED	17.2 MPH	18.0 MPH
ENERGY DISSIPATED BY DAMAGE	35274.2 FT-LB	44958.9 FT-LB
SPEED ALONG LINE THRU CGS	17.1 MPH	17.4 MPH
SPEED ORTHOG. TO CG LINE	1.6 MPH	4.4 MPH
CLOSING VELOCITY	34.5 MPH	

SUMMARY OF CRASH RESULTS

TEST #11 VEGA VS TORINO

VEHICLE # 1

IMPACT SPEED MPH	SPEED CHANGE MPH TOTAL	LONG.	LATERAL	BASIS OF RESULTS
				SPINOUT TRAJECTORIES AND CONSERVATION OF LINEAR MOMENTUM
17.2	21.0	-21.0	.3	SPINOUT TRAJECTORIES AND DAMAGE
	21.1	-21.0	-1.8	DAMAGE DATA ONLY

VEHICLE # 2

IMPACT SPEED MPH	SPEED CHANGE MPH TOTAL	LONG.	LATERAL	BASIS OF RESULTS
				SPINOUT TRAJECTORIES AND CONSERVATION OF LINEAR MOMENTUM
18.0	13.2	-13.2	.2	SPINOUT TRAJECTORIES AND DAMAGE
	13.2	-13.2	1.2	DAMAGE DATA ONLY

SCENE INFORMATION

	VEHICLE # 1		VEHICLE # 2	
IMPACT X-POSITION	15.70	FT.	0.00	FT.
IMPACT Y-POSITION	-4.00	FT.	0.00	FT.
IMPACT HEADING ANGLE	170.98	DEG.	0.00	DEG.
REST X-POSITION	25.60	FT.	8.60	FT.
REST Y-POSITION	-6.40	FT.	.40	FT.
REST HEADING ANGLE	169.98	DEG.	0.00	DEG.
END-OF-ROTATION X-POSITION	15.70	FT.	0.00	FT.
END-OF-ROTATION Y-POSITION	-4.00	FT.	0.00	FT.
END-OF-ROTATION HEADING ANGLE	170.98	DEG.	0.00	DEG.
DIRECTION OF ROTATION	CW		NONE	
AMOUNT OF ROTATION	<360		<360	

COLLISION CONDITIONS

VEHICLE # 1				VEHICLE # 2			
XC10'	=	15.7	FT.	XC20'	=	0.0	FT.
YC10'	=	-4.0	FT.	YC20'	=	0.0	FT.
PSI10	=	171.0	DEGREES	PSI20	=	0.0	DEGREES
PSI1D0	=	0.0	DEG/SEC	PSI2D0	=	0.0	DEG/SEC
U10	=	17.2	MPH	U20	=	18.0	MPH
V10	=	0.0	MPH	V20	=	0.0	MPH

SEPARATION CONDITIONS

XCS1	=	15.7	FT.	XCS2	=	0.0	FT.
YCS1	=	-4.0	FT.	YCS2	=	0.0	FT.
PSIS1	=	171.0	DEG	PSIS2	=	0.0	DEG
US1	=	-3.8	MPH	US2	=	4.8	MPH
VS1	=	.3	MPH	VS2	=	.2	MPH
PSISD1	=	0.0	DEG/SEC	PSISD2	=	0.0	DEG/SEC

RELATIVE VELOCITY DATA

	VEHICLE # 1		VEHICLE # 2	
SPEED CHANGE (TRAJ. + DAMAGE)	21.0	MPH	13.2	MPH
	-.8	DEG	-.9	DEG
SPEED CHANGE (DAMAGE ONLY)	21.1	MPH	13.2	MPH
	5.0	DEG	-5.0	DEG
IMPACT SPEED	17.2	MPH	18.0	MPH
ENERGY DISSIPATED BY DAMAGE	35274.2	FT-LB	44958.9	FT-LB
SPEED ALONG LINE THRU CGS	17.1	MPH	17.4	MPH
SPEED ORTHOG. TO CG LINE	1.6	MPH	4.4	MPH
CLOSING VELOCITY	34.5	MPH		

SUMMARY OF DAMAGE DATA (* INDICATES DEFAULT VALUE)

VEHICLE # 1			VEHICLE # 2		
TYPE	SUBCOMPACT		TYPE	INTERMEDIATE	
WEIGHT	3041.0 LBS.		WEIGHT	4850.0 LBS.	
VDI	12FYEW3		VDI	12FYEW3	
L	32.5 IN.		L	32.3 IN.	
C1	22.0 IN.		C1	29.5 IN.	
C2	20.2 IN.		C2	26.3 IN.	
C3	18.5 IN.		C3	23.0 IN.	
C4	16.8 IN.		C4	16.7 IN.	
C5	15.0 IN.		C5	14.3 IN.	
C6	12.5 IN.		C6	11.0 IN.	
D	-14.2 IN.		D	-15.4 IN.	
RHO	1.00	*	RHO	1.00	*
ANG	5.0 DEG.		ANG	355.0 DEG.	

DIMENSIONS AND INERTIAL PROPERTIES

A1 =	46.3 INCHES	A2 =	54.7 INCHES
B1 =	50.1 INCHES	B2 =	59.2 INCHES
TR1 =	54.6 INCHES	TR2 =	61.8 INCHES
I1 =	23224.6 LB-SEC**2-IN	I2 =	46956.1 LB-SEC**2-IN
M1 =	7.870 LB-SEC**2/IN	M2 =	12.552 LB-SEC**2/IN
XF1 =	83.3 INCHES	XF2 =	98.8 INCHES
XR1 =	-91.6 INCHES	XR2 =	-114.0 INCHES
YS1 =	33.6 INCHES	YS2 =	38.5 INCHES

ROLLING RESISTANCE

VEHICLE # 1		VEHICLE # 2	
RF	.01	RF	.01
LF	.01	LF	.01
RR	.10	RR	.20
LR	.10	LR	.20

MU---------- .67

TEST # 12 VEGA VS TORINO

```
 2. SIZE CATEGORIES?
?S I

 3. VDI, #1
?12FYEW4

 4. VDI, #2
?S

 3. VDI, #1
?12FDEW4

 4. VDI, #2
?12FYEW4

 5. ACTUAL WEIGHTS? (Y OR N)
?Y

 6. WEIGHT #1
?3130.

 7. WEIGHT #2
?4512.

 8. REST & IMPACT? (Y OR N)
?Y

 9. REST COORDINATES?
?22.3 -5.5 118. 6.8 2.6 -12.

10. IMPACT COORDINATES?
?15.7 -4. 171. 0 0 0

11. SKIDDING OF # 1? (Y OR N)
?Y

12. SKIDDING STOP BEFORE REST? (Y OR N)
?N

14. CURVED PATH? (Y OR N)
?N

16. ROTATION DIRECTION #1?
?CCW

17. MORE THAN 360 DEG? (Y OR N)
?N

18. SKIDDING OF # 2? (Y OR N)
?Y

19. SKIDDING STOP BEFORE REST? (Y OR N)
?N
```

21. CURVED PATH? (Y OR N)
?N

23. ROTATION DIRECTION # 2?
?CCW

24. MORE THAN 360 DEG? (Y OR N)
?N

25. TIRE-GROUND FRICTION?
?.87

26. ROLLING RESISTANCE OPTION?(1 OR 2)
?1

27. ROLL. RESISTANCES, INDIV. WHEELS # 1
?.01 .01 .2 .2

28. ROLL. RESISTANCES, INDIV. WHEELS # 2
?.01 .01 .2 .2

31. TRAJECTORY SIMULATION? (Y OR N)
?N

37. DAMAGE DIMENSIONS? (Y OR N)
?Y

41. END DAMAGE WIDTH #1
?32.

42. END DAMAGE DEPTH #1
?38.6 34.6 29.5 26. 19.6 14.25

43. END DAMAGE MIDPOINT OFFSET #1
?2.75

47. END DAMAGE WIDTH #2
?28.25

48. END DAMAGE DEPTH #2
?39.5 33. 28.75 23.75 19.2 15.

49. END DAMAGE MIDPOINT OFFSET #2
?-10.6

52. FORCE DIRECTIONS (Y OR N)
?Y

53. PRINCIPAL FORCE ANGLE #1?
?5.

54. PRINCIPAL FORCE ANGLE #2?
?-5.

SUMMARY OF CRASH RESULTS

TEST # 12 VEGA VS TORINO

	VEHICLE # 1	VEHICLE # 2
SPEED CHANGE (TRAJ. + DAMAGE)	28.2 MPH	20.0 MPH
	3.1 DEG	-13.1 DEG
SPEED CHANGE (DAMAGE ONLY)	28.2 MPH	19.6 MPH
	5.0 DEG	-5.0 DEG
IMPACT SPEED	19.8 MPH	30.2 MPH
ENERGY DISSIPATED BY DAMAGE	82653.4 FT-LB	59966.1 FT-LB
SPEED ALONG LINE THRU CGS	19.7 MPH	29.3 MPH
SPEED ORTHOG. TO CG LINE	1.8 MPH	7.5 MPH
CLOSING VELOCITY	49.0 MPH	

