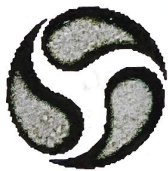# NASS

VEHICLE

MEASUREMENT

TECHNIQUES

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TABLE OF CONTENTS

NASS VEHICLE MEASUREMENT TECHNIQUES

1.0 INTRODUCTION

This document was developed to provide a guideline for the collection of vehicle damage data for the various reconstruction algorithm programs used in NASS. Included within this manual are techniques for field vehicle damage data collection and instructions regarding the use of these measurements.

It is important that the Researcher understand that he/she must provide data for the computer program in a format which will generate the most accurate results. Because there are a variety of accident types and configurations, the logic of the program must be considered when preparing the data for input.

The reconstruction program stiffness coefficients are derived from staged collision data. The reconstruction programs assume a homogeneous stiffness, therefore, determining whether the collision damage occurred at a structurally strong or weak area of the vehicle is beyond the capability of the programs. As a result, the most rigid structure in the damaged plane (except for the sill/frame on side planes) must always be given the primary emphasis when obtaining the vehicle measurements. If the structure of the vehicle no longer reflects the stiffness coefficients due to significant deterioration or modification, the vehicle is not applicable to the program. When the most rigid structure (e.g., frame or side door beam) of the vehicle is not involved, such as in extreme underrides (see Appendix B), the stiffness coefficients are no longer valid and the reconstruction programs should not be utilized.

Since only one vehicle damage data set can be entered for each impact, emphasis is placed on the damage level at which the stiffness coefficients were determined (i.e., frame or bumper level. on end plane damage and door beam level on side plane damage). As an example, the majority of end impacts use the crush profiles generated at the bumper level while side impacts should be measured along the door guard beam when applicable. Using these procedures as the rule, certain other types of impacts which violate the basic WinSMASH assumptions have been accepted by making adjustments to the damage measurement values.

The basis for field data collection is the point-to-point vehicle measurement technique. The measurements are obtained by establishing a reference line, measuring the residual crush and subtracting the bumper/body taper to obtain the resultant crush profile.

2.0 POINT-TO-POINT MEASURING TECHNIQUE
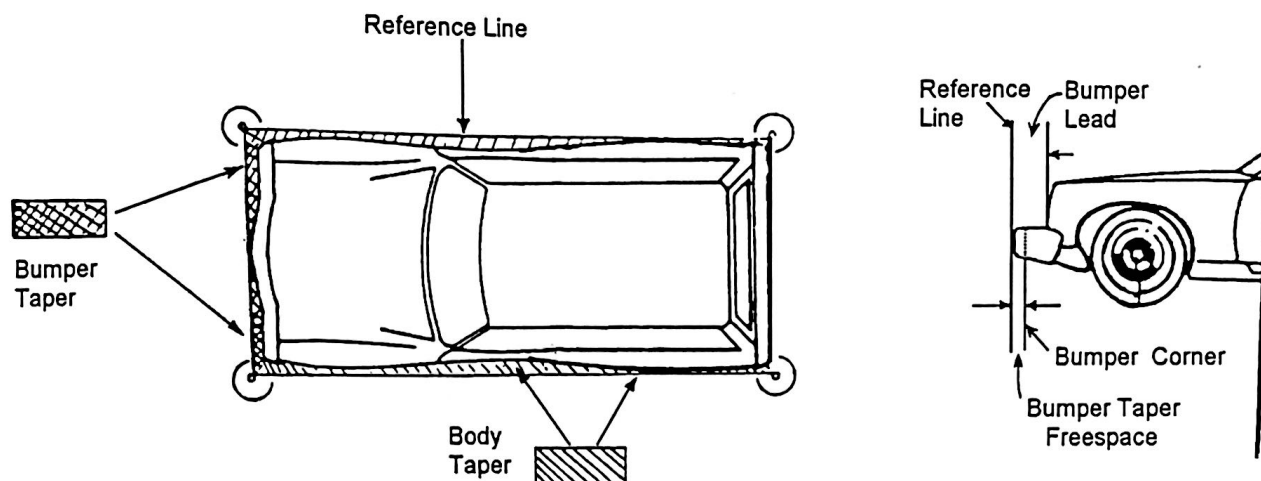
FIGURE 1: FREESPACE

Point-to-point measurement is defined as the actual distance a specific component moved within its damaged plane. Freespace is the area between the original (undamaged) surface of the vehicle and the reference line created by the body and/or bumper taper. See Figure 1. This freespace must be subtracted from **C** measurements when measuring from the reference line to the damaged area. Similarly, when measuring above the bumper to points on the vehicle's front end (grille or front edge of the hood or fenders), the bumper lead and taper must be subtracted to obtain actual crush. See Figure 2.
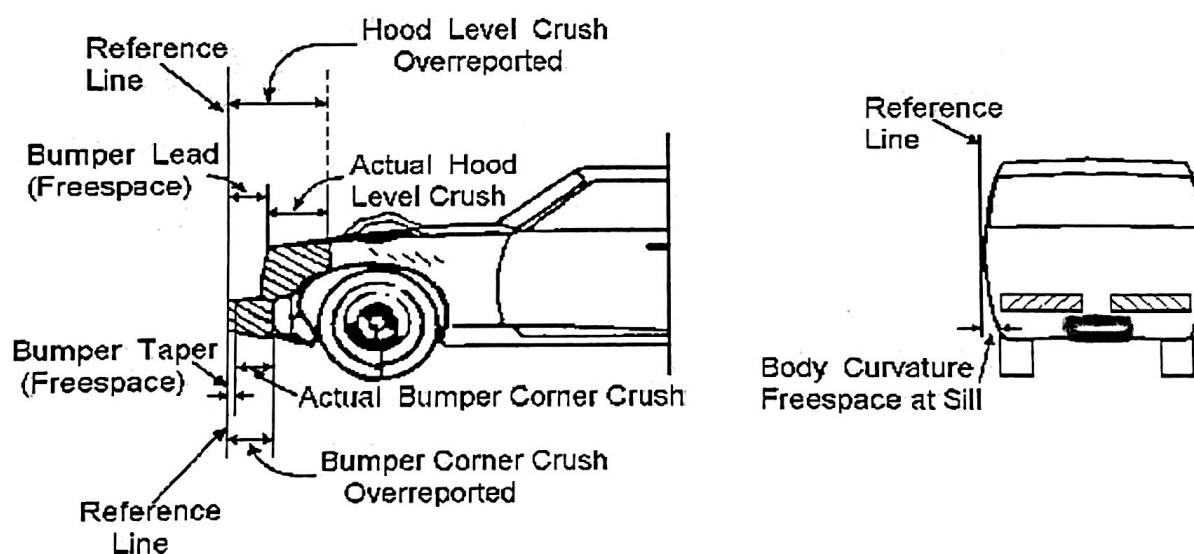
FIGURE 2: BUMPER LEAD and TAPER, and SIDE BODY CURVATURE

3.0 INPUT FOR THE RECONSTRUCTION PROGRAMS: L, C, and D DIMENSIONS

In order to describe the vehicle damage profile to the reconstruction program, the length (L), depth (Cs), and the location (D) of the damage must be documented. These dimensions are defined in the following paragraphs.

3.1 The L Dimensions

The Field L is the length of the contact and induced damage (restricted to the initial plane of contact, end or side) measured parallel to the reference line. The undeformed end width (UEW) is the distance on an undamaged end plane measured corner to corner.

On end plane impacts where the contact and induced damage includes the entire width of the end plane (i.e., corner to corner), use the undeformed end width for the L in WinSMASH except for pole type impacts. If the contact and induced damage does not extend across the entire end plane, or if it is a pole type impact, then use the Field L for the L in WinSMASH. See Figure 3.
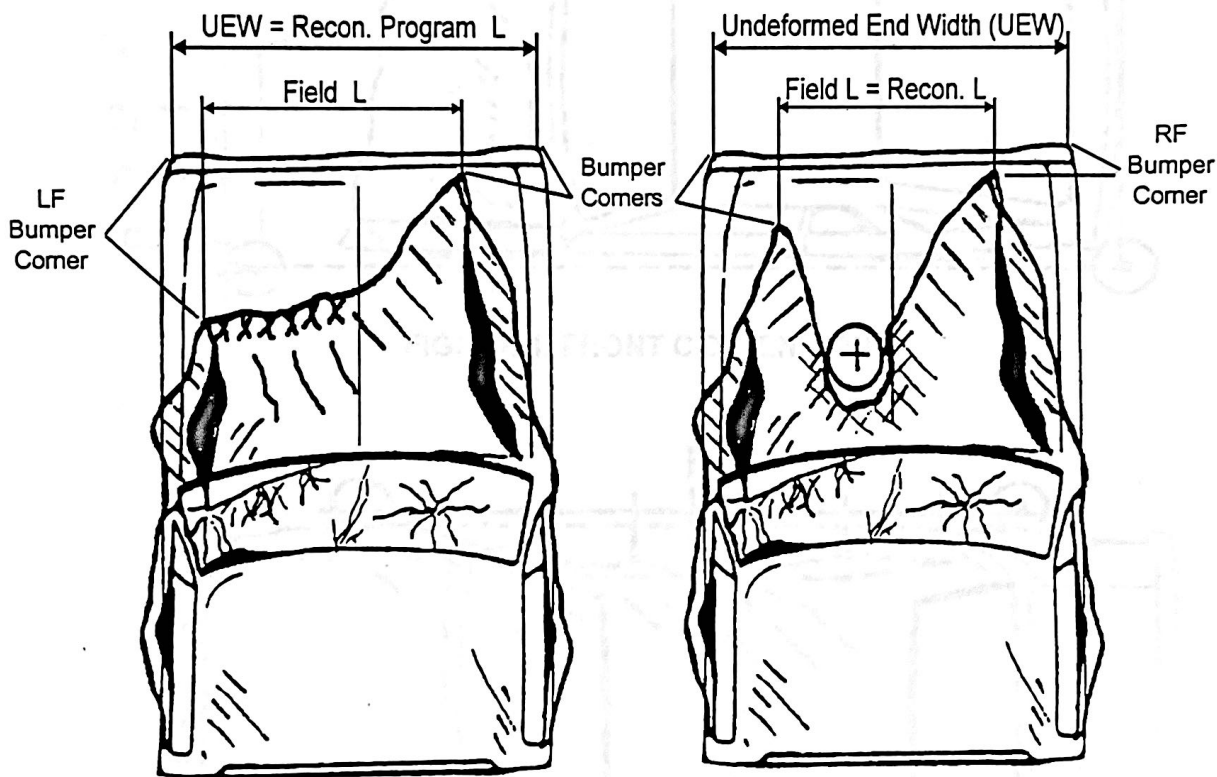
FIGURE 3: L DIMENSIONS

On side plane impacts, enter the Field L for the L in WinSMASH regardless of the length of the damage (contact and induced).

