MACHINE VS. MAN

By Arthur C. Croft, DC, MS, MPH, FACO, FACFE

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Sixth volunteer	Daniel Voss
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No video or film footage or still photography has been altered in any way, other than to add labels representing actual crash parameters.

Filmed on location at the **United States Naval Training Center**, San Diego, California, August 1999 and August 2000. Research funded by the **Spine Research Institute of San Diego** and the **Center for Research into Automotive Safety and Health** (CRASH), a non-profit corporation, and by contributions from **VF Works** and **Dynamic Motion X-ray**.

Special thanks to the United States Navy and to the City of San Diego Training Facility, Fire and Life Safety Services. Thanks also to John Lytle of San Diego Mist and Shade.

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Instrumentation

Accelerometers

Headgear array consisted of three triaxial blocks of IC Sensors 3031-050 (50 g) accelerometers tightly affixed to the head via a lightweight headband. Peripheral head acceleration measurements were resolved to the approximate head static center of gravity via an algorithm which utilized the locations of each triaxial block relative to known anatomical landmarks.

A low profile triaxial block of thoracic accelerometers was constructed using two Entran EGAXT-50 (50 g) accelerometers and one IC Sensors 3031-050 (50 g). The accelerometers were affixed to the subjects with medical adhesive and tightly fitted straps at the approximate level of C7-T1 on the anterior torso.

For the lumbar measurements, a lightweight uniaxial IC Sensors 3031-050 (50 g) accelerometer was affixed with medical adhesive to the base of the subjects' lumbar spines at approximately the level of L5-S1.

Target and bullet vehicle accelerometers consisted of a triaxial block of 3031-050 (gain adjusted to ± 15 g full scale) accelerometers affixed with sheet metal screws to each vehicle's chassis at the approximate static center of gravity.

Analog to digital conversion was performed by a 12-bit A/D converter operating with a maximum conversion rate of 330,000 samples per second. All data were collected following the general theory of Society of Automotive Engineers (SAE) Recommended Practice: Instrumentation for Impact Test—Part 1—Electronic Instrumentation—J211/1 Mar95. (SAE, 1996). All accelerometer data was collected at 1000 Hz. Vehicle accelerations were filtered using an SAE Class 60 filter. Vehicle changes in velocity were calculated from vehicle acceleration data filtered with an SAE Class 180 filter. Occupant accelerometer data was filtered with and SAE Class 60 filter. Vehicle speeds were also measured in tests s99-1 through s99-9 using a 5^{th} wheel (MEA 5^{th} Wheel, Richmond, BC) attached to each vehicle. Data were acquired at 128 Hz simultaneously for both vehicles for the period 1 sec before to 4 sec after impacts.

Time traps

Time traps for recording vehicle impact speed consisted of custom built Timer Interval Meters with internal clock calibrated to an NIST traceable source. The pressure sensitive tape switches were Tape Switch Corporation Type 102A, requiring 40 ounce pressure for activation.

Cameras

Vehicle and some occupant motions were recorded using a Locam 500 fps pin-registered high speed film camera, 1/3 shutter (1/1500 sec) loaded with Kodak type 7251 color reversal film; 50 mm lens. Occupant kinematics were also recorded with a Memrecam Ci high speed digital video camera at 500 fps with 1/3 shutter (1/1500 sec); 12.5-75 mm lens. Digital data was then downloaded to S-VHS video decks and DV decks. Record times were 3.4 sec in duration and operated with a pre-event acquisition trigger. Backup high speed footage was recorded on some tests (s00-1 through s00-18) at 240 fps using a JVC 9800 digital camera, and at 120 fps using a JVC 9500 digital video camera. On-board digital recordings were made with two Sony VX1000 DVs, one and Sony VX2000 DV, and one Sony TR750 Hi8 video camera set at the highest possible shutter speed. Off-board film recordings were made using a 16 mm Eclair ACL film camera and a 16 mm Bolex Rex-5 film camera using Fuji F125 color negative film, ASA 125. Beta SP video was shot using a JVC KY27B camera. Still sequences were recorded with a Nikon F3 with MD-4 motor drive and a Nikon F4 with internal motor drive using Fuji 200 ASA color negative film. Exposure was 1/1000 sec per frame.

Hi-gain 3M Photoreflective targets placed at measured distances were utilized as occupant and vehicle targets. Standard red and white tape was used on test vehicles.