SUMMARY OF CRASH RESULTS

TEST # 12 VEGA VS TORINO

VEHICLE # 1

IMPACT SPEED MPH	SPEED CHANGE MPH TOTAL	LONG.	LATERAL	BASIS OF RESULTS
				SPINOUT TRAJECTORIES AND CONSERVATION OF LINEAR MOMENTUM
19.8	28.2	-28.1	-1.6	SPINOUT TRAJECTORIES AND DAMAGE
	28.2	-28.1	-2.5	DAMAGE DATA ONLY

VEHICLE # 2

IMPACT SPEED MPH	SPEED CHANGE MPH TOTAL	LONG.	LATERAL	BASIS OF RESULTS
				SPINOUT TRAJECTORIES AND CONSERVATION OF LINEAR MOMENTUM
30.2	20.0	-19.5	4.6	SPINOUT TRAJECTORIES AND DAMAGE
	19.6	-19.5	1.7	DAMAGE DATA ONLY

SCENE INFORMATION

	VEHICLE # 1		VEHICLE # 2	
IMPACT X-POSITION	15.70	FT.	0.00	FT.
IMPACT Y-POSITION	-4.00	FT.	0.00	FT.
IMPACT HEADING ANGLE	170.98	DEG.	0.00	DEG.
REST X-POSITION	22.30	FT.	6.80	FT.
REST Y-POSITION	-5.50	FT.	2.60	FT.
REST HEADING ANGLE	117.99	DEG.	-12.00	DEG.
DIRECTION OF ROTATION	CCW		CCW	
AMOUNT OF ROTATION	<360		<360	

COLLISION CONDITIONS

VEHICLE # 1				VEHICLE # 2			
XC10'	=	15.7	FT.	XC20'	=	0.0	FT.
YC10'	=	-4.0	FT.	YC20'	=	0.0	FT.
PSI10	=	171.0	DEGREES	PSI20	=	0.0	DEGREES
PSI1D0	=	0.0	DEG/SEC	PSI2D0	=	0.0	DEG/SEC
U10	=	19.8	MPH	U20	=	30.2	MPH
V10	=	0.0	MPH	V20	=	0.0	MPH

SEPARATION CONDITIONS

XCS1	=	15.7	FT.	XCS2	=	0.0	FT.
YCS1	=	-4.0	FT.	YCS2	=	0.0	FT.
PSIS1	=	171.0	DEG	PSIS2	=	0.0	DEG
US1	=	-8.3	MPH	US2	=	10.7	MPH
VS1	=	-1.6	MPH	VS2	=	4.6	MPH
PSISD1	=	-106.9	DEG/SEC	PSISD2	=	-22.4	DEG/SEC

RELATIVE VELOCITY DATA

	VEHICLE # 1	VEHICLE # 2
SPEED CHANGE (TRAJ. + DAMAGE)	28.2 MPH	20.0 MPH
	3.1 DEG	-13.1 DEG
SPEED CHANGE (DAMAGE ONLY)	28.2 MPH	19.6 MPH
	5.0 DEG	-5.0 DEG
IMPACT SPEED	19.8 MPH	30.2 MPH
ENERGY DISSIPATED BY DAMAGE	82653.4 FT-LB	59968.1 FT-LB
SPEED ALONG LINE THRU CGS	19.7 MPH	29.3 MPH
SPEED ORTHOG. TO CG LINE	1.8 MPH	7.5 MPH
CLOSING VELOCITY	49.0 MPH	

SUMMARY OF DAMAGE DATA (* INDICATES DEFAULT VALUE)

VEHICLE # 1			VEHICLE # 2		
TYPE----------	SUBCOMPACT		TYPE----------	INTERMEDIATE	
WEIGHT-------	3130.0 LBS.		WEIGHT-------	4512.0 LBS.	
VDI-----------	12FDEW4		VDI-----------	12FYEW4	
L------------	32.0 IN.		L------------	28.3 IN.	
C1-----------	38.6 IN.		C1-----------	39.5 IN.	
C2-----------	34.6 IN.		C2-----------	33.0 IN.	
C3-----------	29.5 IN.		C3-----------	28.8 IN.	
C4-----------	26.0 IN.		C4-----------	23.8 IN.	
C5-----------	19.6 IN.		C5-----------	19.2 IN.	
C6-----------	14.3 IN.		C6-----------	15.0 IN.	
D------------	.4 IN.		D------------	-12.7 IN.	
RHO----------	1.00	*	RHO----------	1.00	*
ANG----------	5.0 DEG.		ANG----------	355.0 DEG.	

DIMENSIONS AND INERTIAL PROPERTIES

A1	= 46.3 INCHES	A2	= 54.7 INCHES
B1	= 50.1 INCHES	B2	= 59.2 INCHES
TR1	= 54.6 INCHES	TR2	= 61.8 INCHES
I1	= 23904.3 LB-SEC**2-IN	I2	= 43683.7 LB-SEC**2-IN
M1	= 8.100 LB-SEC**2/IN	M2	= 11.677 L
XF1	= 83.3 INCHES	XF2	= 98.8 INCHES
XR1	= -91.6 INCHES	XR2	= -114.0 INCHES
YS1	= 33.6 INCHES	YS2	= 38.5 INCHES

ROLLING RESISTANCE

VEHICLE # 1		VEHICLE # 2	
RF-----------	.01	RF-----------	.01
LF-----------	.01	LF-----------	.01
RR-----------	.20	RR-----------	.20
LR-----------	.20	LR-----------	.20