3.2   The C Dimensions

The C dimensions are crush depth measurements taken at specific points along the Field L to report the damage depth of the crush profile. The **C** dimensions, generally referred to as crush measurements, are obtained at two, four, or six equally spaced points along the Field L. NASS protocol dictates that six Cs be obtained whenever possible to enhance the accuracy of the reconstruction program. See Figures 4 and 5.

Only one set of Cs can be entered into the program, although measurements at additional planes may be required for averaging. The crush profile entered must be the best representation of the structural damage to the vehicle. For additional information on obtaining C measurements, refer to the end and side plane damage documentation procedures which follow on pages 8 through 19.
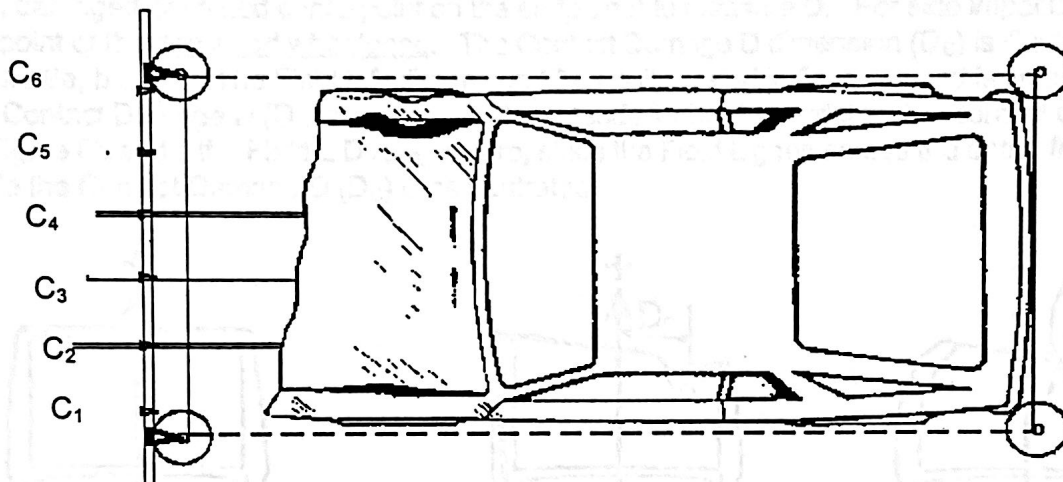
FIGURE 4: FRONT C DIMENSIONS

C_{MAX}
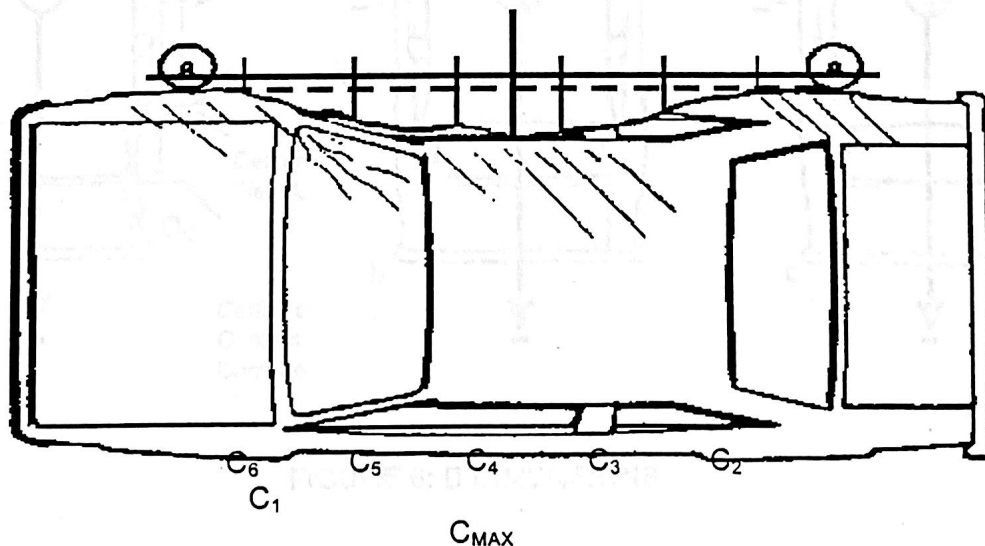
FIGURE 5: SIDE C DIMENSIONS

3.3   The D Dimension

There are two measured D dimensions used in WinSMASH. They can be either positive or negative values. The Contact Damage D dimension (D_C) is the distance from the center of the contact damage width to either:

> the vehicle's damaged endplane center or
> the damaged wheelbase center

This is represented by the CG symbol in Figure 6a,b,c. It is measured along the general slope of the damaged plane (do not bend the tape measure to follow each dent). The Field L D dimension (D_{FL}) is the distance from the center of the Field L (contact and induced damage) to the vehicle's damaged endplane center or the damaged wheelbase center, measured along the general slope of the damaged plane. On end impacts, use the vehicle's damaged centerline (i.e., damaged or shifted centerpoint on the endplane) to measure D. For side impacts, use the midpoint of the damaged wheelbase. The Contact Damage D dimension (D_C) is illustrated in Figure 6a, b and c. The Field L D dimension (D_{FL}) is illustrated in figure 4a and is smaller than the Contact Damage D (D_C) since the Field L extends further forward than the contact damage. In Figure 6b and c the Field L D (D_{FL}) is zero, since the Field L goes across the entire front end, while the Contact Damage D (D_C) is as illustrated.
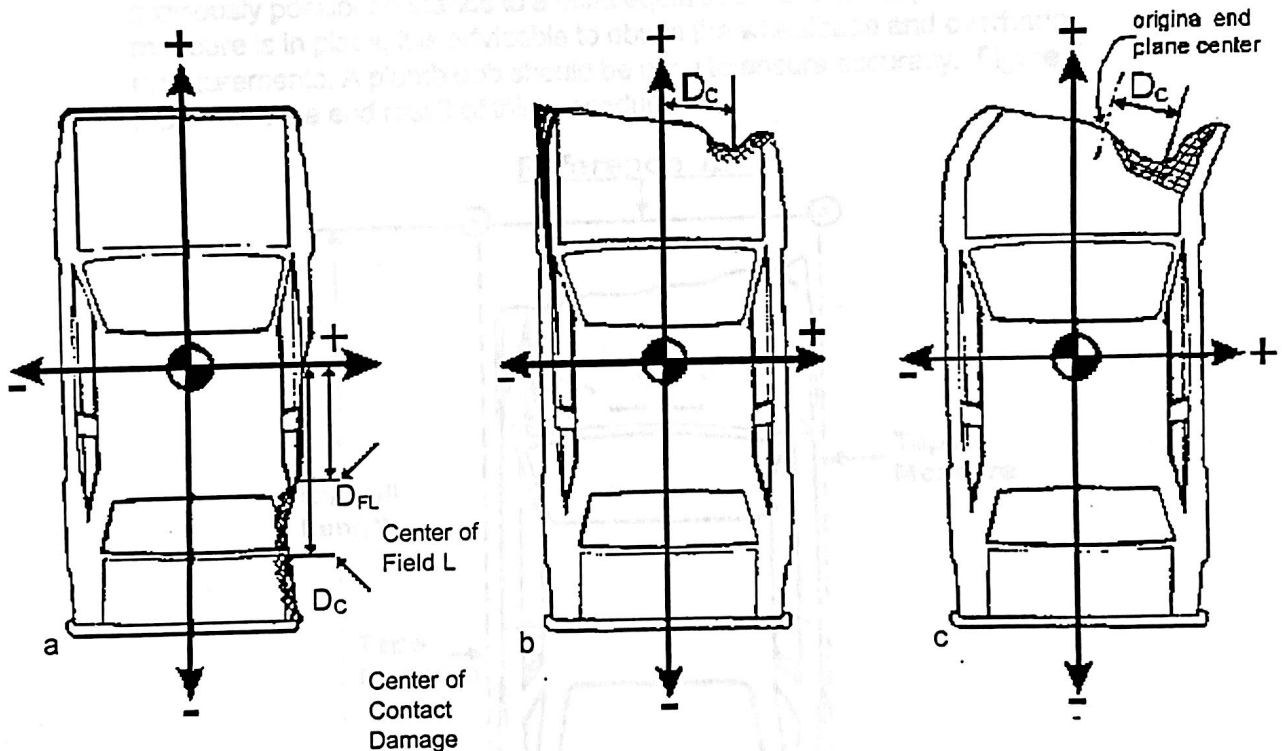
FIGURE 6: D DIMENSIONS