Results

In the following table, crash test data for CRASH 99 (August 1999) and CRASH 2000 (August 2000) is presented. Further data on the volunteers is presented below, as are vehicle specifications. The sequence number (seq. #) refers to the actual crash order of testing on the two crash dates. The letters in parentheses indicate impact vector as either rear (R), frontal (F), side (S), or sideswipe (SS). The vehicle placards are visible in many of the tests and this alphanumeric data is also provided, although it has no other significance for the viewer. The video number (e.g., s99-1) corresponds to the numbers provided in the actual videotape prior to the showing of the crash sequence. The closing velocity (V_c), delta V (ΔV), and resultant head acceleration are also provided. In some instances, equipment malfunction resulted in data being lost. This is represented by "dl."

Some crash tests are not shown due either to their similarity to others, poor quality video, or in the interest of time.

CRASH 1999						
Volunteer	**Seq. #**	**Vehicle placard**	**Video #**	**V_c (mph)**	**ΔV (mph)**	**Head linear res. (g)**
MC	1 (R)	T24401	s99-1	5.4	dl	dl
MC	2 (R)	T24402	s99-2	9.3	5.2	12.5
MC	3 (R)	T24403	s99-3	9.9	6.0	13.0
CH	4 (R)	T24404	Not shown	3.7	3.2	5.6
CH	5 (R)	T24405	Not shown	7.2	5.8	11.1
CH	6 (R)	T24406	s99-6	6.6	5.6	13.5
CH	7 (R)	T24407	s99-7	4.1	3.3	6.8
CH	8 (R)	T24408	Not shown	7.2	5.7	12.8
CH	9 (R)	T24409	s99-9	7.0	5.2	8.9
JM	10 (S)	T24410	s99-10	7.6	3.1 (1)	4.6 (2)
JM	11 (S)	T24411	Not shown	6.8	dl	Min
JM	12 (S)	T24412	Not shown	6.6	dl	Min
JM	13 (S)	T24413	Not shown	7.5	4.5	Min
JM	14 (SS)	T24414	s99-14	14.0	n/a	1.2
RH	15 (F)	T24415	s99-15	36.9	17.1	10.3
1. Early trigger. Approximate velocity. 2. Center z acceleration.						
CRASH 2000						
Volunteer	**Seq. #**	**Vehicle placard**	**Video #**	**V_c (mph)**	**ΔV (mph)**	**Head linear res. (g)**
JH	1 (R)	T256-01	s00-1	4.8	3.8	5.0

JH	2 (R)	T256-02	s00-2	7.8	5.8	12.7
JH	3 (R)	T256-03	s00-3	8.3	5.9	8.2
JH	4 (F)	T256-04	Not shown	4.1	dl	dl
JH	5 (F)	T256-05	s00-5	3.8	dl	1.6
JH	6 (F)	T256-06	s00-6	7.7	5.5	2.9
CH	7 (F)	T256-07	Not shown	4.2	3.2	1.7
CH	8 (F)	T256-08	s00-8	7.9	5.6	3.1
CH	9 (F)	T256-09	s00-9	9.9	7.1	4.6
CH	10 (R)	T256-10	s00-10	3.0	2.8	2.9
CH	11 (R)	T256-11	s00-11	7.5	6.0	12.8
CH	12 (R)	T256-12	s00-12	8.6	6.7	15.0
DV	13 (R)	T256-13	s00-13	3.6	2.9	4.0
DV	14 (R)	T256-14	s00-14	5.5	4.7	7.8
DV	15 (R)	T256-15	s00-15	7.2	5.8	4.3
DV	16 (F)	T256-16	s00-16	2.7	dl	1.3
DV	17 (F)	T256-17	s00-17	7.2	4.2	dl
DV	18 (F)	T256-18	s00-18	9.9	5.6	dl
RH/JH	19 (F)	T256-19	s00-19	dl	dl/15.7	dl

Volunteers

MC: male, age 28 yr, height 71 inches, weight 195 lb

CH: female, age 36 yr, height 62 inches, weight 122 lb

JM: female, age 41 yr, height 67 inches, weight 125

RH: male, age 40 yr, height 70 inches, weight 210 lb

JH: male, age 44 yr, height 74 inches, weight 188 lb

DV: male, age 25 yr, height 71 inches, weight 180 lb

Vehicle numbers

1. 1991 Lincoln Continental 4-Door Executive Series.
    a. VIN# 1LNCM9747MY646735

