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A Scientific Approach to Documenting Evidence for Accident Reconstruction

REFERENCE: Van Kirk, D. J., **"A Scientific Approach to Documenting Evidence for Accident Reconstruction,"** *Journal of Forensic Sciences*, JFSCA, Vol. 29, No. 3, July 1984, pp. 806-815.

ABSTRACT: Accident investigators have not had a consistent method of viewing accidents to gather the necessary information to allow other forensic scientists, particularly those who specialize in reconstructing accidents, to render as accurate and complete an opinion as possible. This paper presents a step-by-step procedure for examining and documenting the accident scene for both rural and urban accidents, as well as impacts to the exterior of the vehicle and interior damage caused by secondary occupant impacts. Diagrams of camera angles and scene configurations are also shown, along with a detailed description of how to use them to record accident data. A check list for accident data for reconstruction is also presented.

KEYWORDS: forensic science, accidents, accident investigation, accident reconstruction, accident scene, vehicle damage, investigation methods, investigation check list

Many people assume that accident *investigation* and accident *reconstruction* mean the same thing. To the forensic engineer, however, they are as different as day and night, even though they are closely related. The investigator "observes or studies by close examination" [*1*] and, we might also add, preserves and documents the evidence he or she finds. The reconstructionist must take this evidence and rebuild the accident, a microsecond at a time.

If the documentation is sketchy and the preservation photography poor or disjointed, the reconstructionist cannot develop an accurate representation of the scene. In dealing with police investigators, paralegals, and a plethora of other pseudotechnical personnel, I have found that many investigators are in a hurry to get the job done and are not willing to follow even a rudimentary procedure to eliminate the possibility of missed evidence or misleading or confusing documentation.

In investigating more than 4000 accident cases,[2] I have developed a set of guidelines that I use when called to the scene of an accident [*2-4*]. I have refined them over the years of my practice and I would like to offer them for use by the forensic science community.

To show how these guidelines can be used I have chosen the example of a vehicular rather than a industrial or commercial accident, not because it is any easier, but because it represents an open situation which is unique to the forensic scientist. In investigating a murder case, for example, one finds a very detailed, closed environment, which can be thoroughly examined and documented. Vehicular accidents are exactly the opposite. By the time the investigator arrives—one can only hope that this is within a few hours of the accident—many

Received for publication 22 Aug. 1983; revised manuscript received 27 Oct. 1983; accepted for publication 14 Nov. 1983.

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[2] During these 4000 investigations, no particular system was used to document the accidents. The method presented in this paper evolved over time and was refined in my private practice in later years.

pairs of feet have trampled over the area, including the impact site, and many pairs of hands have picked up, discarded, or moved around artifacts that could have a bearing on the reconstruction. The principal investigator is *the* individual who must control the scene. He literally has the final decision of the litigation in his grasp. The case can be won or lost through his foresight or thoughtlessness of investigatory techniques. Thus the investigator must not only observe and document the obvious; he or she must also be able to discover the not-so-obvious details necessary for an accurate reconstruction.

This paper presents a new and unique procedure for investigating a vehicular accident. This type of accident has four basic components: first, the scene or location where it occurred; second, the vehicles involved; third, the occupants; and fourth, the witnesses. We are only going to discuss the first two components at this time, the scene and the vehicles involved. The remaining two will be the topic of a subsequent paper.

The Accident Scene

The accident scene can be broken down into two areas: urban and rural locations. In an urban accident, many details are inadvertently deleted by the investigator. A typical urban configuration (Fig. 1) may include left turn lanes, right turn lanes, a straight through, alley ways, corners, utility poles, and so on, but not all of these are listed in a typical investigator's report. Most investigators overlook many of these details because they do not consider them important. Our aim is to put them back into the report.