4.0 DOCUMENTATION OF VEHICLE END PLANE IMPACTS (FRONT OR REAR)

4.1 Establishment of a Reference Line for Crush Profile Measurements

The reference line used for vehicle end plane crush measurements is generally placed to represent an undamaged vehicle's overall length.
1. Place two measurement stands on the undamaged end of the vehicle adjacent to each corner.
2. Extend a string line between the measurement stands such that the line is contacting only the furthermost longitudinal projection of the end plane. This point may be identified by the bumper peak at the centerline, or by original equipment bumper guards on the vehicle. Aftermarket bumper guards, spare tires, trailer hitches or similar add-on equipment should not be considered. Adjust the string line so it is at equal longitudinal distances (forward/rearward) from each bumper corner or from an undamaged component that can be identified on each side of the vehicle (e.g., side marker lights, axle center).
3. Using a tape measure, locate the reference line for the damaged end plane (original undamaged position) by measuring parallel to each side of the vehicle from the previously positioned stands to a point equal to the overall length. While the tape measure is in place, it is advisable to obtain the wheelbase and overhang measurements. A plumb bob should be used to ensure accuracy. Figure 7 represents the end result of this procedure.
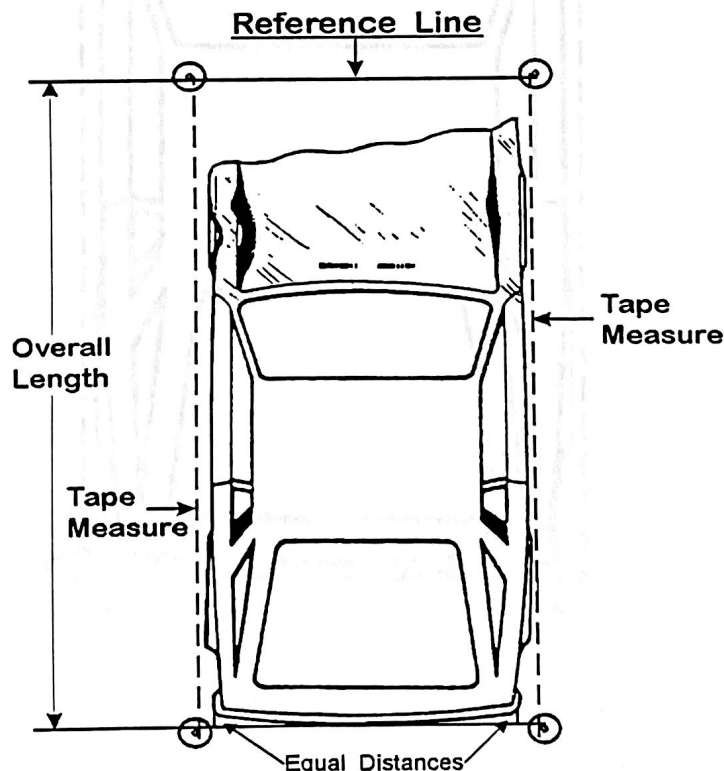
4.2   Placement of Contour Gauge

When a contour gauge is used to document the C positions, both the reference line and the damage contour gauge are attached to the same stands. The reference line is established in accordance with Section 4.1. The contour gauge is constructed beyond the reference line by orienting the two swivel mounting clamps away from the vehicle. The end result of this method is illustrated in Figure 8.
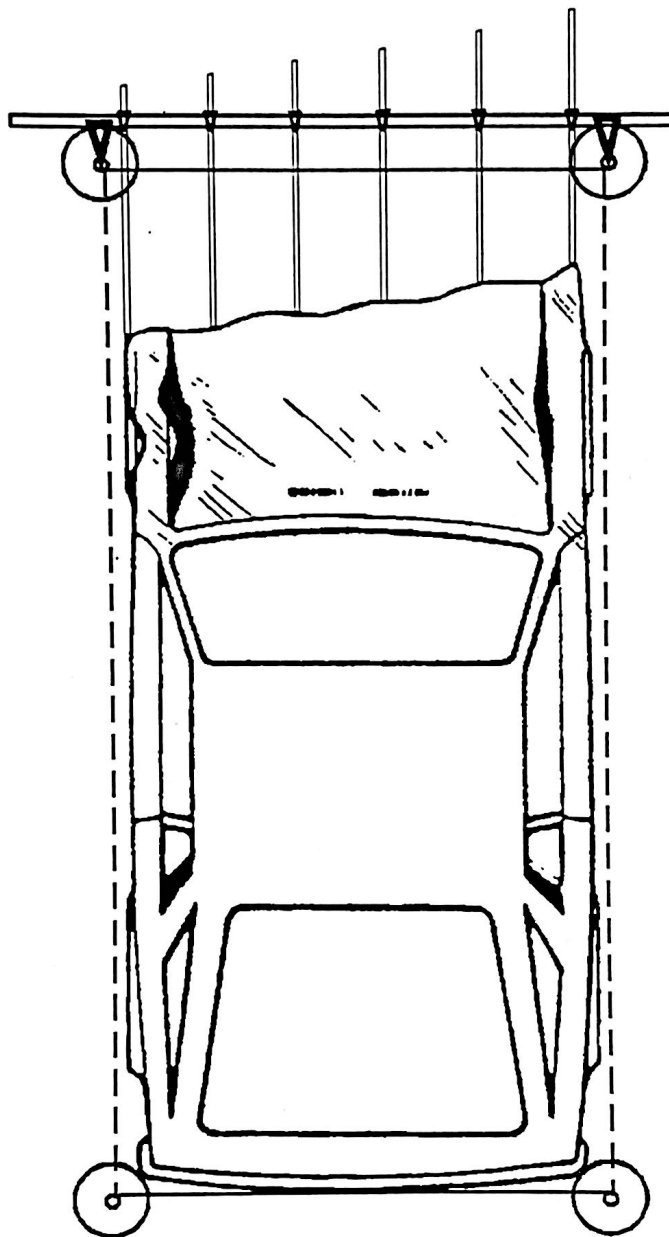
FIGURE 8: CONTOUR GAUGE

4.3   Documentation of the Damaged End Plane Crush Profile

For end plane impacts the Field L, length of the damaged area including contact and induced damage, does not extend laterally beyond the bumper corners. In other words, end plane crush should only be measured to vehicle components that were originally on the end plane of the vehicle. Once the reference line has been established as described in section 4.1, the crush profile should be documented as follows:

a.   Assemble the contour gauge (see Appendix A).

b.   On the end plane of a vehicle, C_1, is defined as the left (driver's perspective) end point of the damage. Place a calibrated rod at this point.

c. C_6 is defined as the right (driver's perspective) end point of the damage. Place a calibrated rod at this point.

   Note: If the damage involves the entire end plane, C_1, will be the left bumper corner and C_6 will be the right bumper corner.

d.   Measure the distance between the calibrated rods (C_1 and C_6) parallel to the reference line and record the distance as the Field L.

e.   Divide the Field L by five to determine the spacing of the six C locations and place an additional calibrated rod at each of those points.

f.   With the contour gauge in place, measure the crush profile parallel to the calibrated rod at each C location and record these dimensions. The Cs should always be taken at the structure level (bumper) and along the level of maximum crush (grill level in a frontal override) if different from the structure level.

g.   Measure and record the maximum crush (C_{max}) point. This point should be highlighted with the red contour gauge clamp for photographic purposes. C_{max} is recorded for determining the CDC extent zone.

h.   Subtract the appropriate freespace at each C position and the maximum crush position to obtain the correct crush.

i.   Locate the contact damage, record the length, and reference the location. This is used for CDC.

j.   Measure the value of the Contact Damage D and the Field L D dimension.

k.   Measure and record any shifting of the frame rails and/or corners of the vehicle. See Appendix C.

Figure 9 represents the end result of this procedure for vehicles with a damage profile within the confines of the reference line. In Figure 10, the right bumper corner (C_6) extends beyond the reference line. The Field L includes both bumper corners and should not extend beyond those corners.

When the actual point on the vehicle has been moved outward, such as in an offset frontal impact where the non-contacted side of the bumper rotates outward, beyond the reference line, the measurement is negative since it moved out from its original position rather than crushed in. Since most reconstruction programs cannot handle negative values, zero is entered at these locations. In situations where the bumper was snagged and pulled outward during separation or during a subsequent impact, you would ignore that portion of the bumper affected by the snagging and measure to a representative crush plane either behind or above the bumper.
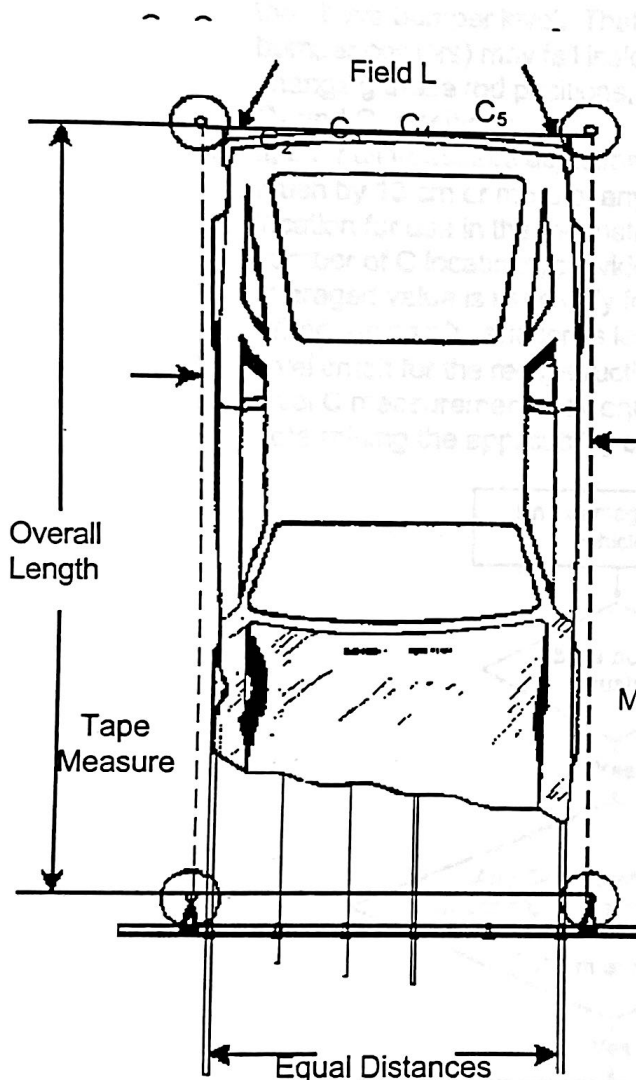
FIGURE 9: DAMAGE PROFILE WITHIN FIELD L
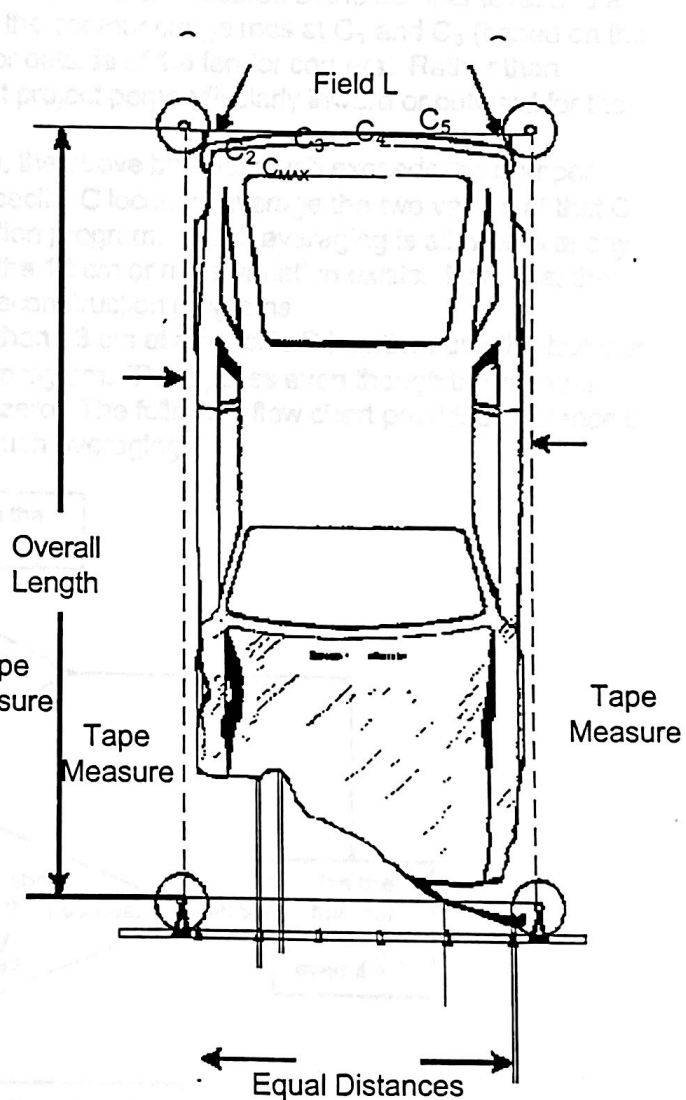
FIGURE 10: DAMAGE PROFILE BEYOND FIELD L