2. 1991 Honda Civic DX 4-Door.
    a. VIN# JHMED3641MS013953

3. 1989 Ford Tempo LX 4-Door.
    a. VIN# 1FAPP37X2KK176690

4. 1992 Chrysler Le Baron convertible.
    a. VIN# 1CEXU4535NF267706

Vehicle Specifications

MAKE: 1991 LINCOLN, CONTINENTAL BASE/SIGNATURE 4DR SEDAN

A:	Longitudinal distance between the center of the front bumper and the center of the base of the windshield	57.9 in
B:	Passenger car Longitudinal distance between the center of the rear bumper and the center of the base of the backlight Station wagon and vans Longitudinal distance between the backlight top molding and the front door latch pillar Pick-ups Longitudinal distance between the rearmost projection and the front door latch pillar	32.7 in
C:	The maximum vertical height of the side glass	16.1 in
D:	Vertical distance between the base of the side glass and the lower edge of the rocker panel	28.3 in
E:	Distance between side rails or maximum width of top	45.7 in
F:	The front overhang	45.7 in
G:	The rear overhang	52.0 in
WB:	Wheelbase	109.1 in
OL:	Overall length	205.1 in
OW:	Overall width	72.8 in
OH:	Overall height	55.5 in
CW:	Curb weight	3663 lbs

TWF: Front track width	N/A
TWR: Rear track width	N/A
WDIST: Front/Rear weight distribution	62/38 %

MAKE: 1991 HONDA, CIVIC DX/LX 4 DR SEDAN

A: Longitudinal distance between the center of the front bumper and the center of the base of the windshield	43.7 in
B: Passenger car Longitudinal distance between the center of the rear bumper and the center of the base of the backlight	
Station wagon and vans Longitudinal distance between the backlight top molding and the front door latch pillar	24.4 in
Pick-ups Longitudinal distance between the rearmost projection and the front door latch pillar	
C: The maximum vertical height of the side glass	15.4 in
D: Vertical distance between the base of the side glass and the lower edge of the rocker panel	26.4 in
E: Distance between side rails or maximum width of top	40.2 in
F: The front overhang	32.3 in
G: The rear overhang	38.6 in
WB: Wheelbase	98.4 in
OL: Overall length	168.9 in
OW: Overall width	66.5 in
OH: Overall height	53.5 in
CW: Curb weight	2189 lbs
TWF: Front track width	N/A
TWR: Rear track width	N/A

WDIST:	Front/Rear weight distribution	N/A

MAKE: 1989 FORD CARS, TEMPO L/GL/LX/GLS/4 WD 4 DR SEDAN

A:	Longitudinal distance between the center of the front bumper and the center of the base of the windshield	51.2 in
B:	Passenger car Longitudinal distance between the center of the rear bumper and the center of the base of the backlight	
	Station wagon and vans Longitudinal distance between the backlight top molding and the front door latch pillar	28.3 in
	Pick-ups Longitudinal distance between the rearmost projection and the front door latch pillar	
C:	The maximum vertical height of the side glass	13.8 in
D:	Vertical distance between the base of the side glass and the lower edge of the rocker panel	28.0 in
E:	Distance between side rails or maximum width of top	41.3 in
F:	The front overhang	35.8 in
G:	The rear overhang	43.3 in
WB:	Wheelbase	100.0 in
OL:	Overall length	177.2 in
OW:	Overall width	69.3 in
OH:	Overall height	52.8 in
CW:	Curb weight	2581 lbs
TWF:	Front track width	55.5 in
TWR:	Rear track width	57.5 in
WDIST:	Front/Rear weight distribution	61/39 %

MAKE: 1992 CHRYSLER, LE BARON CONVERTIBLE/LX/GTC CONVERTIBLE

A:	Longitudinal distance between the center of the front bumper and the center of the base of the windshield	59.1 in
B:	Passenger car Longitudinal distance between the center of the rear bumper and the center of the base of the backlight	
	Station wagon and vans Longitudinal distance between the backlight top molding and the front door latch pillar	29.1 in
	Pick-ups Longitudinal distance between the rearmost projection and the front door latch pillar	
C:	The maximum vertical height of the side glass	N/A
D:	Vertical distance between the base of the side glass and the lower edge of the rocker panel	27.6 in
E:	Distance between side rails or maximum width of top	N/A
F:	The front overhang	42.9 in
G:	The rear overhang	40.6 in
WB:	Wheelbase	100.4 in
OL:	Overall length	185.0 in
OW:	Overall width	68.5 in
OH:	Overall height	52.4 in
CW:	Curb weight	3045 lbs
TWF:	Front track width	N/A
TWR:	Rear track width	N/A
WDIST:	Front/Rear weight distribution	N/A

