Energy, Momentum and the Chaos of Time

As Dawn's chariot races from the dark emptiness of the Netherworld and climbs majestically skyward, her brilliant golden orb illuminates the awakening landscape below. The heavily muscled battle-steeds stand ready to carry their valiant masters forward in search of dragons to slay, windmills to tilt, quarry to kill and carry home to the hearth, or maybe just to pick up little Jimmy from soccer practice.

This is where the tale of adventure begins, but like the gut-wrenching tale of the war in Vietnam, ***Apocalypse Now***, our tale begins not at the beginning, but at the end.

Final Rest

It is here at the end that our tale must begin. Not at the beginning, for the beginning rarely divulges any clues as to what events will soon unfold. Even the mystifying Oracle at Delphi would find it a daunting task to foretell the details of the events that will soon occur. It is at the end that we must start our search for the facts and the truth.

How did we arrive at final rest? Were we driven here by the chaotic forces of nature, or was it by the will and the strength of man? Who or what was in control, was entropy, or the human, the primary directing force?

More often than not, in most of the serious injury or fatality investigations, the driver was just along for the ride after the collision. Those restrained by belts or harnesses may remain in a position where control is possible, but are likely so disoriented that exercising control over the careening vehicle is realistically improbable. Often the drivers are thrown about in such a manner as to make any exercise of control impossible.

Whether under the control of a human driver or chaos theory, it is our task to uncover the various factors accounting for the particular path taken by the vehicle from collision to final rest. These factors may include but are not limited to braking, steering, grade and surface friction.

How do we determine the point of final rest? The answer seems rather obvious. It is the location of the vehicles when they finally came to a stop. Occasionally this point may have little to do with our analysis of the collision, but it is a place to start. Sometimes one or even both drivers may flee the scene and the point may never be located, but this is rarely the case.

The rigorous analysis of the path from collision to final rest can often yield the velocity of the vehicle post-impact. This velocity by definition includes both the speed and angle of the departing vehicle. Minute attention to detail is often required in this analysis but the rewards will be invaluable in our analysis of the collision.

By carefully measuring, photographing and otherwise documenting the scene, the data collected will not only aid our analysis, it will also have a far greater chance of being admitted into evidence if the case is ever prosecuted in a court of law. The preceding sentence contains an important thought, which will be explored at length later in this document. Please re-read it carefully as it is worth remembering.

After briefly glimpsing the end, it is now time to look at some recent history.

Once upon a Time…

Let us begin with a few excerpts from the Crash3 Technical Manual. [Editor's note: Quoted material was copied directly from its source. No attempt has been made to correct the original grammar, spelling and punctuation.]

"CRASH is an acronym for Calspan Reconstruction of Accident Speeds on the Highway."

"Two separate and independent methods are used to estimate the change in vehicle speeds experienced by the vehicles. The first method, Trajectory Analysis, makes use of the impact and rest positions and other trajectory data and is based on work-energy relationships for the spinout trajectory and the conservation of linear momentum for the collision. The other method, Damage Analyses, makes use of detailed measurements of the structural deformation of each vehicle to arrive at an estimate of the energy required to produce the observed vehicle damage. These two methods can be used to check each other since they should yield similar results if the user possesses sufficient information to fully utilize both methods."

"CRASH3 is not, nor was it intended, to be a high fidelity collision simulation program. In most accidents, only a minimum amount of data are available, and even these data are only available second hand. CRASH3 is intended primarily as a tool for making standardized assessment of an accident's severity."

"$$\Delta V_{true} = -0.7 + 1.1\,\Delta V_{estimate} \qquad (1.1)$$

On the average, CRASH3 overestimated the change in velocity by about 10 percent as shown by the slope of the equation (1.1) If one examines individual cases, however, the error may be as high as 40 percent. Accepting the results of a particular CRASH3 run as absolute truth is plainly unwise."

www-nass.nhtsa.dot.gov/NASS/MANUALS/Crash3Man.pdf

CRASH3 was an attempt to equate the damage severity of an accident to the severity of injury suffered by the occupants. If the correlation proved timely and valid, it could greatly assist medical personnel, especially emergency room physicians, in diagnosing the injuries. This could be a valuable life-saving tool, but only if a timely, reliable and consistent correlation could be made.

CRASH3 is also used as a pre-processor for the collision phase of the **SMAC** (infra) program. Without going into the pros and cons of this usage now, it is interesting to note that some feel that in its present form **CRASH3** is doomed to obsolescence.

"Update 2003*: With the phenomenal performance enhancements of PC computers, research related to SMACITER will soon eliminate the need for any version of CRASH. As part of our research, we incorporated the original version of CRASH to create starter values for m-smac which SMACITER then automatically iterates to reconstruct the accident. Therefore to the user the SMACITER program will behave very much in the same way as CRASH except that it will produce results with the accuracy and reliability of the SMAC program."*

www.mchenrysoftware.com/mcrash.htm

Since the subject has now been broached, let us look at the evolution and description of the **SMAC** program from those intimately involved in its creation.

*"In 1970, NHTSA sponsored a research project to develop a computer program that would achieve improved uniformity, as well as improvements in accuracy and detail, in the interpretation of physical evidence in highway accidents. The resulting prototype computer program was the **S**imulation **M**odel of **A**utomobile **C**ollisions (**SMAC**, Ref 1 Ref 58, Ref 59).*

SMAC is a time-domain mathematical model in which the vehicles are represented by differential equations derived from Newtonian mechanics combined with empirical relationships for some components (e.g., crush properties, tires) that are solved for successive time increments by digital integration. Each vehicle is limited to the three degrees of freedom associated with plane motion (i.e., 2 translation, 1 rotation). The tire forces are modeled by a non-dimensional side force function and the "friction circle" concept is included for the interaction between side and circumferential tire forces. The collision force simulation is achieved by means of the modeling of each vehicle as a rigid mass surrounded by an isotropic, homogeneous periphery that exhibits elastic plastic behavior.

The SMAC computer model is an "open-form" of reconstruction procedure wherein the user specifies the dimensional, inertial, crush and tire properties of the vehicles, the initial speeds, angles and driver-control inputs. The program, through step-wise integration of the equations of motion, produces detailed time-histories of the vehicle trajectories including the collision responses. The user compares the SMAC-predicted trajectories and collision deformations with the physical evidence to determine the degree of correlation. Iterative runs can then be performed, varying initial speeds, heading angles and control inputs until an acceptable match of the physical evidence is achieved."

www.mchenrysoftware.com/msmac.htm (Mar 2007)