4.4   End Plane Impacts: Exceptions to Standard Measurement Protocol

4.4.1 Crush Averaging for Underride Impacts

Underride impacts result in uneven crush patterns between the bumper level and above bumper level. The following protocols is used in NASS for underride crush profiles.

a. Set the contour gauge up and measure the bumper level first, then raise the contour gauge to the above bumper level and measure it using the same C locations. If the grill and fender crush slopes rearward (i.e., it is not vertical), measure to the mid-line. If the grill is broken away, measure to the radiator or radiator support. Never measure to the hood edge, since it is designed to fold up easily. In some cases, there will be a difference between the Field L measured at the bumper level and at the above bumper level. That is, the contour gauge rods at C_1 and C_6 (based on the bumper corners) may fall inside or outside of the fender corners. Rather than changing these rod positions, just project perpendicularly inward or outward for the C_1 and C_6 positions.

b. If, after all freespace adjustments, the above bumper crush exceeds the bumper crush by 13 cm or more at any specific C location, average the two values at that C location for use in the reconstruction program. Crush averaging is allowable at any number of C locations, provided the 13 cm or more variation exists. Note that the averaged value is used only for reconstruction programs.

c. When the crush variation is less than 13 cm at a specific C location, use the bumper level crush for the reconstruction program. This applies even though the bumper level C measurement may equal zero. The following flow chart provides guidance in determining the applicability of crush averaging.
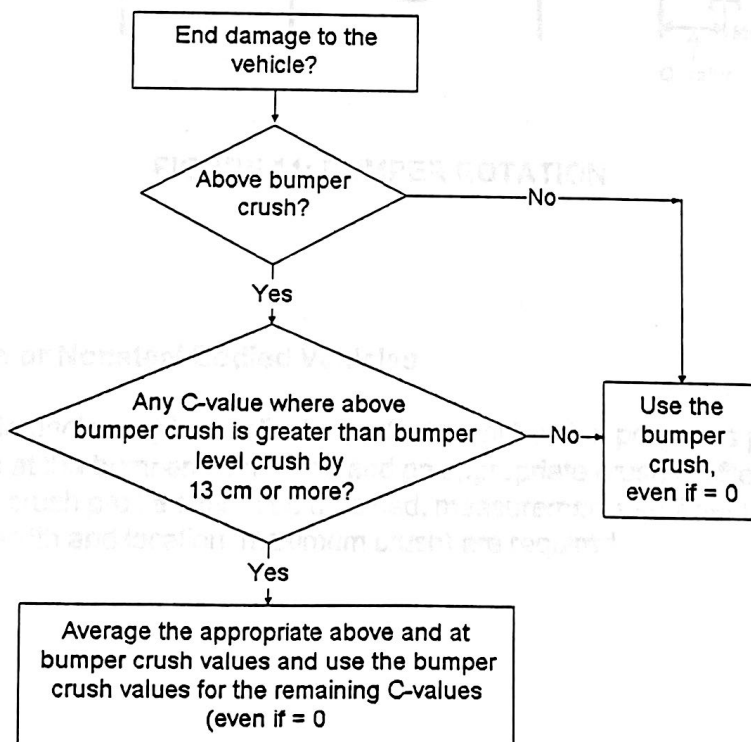
4.4.2 EAD Movement

When EAD compression is the only damage to the vehicle, record the value but do not use it as a reconstruction program input or when averaging crush as described in Section 4.4.1. Use the bumper crush even if it is equal to zero.

Some reconstruction algorithms will not accept zero (0) crush at all six C positions, therefore, substitute one tenth of one centimeter (.1) as the input value for C_1, and C_6.

4.4.3 Vertical Bumper Rotation

If the bumper is rotated or twisted by the impact forces, an error in C measurement of 3cm to 10cm can occur, depending on the degree of rotation and the size of the bumper. Crush measurements should be taken between the reference line and the midpoint of the bumper face whenever this situation exists. Figure 11 illustrates these situations.
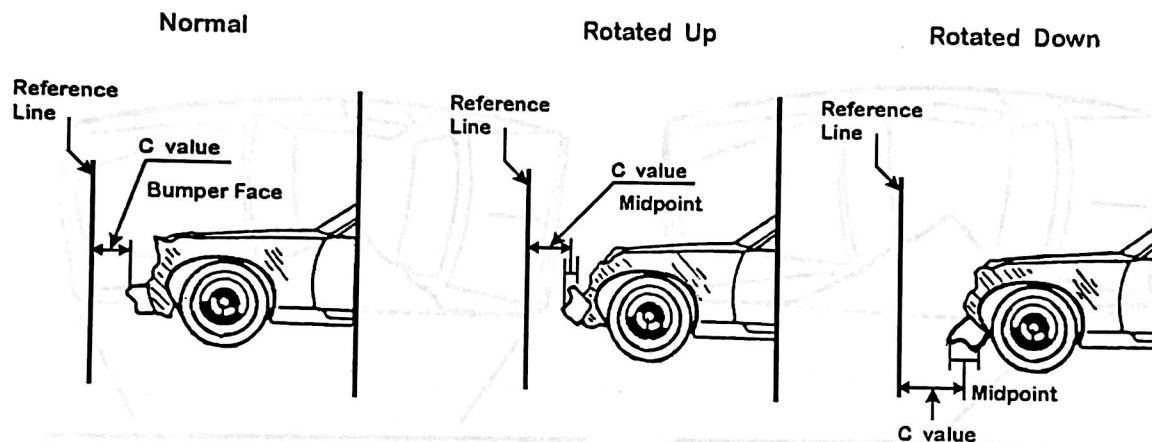
FIGURE 11: BUMPER ROTATION

4.4.4 Fiberglass or Nonsteel Bodied Vehicles

End plane impacts may be applicable to the reconstruction programs provided the maximum crush is at the bumper/frame area and an appropriate crush profile can be obtained. If a representative crush profile cannot be obtained, measurements sufficient to encode a CDC (contact damage width and location, maximum crush) are required.

5.0 DOCUMENTATION OF VEHICLE SIDE IMPACTS

The following protocols should be used when documenting side impacts.

5.1 Establishment of a Reference Line

There are two methods of reference line placement. They are: 1) the body contour reference line and 2) the measurement stand reference line. Vehicle bending (i.e., bowing) is **not** a consideration when selecting a reference line placement method.

The body contour reference line should be used whenever the string line can follow the body contour with little or no disruption (Figure 12). The measurement stand reference line should be used whenever the impact involves a corner <u>or</u> damage alters the vehicle profile such that the first method cannot be used (Figure 13). When uncertain which method to use, use the measurement stand reference line method.
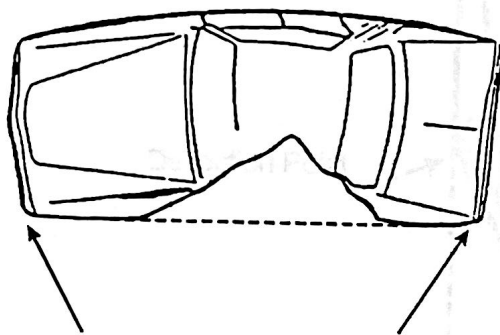
Stringline is attached on body panel just above bumper corners

Protruding damage would cause over reporting of crush and prohibits using the body contour method

FIGURE 12: ACCEPTABLE REFERENCE LINE PLACEMENT

FIGURE 13: UNACCEPTABLE REFERENCE LINE PLACEMENT

5.1.1 Establishing the Body Contour Reference Line

The following protocol should be used whenever the damage (contact and induced), as defined by the deflection points, is inboard of both vehicle ends and nothing protrudes from the side of the vehicle that would deflect the reference line. This method does **not** require freespace adjustments to the crush measurements provided that the measurements are taken near the mid-door vertical level which is the maximum width of the side body contour. If measurements are taken near the sill or near the beltline, then freespace adjustments must be made to compensate for the side body contour.

Attach a string line from the leading edge at the front body panel immediately above the bumper to the trailing edge of the rear body panel immediately above the bumper.