MAKE: 1992 FORD CARS, TAURUS L/GL/LX 4DR SEDAN

A:	Longitudinal distance between the center of the front bumper and the center of the base of the windshield	53.1 in
B:	Passenger car Longitudinal distance between the center of the rear bumper and the center of the base of the backlight	
	Station wagon and vans Longitudinal distance between the backlight top molding and the front door latch pillar	27.6 in
	Pick-ups Longitudinal distance between the rearmost projection and the front door latch pillar	
C:	The maximum vertical height of the side glass	14.6 in
D:	Vertical distance between the base of the side glass and the lower edge of the rocker panel	28.3 in
E:	Distance between side rails or maximum width of top	44.1 in
F:	The front overhang	40.2 in
G:	The rear overhang	46.1 in
WB:	Wheelbase	105.9 in
OL:	Overall length	192.1 in
OW:	Overall width	71.3 in
OH:	Overall height	53.9 in
CW:	Curb weight	3146 lbs
TWF:	Front track width	N/A
TWR:	Rear track width	N/A
WDIST:	Front/Rear weight distribution	64/36 %

MAKE: 1994 HYUNDAI, EXCEL 2DR HATCHBACK CX/CXL

A: Longitudinal distance between the center

	of the front bumper and the center of the base of the windshield	47.6 in
B:	Passenger car Longitudinal distance between the center of the rear bumper and the center of the base of the backlight	
	Station wagon and vans Longitudinal distance between the backlight top molding and the front door latch pillar	32.3 in
	Pick-ups Longitudinal distance between the rearmost projection and the front door latch pillar	
C:	The maximum vertical height of the side glass	15.4 in
D:	Vertical distance between the base of the side glass and the lower edge of the rocker panel	27.6 in
E:	Distance between side rails or maximum width of top	37.0 in
F:	The front overhang	34.3 in
G:	The rear overhang	31.9 in
WB:	Wheelbase	93.7 in
OL:	Overall length	161.4 in
OW:	Overall width	63.4 in
OH:	Overall height	51.6 in
CW:	Curb weight	2143 lbs
TWF:	Front track width	54.7 in
TWR:	Rear track width	52.8 in
WDIST:	Front/Rear weight distribution	N/A

Talking Points

Because many courts will not allow the audio portion of the videotape to be played out of concern that this might unduly bias the presentation (due perhaps to the narrator's persuasive voice or the dramatic sounds of crashes), there is no audio portion of this tape. All crash scenes are preceded by a six-second splash screen indicating the crash number, volunteer, closing velocity, delta V, and resultant head acceleration.

Watching these crashes from different perspectives and at different playback speeds allows the viewer to see details not otherwise visible. Some talking points that might be used when the video is being shown are provided below.

1. The contrast between the real time footage and the slow motion footage is notable. At real speeds, many of the lower speed crashes appear quite trivial. But, when viewed in slow motion, the extraordinary forces of compression, tension, shear (both forward and rearward), and bending moment are easier to appreciate.
2. Notice the difference between the acceleration of the male vs. female subjects. Females generally experience greater head acceleration than males. Also note that males interact more violently with the seat back and head restraint. This gives them more ride down and reduces their acceleration. However, they tend to experience more extension due to this and their generally higher head position.
3. In most cases, residual bumper damage is either absent or minimal. In the early crashes, the Honda front bumper fasteners are damaged, resulting in a drooping of the bumper. However, the foam core and plastic fascia were undamaged, aside from scratches. The rear sheet metal above the bumper was dented slightly when struck by the Lincoln, due to the Lincoln’s pointed nose section. This was also minimal damage. Until the last high speed crash, the Chrysler Le Baron was never damaged, aside from scratches. The Ford Taurus did undergo progressive damage in additional crashes.
4. The Earth coordinate grid in the background allows the viewer to see Newton’s first law of motion in action. It clearly shows how the occupant is actually struck by his vehicle and set into motion.
5. Volunteers were told to apply brakes as they would normally do at a traffic signal and the vehicles were in gear and running. Notice how the foot comes away from the brake pedal and the hands come away from the steering wheel. This allows the vehicle to accelerate unopposed.
6. In crash s99-3 the subject, MC, did sustain minor injury and was retired from further testing. He recovered completely in several days.
7. In crash s99-6, CH, reapplies the brake very quickly after initial contact. Since the Lincoln still had some forward momentum after the first crash, it struck her a second time.
8. In crash s99-7, the driver of the Ford Tempo, which also proved to be quite durable in terms of standing up to several crashes without bumper damage, holds a coffee mug without spilling the contents. This illustrates some of the disparity between frontal and rear crashes.
9. Crash s99-9 is a braced crash. Notice the subject relax after the test. In other crashes, subjects listened to the car radio and a CD through small earphones in order to distract them from the exact moment of crash. They were also told to relax as they would during normal driving. However, analysis of video suggests full relaxation was not achieved in all cases. We did not verify the state of