MU----------- .87

1. TITLE?
?TEST # 3 TORINO VS PINTO

2. SIZE CATEGORIES?
?I S

3. VDI, #1
?12FZEN1

4. VDI, #2
?06BZEN1

5. ACTUAL WEIGHTS? (Y OR N)
?Y

6. WEIGHT #1
?4949

7. WEIGHT #2
?3120

8. REST & IMPACT? (Y OR N)
?Y

9. REST COORDINATES?
?111.4 2. -4. 161.5 6.4 -19.

10. IMPACT COORDINATES?
?0. 0. 0. 15. 2.2 10.

11. SKIDDING OF # 1? (Y OR N)
?N

14. CURVED PATH? (Y OR N)
?N

16. ROTATION DIRECTION #1?
?N

17. MORE THAN 360 DEG? (Y OR N)
?N

18. SKIDDING OF # 2? (Y OR N)
?N

21. CURVED PATH? (Y OR N)
?N

23. ROTATION DIRECTION # 2?
?N

24. MORE THAN 360 DEG? (Y OR N)
?N

25. TIRE-GROUND FRICTION?
?.87

26. ROLLING RESISTANCE OPTION?(1 OR 2)
?1

27. ROLL. RESISTANCES, INDIV. WHEELS # 1
?.01 .01 .09 .09

28. ROLL. RESISTANCES, INDIV. WHEELS # 2
?.01 .01 .1 .1

31. TRAJECTORY SIMULATION? (Y OR N)
?N

37. DAMAGE DIMENSIONS? (Y OR N)
?Y

41. END DAMAGE WIDTH #1
?30.

42. END DAMAGE DEPTH #1
?2. 2. 1.5 1.75 2. 2.25

43. END DAMAGE MIDPOINT OFFSET #1
?22.

47. END DAMAGE WIDTH #2
?30.

48. END DAMAGE DEPTH #2
?6.5 6.75 5.75 5. 3.75 3.

49. END DAMAGE MIDPOINT OFFSET #2
?5.

52. FORCE DIRECTIONS (Y OR N)
?Y

53. PRINCIPAL FORCE ANGLE #1?
?0.

54. PRINCIPAL FORCE ANGLE #2?
?170.

SUMMARY OF CRASH RESULTS

TEST # 3 TORINO VS PINTO

	VEHICLE # 1	VEHICLE # 2
SPEED CHANGE (TRAJ. + DAMAGE)	3.1 MPH	5.4 MPH
	-3.9 DEG	154.7 DEG
SPEED CHANGE (DAMAGE ONLY)	3.1 MPH	4.9 MPH
	.0 DEG	170.0 DEG
IMPACT SPEED	15.2 MPH	10.4 MPH
ENERGY DISSIPATED BY DAMAGE	2685.4 FT-LB	1795.2 FT-LB
SPEED ALONG LINE THRU CGS	15.1 MPH	-10.4 MPH
SPEED ORTHOG. TO CG LINE	-2.1 MPH	-.4 MPH
CLOSING VELOCITY	4.6 MPH	

SUMMARY OF CRASH RESULTS

TEST # 3 TORINO VS PINTO

VEHICLE # 1

IMPACT SPEED MPH	SPEED CHANGE MPH TOTAL	LONG.	LATERAL	BASIS OF RESULTS
				SPINOUT TRAJECTORIES AND CONSERVATION OF LINEAR MOMENTUM
15.2	3.1	-3.1	.2	SPINOUT TRAJECTORIES AND DAMAGE
	3.1	-3.1	0.0	DAMAGE DATA ONLY

VEHICLE # 2

IMPACT SPEED MPH	SPEED CHANGE MPH TOTAL	LONG.	LATERAL	BASIS OF RESULTS
				SPINOUT TRAJECTORIES AND CONSERVATION OF LINEAR MOMENTUM
10.4	5.4	4.9	-2.3	SPINOUT TRAJECTORIES AND DAMAGE
	4.9	4.9	-.9	DAMAGE DATA ONLY

SCENE INFORMATION

	VEHICLE # 1		VEHICLE # 2	
IMPACT X-POSITION	-.81	FT.	14.48	FT.
IMPACT Y-POSITION	0.00	FT.	2.11	FT.
IMPACT HEADING ANGLE	0.00	DEG.	10.00	DEG.
REST X-POSITION	111.40	FT.	181.50	FT.
REST Y-POSITION	2.00	FT.	6.40	FT.
REST HEADING ANGLE	-4.00	DEG.	-19.00	DEG.
END-OF-ROTATION X-POSITION	-.81	FT.	14.48	FT.
END-OF-ROTATION Y-POSITION	0.00	FT.	2.11	FT.
END-OF-ROTATION HEADING ANGLE	0.00	DEG.	10.00	DEG.
DIRECTION OF ROTATION	NONE		NONE	
AMOUNT OF ROTATION	<360		<360	

COLLISION CONDITIONS

VEHICLE # 1			VEHICLE # 2		
XC10'	=	-.8 FT.	XC20'	=	14.5 FT.
YC10'	=	0.0 FT.	YC20'	=	2.1 FT.
PSI10	=	0.0 DEGREES	PSI20	=	10.0 DEGREES
PSI1D0	=	0.0 DEG/SEC	PSI2D0	=	0.0 DEG/SEC
U10	=	15.2 MPH	U20	=	10.4 MPH
V10	=	0.0 MPH	V20	=	0.0 MPH

SEPARATION CONDITIONS

XCS1	=	-.8 FT.	XCS2	=	14.5 FT.
YCS1	=	0.0 FT.	YCS2	=	2.1 FT.
PSIS1	=	0.0 DEG	PSIS2	=	10.0 DEG
US1	=	12.1 MPH	US2	=	15.3 MPH
VS1	=	.2 MPH	VS2	=	-2.3 MPH
PSISD1	=	0.0 DEG/SEC	PSISD2	=	0.0 DEG/SEC

RELATIVE VELOCITY DATA

	VEHICLE # 1	VEHICLE # 2
SPEED CHANGE (TRAJ. + DAMAGE)	3.1 MPH	5.4 MPH
	-3.9 DEG	154.7 DEG
SPEED CHANGE (DAMAGE ONLY)	3.1 MPH	4.9 MPH
	.0 DEG	170.0 DEG
IMPACT SPEED	15.2 MPH	10.4 MPH
ENERGY DISSIPATED BY DAMAGE	2685.4 FT-LB	1795.2 FT-LB
SPEED ALONG LINE THRU CGS	15.1 MPH	-10.4 MPH
SPEED ORTHOG. TO CG LINE	-2.1 MPH	-.4 MPH
CLOSING VELOCITY	4.6 MPH	

SUMMARY OF DAMAGE DATA (* INDICATES DEFAULT VALUE)

VEHICLE # 1			VEHICLE # 2		
TYPE---------	INTERMEDIATE		TYPE---------	SUBCOMPACT	
WEIGHT------	4949.0 LBS.		WEIGHT------	3120.0 LBS.	
VDI---------	12FZEW1		VDI---------	00BZEW1	
L-----------	30.0 IN.		L-----------	30.0 IN.	
C1----------	2.0 IN.		C1----------	6.5 IN.	
C2----------	2.0 IN.		C2----------	6.8 IN.	
C3----------	1.5 IN.		C3----------	5.8 IN.	
C4----------	1.8 IN.		C4----------	5.0 IN.	
C5----------	2.0 IN.		C5----------	3.8 IN.	
C6----------	2.3 IN.		C6----------	3.0 IN.	
D-----------	22.3 IN.		D-----------	3.0 IN.	
RHO---------	1.00	*	RHO---------	1.00	*
ANG---------	0.0 DEG.		ANG---------	170.0 DEG.	

DIMENSIONS AND INERTIAL PROPERTIES

A1	=	54.7 INCHES	A2	=	46.3 INCHES
B1	=	59.2 INCHES	B2	=	50.1 INCHES
TR1	=	61.8 INCHES	TR2	=	54.6 INCHES
I1	=	47914.6 LB-SEC**2-IN	I2	=	23628.0 LB-SEC**2-IN
M1	=	12.808 LB-SEC**2/IN	M2	=	8.075 LB-SEC**2/IN
XF1	=	98.8 INCHES	XF2	=	83.3 INCHES
XR1	=	-114.0 INCHES	XR2	=	-91.6 INCHES
YS1	=	38.5 INCHES	YS2	=	33.6 INCHES

ROLLING RESISTANCE

VEHICLE # 1		VEHICLE # 2	
RF----------	.01	RF----------	.01
LF----------	.01	LF----------	.01
RR----------	.09	RR----------	.10
LR----------	.09	LR----------	.10