Figure 14 represents the end result of this procedure.
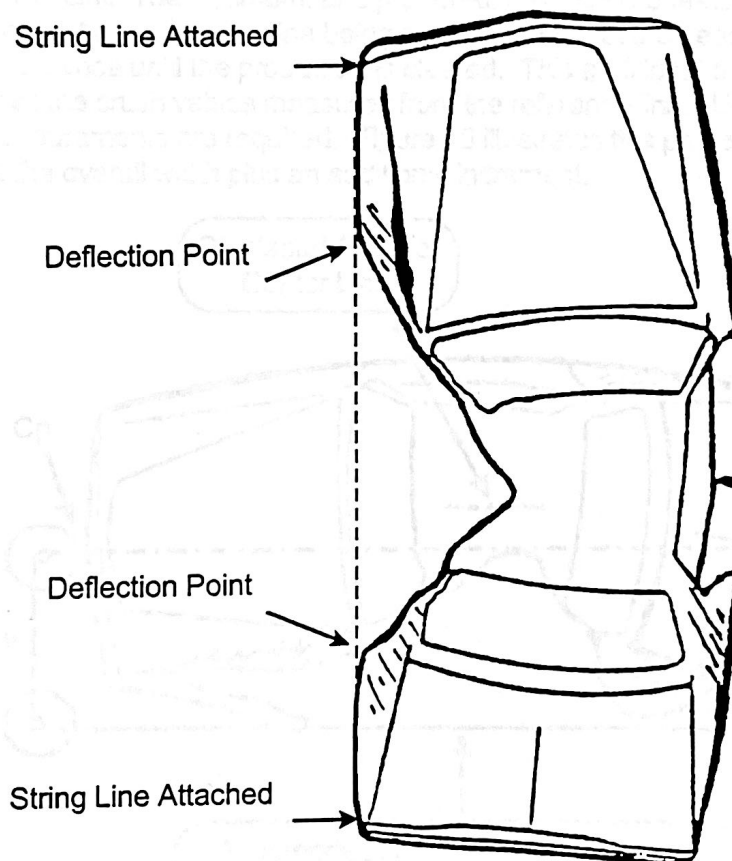
FIGURE 14: BODY CONTOUR REFERENCE LINE

5.1.2 Establishing the Measurement Stand Reference Line

In the majority of side impacts, the reference line will be attached directly to the vehicle. For those vehicles where this is not possible (e.g., sheet metal displacement or door protrusion alters the path of the reference line or crush extends to the corner of the vehicle), the reference line must be established using measurement stands. The basic principle of measurement stand placement is to establish a reference line at right angles from known points so actual crush can be determined.

In order to establish a reference line using the measurement stand method, it is essential to accurately locate the vehicle end plane centerpoint (Cp). The centerpoint is defined as the specific point on the end plane that defines the mid-point of that plane.

Example #1: Because the vehicle has protruding damage, the measurement stand reference line method is required. In order to establish a reference line that takes into account any bowing, each end of the reference line must be set out a constant distance from each endplane centerpoint. The minimum, and preferred, distance is one-half the overall width. If protrusions prohibit the reference line being established there, then each stand must be set out an additional distance until the protrusion is cleared. This additional distance is, of course, subtracted from the crush values measured from the reference line. Using this method, freespace measurements are required. Figure 15 illustrates this procedure where the stands are set out ½ the overall width plus an additional increment.
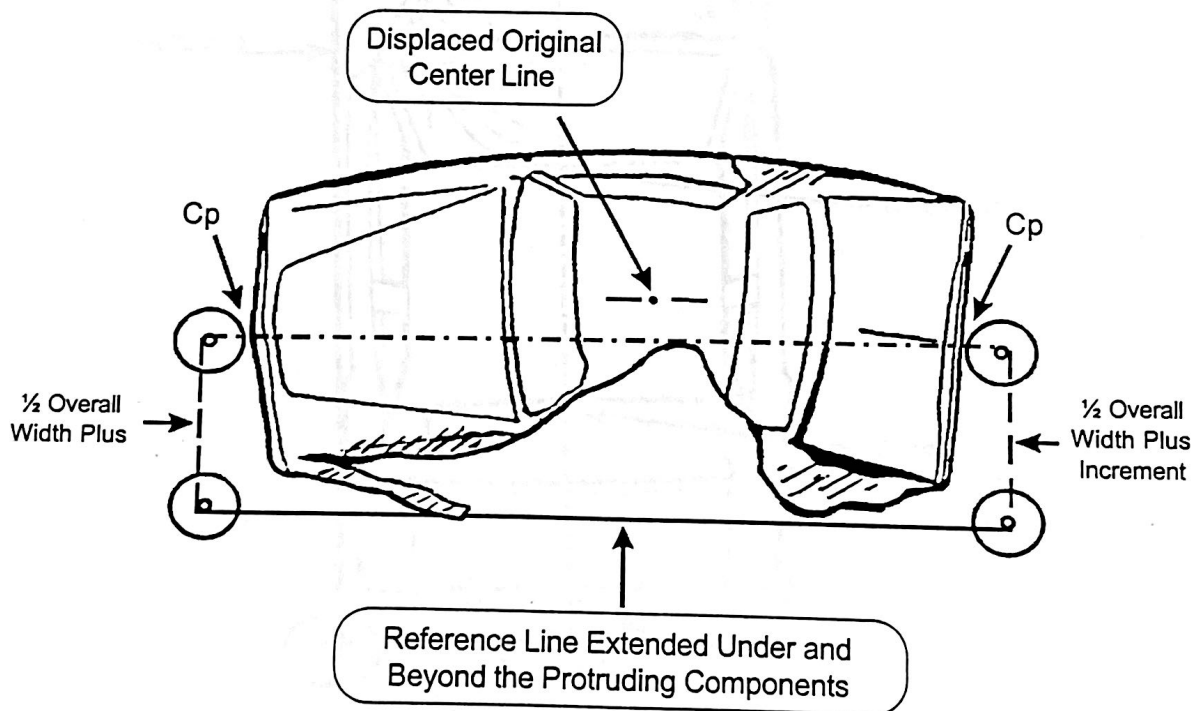
**FIGURE 15: REFERENCE LINE
USING STANDS DUE TO PROTRUSIONS**

Example #2: The front end is displaced laterally <u>away</u> from the impacting force and is no longer aligned with the centerline of the vehicle. In this situation the original centerline or projected centerpoint must be used and is defined by projecting the centerline through the vehicle from the centerpoint on the opposite undamaged end. Figure 16 illustrates this procedure.   Again, freespace measurements are required.
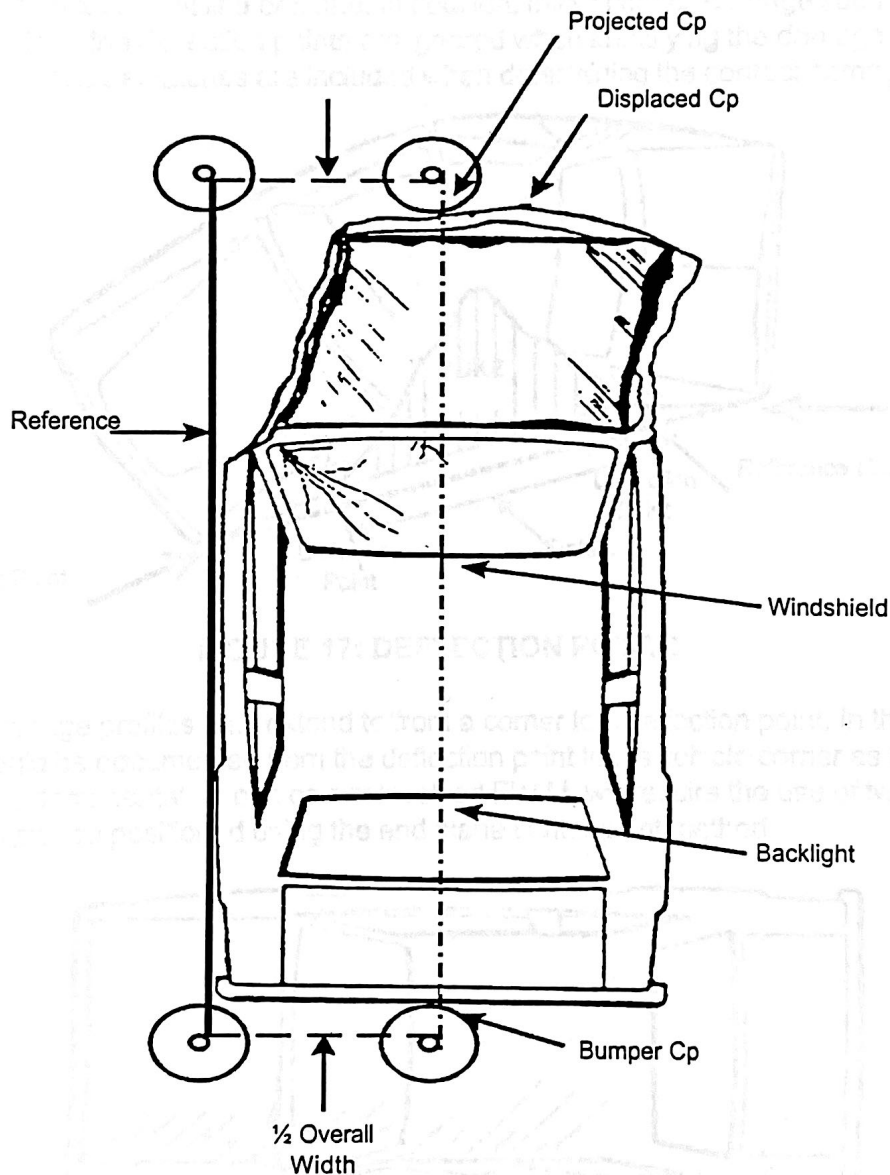
**FIGURE 16: REFERENCE LINE
USING STANDS DUE TO DAMAGED CORNER**