Table 1 shows a checklist of information that must be recorded. First of all, pick a reference point as the origin for all measurements: not the point where the accident occurred but a known point that will not be changed two or three years from now when someone else goes out to look at the scene. A good example would be a telephone or utility pole. Check the engineering office of the utility or phone company; they have a number on each pole. Whatever you

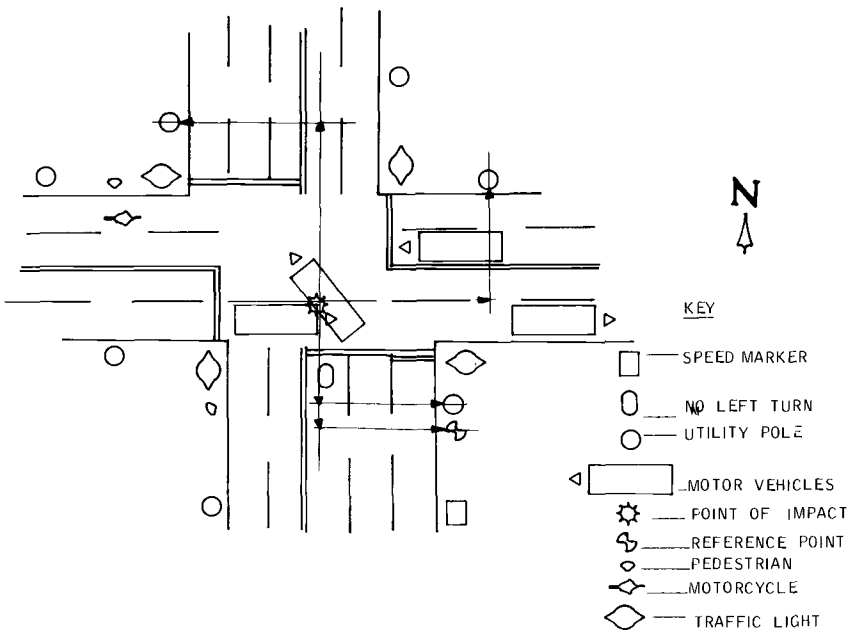

FIG. 1—*Sample urban accident configuration at an intersection.*

TABLE 1—*Reconstruction checklist.*

Scene
Urban or rural
Configuration
Reference point (R.P.)
Debris—location
Point of impact (P.I.)
Final resting point (if different than point of impact)
Origin of initial action
Skid marks (all)
Road bed and shoulder damage
Road hazards
Configuration details
Stop signs, poles, traffic lights
Driveways, buildings, curbing, unique intersections
Trees, culverts, mounds, fences, and posts
Plowed fields, types of shoulders (gravel, blacktop)
Vehicle
Exterior
14 camera angles (Minimum)
Additional close-ups of damage
Missing components
Unusual or unexplained damage
Interior: frontal, side, rear
Windshield bulge
Instrument panel damage
Sunvisor and header damage
Door trim panel abrasions and dents
Seat back and cushion damage
Observe all interior surfaces for abrasions, cuts, dents, or other unexplained damage

choose, make sure you know it can be located in the future; then mark and measure all debris at the scene from that reference point.

Take a picture of the reference point location. Mark and record the final resting point of the vehicles involved. Determine the point of impact. Your opinion may change later on, but you should still list your initial reasoning process and the reasons for your believing it to be that the point of impact. Measure the distance from your reference point to the point of impact and record it. In many cases, some evasive action may have taken place. Was there a tire failure or did something else fail, say in the suspension? Was there something in the way—a child, a tree limb, possibly a small animal? You may be able to back up from the point of impact and find the origin of this evasive action. Determine the length and number of skid marks, both front and rear. Examine the scene for curb damage. Which vehicle was it from? Did the bumpers scrape the curb? Did the tire roll over so that the rim actually damaged the cement? Look for fresh marks (with no embedded grease or dirt). If marks are present that are not fresh, record them anyway but note *that they were not fresh.*

Look for road hazards: was there a bump or a pothole caused by the previous winter? Was the curbing missing? Measure and record. How close was the final resting point to the nearest building? Measurements must be taken because debris will be everywhere and you will need this additional information to complete the investigation.

The investigator must fill in as many of these details on his sketch as possible, as shown in Fig. 1. Was the impact near a driveway? How far is it from the nearest utility pole? Look for damaged signposts, street markings, traffic lights that are not working—anything unusual that would help the reconstructionist to render an opinion. Figure 2 shows a diagram for re-

cording an accident that is not at an intersection. These diagrams can be made into pads and carried by the investigator.