MU---------- .87

1. TITLE?
?TEST # 4 TORINO VS PINTO

2. SIZE CATEGORIES?
?I S

3. VDI, #1
?12FZEW3

4. VDI, #2
?05BYEW5

5. ACTUAL WEIGHTS? (Y OR N)
?Y

6. WEIGHT #1
?4980

7. WEIGHT #2
?3190

8. REST & IMPACT? (Y OR N)
?Y

9. REST COORDINATES?
?42.8 54.5 137.5 63.9 62.5 88.

10. IMPACT COORDINATES?
?0. 0. 1. 16.4 3.4 10.

11. SKIDDING OF # 1? (Y OR N)
?Y

12. SKIDDING STOP BEFORE REST? (Y OR N)
?Y

13. END OF SKIDDING COORDINATES?
?20. 5. 10.

14. CURVED PATH? (Y OR N)
?N

16. ROTATION DIRECTION #1?
?CW

17. MORE THAN 360 DEG? (Y OR N)
?N

18. SKIDDING OF # 2? (Y OR N)
?Y

19. SKIDDING STOP BEFORE REST? (Y OR N)
?Y

20. END OF SKIDDING COORDINATES?
?35. 2. 10.

21. CURVED PATH? (Y OR N)
?N

23. ROTATION DIRECTION # 2?
?CW

24. MORE THAN 360 DEG? (Y OR N)
?N

25. TIRE-GROUND FRICTION?
?.57

26. ROLLING RESISTANCE OPTION?(1 OR 2)
?1

27. ROLL. RESISTANCES, INDIV. WHEELS # 1
?.01 .01 .2 .2

28. ROLL. RESISTANCES, INDIV. WHEELS # 2
?.01 .01 .2 .2

31. TRAJECTORY SIMULATION? (Y OR N)
?N

37. DAMAGE DIMENSIONS? (Y OR N)
?Y

41. END DAMAGE WIDTH #1
?41.5

42. END DAMAGE DEPTH #1
?6.3 7.8 9.8 12.5 14.8 18.3

43. END DAMAGE MIDPOINT OFFSET #1
?16.1

47. END DAMAGE WIDTH #2
?41.8

48. END DAMAGE DEPTH #2
?38. 31.5 29. 24. 19.5 14.8

49. END DAMAGE MIDPOINT OFFSET #2
?-9.1

52. FORCE DIRECTIONS (Y OR N)
?N

SUMMARY OF CRASH RESULTS

TEST # 4 TORINO VS PINTO

	VEHICLE # 1	VEHICLE # 2
SPEED CHANGE (TRAJ. + DAMAGE)	10.3 MPH	13.0 MPH
	-28.4 DEG	160.4 DEG
SPEED CHANGE (DAMAGE ONLY)	9.1 MPH	14.1 MPH
	.0 DEG	150.0 DEG
IMPACT SPEED	31.9 MPH	4.9 MPH
ENERGY DISSIPATED BY DAMAGE	23465.1 FT-LB	30481.1 FT-LB
SPEED ALONG LINE THRU CGS	31.3 MPH	-4.9 MPH
SPEED ORTHOG. TO CG LINE	-5.9 MPH	.1 MPH
CLOSING VELOCITY	26.4 MPH	

SUMMARY OF CRASH RESULTS

TEST # 4 TORINO VS PINTO

VEHICLE # 1

IMPACT SPEED MPH	SPEED CHANGE MPH TOTAL	LONG.	LATERAL	BASIS OF RESULTS
				SPINOUT TRAJECTORIES AND CONSERVATION OF LINEAR MOMENTUM
31.9	10.3	-9.1	4.9	SPINOUT TRAJECTORIES AND DAMAGE
	9.1	-9.1	.0	DAMAGE DATA ONLY

VEHICLE # 2

IMPACT SPEED MPH	SPEED CHANGE MPH TOTAL	LONG.	LATERAL	BASIS OF RESULTS
				SPINOUT TRAJECTORIES AND CONSERVATION OF LINEAR MOMENTUM
4.9	13.0	12.2	-4.4	SPINOUT TRAJECTORIES AND DAMAGE
	14.1	12.2	-7.1	DAMAGE DATA ONLY

SCENE INFORMATION

	VEHICLE # 1		VEHICLE # 2	
IMPACT X-POSITION	0.00	FT.	16.40	FT.
IMPACT Y-POSITION	0.00	FT.	3.40	FT.
IMPACT HEADING ANGLE	1.00	DEG.	10.00	DEG.
REST X-POSITION	42.80	FT.	63.90	FT.
REST Y-POSITION	54.50	FT.	62.50	FT.
REST HEADING ANGLE	137.48	DEG.	87.99	DEG.
END-OF-ROTATION X-POSITION	20.00	FT.	35.00	FT.
END-OF-ROTATION Y-POSITION	5.00	FT.	2.00	FT.
END-OF-ROTATION HEADING ANGLE	10.00	DEG.	10.00	DEG.
DIRECTION OF ROTATION	CW		CW	
AMOUNT OF ROTATION	<360		<360	

COLLISION CONDITIONS

VEHICLE # 1				VEHICLE # 2			
XC10'	=	0.0	FT.	XC20'	=	16.4	FT.
YC10'	=	0.0	FT.	YC20'	=	3.4	FT.
PSI10	=	1.0	DEGREES	PSI20	=	10.0	DEGREES
PSI1D0	=	0.0	DEG/SEC	PSI2D0	=	0.0	DEG/SEC
U10	=	31.9	MPH	U20	=	4.9	MPH
V10	=	0.0	MPH	V20	=	0.0	MPH

SEPARATION CONDITIONS

XCS1	=	0.0	FT.	XCS2	=	16.4	FT.
YCS1	=	0.0	FT.	YCS2	=	3.4	FT.
PSIS1	=	1.0	DEG	PSIS2	=	10.0	DEG
US1	=	22.8	MPH	US2	=	17.1	MPH
VS1	=	4.9	MPH	VS2	=	-4.4	MPH
PSISD1	=	18.2	DEG/SEC	PSISD2	=	0.0	DEG/SEC

RELATIVE VELOCITY DATA

	VEHICLE # 1		VEHICLE # 2	
SPEED CHANGE (TRAJ. + DAMAGE)	10.3	MPH	13.0	MPH
	-28.4	DEG	160.4	DEG
SPEED CHANGE (DAMAGE ONLY)	9.1	MPH	14.1	MPH
	.0	DEG	150.0	DEG
IMPACT SPEED	31.9	MPH	4.9	MPH
ENERGY DISSIPATED BY DAMAGE	23465.1	FT-LB	30481.1	FT-LB
SPEED ALONG LINE THRU CGS	31.3	MPH	-4.9	MPH
SPEED ORTHOG. TO CG LINE	-5.9	MPH	.1	MPH
CLOSING VELOCITY	26.4	MPH		

SUMMARY OF DAMAGE DATA

(* INDICATES DEFAULT VALUE)

	VEHICLE # 1		VEHICLE # 2
TYPE	INTERMEDIATE	TYPE	SUBCOMPACT
WEIGHT	4980.0 LBS.	WEIGHT	3190.0 LBS.
VDI	12FZEW3	VDI	05BYEW5
L	41.5 IN.	L	41.8 IN.
C1	6.3 IN.	C1	36.0 IN.
C2	7.8 IN.	C2	31.8 IN.
C3	9.8 IN.	C3	29.0 IN.
C4	12.5 IN.	C4	24.0 IN.
C5	14.8 IN.	C5	19.5 IN.
C6	18.3 IN.	C6	14.6 IN.
D	19.7 IN.	D	-11.9 IN.
RHO	1.00 *	RHO	1.00 *
ANG	360.0 DEG. *	ANG	150.0 DEG. *

DIMENSIONS AND INERTIAL PROPERTIES

A1	= 54.7 INCHES	A2	= 46.3 INCHES
B1	= 59.2 INCHES	B2	= 50.1 INCHES
TR1	= 61.6 INCHES	TR2	= 54.6 INCHES
I1	= 48214.8 LB-SEC**2-IN	I2	= 24362.6 LB-SEC**2-IN
M1	= 12.888 LB-SEC**2/IN	M2	= 8.256 LB-SEC**2/IN
XF1	= 96.8 INCHES	XF2	= 83.3 INCHES
XR1	= -114.0 INCHES	XR2	= -91.6 INCHES
YS1	= 38.5 INCHES	YS2	= 33.6 INCHES

ROLLING RESISTANCE

	VEHICLE # 1		VEHICLE # 2
RF	.01	RF	.01
LF	.01	LF	.01
RR	.20	RR	.20
LR	.20	LR	.20

MU ---------- .87

```
?TEST # 5 TORINO VS CIVIC

 2. SIZE CATEGORIES?
?I M

 3. VDI, #1
?12FZEW1

 4. VDI, #2
?05BDEW8

 5. ACTUAL WEIGHTS? (Y OR N)
?Y

 6. WEIGHT #1
?4000

 7. WEIGHT #2
?2530

 8. REST & IMPACT? (Y OR N)
?Y

 9. REST COORDINATES?
?241.6 0. 3. 56.9 39. 262.

 10. IMPACT COORDINATES?
?0. 0. 0. 14.9 3.4 10.

 11. SKIDDING OF # 1? (Y OR N)
?N

 14. CURVED PATH? (Y OR N)
?N

 16. ROTATION DIRECTION #1?
?CW

 17. MORE THAN 360 DEG? (Y OR N)
?N

 18. SKIDDING OF # 2? (Y OR N)
?Y

 19. SKIDDING STOP BEFORE REST? (Y OR N)
?Y

 20. END OF SKIDDING COORDINATES?
?55. 25. 260.

 21. CURVED PATH? (Y OR N)
?Y
```

22. POINT ON CURVE?
?40. 10.

~~23. ROTATION DIRECTION # 2?~~
?CW

24. MORE THAN 360 DEG? (Y OR N)
?N

~~25. TIRE-GROUND FRICTION?~~
?.87

26. ROLLING RESISTANCE OPTION?(1 OR 2)
?1

27. ROLL. RESISTANCES, INDIV. WHEELS # 1
?.01 .01 .2 .2

~~28. ROLL. RESISTANCES, INDIV. WHEELS # 2~~
?.2 .2 .01 1.