5.2 Documentation of the Vehicle Side Plane Crush Profile

5.2.1 Identify the Field L

When measuring side damage, the length of the damaged area is the Field L. When the damage does not include the corner of the side plane of the vehicle, the Field L is identified by deflection points which form a "yoke" in the vehicle profile (See Figure 17). The yoke can generally be identified by sighting along the body side profile from each end of the vehicle and observing where the damage area departs from the original body contour. Note that this body contour may not be a straight line or plane. In addition, minor contact damage such as surface scratches outside of the deflection points are ignored when identifying the damage yoke, however, such surface scratches are included when determining the contact damage for CDC.
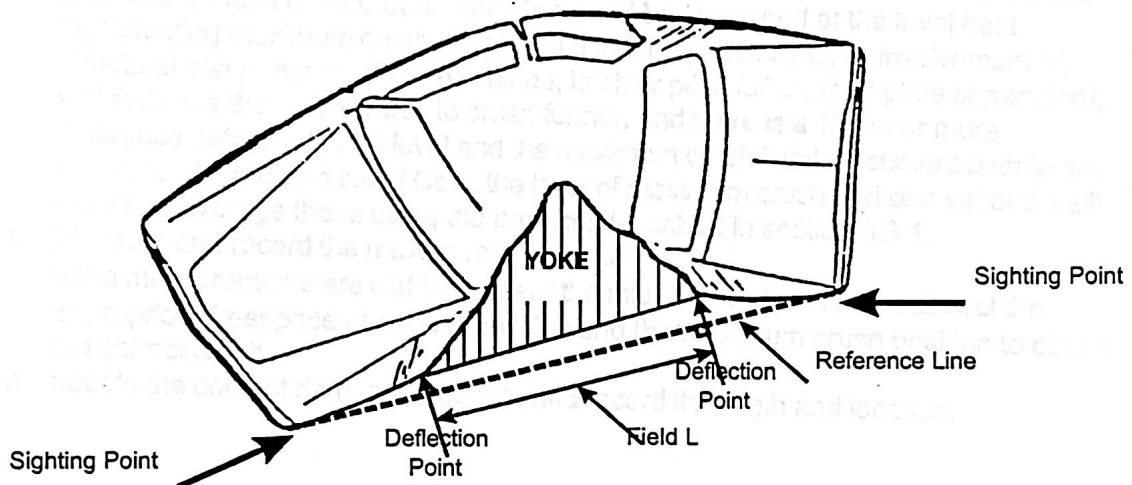
FIGURE 17: DEFLECTION POINTS

Side damage profiles may extend to/from a corner to a deflection point. In this situation the Field L would be documented from the deflection point to the vehicle corner as illustrated in Figure 18. The documentation of a corner involved Field L will require the use of two measurement stands positioned using the end plane center point method.
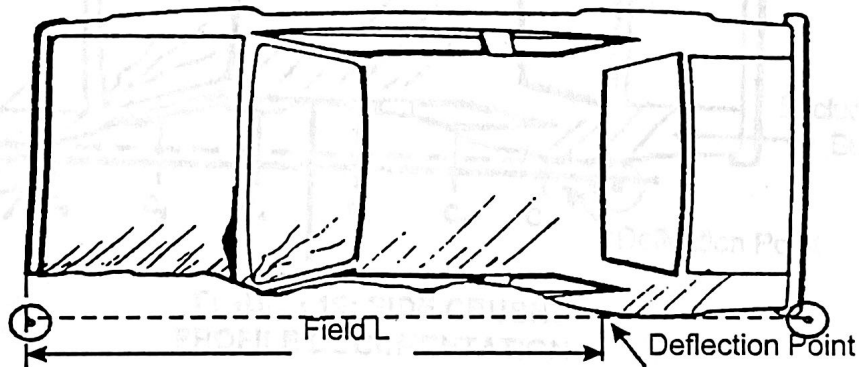
FIGURE 18: DEFLECTION POINT TO CORNER

5.2.2 Documenting the Damage Profile

Set up the appropriate reference line and identify the Field L. Then measure the side damage using steps a-h (see Figure 19).

a. On sideplanes C_1 is the rear most deflection point or damage end point. Locate C_1 and place a calibrated rod at this point.

b. C_6 is the forward most deflection point or damage end point. Locate C_6 and place a calibrated rod at this point.

c. Measure the distance between C_1 and C_6 parallel to the reference line and record the distance as the Field L.

d. To obtain the location of the remaining four Cs, divide the Field L by five and place a calibrated rod at each of these points.

e. Measure the crush profile at the six C locations perpendicular to the reference line and record these dimensions. The Cs should be measured at the level best representing maximum crush keeping in mind the proximity to, or involvement of, structural components. If there is hinge, latch or pillar failure (complete separation), which allows the side surface to crush further, and there is a 13 cm or more difference between the sill level and the maximum crush level, document both levels of crush. Record one set of Cs at the level of maximum crush and one set at the sill level and average these using the protocol described in section 6.3.1.

f. Measure and record the maximum crush point.

g. If the measurements are **not** taken near the mid-door vertical level, subtract the appropriate freespace at each C position and the maximum crush position to obtain the correct crush.

h. Locate the contact damage, measure and record its length and location.
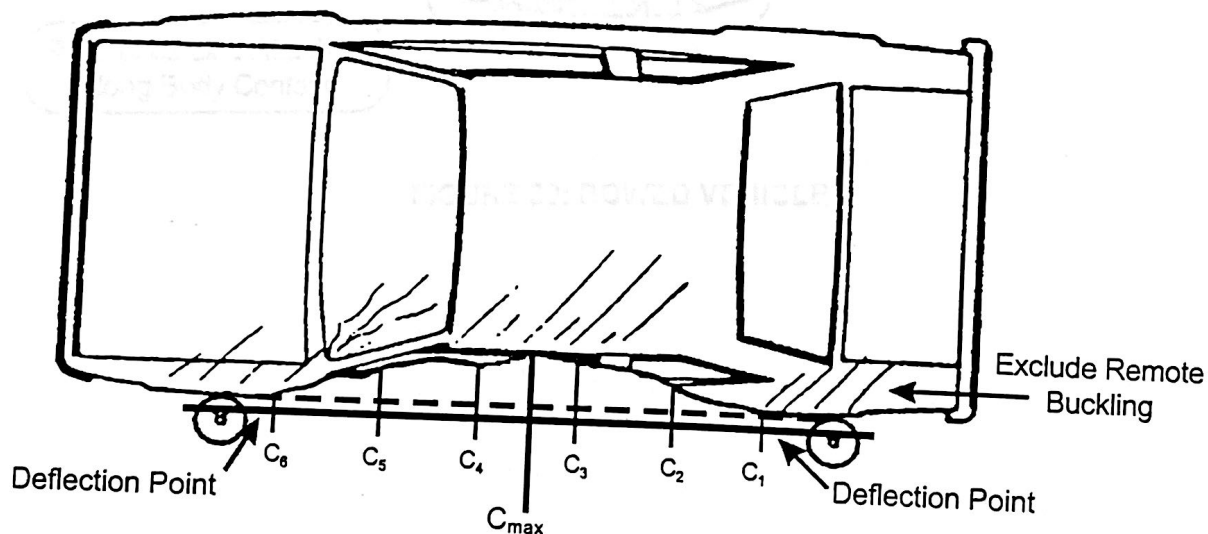

FIGURE 19: SIDE CRUSH PROFILE DOCUMENTATION

The procedure for handling the severely bowed vehicle (banana shape) is the same (body contour method) as in Figure 19. This method automatically includes the bowing in the crush measurements. Figure 20 represents the end result of this procedure including steps a-h in Section 5.2.2.
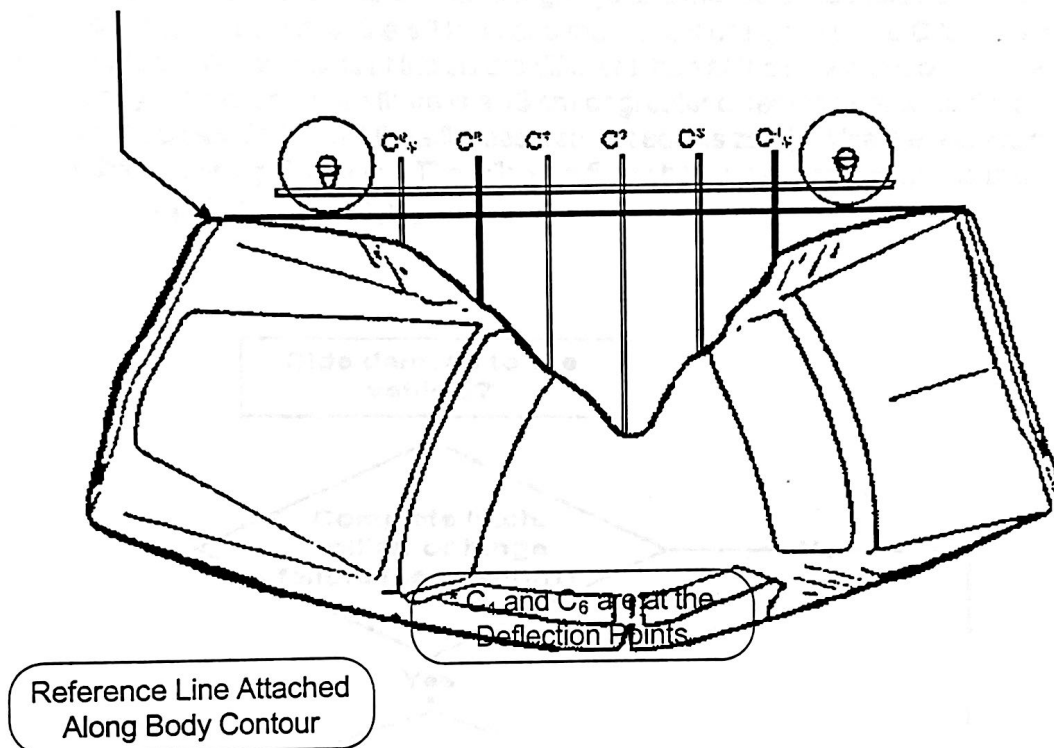

FIGURE 20: BOWED VEHICLE

5.3 Side Plane Impacts: Exceptions to Standard Measurement Protocol

5.3.1 Crush Averaging for Underride Damage

An underride impact will result in uneven crush patterns between the sill and sheet metal panels above the sill. The following protocol is used in the NASS when side underride crush profiles are encountered. An adjustment to crush will be made only when there is **complete latch, pillar or hinge failure/separation** which allows the surface to crush further than normal.