In an urban environment, accidents occur at both high and low speeds. Rural accidents also almost always occur at high speeds. Figure 3 shows a straight section of rural road. There is a lot of information on this chart, all of which will be useful to the investigator. It is important to show culverts or mounds that could possibly have been built up by road construction

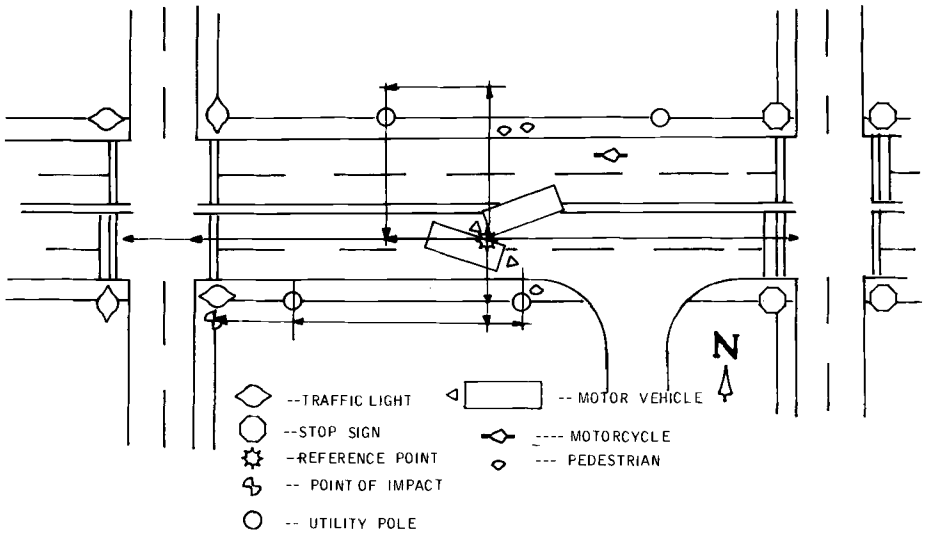

FIG. 2—*Sample urban accident configuration on a straight section of road.*

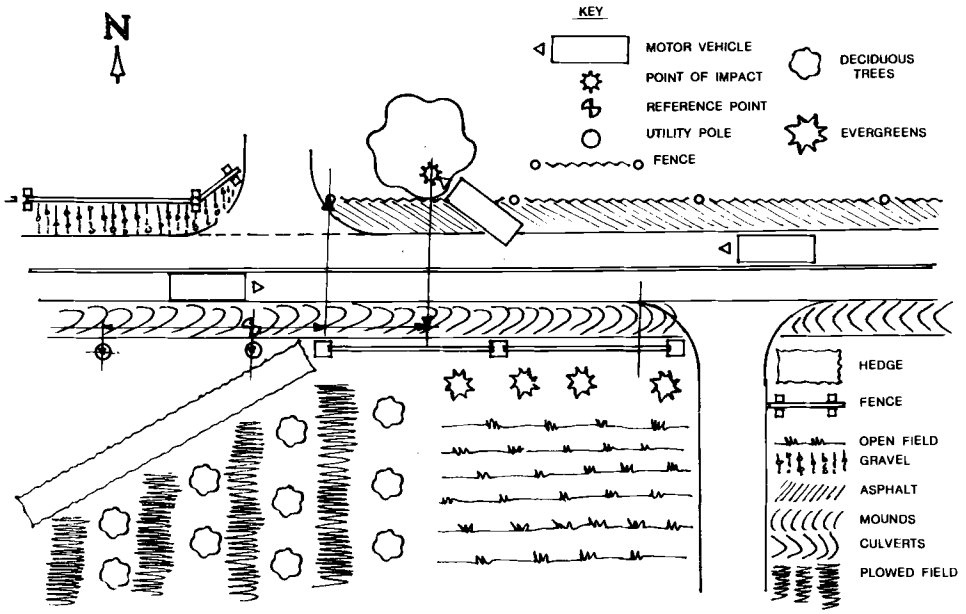

FIG. 3—*Sample rural accident configuration on a straight section of road.*

crews, different types of fences, open fields, plowed fields, gravel or blacktop shoulders, driveways, and other such details. Accident victims may be thrown from their cars and it is important to show where they land—in gravel, fields, fences, or up against trees. A medical report may tell you that gravel was found in the victim's head wound, while the police report does not mention that the shoulder was gravel. Investigators should learn to fill in the chart completely: there can never be too much information for the reconstructionist.