31. TRAJECTORY SIMULATION? (Y OR N)
?N

~~37. DAMAGE DIMENSIONS? (Y OR N)~~
?Y

41. END DAMAGE WIDTH #1
?33.5

~~42. END DAMAGE DEPTH #1~~
?1.4 1.4 2. 2.1 2.3 2.9

43. END DAMAGE MIDPOINT OFFSET #1
?20.3

~~47. END DAMAGE WIDTH #2~~
?53.

48. END DAMAGE DEPTH #2
~~?30. 30.5 31.5 23. 13.3 6.~~

~~49. END DAMAGE MIDPOINT OFFSET #2~~
?-1.6

52. FORCE DIRECTIONS (Y OR N)
?Y

53. PRINCIPAL FORCE ANGLE #1?
?0.

54. PRINCIPAL FORCE ANGLE #2?
?170.

SUMMARY OF CRASH RESULTS

TEST # 5 TORINO VS CIVIC

	VEHICLE # 1	VEHICLE # 2
SPEED CHANGE (TRAJ. + DAMAGE)	8.1 MPH	15.2 MPH
	.0 DEG	162.9 DEG
SPEED CHANGE (DAMAGE ONLY)	8.1 MPH	14.8 MPH
	.0 DEG	170.0 DEG
IMPACT SPEED	33.8 MPH	10.5 MPH
ENERGY DISSIPATED BY DAMAGE	3114.8 FT-LB	30255.6 FT-LB
SPEED ALONG LINE THRU CGS	33.0 MPH	-10.5 MPH
SPEED ORTHOG. TO CG LINE	-7.5 MPH	.5 MPH
CLOSING VELOCITY	22.5 MPH	

SUMMARY OF CRASH RESULTS

TEST # 5 TORINO VS CIVIC

VEHICLE # 1

IMPACT SPEED MPH	SPEED CHANGE MPH TOTAL	SPEED CHANGE MPH LONG.	SPEED CHANGE MPH LATERAL	BASIS OF RESULTS
				SPINOUT TRAJECTORIES AND CONSERVATION OF LINEAR MOMENTUM
33.8	8.1	-8.1	0.0	SPINOUT TRAJECTORIES AND DAMAGE
	8.1	-8.1	0.0	DAMAGE DATA ONLY

VEHICLE # 2

IMPACT SPEED MPH	SPEED CHANGE MPH TOTAL	SPEED CHANGE MPH LONG.	SPEED CHANGE MPH LATERAL	BASIS OF RESULTS
				SPINOUT TRAJECTORIES AND CONSERVATION OF LINEAR MOMENTUM
10.5	15.2	14.5	-4.5	SPINOUT TRAJECTORIES AND DAMAGE
	14.8	14.5	-2.8	DAMAGE DATA ONLY

SCENE INFORMATION

	VEHICLE # 1		VEHICLE # 2	
IMPACT X-POSITION	0.00	FT.	14.90	FT.
IMPACT Y-POSITION	0.00	FT.	3.40	FT.
IMPACT HEADING ANGLE	0.00	DEG.	10.00	DEG.
REST X-POSITION	241.00	FT.	56.90	FT.
REST Y-POSITION	0.00	FT.	39.00	FT.
REST HEADING ANGLE	3.00	DEG.	281.97	DEG.
END-OF-ROTATION X-POSITION	0.00	FT.	55.00	FT.
END-OF-ROTATION Y-POSITION	0.00	FT.	23.00	FT.
END-OF-ROTATION HEADING ANGLE	0.00	DEG.	259.97	DEG.
POINT-ON-CURVE X-POSITION			40.00	FT.
POINT-ON-CURVE Y-POSITION			10.00	FT.
DIRECTION OF ROTATION	CW		CW	
AMOUNT OF ROTATION	<360		<360	

COLLISION CONDITIONS

VEHICLE # 1			VEHICLE # 2		
XC10'	=	0.0 FT.	XC20'	=	14.9 FT.
YC10'	=	0.0 FT.	YC20'	=	3.4 FT.
PSI10	=	0.0 DEGREES	PSI20	=	10.0 DEGREES
PSI1D0	=	0.0 DEG/SEC	PSI2D0	=	0.0 DEG/SEC
U10	=	33.8 MPH	U20	=	10.5 MPH
V10	=	0.0 MPH	V20	=	0.0 MPH

SEPARATION CONDITIONS

XCS1	=	0.0 FT.	XCS2	=	14.9 FT.
YCS1	=	0.0 FT.	YCS2	=	3.4 FT.
PSIS1	=	0.0 DEG	PSIS2	=	10.0 DEG
US1	=	25.7 MPH	US2	=	25.1 MPH
VS1	=	0.0 MPH	VS2	=	-4.5 MPH
PSISD1	=	0.0 DEG/SEC	PSISD2	=	300.5 DEG/SEC

RELATIVE VELOCITY DATA

	VEHICLE # 1	VEHICLE # 2
SPEED CHANGE (TRAJ. + DAMAGE)	8.1 MPH	15.2 MPH
	.0 DEG	162.9 DEG
SPEED CHANGE (DAMAGE ONLY)	8.1 MPH	14.8 MPH
	.0 DEG	170.0 DEG
IMPACT SPEED	33.8 MPH	10.5 MPH
ENERGY DISSIPATED BY DAMAGE	3114.8 FT-LB	30255.6 FT-LB
SPEED ALONG LINE THRU CGS	33.0 MPH	-10.5 MPH
SPEED ORTHOG. TO CG LINE	-7.5 MPH	.5 MPH
CLOSING VELOCITY	22.5 MPH	

SUMMARY OF DAMAGE DATA (* INDICATES DEFAULT VALUE)

VEHICLE # 1		VEHICLE # 2	
TYPE	INTERMEDIATE	TYPE	MINICAR
WEIGHT	4600.0 LBS.	WEIGHT	2530.0 LBS.
VDI	12FZEW1	VDI	05BDEW8
L	33.5 IN.	L	53.0 IN.
C1	1.4 IN.	C1	36.0 IN.
C2	1.4 IN.	C2	36.5 IN.
C3	2.0 IN.	C3	31.5 IN.
C4	2.1 IN.	C4	23.0 IN.
C5	2.3 IN.	C5	13.3 IN.
C6	2.9 IN.	C6	6.0 IN.
D	22.3 IN.	D	-7.7 IN.
RHO	1.00 *	RHO	1.00 *
ANG	0.0 DEG.	ANG	170.0 DEG.