When this occurs, set up the contour gauge and measure the maximum crush level first, then slide the gauge down to the sill level and measure it using the same C locations and Field L (even if the deflection points at the sill are different than at the maximum crush level). Average any C location where there is a 13 cm or greater difference between the sill and maximum crush levels (even if the sill measurement equals zero). Use the maximum crush level for the remaining C values. The following flow chart will provide guidance in determining the applicability of crush averaging.

```
        ┌─────────────────────┐
        │  Side damage to the │
        │      vehicle?       │
        └─────────────────────┘
                  │
                  ▼
            ◇ Complete latch, ◇
            pillar, or hinge ─────No─────┐
            failure (separation)?        │
                  │                      │
                 Yes                     │
                  ▼                      │
        ◇ Any C-value            ◇       │   ┌──────────────┐
        where maximum crush              │   │ Use the max  │
        is greater than sill ───No──────►│   │ crush level  │
        level crush by 13 cm             │   │   values     │
        or more? ◇                       │   │ even if = 0  │
                  │                          └──────────────┘
                 Yes
                  ▼
    ┌─────────────────────────────────────┐
    │ Average the C values which have a    │
    │ greater than or equal to 13 cm       │
    │ difference between the sill and max  │
    │ crush levels (even if the sill       │
    │ measurement = 0). Use the max crush  │
    │ values for the remaining C locations │
    └─────────────────────────────────────┘
```
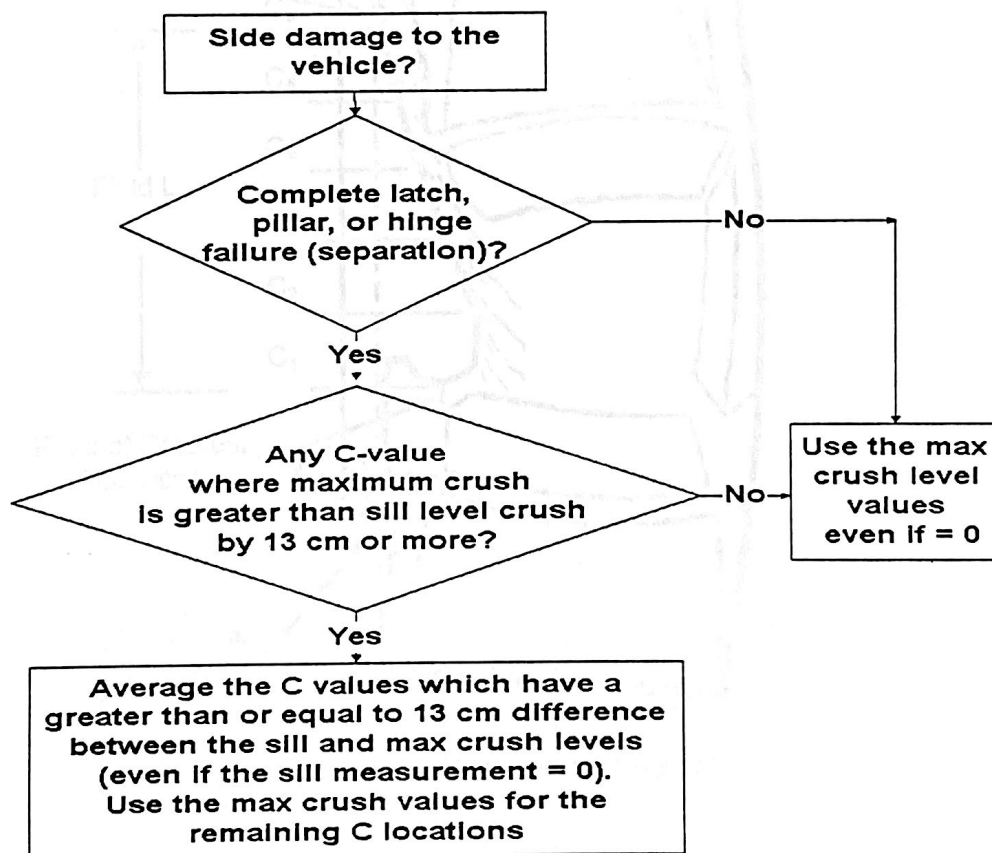
5.3.2 Fiberglass or Nonsteel Bodied Vehicles

Reconstruction programs may be applicable to sideplane impacts of non-steel bodied vehicles provided the maximum crush is at the sill/frame area or the pillars and door beam area and an appropriate crush profile can be measured to a substantial structure. In most cases this may involve measuring to the steel reinforcement beam behind a plastic door or sill. In this type of situation, free space will be significant and must be taken into account.

5.3.3 Side Impact Resulting in Pocketing Damage
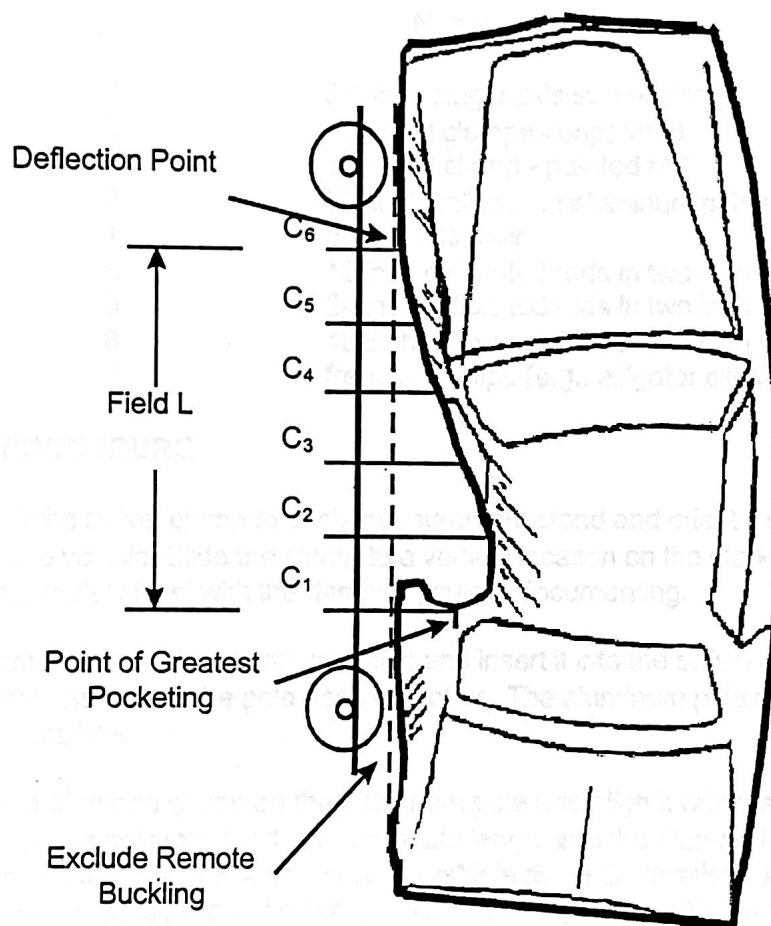
FIGURE 21: POCKETING DAMAGE

The Field L in Figure 21 is measured to the point of greatest pocketing. The C_1 measurement is the perpendicular distance between the reference line and the point of greatest pocketing. The point of greatest pocketing is not necessarily the point of maximum lateral penetration.

APPENDIX A

DAMAGE CONTOUR GAUGE

WHEN TO USE

The damage contour gauge is used whenever the vehicle under observation is within the scope of the reconstruction programs (i.e., passenger car, light truck, or van), and the damage resulted from a horizontal impact.

EQUIPMENT DESCRIPTION

Item	Amount	Name
A	2	3/4 inch single axis swivel clamps
B	6	diamond clamps - unpainted
C	1	diamond clamp - painted red
D	2	5/8 inch collapsible aluminum poles, 76 ½ inches long
E	1	5/8 inch coupler
F	6	10 inch calibrated rods in two inch increments
G	6	24 inch calibrated rods in two inch increments
H	6	48 inch calibrated rods in two inch increments
I	7	freespace clips (e.g., alligator clips)

SET-UP PROCEDURE

1. Attach the swivel clamp to each measurement stand and orient it so that it extends away from the vehicle. Slide the clamp to a vertical location on the stand so that it is approximately level with the damage you are documenting.

2. Assemble one of the aluminum poles and insert it into the swivel clamps; tighten down on at least one end so the pole does not rotate. The aluminum pole must be parallel to the reference line.

3. Place a diamond clamp on the aluminum pole and align it with the approximate position of C_1. Insert a calibrated rod of appropriate length into the diamond clamp and position the rod such that the red end contacts the vehicle at the C_1 position. Adjust the clamp to ensure the rod is perpendicular to the string line, parallel with the ground and pointed at the C_1 position.

4. Repeat the previous step for C_6.

5. Measure the distance between the calibrated rods, C_1 and C_6, to determine the Field L measurement.

6. Divide the Field L measurement by five to determine the interval between each C position.

7. Position the remaining diamond clamps on the aluminum pole so they are at approximately equal intervals from each other.

8. Select calibrated rods of appropriate length and insert them in the C_2 through C_5 diamond clamps, respectively. Remember to insert the _red end_ first. Position each rod end adjacent to but not touching the damaged plane.

9. Extend and lock a tape measure at a value a couple of inches longer than the interval determined in step 6. Place the zero end of the tape on the C_1, calibrated rod and measure to the C_2 position. Move the clamps/rod assembly to the proper position and tighten the clamp.

10. Repeat Step 9 above for C_3 through C_5. Check the interval between C_5 and C_6. Some adjustments may be necessary to obtain the proper interval between each C position. Do not be concerned if the interval between two rods is off by less than 1cm. If the interval is off significantly, however, C_1 through C_6 must be adjusted to ensure they are relatively equidistant.

11. Attach the red diamond clamp to the aluminum pole if the maximum crush does not coincide with any of the C_1 through C_6 rods. Insert the appropriate calibrated rod to quantify the maximum crush value. If the maximum crush is located at a specific C-position, replace the existing clamp with the red diamond clamp to indicate the location of maximum crush.

12. If freespace is known or has been reasonably estimated, illustrate the amount of freespace for each calibrated rod by placing the freespace clip on the rod such that the distance between the _vehicle end_ of the clip and the reference line represents freespace. Record the freespace values.

13. Freespace is subtracted from the measured crush to determine the resultant crush profile.

USING THE GAUGE WHEN AVERAGING DAMAGE PATTERNS AT DIFFERENT LEVELS FOR THE SAME IMPACT

When the penetration from an impact varies between two different horizontal planes (e.g., sill and above sill) and must be averaged to ensure consistency with NASS procedures, the contour gauge is set up to _first_ quantify the damage with the longer Field L. The rods are put in place, adjusted for free space, if applicable, and then photographed. It is then a simple matter to measure the damage at the remaining horizontal plane by backing out the rods, raising/lowering the aluminum pole to the new plane, and then position the rods to represent the crush profile. Adjust for free-space, if applicable, and photograph.