Again we go through the checklist. Pick known reference points as the origin of all measurements. You will find in most rural locations that most telephone or utility poles are numbered. The final resting point must be measured. Mark and measure all debris. Now, in rural areas debris is going to roll a long way. Windshields pop out and can be thrown 9 or 12 m (30 or 40 ft). Wheels roll off cars for several hundred feet. Look for them, try to determine how they reached their positions, and take pictures before you move anything. Record the point of impact. Look for a place where evasive action may have taken place—here more so than in the city because long curves and or slight bumps in roads can cause peculiar things to happen to a vehicle traveling at high speeds. Locate and measure skid marks. In this case skid marks will be left on the blacktop or concrete; and you will see the result of skidding in the gravel, in the grass, across a field, and even across a culvert. Make sure that you measure the width and depth of all culverts. This can be extremely important if there is a witness report stating that the vehicle jumped or skidded across one. Examine the roadbed for shoulder damage or unusual markings; observe the area before the point of impact for hazards, bumps, or construction work. Record all such observations. Was there damage to stationary objects such as trees or utility poles, fence posts, culverts, mail boxes, or culvert drains? Measure and record all damage, fresh or old. Fill in as many details as possible. Figure 4 shows a curved section of rural road. Again, fill in all the details that you can. Make sure you have recorded all information near the impact and resting point of the vehicle.

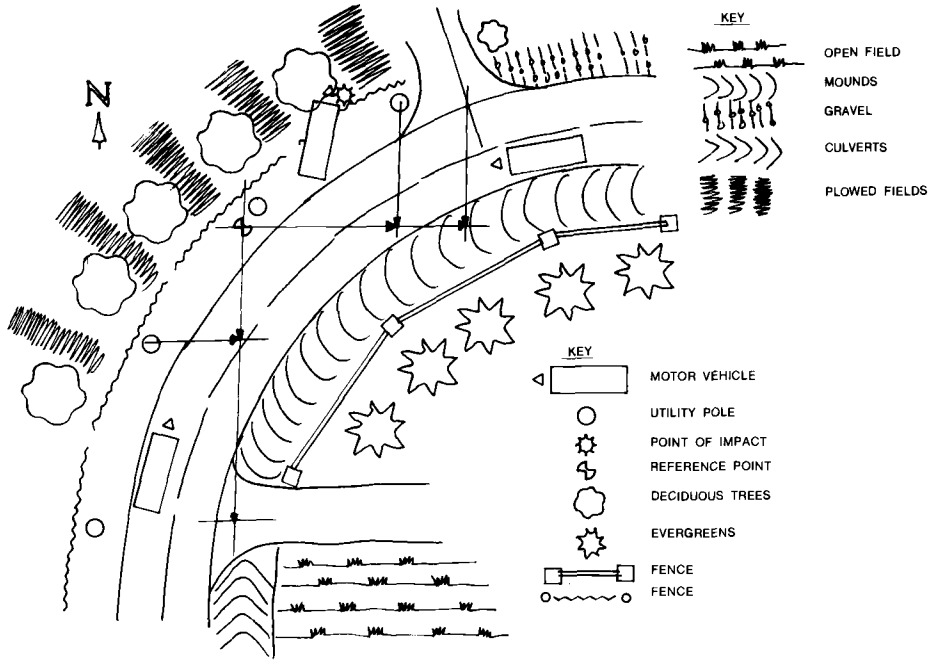

FIG. 4—*Sample rural accident configuration on a curved section of road.*

The configurations shown in Figs. 1 through 4 are only examples for the on-site investigators. They are not drawn to scale and are meant to show that measurements must be taken from landmarks with an identifiable location, such as telephone poles, light poles, or emergency phone boxes. Measurements taken from trees, curb extensions, or the sides of buildings are not reliable because when the accident is being reconstructed two to four years later, the trees may be cut down, the curbing has either been changed or is missing, and the building removed or renovated. The landmarks mentioned and shown in Figs. 1 through 4 will have a recorded history by the city or utility companies.

Specialized equipment is not required if the investigator uses the examples shown in Figs. 1 through 4. In addition, the investigator must fill in the other data, such as location of traffic lights, signpost markers, and other motor vehicles. I have suggested that measurements be taken from a reference point so that the presumed point of impact will not be the origin of measurements in case it is wrongly chosen. The location of debris is important in the reconstruction of any accident and must be measured and recorded. These are not assumed data but actual, physical data that *must be* recorded at the scene, especially if components are missing from the vehicle and is not easily found near the point of impact.