DIMENSIONS AND INERTIAL PROPERTIES

A1	= 54.7 INCHES	A2	= 45.1 INCHES
B1	= 59.2 INCHES	B2	= 48.1 INCHES
TR1	= 61.8 INCHES	TR2	= 51.1 INCHES
I1	= 44535.7 LB-SEC**2-IN	I2	= 13134.5 LB-SEC**2-IN
M1	= 11.905 LB-SEC**2/IN	M2	= 6.548 LB-SEC**2/IN
XF1	= 98.8 INCHES	XF2	= 76.0 INCHES
XR1	= -114.0 INCHES	XR2	= -83.8 INCHES
YS1	= 38.5 INCHES	YS2	= 30.4 INCHES

ROLLING RESISTANCE

VEHICLE # 1		VEHICLE # 2	
RF	.01	RF	.20
LF	.01	LF	.20
RR	.20	RR	.01
LR	.20	LR	1.00

MU .87

APPENDIX III

SMAC INPUT DECKS

```
SIMULATION MODEL OF AUTOMOBILE COLLISIONS
*RICSAC TEST #1 *
0.0       4.0       0.01      0.001     0.01      0.001     30.0      5.0       2.0           1
-187.8    124.5     -30.0     0.0       357.26    0.0                                         2
0.0       -65.8     90.0      0.0       357.28    0.0                                         3
50.89     65.11     61.1      45319.    12.034    0.0       90.99     -118.31   38.3          4
45.69     48.51     55.4      23676.    8.023     0.0       83.19     -85.81    34.7          5
-12338.   -12338.   -10991.   -10991.                                                         6
-7547.    -7547.    -7108.    -7108.                                                        7
0.0       0.30      0.10      0.0                                                           8
-22.3        -22.3        -22.3        -22.3
-22.3        -22.3        -22.3        -22.3
-300.        -300.        -300.        -300.
-300.        -300.        -300.        -300.
0.0       0.30      0.10      0.0                                                           9
-15.55       -15.55       -15.55       -15.55
-15.55       -15.55       -15.55       -15.55
-400.        -400.        -400.        -400.
-400.        -400.        -400.        -400.
0.0       0.30      0.10      1.0                                                           10
0.0       0.30      0.10      1.0                                                           11
-500.     500.      500.      500.      0.67      0.67      0.0                               12
2.0       0.2       15.0      5.0       50.       50.       1.50                              13
0.04600 1.7547-31.6711-5                                                                    14
                                                                                          9999
```

```
SIMULATION MODEL OF AUTOMOBILE COLLISIONS
+ RICSAC  TEST #2  CHEVELLE-PINTO 31.5MPH
0.0       4.0       0.01      0.001     0.01      0.001     3[illegible].0      5.0       2.0            1
-187.8    124.5     -30.0     0.0       565.0     0.0                                                2
0.0       -65.8     90.0      0.0       565.0     0.0                                                3
52.45     63.55     61.1      45019.    12.034    0.0       92.45     -116.05 38.3                   4
46.75     47.45     55.4      23676.    8.023     0.0       8[illegible].75     -84.45    34.7                 5
-12338.   -12338.   -10991.   -10991.                                                                6
-7547.    -7547.    -7508.    -7508.                                                                 7
0.0       0.30      0.10      0.0                                                                    8
-22.3       -300.       -800.       -800.
-22.3       -22.3       -22.3       -22.3
-270.0      -270.0      -270.0      -270.0
-270.0      -270.0      -270.0      -270.0
0.0       0.30      0.10      0.0                                                                    9
-15.55      -700.0      -700.0      -700.0
-15.55      -15.55      -15.55      -15.55
-270.0      -270.0      -270.0      -270.0
-270.0      -270.0      -270.0      -270.0
0.0       0.30      0.10      1.0                                                                   10
0.0       0.30      0.10      1.0                                                                   11
-500.     500.      500.      500.      0.87      0.87      0.0                                     12
2.0       0.2       15.0      5.0       70.       30.       0.75                                    13
0.04606 1.7547-31.6711-5                                                                            14
                                                                                                  9999
```

```
SIMULATION MODEL OF AUTOMOBILE COLLISIONS
***   TEST #6 CHEVELLE VS RABBIT   ***
0.0       4.0       0.01      0.001     0.01      0.1       3 .0      5.0       2.0       00000001
0.0       0.0       0.0       0.0       377.9     0.0                                     00000002
146.      12.       120.      0.0       377.9     0.0                                     00000003
50.5      60.5      62.0      35237.    11.2      0.0       9.8       -113.7    38.3      00000004
40.3      54.6      56.0      15616.    6.83      0.0       6.3       -38.67    30.5      00000005
-11110.   -11110.   -9266.    -9266.                                                    00000006
-7186.    -7186.    -5295.    -5295.                                                    00000007
0.0       0.3       0.1       0.0                                                       00000008
-12.           -12.           -12.           -12.
-12.           -12.           -12.           -12.
-196.          -196.          -196.          -196.
-196.          -196.          -196.          -196.
0.0       0.3       0.1       0.0                                                       00000009
-150.          -150.          -150.          -150.
-150.          -150.          -150.          -150.
-11.           -11.           -11.           -11.
-11.           -11.           -11.           -11.
0.0       .9        .1                                                                        10
0.0            0.0            -1.5           -3.0           -3.0           -3.0           -1.5           0.0
0.0            0.0            0.0
0.0            0.0            -1.5           -3.0           -3.0           -3.0           -1.
0.0            0.0            0.0
0.0       0.3       0.1       1.0                                                       00000011
-500.0    500.0     500.0     500.0     .87       .87       0.0                           00000012
2.0       0.2       15.       5.0       70.       30.       0.7                           00000013
0.04606 1.7547-31.6711-5                                                                00000014
                                                                                            9999
```

```
SIMULATION MODEL OF AUTOMOBILE COLLISIONS
***   TEST #7 CHEVELLE VS RABBIT   ***
0.0      4.0      0.01     0.001    0.01     0.1      30.0     5.0      2.0         0000001
0.0      0.0      0.0      0.0      512.2    0.0                                   0000002
148.0    9.0      1.0.     0.0      512.2    0.0                                   0000003
50.5     60.5     62.0     40050.   11.2     0.0      54.6     -113.7   38.3       0000004
39.7     55.3     56.0     15610.   0.75     0.0      0 .86    -90.44   30.5       0000005
-11109. -11109. -2205.   -2205.                                                    0000006
-7185.   -7185.   -5153.   -5153.                                                  0000007
0.0      0.3      0.1      0.0                                                     0000008
-12.        -12.        -12.        -12.
-12.        -12.        -12.        -12.
-196.       -196.       -196.       -196.
-196.       -196.       -196.       -196.
0.0      0.3      0.1      0.0                                                     0000009
-110.       -110.       -110.       -110.
-110.       -110.       -110.       -110.
-8.         -8.         -600.       -600.
-8.         -8.         -8.         -8.
0.0      0.3      0.1      1.0                                                     00000010
0.0      0.3      0.1      1.0                                                     00000011
-500.0   500.0    500.0    500.0    .67      .67      0.0                          00000012
2.0      0.5      20.0     5.0      70.      50.      0.3                          00000013
0.04000 1.7547-31.6711-5                                                           00000014
                                                                                      9999
```

```
SIMULATION MODEL OF AUTOMOBILE COLLISIONS (SMAC)
TEST #8    MALIBU VS.MALIBU
0.0       4.0       0.01      0.001     0.01      0.1       30.0      5.0       2.0            1
-133.1    26.5      0.0       0.0       365.2     0.0                                          2
0.0       0.0       90.0      0.0       365.2     0.0                                          3
50.5      60.5      62.0      47654.    11.59     0.0       94.8      -113.7    38.3           4
50.5      60.5      62.0      50121.    12.19     0.0       94.8      -113.7    38.3           5
-11062.4-11062.4-10116.8-10116.8                                                             6
-12007.8-10589.6-11156.9-10778.7                                                             7
0.0       0.3       0.1       0.0                                                            8
-12.0        -12.0        -12.0        -12.0
-12.0        -12.0        -12.0        -12.0
-300.        -300.        -300.        -300.
-300.        -300.        -300.        -300.
0.0       0.3       0.1       0.0                                                            9
-12.0        -12.0        -12.0        -12.0
-12.0        -12.0        -12.0        -12.0
-300.        -300.        -300.        -300.
-300.        -300.        -300.        -300.
0.0       1.8       0.1       0.0                                                            10
0.0          0.0          2.0          1.0          -1.0         0.0          -1.0
1.0          2.0          2.0          3.0          4.0          6.0          7.5
9.0          10.5         11.0         11.0         11.0
0.0          0.0          2.0          1.0          -1.0         0.0          -1.0
1.0          2.0          2.0          3.0          4.0          6.0          7.5
9.0          10.5         11.0         11.0         11.0
0.0       1.5       0.1       0.0                                                            11
0.0          8.0          11.0         11.0         11.0         16.0         18.0
16.0         11.0         10.0         11.0         12.0         13.0         12.0
12.0         12.0
0.0          8.0          11.0         11.0         11.0         16.0         18.0
16.0         11.0         10.0         11.0         12.0         13.0         12.0
12.0         12.0
1100.     -1100.0   -1100.0   -1100.0   0.87      0.87      0.0                                12
2.0       0.3       20.0      5.0       80.0      60.00     1.00                               13
0.04606 1.7547-31.6711-5                                                                     14
                                                                                           9999
```