pretension using sEMG. It is also likely that volunteers who do know they are about to be struck will react more briskly than real world occupants caught by surprise. The extent to which this may be true is unknown, nor is it clear how earlier reaction would affect the kinematic response. It is clear, however, that subject CH does actively decelerate her head in most crashes. This occurs with about 120 msec, faster than would probably occur in an unaware occupant.

10. In the side impact crash s99-10, the subject's lateral head motion is quite marked. Yet she felt quite certain that her head did not move at all. The subject of crash s99-1 also stated that his head did not strike the head restraint. Other researchers have found that about 30% of volunteers report an initial forward motion rather than the true initial rearward motion.
11. In crash s99-14 the lateral kinematic to the driver is trivial. It is important to remember that not all sideswipe crashes are the same. With a more solid contact, in which more resultant property damage would accrue, the lateral forces can be greater. And post impact swerving can also subject occupants to further forces.
12. In the high speed airbag deployment, s99-15, the closing velocity was 36.9 mph. There was no occupant in the Ford Tempo and the Honda Civic was placed sideways in front of the Tempo to forestall its runout. Although property damage to both cars—and especially the Tempo—is extensive, note that the head acceleration of the Lincoln driver is actually lower than those of many lower speed rear impact crashes in which there is little or no property damage. This illustrates that many other factors aside from delta V and property damage must be considered in assessing risk for injury. In this case, the driver made himself very stiff, and the longer duration of the plastic crash gave him plenty of ride down.
13. In crash s00-2, you can again see how the larger male violently interacts with his seat back and head restraint. Notice that, initially, as with the Lincoln tests, the subject's lumbar region and pelvis cause the seat back to move rearward, and the head restraint relatively lower—both positions which place the subject at greater risk for injury.
14. The differences between frontal and rear crashes are illustrated in crash tests s00-1 through s00-18. Subjects experienced three rear impacts, starting with one at very low speed and ending with one for which they were told to brace. They also experienced three frontal crashes. The order of the crashes were staggered, with JH and DV experiencing first the rear impact type, and CH experiencing first the frontal type. Subjects were crashed at similar speeds while sitting in the same vehicles and colliding with the same vehicles. The only variable was crash vector. The differences between these two crash types is remarkable, with the rear impact type resulting in a more complicated biphasic kinematic, while the frontal resulted in only a monophasic kinematic. In general, head accelerations were much higher in the rear impact tests.
15. The volunteer in crash s00-18 drives his vehicle in under its own power. This is the only test, other than the higher speed frontal tests, in which the crash occurred under full power conditions. This was planned to be a higher speed test, beyond the ability of the push team.

16. In tests s00-16 and s00-17, notice that the Hyundai Excel stops (or nearly stops) after impact. The law of conservation of momentum tells us that much of that car's momentum has been transferred to the struck car.

Frequently Asked Question

The most frequently asked question concerns the risk of injury in these low speed crash tests. Specifically, does this video imply some quantification of risk for injury? The short answer is no. These tests are conducted to learn more about occupant kinematics and the interactions between the occupant and his/her vehicle, as well as the interactions between the two vehicles. Greater knowledge in these areas will allow us to better understand how to build safer, more crashworthy vehicles. Our goal is not to explore the limits of human tolerance to the various forces experienced in low speed crashes, nor is it our goal to investigate or measure the actual risk for occupant injury in such crashes.