The Vehicle's Exterior

The second component of our accident investigation is the vehicle. I always try to photograph the exterior from 14 different camera angles.[3] An overall view is most important since it establishes the vehicle in question. The type, construction, engine size, and other data all can be found later in the specification literature. If you do not have an overall view it is difficult if not impossible to determine whether the vehicle is a two-door sports coupe, convertible, or family sedan, you will miss a most important piece of data.

Figure 5 shows four wide-angle views—one front, one rear, and one from each side, which will establish the make and model of the vehicle and also general damage areas. Next, sectional camera shots (Fig. 6) are required of the major sheet metal components of the vehicle—the front fenders, front and rear doors, and rear quarter panels. These views are medium close-up; they afford the reconstructionist a closer look at each component and how extensive the damage was.

Next we have the close-ups—three-quarter angle views, front left and right and rear left and right, as shown in Fig. 7. Why are these necessary? Damage to the side of the vehicle will show up at a low angle. If the impact was a side penetration, how deep was it? These views can show the reconstructionist the depth as well as the spread of the damage. If a measurement of the depth, in inches, is taken it will be necessary to use marker strips of alternate black and white areas, each 1 in. wide. These can easily be picked out of the photograph later.

Figure 8 shows all 14 camera angles. These must be considered only a minimum. Close-ups must be taken of other damage not completely covered previously; these should show the depth and direction of impact as seen from each of four directions—top and bottom, left and right. It is very important to know, for instance, whether the car was skidding on its roof going down a street or sliding on its tires. Look for sheet metal folds. The metal used in cars has been decreasing in thickness for the last ten years; nowadays it is usually no more than 0.635 mm (0.024 in.) thick. This thinner gage metal folds over on many types of impacts, with the direction of the fold revealing the direction of impact. Scrapes and scratches are

[3]The photographic techniques described here are only intended to show the direction and depth of penetration from a qualitative standpoint. They are meant to show subjectively how the investigator can photograph the entire vehicle and show the damage it sustained on all sides because of the complex nature of the automobile being a weldment of sheet metal components.

These techniques should not be construed as being related to photogrammetry and are not to be used as tools for measuring deformation.

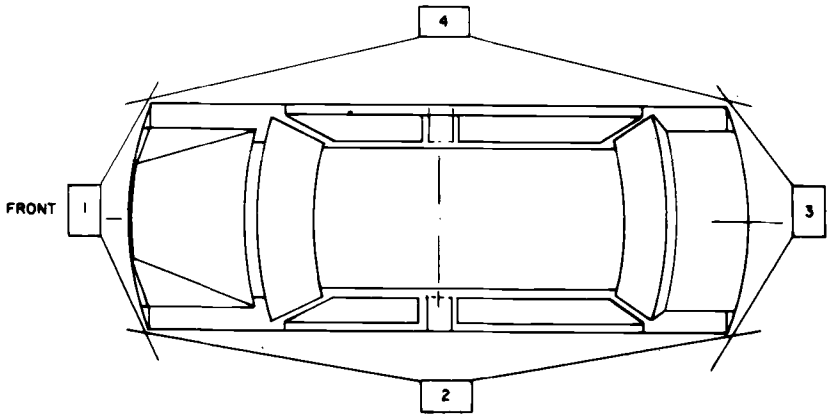

FIG. 5—*Four wide-angle shots giving an overall view of the vehicle exterior.*

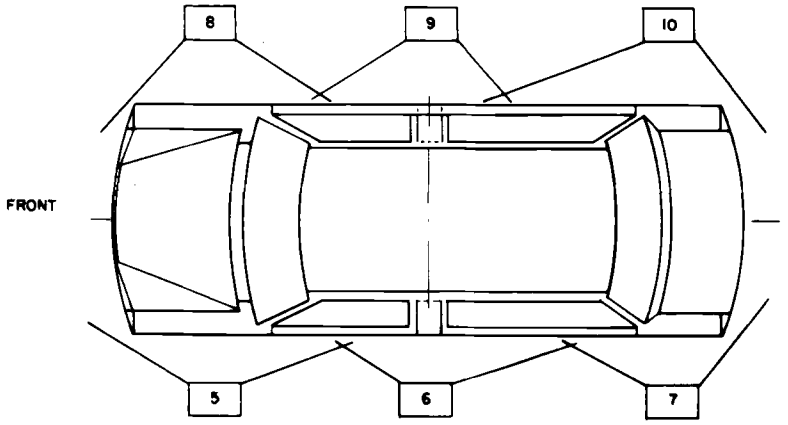

FIG. 6—*Camera angles for sectional shots of front fenders, front and rear doors, and rear quarter panels.*

also very important, since they will indicate the directions in which the vehicle was traveling during impact. Many wheels today are aluminum, so they retain the damage from an impact—scrapes, gouges, or dents.