ASSEMBLING THE CONTOUR GAUGE WHEN FIELD L EXCEEDS 185cm

Larger Field Ls (>185cm) require the use of the second aluminum pole, or at least some part thereof. The additional section is attached to the first pole by using the <u>plastic coupler</u> that is supplied with the contour gauge.

Some damage profiles may have Field Ls exceeding the length of both fully assembled and joined poles. In these cases, the Researcher will not be able to position a calibrated rod at either C_1 or C_6 since one or the other end of the damage must be sacrificed when the L exceeds the length of the poles. It is suggested that the C position with the smaller value be positioned beyond the contour gauge. Measure the C value with a tape measure, and highlight its location using either a magnet or a piece of reflective tape.

APPENDIX C

DOCUMENTING SHIFT/BOWING FOR CDC

LATERAL (HORIZONTAL) END SHIFT

For CDC incrementation purposes only, determine if the vehicle end structure (both frame rails or unibody) has shifted 10cm or more. A technique for determining lateral (horizontal) end shift is to determine the undamaged centerline of the vehicle (best estimate usually made by aligning the inside rearview mirror with the center of the back light) and projecting the centerline to the end(s) of the vehicle.

Measure the distance from the projected undamaged centerline to each frame rail end and compare this value to half the distance between the undamaged frame rails. A similar vehicle may have to be located to obtain this value. If an exemplar vehicle is not likely to be located, estimate the position of the undamaged frame end by projecting forward from the undamaged areas of the frame. Measure the half distance between the projected centerline and the projected undamaged frame end. If the measured value from the projected undamaged centerline differs from the half distance by 10cm or more for each frame rail end, increment the PDOF for shift. Another method for vehicles equipped with a frame is to estimate the position of undamaged frame ends by projecting forward from an undamaged portion of each frame member, then measure from this point to the damaged frame end to determine the amount of shift. Refer to Figure 1.
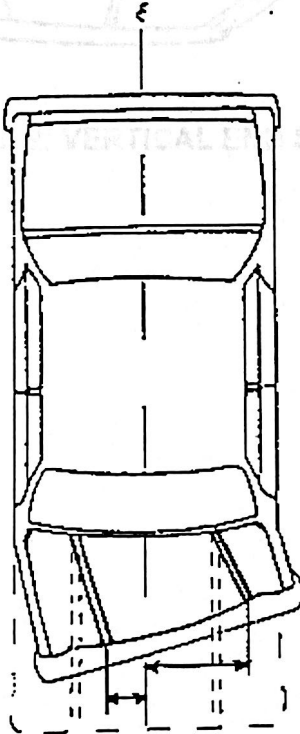

FIGURE 1: LATERAL END SHIFT

For vehicles with unibodies, measure the distance from the undamaged centerline to the center of the shifted unibody end to determine the amount of end shift.

VERTICAL END SHIFT

Incrementing for <u>vertical shift</u> requires that only one frame rail (or portion of a unibody) shift vertically 10cm or more. If only one side (e.g., frame rail) of the end has shifted vertically, then you need only to compare it to the non-shifted side to determine if the shift is present. If the entire end has shifted vertically, then additional techniques may be required to accurately estimate the amount of shift. For example, measure vertically from the ground to the end of the frame/unibody and compare the measurement to that of an undamaged exemplar vehicle or to the, opposite, undamaged end of the vehicle. Keep in mind that the vehicle's levelness will affect your measurements. If this procedure is not possible, estimate the position of the undamaged frame end by projecting forward from the undamaged areas of the frame. Measure from this estimated point to the damaged frame rail end (unibody) and annotate that the amount of shift is approximated. Figure 2 illustrates vertical end shift.
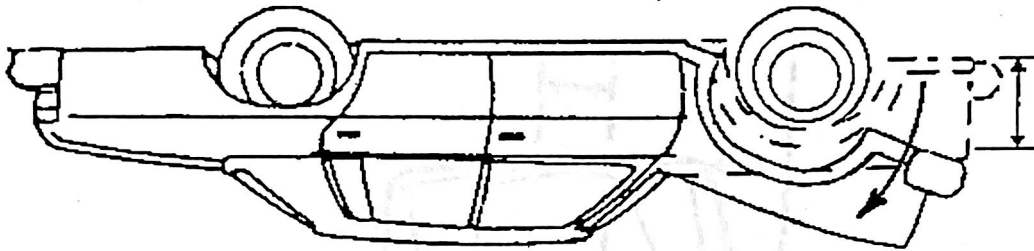
FIGURE 2: VERTICAL END SHIFT

BOWING SHIFT

Incrementing for bowing requires that, when struck in the side (usually between the axles) at least one end of the vehicle bows 10cm or more toward the impacted side. This is measured either at the original centerline of the vehicle or on the side opposite that which is impacted. When measuring at the centerline, use the inside rearview mirror/mount and the center of the back light to determine the original centerline. Project this out to the end plane, then measure from this projected point to the shifted center of the end plane (usually the center point of the bumper). If this measurement is 10cm or more at **either end** of the vehicle, increment the CDC. If you cannot locate the center(s) of the end plane(s), then run a stringline tangent to the undamaged side and parallel to the original centerline. Then measure from the stringline to the side of the bumper at the corner of the vehicle. If this measurement is 10cm or more at **either end** of the vehicle, then increment the CDC appropriately. Refer to Figure 3.
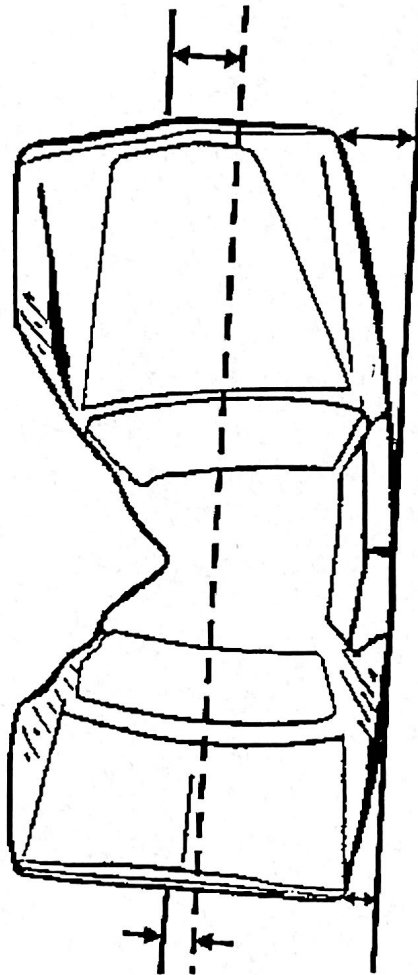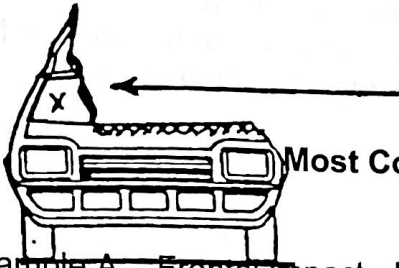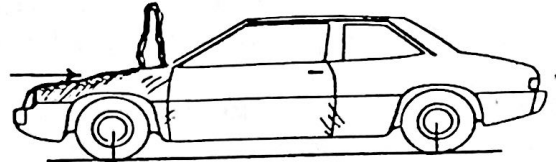

FIGURE 3: BOWING
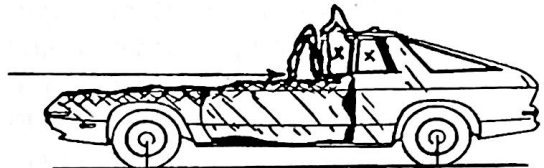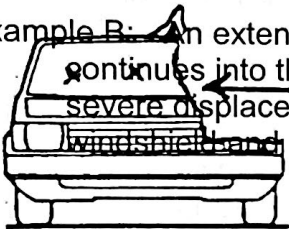
SEVERE UNDERRIDE DAMAGE

### Most Computer Reconstruction Programs Not Applicable

Example A: Frontal Impact - Damage is above the bumper/frame level. There is minimal engagement to the radiator and/or support components. Damage is generally restricted to the grille area, hood, and the top of the fenders.

Example B: An extension of Example A, damage continues into the greenhouse resulting in severe displacement of the hood, A pillars, windshield and header.

Example C: Frontal impact: Damage is restricted to the greenhouse area.   There is no contact below the beltline.
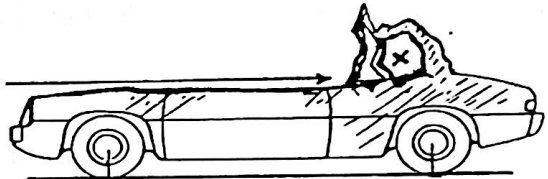
Note: Similar damage profiles to those represented in Examples A, B, and C which occur to the rear plane are also severe underrides.

Example D: Due to the lack of mechanical parts, the area between the beltline and frame is significantly less rigid in rear impacts than in frontal impacts. Consequently, impacts which are above the bumper/frame area and which result in crush that extends beyond the rearmost pillar area are generally considered severe underrides and are excluded from most reconstruction programs.
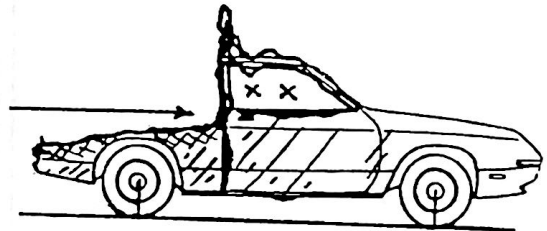
Example E: Side impacts which are restricted to the

area above the beltline, specifically the greenhouse, are considered severe underrides and are excluded from most reconstruction programs.

Example F: Side impact - While door guard beams provide structural rigidity, impacts which are restricted to the area above the sill/frame require caution with respect to the use of a reconstruction program. In Example F substantial greenhouse damage involves nearly one half of the passenger compartment. In most cases, this constitutes severe underride; however, some reconstruction programs may apply to less severe impacts above the sill/frame. Also, this would probably result in a latch, hinge or pillar failure which would require using the averaging technique stated in section 5.3.1. to obtain a crush profile for use in a reconstruction program.