Volunteers are carefully selected in order to minimize the risk for injury. Exclusion criteria includes history of neck injury or neck pain or headaches, history of any significant pre-existing spinal condition, or a poor level of fitness. Moreover, we eliminated or reduced the impact of all known risks factors for injury to the extent possible. Crash speeds were also limited to those we believed would be tolerated by these relatively physically fit and healthy volunteers. Thus, these subjects and the crash scenarios they participated in in the video cannot be considered representative of the entire universe of real world drivers or crash conditions. Moreover, beyond the point already made that it was not our intent to explore risk, the relatively small number of crashes does not allow us to apply tests of statistical significance in order to determine whether our outcome (e.g., one subject with a minor injury out of four exposed to rear impact crashes) is a reliable proxy for real world risk at these crash speeds. This same limitation exists in other published crash studies as well, despite the fact that some have erroneously argued that these studies can be used as a measure for injury risk. Therefore, the argument cannot be made from our data that *only minor injuries result from crashes at these speeds* or that *only 25% of persons exposed to these crashes is likely to be injured*. In fact, the clinical and epidemiological literature would support neither statement. The video should be viewed only for the purpose of understanding the resulting occupant kinematics of low speed crashes of various vectors.

Recommended Reading

In order to better understand many of the details that might otherwise remain hidden within the frames of these video clips, some additional reading or study might be needed. The following sources will be helpful.

1. Croft AC: Biomechanics. In Foreman SM, Croft AC (eds), second edition, *Whiplash Injuries: the Cervical Acceleration/Deceleration Syndrome*, Baltimore, Lippincott-Williams & Wilkins, 1995.
2. Croft AC: Module 1 of Whiplash: the Masters' Program, Spring Valley, Spine Research Institute of San Diego, 2000.
3. Croft AC: Proceedings of the Annual Advanced Program, Spring Valley, Spine Research Institute of San Diego, (available yearly).

Companion Products

Several other products offered by the Spine Research Institute of San Diego, and developed by Dr. Croft, are likely to be of interest to purchasers of this videotape. They include the following. Additional information about products or upcoming seminars can be obtained by asking for the free CD-ROM which has product information, software demos, free clipart, and other goodies.

1. ***Whiplash: the Poster SYSTEM***. A series of eight full color posters depicting risk factors, types of trauma, mechanism of injury, common myths and facts, and many other important details about whiplash. Also comes with eight ***Poster Pads*** which are 8.5 by 11 inch full color miniatures which can be given to patients, arbitrators, or juries. Comes with carrying case, colored marking pens, and a booklet with scientific references for the material covered.
2. ***Whiplash: a Patient's Guide to Recovery.*** These 80-page booklets help explain the A-Zs of whiplash to patients. Also a handy giveaway for lawyers.
3. ***Hypertext 2.0.*** A software program containing all four Modules of Dr. Croft's ***Whiplash: the Masters' Certification Program***. Search, read, copy and paste, or print from it. Probably the most versatile compilation of recent whiplash material in the world. Plug-ins available include the ***Proceedings of the Advanced Programs*** for 1998 through the year 2000, and the ***Whiplash Database***.
4. ***Whiplash.*** Dr. Croft's EMMY-nominated patient education videotape. Note: this is a tape designed for chiropractors. Spanish and looped versions available.
5. ***Whiplash:*** the Epidemic, version 5.0. A slide presentation program on the subject of whiplash. Comes with Kodak carousel of full color slides and instruction book. Custom title slides available. An excellent program for educating attorneys and lay audiences alike.
6. ***The CRASH Report***. A monthly subscription newsletter that covers the latest breaking news in whiplash. From the engineering literature to the clinical, Dr. Croft, a manuscript reviewer for several journals, including those of SAE and *Spine*, critiques the latest literature in detail. It's the best way to stay on the cutting edge of your science. Most issues are 20 plus pages.

Legal Cases Involving Videotape as Evidence

Can you bring a videotape into a legal proceeding to be used as illustrative evidence? Will an arbitrator or judge allow it? Can opposing counsel successfully object to it? The answer to these questions are largely dependent upon the foundation that is put forth for bringing the videotape in. The following cases should offer insight into how best to argue for the inclusion of this type of illustrative evidence during an expert's testimony.