Missing components are also very important. Is the chrome trim intact? Is the windshield or rear window missing? Where is it if not in place on the car? Has it been broken out from the inside or outside of the car? Many investigators forget that emergency crews remove windshields during extractions. Are the headlight and taillight lenses and covers missing or cracked? Where are they? Try to find them at the scene. Wheel covers pop off and roll for hundreds of yards. They might not have been accounted for. Interior trim components are sometimes pushed outside of a vehicle; look for those also.

Examine the exterior for unusual or unexplained damage. If the primary impact was on the right side of the car, did anything happen to the left? For example, if a vehicle slides across a field, could it hit a rock and break the off-side wheel loose from the axle? It is the investigator's job to determine the cause for *all* the damage to a vehicle, not only the initial impact damage. This is most easily done at the scene, not months or years later by the reconstructionist. Check for undercarriage dents by having a tow truck lift the car up and take pic-

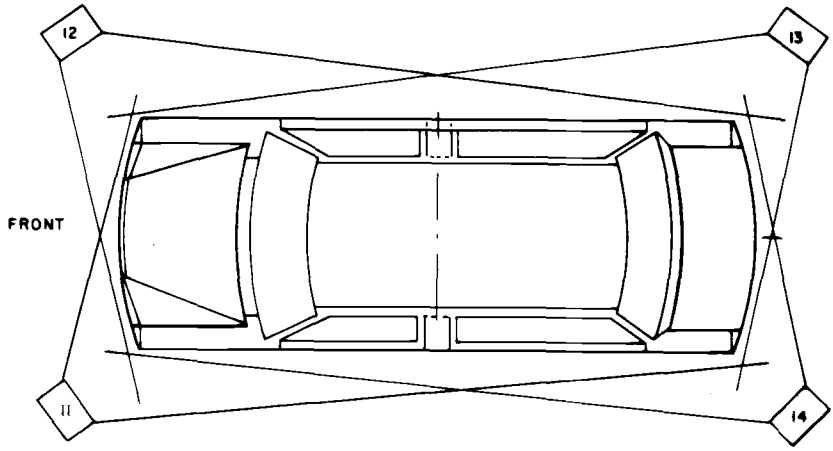

FIG. 7—*Camera angles for close-up views of front left and right and rear left and right.*

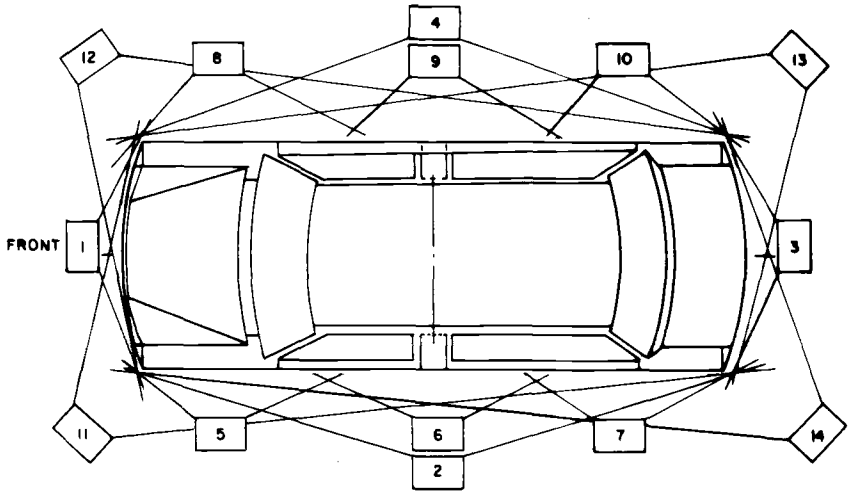

FIG. 8—*All 14 camera angles.*

tures of the underside components. Look for punctures in sheet metal and try to determine whether they were caused by a bullet, or maybe by a flying rock or even a steel rod lying in the street that somehow became airborne and punctured the vehicle exterior.