SIMULATION MODEL OF AUTOMOBILE COLLISIONS

*** TEST #9 HONDA VS TORINO 90 DEG FRONT/SIDE 21.2/21.2MPH

0.0	5.0	0.01	0.001	0.01	0.100	30.0	5.0	2.0	00000001
0.0	0.0	0.0	0.0	373.1	0.0				00000002
102.33	-64.69	90.0	0.0	373.1	0.0				00000003
37.17	49.83	50.8	12281.	5.875	0.0	62.77	-84.13	29.6	00000004
54.56	63.94	63.45	58000.	12.76	0.0	100.29	-117.5	39.65	00000005
-5959.	-5959.	-4446.	-4446.						00000006
-12193.	-12193.	-10406.	-10406.						00000007
0.0	0.3	0.1	0.0						00000008
-200.	-200.	-200.	-200.						
-200.	-200.	-200.	-200.						
-7.	-7.	-7.	-7.						
-7.	-7.	-7.	-7.						
0.0	0.8	0.1	0.0						00000009
-1400.	-1400.	-1400.	-280.	-280.	-280.	-14.			
-14.	-14.								
-14.	-14.	-14.	-14.	-14.	-14.	-14.			
-14.	-14.								
-175.	-175.	-175.	-175.	-175.	-175.	-175.			
-175.	-175.								
-175.	-175.	-175.	-175.	-175.	-175.	-175.			
-175.	-175.								
0.0	1.5	0.1	0.0						00000010
0.0	4.0	-1.0	-2.0	-2.0	0.0	2.0			
2.0	0.0	1.0	4.0	10.0	12.0	8.0			
8.0	8.0								
0.0	4.0	-1.0	-2.0	-2.0	0.0	2.0			
2.0	0.0	1.0	4.0	10.0	12.0	8.0			
3.0	8.0								
0.0	1.8	0.1	0.0						00000011
0.0	8.0	4.0	12.0	12.0	8.0	6.0			
6.0	6.0	6.0	8.0	8.0	8.0	8.0			
11.0	13.0	16.0	16.0	16.0					
0.0	8.0	4.0	12.0	12.0	8.0	6.0			
6.0	6.0	6.0	8.0	8.0	8.0	8.0			
11.0	13.0	16.0	16.0	16.0					
-500.0	500.0	500.0	500.0	.87	.87	0.0			00000012
2.0	0.2	15.	5.0	60.0	50.0	0.7			00000013
0.04000	1.7547-31.6711-5								00000014
									9999

```
SIMULATION MODEL OF AUTOMOBILE COLLISIONS
***    TEST #10   HONDA VS  TORINO  90 DEG  FRONT/SIDE  33.3/33.3MPH
0.0        3.92       0.01       0.001      0.01       0.100      30.0       5.0        2.0          00000001
0.0        0.0        0.0        0.0        586.1      0.0                                          00000002
101.05     -72.2      90.0       0.0        536.1      0.0                                          00000003
36.37      50.63      50.8       10000.     6.004      0.0        61.42      -85.48     29.6         00000004
55.38      63.12      63.45      50000.     12.29      0.0        101.8      -116.0     39.65        00000005
-6168.     -6188.     -4446.     -4446.                                                             00000006
-11598.    -11598.    -10176.    -10176.                                                            00000007
0.0        1.0        0.1        0.0                                                                00000008
-1400.       -1400.       -1400.       -1400.       -275.        -275.        0
-0.0         -275.        -275.        -275.
-1400.       -1400.       -1400.       -1400.       -275.        -275.        -550.
-550.        -275.        -275.        -275.
-7.          -7.          -7.          -7.          -7.          -7.          -7.
-7.          -7.          -7.          -7.
-7.          -7.          -7.          -7.          -7.          -7.          -7.
-7.          -7.          -7.          -7.
0.0        0.8        0.1        0.0                                                                00000009
0.0          0.0          0.0          -13.         -13.         -13.         -13.
-13.         -13.
-13.         -13.         -13.         -13.         -13.         -13.         -13.
-13.         -13.
-300.        -300.        -300.        -300.        -300.        -300.        -300.
-300.        -300.
-300.        -300.        -300.        -300.        -300.        -300.        -300.
-300.        -300.
0.0        0.8        0.1        0.0                                                                00000010
0.0          4.0          4.0          -12.         -20.         -16.         -4.0
-4.0         -4.0
0.0          4.0          4.0          -12.         -20.         -16.         -4.0
-4.0         -4.0
0.0        2.0        0.1        0.0                                                                00000011
0.0          4.0          11.0         11.0         11.0         11.0         11.0
11.          11.          11.          11.          10.          9.           8.
7.           6.           5.           5.           5.           5.           5.
0.0          0.0          1.0          1.0          2.0          0.0          0.0
-1.0         -4.0         -8.0         -9.0         -8.0         -4.0         -1.0
1.0          2.0          3.0          4.0          5.0          5.0          5.0
-500.0     1125.      500.0      1125.      .87        0.55       0.0                               00000012
2.0        0.2        15.        5.0        70.0       60.0       0.55                                    13
0.04606    1.7547-31.6711-5                                                                         00000014
                                                                                                        9999
```

```
SIMULATION MODEL OF AUTOMOBILE COLLISIONS
***  TEST #11   VEGA   VS TURINO OFFSET HEAD ON 20.4/20.4MPH
0.0      4.0      0.01     0.001    0.01     0.001    30.0     5.0      2.0       00000001
188.7    -49.45   170.0    0.0      359.0    0.0                                  00000002
0.0      0.0      0.0      0.0      359.0    0.0                                  00000003
49.45    47.5     55.2     22394.   7.92     0.0      87.8     -84.4    32.7      00000004
54.4     63.6     63.45    56546.   12.63    0.0      100.4    -117.4   39.65     00000005
-6876.   -6876.   -7151.   -7151.                                                 00000006
-12056.  -12056.  -10314.  -10314.                                                00000007
0.0      0.3      0.1      0.0                                                    00000008
-16.       -16.       -16.       -16.
-16.       -16.       -16.       -16.
-285.      -285.      -285.      -285.
-285.      -285.      -285.      -285.
0.0      0.3      0.1      0.0                                                    00000009
-13.       -13.       -13.       -13.
-13.       -13.       -13.       -13.
-180.      -180.      -180.      -180.
-180.      -180.      -180.      -180.
0.0      .15      .025     0.0                                                          10
0.         0.         0.                    -3.        -6.        -6.        -6.
0.         0.         0.                    -3.        -6.        -6.        -6.
0.0      0.3      0.1      1.0                                                    00000011
-500.0   500.0    500.0    500.0    .87      .87      0.0                         00000012
2.0      0.2      15.      5.0      60.0     60.0     .7                          00000013
0.04606 1.7547-31.6711-5                                                          00000014
                                                                                      9999
```

```
SIMULATION MODEL OF AUTOMOBILE COLLISIONS
***   TEST #12   VLGA   VS  TORINO OFFSET HEAD ON 31.5/31.5MPH
0.0        4.0       0.01       0.001      0.01      0.001     30.0      5.0       2.0         00000001
187.1      -43.00    176.0      0.0        554.3     0.0                                       00000002
0.0        0.0       0.0        0.0        554.3     0.0                                       00000003
47.2       49.58     55.2       23044.     8.15      0.0       64.2      -88.0     32.7        00000004
55.62      62.38     63.45      52604.     11.75     0.0       102.7     -115.1    39.65       00000005
-7380.     -7380.    -3500.     -3500.                                                                0
-11002.    -11002.   -9810.     -9810.                                                         00000007
0.0        0.3       0.1        0.0                                                            00000008
-8.            -8.            -8.            -8.
-600.          -600.          -600.          -600.
-156.          -156.          -156.          -156.
-156.          -156.          -156.          -156.
0.0        0.3       0.1        0.0                                                            00000009
-13.           -13.           -13.           -13.
-13.           -13.           -13.           -13.
-222.          -222.          -222.          -222.
-222.          -222.          -222.          -222.
0.0            .27       0.045      0.0                                                              10
0.0            0.0            0.0            6.0          12.          12.          12.
0.0            0.0            0.0            6.0          12.          12.          12.
0.0        0.3       0.1        1.0                                                            00000011
-500.0     500.0     500.0      500.0      .87       .87       0.0                             00000012
2.0        0.2       15.        5.0        60.0      55.0      .7                              00000013
0.04606 1.7547-31.6711-5                                                                       00000014
                                                                                                   9999
```