16 F.3d 1083
38 Fed. R. Evid. Serv. 1253
(Cite as: 16 F.3d 1083)

United States Court of Appeals, Tenth Circuit

Lewis R. ROBINSON, Nancy D. Robinson, Darwin T. Turnbull, III, as personal representatives of the Estate of Julia Ann Turnbull, deceased, an Oklahoma citizen, Plaintiffs-Appellees and Cross-Appellants.
v.
MISSOURI PACIFIC RAILROAD COMPANY, doing business as Union Pacific Railroad Company, a Delaware Corporation, Defendant-Appellant and Cross-Appellee.

Nos. 92-6099, 92-6112

773 P.2d 1120
(Cite as: 70 Haw. 419, 773 P.2d 1120)

Supreme Court of Hawaii

Louis LEOVSKY and Molly Leovsky, Plaintiffs-Appellants,
v.
Laurie CARTER, Michael Clark, and County of Hawaii, Defendants-Appellees, and COUNTY OF HAWAII, a municipal corporation, Third-Party Plaintiff-Appellee,
v.
Richard A. Williams, III, Third-Party Defendant.

No. 13187

973 F.2d 1434
37 Fed. R. Evid. Serv. 225, Prod.Liab.Rep. (CCH) P 13,373
(Cite as: 979 F.2d 1434)

United States Court of Appeals, Tenth Circuit

FOUR CORNERS HELICOPTERS, INC., a Colorado corporation; Jenny R. Paton, as surviving spouse and as personal representative of the Estate of William Paton, deceased, Plaintiffs-Appellees,
v.
TURBOMECA, S.A., a French corporation, Defendant-Appellant, and Societe Nationale Industrielle Aerospatiale, a French corporation; Aerospatiale Helicopter Corporation, a Delaware corporation; Avialle, Inc., a Delaware corporation; Roberts Aircraft, Inc., an Arizona corporation, Defendants.

No. 91-1295

812 F.2d 1265
55 USLW 2535, 22 Fed. R. Evid. Serv. 841
(Cite as: 812 F.2d 1265)

United States Court of Appeals, Tenth Circuit.

Clifford R. BANNISTER, Plaintiff-Appellee,
v.
TOWN OF NOBLE, OKLAHOMA, Defendant Appellant.

No. 84-1433.

638 F.2d 209
7 Fed. R. Evid. Serv. 1726
(Cite as: 638 F.2d 209)

United States Court of Appeals, Tenth Circuit.

Larry J. BRANDT, Plaintiff-Appellant,
v.
Marvin W. FRENCH, Defendant-Appellee.

No. 79-1514.

873 F.2d 1343
27 Fed. R. Evid. Serv. 912
(Cite as: 873 F.2d 1343)

United States Court of Appeals, Tenth Circuit.

Gregory Allen HARVEY, By and Through his legal guardian, Lyle Dean HARVEY, Plaintiff-Appellant,

v.
GENERAL MOTORS CORPORATION, Defendant-Appellee.

No. 87-2593.

989 F.2d 399
38 Fed. R. Evid. Serv. 557, Prod.Liab.Rep. (CCH) P 13,446
(Cite as: 989 F.2d 399)

United States Court of Appeals, Tenth Circuit.

Gregory L. GILBERT, individually and as administrator of the Estate of Deric Gregory Gilbert, deceased, and his wife, Tammy Gilbert, Plaintiffs-Appellants,
v.
COSCO INCORPORATED, a corporation organized and existing under the laws of the State of Indiana, Defendant-Appellee.

No. 91-7005.

847 F.2d 1261
25 Fed. R. Evid. Serv. 1153
(Cite as: 847 F.2d 1261)

United States Court of Appeals, Seventh Circuit.

Edward E. NACHTSHEIM, Personal Representative of the Estate of William W. Steil, and Production Tool Corporation, a domestic corporation, Plaintiffs Appellants,
v.
BEECH AIRCRAFT CORPORATION, a Delaware corporation, Defendant-Appellee.

No. 87-1155.

826 F.Supp. 677
(Cite as: 826 F.Supp. 677)

United States District Court, W.D. New York.

Marjorie DATSKOW, Executrix of the Estates of Robert C. Gross and Susan C. Gross, deceased, and Administratrix of the Estates of Michael and David Gross, deceased, and Grossair, Inc., Plaintiffs,
v.
TELEDYNE CONTINENTAL MOTORS AIRCRAFT PRODUCTS, A DIVISION OF TELEDYNE INDUSTRIES, INC., Defendant.

No. 88-CV-1299L.