If the impact was to the right side of the car but the left window is missing, try to determine how this happened. It is possible that the driver's head struck the side window and fractured it and the pieces fell out into the street. Were the tires flat at the scene or did they go flat later? Take pictures of them and determine why. Check for leaking fuel other than at the gas tank. Many people today work on their cars and change the fuel systems. Look for changes under the car and in the engine compartment. Leakage of all other types, that is, antifreeze or oil, must also be documented. The investigator must use his or her sense of taste and smell to determine which type of fluid is leaking.

The Vehicle Interior

The second most important area is the vehicle interior. This information will allow a biomechanics expert to match the occupants' injury with the interior damage. Look for windshield damage and what is called a stellar impact. When the human head hits a windshield it causes damage in the form of a circular pattern, with cracks radiating from the center. There will also be a bulge in the windshield due to the plastic inner layer of laminated glass. Take a picture of it from the inside of the car and measure it. The biomechanics expert can then determine the amount of force with which the occupant's head struck the windshield. Also look for hair and tissue that might be embedded in the windshield.

Examine the instrument panel for damage caused by occupant impact. Instrument panels today are heavily padded and may not show impact damage. Use your fingers to probe along the whole surface: the metal underneath the padding will have been deformed. When an occupant hits the interior surface at an angle, it leaves a rub mark. Check the depth and location of sun visor impacts: if there are tall people in a small car, their heads will go forward into the sun visors, which are heavily padded, so the damage will not show unless you feel for it. Repeat the same procedure in the rear of the vehicle, because you don't know whether the people were in the rear during the entire time of the collision. It is possible for a rear seat occupant to be thrown forward, causing damage to the windshield and instrument panel. Check the back of the front seats for damage. Examine all the interior surfaces again for unexplained damage.

Side Impacts

The investigator must look for evidence of skin abrasions on the inner door panel. Check for dents in the trim, both above the door glass and below it, as well as missing door handles and window cracks, broken knobs or cracked lenses on the instrument panel. Blood and tissue embedded into any component are always an indication of impact damage.

Look for damage to the front seats and cushions. They fold over and have metal springs inside that retain the initial impact, which could be an indication of speed at impact. The investigator must view the interior of the vehicle from several angles to ensure that he or she has not missed any damaged component and failed to record it.

Rear Impacts

During rear impacts most of the damage is to the headrests or the upper back of the seats. The seats either bend backwards and break off their mounts, indicating severe force or just bend slightly rearwards. Again, report unexplained damages such as dents in trim pieces, headers, or headliners.

Additional Clues for Documentation

You have looked for the obvious; now you must look beyond that. You have to use your fingers to probe the inside of the car. Moldings are padded in luxury cars, so push your fingers along the edge. Is there a dent there? Could it possibly have been made by an occupant during the impact? If you can, cut it open, take off the foam, and take a picture of it. Measure it. Paddings, seat backs, and trim panels are all impact areas that must be examined. You have to use your eyes and hands.

Reconstruction Check List

To make things easier for the on-scene investigator I have developed a checklist that can be used as a memory aide (Table 1). The investigator can take the checklist to the scene of the ac-

cident and actually put a check mark by each item. Take a picture of any unexplained or incidental damage; you cannot go back later when the vehicle has been destroyed to reconfirm any theories.

After you have checked everything off, review the scene and the vehicle a final time, looking for changes that may not have appeared relevant at first glance. A road sign may have been bent by a car riding over it. A dent in that front fender could have been from the bolt in the sign. Take a picture, mark the location, and see if it fits into your reconstruction later.

The investigator must use his eyes, hands, and nose, and try to visualize what happened. Put yourself in the vehicle at the scene and try to think through what happened. This should result in a complete report of the damage which will allow the forensic engineer to make an accurate reconstruction of the accident.

Conclusions

The accident investigation approach shown in this paper has been developed over the course of several years and has proven effective in litigation work. It is not meant to be a panacea for the investigator but rather to offer a logical approach to a very complicated situation—the accident scene.

I hope that other forensic engineers will use this paper as a building block to develop even more sophisticated systems, so we can all move forward and make accident investigation a true science.

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