SIMULATION MODEL OF AUTOMOBILE COLLISIONS
* RICSAC TEST #3 TORINO-PINTO 21.23MPH * RUN 15

0.0	15.0	0.025	0.001	0.01	0.5	30.0	5.0	2.0	00000001
98.0	100.0	0.0	0.0	373.64	0.0				00000002
296.53	142.33	10.0	0.0	0.0	0.0				00000003
55.65	62.32	63.45	58878.	12.888	0.0	111.48	-116.32	39.65	00000004
37.32	56.78	55.4	22602.	8.126	0.0	74.92	-94.08	34.7	00000005
-12386.	-12386.	-11251.	-11251.						00000006
-8793.	-9076.	-5956.	-5662.						00000007
0.0	0.3	0.1	0.0						00000008
-22.3	-22.3	-22.3	-22.3						00000
-22.3	-22.3	-22.3	-22.3						00000
-78.4	-78.4	-78.4	-78.4						00000
-78.4	-78.4	-78.4	-78.4						00000
0.0	0.25	0.05	0.0						00000009
-15.55	-15.55	-15.55	-15.55	-15.55	-15.55				00000
-15.55	-15.55	-15.55	-15.55	-15.55	-15.55				00000
-58.0	-58.0	-58.0	-58.0	-58.0	-58.0				00000
-58.0	-58.0	-58.0	-58.0	-58.0	-58.0				00000
0.0	0.30	0.10	0.0						00000010
-0.45	-0.45	-0.45	-0.45						
-0.45	-0.45	-0.45	-0.45						
0.0	5.0	1.0	0.0						00000011
-1.5	-1.75	-1.75	-1.75	-1.75	-1.75				00000000
-1.5	-1.75	-1.75	-1.75	-1.75	-1.75				00000000
-500.	500.	500.	500.	0.87	0.87	0.0			00000012
2.0	0.2	15.0	5.0	80.0	80.0	0.50			00000013
.06423	3.5417-34.7381-5								00000014
									00000999

```
SIMULATION MODEL OF AUTOMOBILE COLLISIONS                                           0000000
* RICSAC TEST #4   TORINO-PINTO 38.7MPH *   RUN 9                                    00
0.0      5.0      .025     0.001    0.01     0.001    5.0      5.0      2.0         00000001
0.0      0.0      0.0      0.0      651.1    0.0                                    00000002
197.3    41.4     10.0     0.0      0.0      0.0                                    00000003
55.9     62.1     63.45    50174.   12.89    0.0      91.5     -115.9   38.4        00000004
35.7     58.8     55.4     22704.   8.26     0.0      72.9     -96.1    33.25       00000005
-12386.  -12386.  -11252.  -11062.                                                  00000006
-8982.   -9833.   -5673.   -5673.                                                   00000007
0.0      5.0      0.5      0.0                                                      00000008
-26.2       -1048.      -26.2       -26.2       -26.2       -26.2       -26.2       00
-26.2       -26.2       -26.2       -26.2                                           00
-26.2       -26.2       -26.2       -26.2       -26.2       -26.2       -26.2       00
-26.2       -26.2       -26.2       -26.2                                           00
-238.       -238.       -238.       -238.       -238.       -238.       -238.       00
-238.       -238.       -238.       -238.                                           00
-238.       -238.       -238.       -238.       -238.       -238.       -238.       00
-238.       -238.       -238.       -238.                                           00
0.0      5.0      0.5      0.0                                                      00000009
-19.        -19.        -19.        -19.        -19.        -19.        -760.       00
-760.       -760.       -760.       -760.                                           00
-20.8       -20.8       -20.8       -20.8       -20.8       -20.8       -832.       00
-832.       -832.       -832.       -832.                                           00
-120.       -120.       -120.       -120.       -120.       -120.       -120.       00
-120.       -120.       -120.       -120.                                           00
-120.       -336.       -336.       -336.       -336.       -336.       -336.       00
-336.       -336.       -336.       -336.                                           00
0.0      4.0      0.5      0.0                                                      00000010
0.0         4.0         20.0        20.0        20.0        16.0        16.0        00
16.0        16.0                                                                    00
0.0         4.0         20.0        20.0        20.0        16.0        16.0        00
16.0        16.0                                                                    00
0.0      4.0      0.5      0.0                                                      00000011
0.0         6.0         7.0         6.0         6.0         0.0         0.0         00
0.0         0.0                                                                     00
0.0         6.0         7.0         8.0         8.0         0.0         0.0         00
0.0         0.0                                                                     00
-500.0   500.0    500.0    500.0    .87      .87      0.0                           00000012
2.0      0.25     15.      5.0      90.0     35.0     .75                           00000013
0.04606 1.7547-31.6711-5                                                            00000014
                                                                                    00009999
```

```
SIMULATION MODEL OF AUTOMOTIVE COLLISIONS                                                        00000000
* RICSAC TEST #5  TORINO-HONDA 39.3MPH/70.0 *                                                    00000001
0.0       0.0       .010      0.001     0.01      0.1       5.0       5.0       7.0             00000002
0.0       0.0       0.0       0.0       691.0     0.0                                           00000003
178.5     45.0      10.0      0.0       0.0       0.0                                           00000004
35.6      62.4      63.45     52177.    11.9      0.0       99.2      -110.9    35.4            00000005
37.0      46.5      50.0      14000.    6.55      20.0      66.0      -79.1     29.8            00000006
-11015.   -11561.   -1644.    -10070.                                                           00000007
0.0       -850.0    0.0       -4000.                                                            00000008
0.        .3        .1        0.0                                                               00000009
-30.          -30.          -30.          -30.
-30.          -30.          -30.          -30.
-150.         -150.         -150.         -150.
-150.         -150.         -150.         -150.
0.        1.5       .5        0.0
0.0           0.0           0.0           0.0
0.0           0.0           0.0           0.0
0.0           0.0           0.0           0.0
-550.         -550.         -550.         -550.                                             00000010
0.0       1.1       0.1       0.0
2.0           -6.0          -6.0          -6.0          -6.0          -3.0          -2.0
-2.0          -2.0          0.0           0.0           0.0
2.0           -6.0          -8.0          -8.0          -6.0          -3.0          -2.0
-2.0          -2.0          0.0           0.0           0.0                                       11
0.0       2.2       0.1       0.0
0.0           0.0           -4.0          -4.0          3.0           4.0           2.0
0.0           0.0           0.0           0.0           -2.0          -2.0          2.0
0.0           -2.0          -2.0          -6.0          -6.0          -2.0          3.0
0.0           0.0
0.0           0.0           -4.0          -4.0          3.0           4.0           2.0
0.0           0.0           0.0           0.0           -2.0          -2.0          2.0
0.0           -2.0          -2.0          -6.0          -4.0          -2.0          3.0
0.0           0.0                                                                             00000012
-500.0    500.0     500.0     500.0     .67       .67       0.0                                 00000013
2.0       0.25      15.       5.0       90.0      55.0      .75                                 00000014
0.04560   1.7547-31.6711-2                                                                      00000015
```