

Crash Recorders in Racing – An Overview

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ABSTRACT

The crash recorder is an important data gathering device in motorsports. Since the introduction of crash recording in Indy Cars in 1993, the data gathered has been critical in developing improvements in race car structures and driver protection systems. This report will examine which sanctioning bodies use recorders, what type of data is gathered, and how that data is used to improve driver's safety in racing.

Discussion

The crash recorder in a race car differs from the recorder in a production car. In general the recorders in both production cars and race cars gather information (data) on the crash severity. The data they gather is different in scale and used for different purposes. This report will not attempt to describe production recorders other than noting that their primary function is to sense crash conditions that require deployment of airbags and seat belt pre-tensioning. In some cases, they record the data for future analysis.

Brief History

The first crash recorders used in racing were developed for race cars by the Motorsports Technology Group of General Motors (GM Racing). Engineer John Pierce and co-author Dr. John Melvin adapted a recorder that had been used successfully in the shipping industry by Instrumented Sensor Technology (IST) (1). In an excerpt from the IST website written in 1994, "This year for the first time Indy race cars are being equipped with onboard crash recorders for use during time trials and actual races. The Instrumented Sensor Technology, Inc. (IST) model EDR-3 environmental data recorder was selected by the GM Motorsports Technology Group late last year for installation on all 1993 Indy cars. The recorders were widely used on most Indy cars for the first time during the Indianapolis 500 race in May 1993."(1)

Information on the early years with the IST recorder is documented in SAE papers (2) and (3).

The IST recorder shown in Figure 1 was used in the Indy Car Series thru the 1990's and a variant was used by the CART after it separated with the IRL in 1996. A time line showing the various types of recorders used over the years by sanctioning bodies is shown in Table 1.



Figure 1

Type of Data Gathered

Table 2 describes the measuring parameters, memory and software used by the various crash recorder manufacturers and sanctioning bodies.

The data gathered from the crash recorder is primarily the deceleration of the chassis caused by the impact. The recorder is placed as near the driver as possible in order to record the accelerations that the driver would endure during the crash. This deceleration is measured in the X (fore-aft direction), Y (side-to-side direction), and Z (up-down direction) of the car and is commonly referred to as the tri-axial G's. Crash recorders will have

one or two high G tri-axial accelerometers. The crash recorders have a clock that records the time of the crash. Sensors including low G's, temperature and yaw rate have been incorporated into the recorders.

The crash recorders have software packages (Table 2) that will create resultant accelerations, and integrate the accelerations to determine the change in velocity for each axis (delta V). The principal direction of force (PDOF) acting on the car in the crash can be determined from analyzing the time-varying chassis accelerations and computing a resultant direction of acceleration.

Use of the Data

The data collected by the sanctioning bodies is used to:

- Immediately determine the crash severity for use by the medical personnel to aid in injury assessment.
- Determine the primary direction of impact and the resulting decelerations to create a history for types of cars on various tracks
- Investigate changes to the car structure, seat structure, restraint systems and track walls
- Share the information with all sanctioning bodies

Examples of the uses of the data can be seen in the many reports that have been written to improve driver's safety. A number of reports are listed in the discussion with examples of the type of safety research conducted.

Research Studies

The following studies include race car structure, head padding, seat structure, biomechanics research and energy absorbing walls:

1. "Development and Field Performance of Indy Race Car Head Impact Padding" (4)
2. "Biomechanical Principles of Racecar Seat Design for Side Impact" (5)
3. "Spine Fractures in Open Cockpit Open Wheel Race Car Drivers" (6)
4. "In-Service Performance Evaluation of the SAFER Racetrack Barrier" (7)

These studies could not have been accomplished without crash recorders.

Location of the recorders IRL, NASCAR, NHRA Pro Stock and the ALMS Corvette

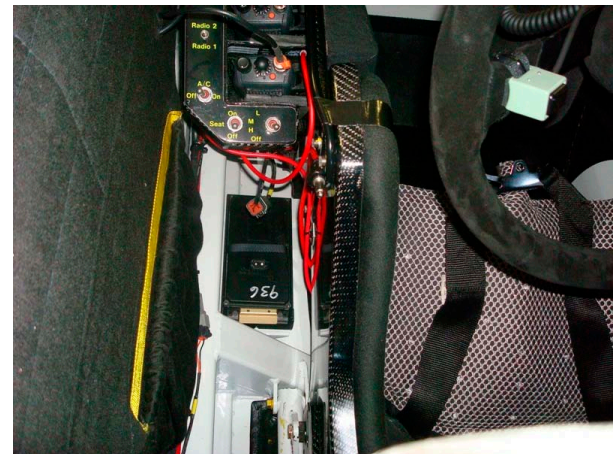
The recorders are secured to the chassis as near the driver as possible on a structure known to be rigid. The

rigid mounting is used when space near the driver permits. The rigid mount is not required when external rigidly mounted accelerometers are used and their outputs are fed to the crash recorder.

The following figure and pictures will show how the recorders are placed in most of the series that use them.



Figure 2



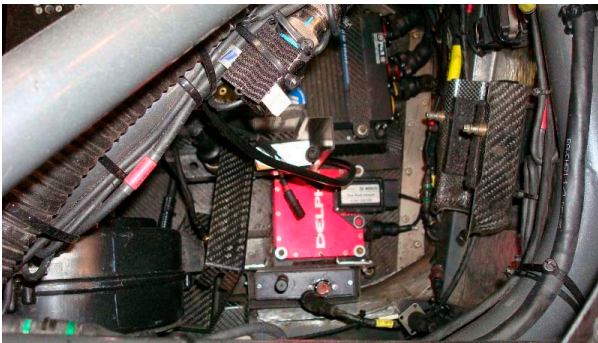
IWI Recorder Location in NASCAR to Left of Driver on the Frame Rail – Plan View

Figure 3



Delphi ADR3 Location in NHRA Pro Stock - Right Side View

Figure 4



Delphi ADR3 Location in the ALMS Corvette on floor of left front foot well - Plan View

Figure 5

CART - IRL - Champ Car

The history of the CART (Table 1) shows that, in cooperation with GM Motorsports Technology Program, they were the first to use the crash recorder, beginning with the IST recorder, and then later changing to the Delphi recorders. The Delphi recorders enabled IRL and CART (later Champ Car) to monitor external inputs from the car and the driver. In a program that began in 2003, the drivers were supplied with Delphi earplug accelerometers (Appendix 4). Information from the driver's head impact is collected and used in safety research.

The IRL also uses the crash recorder to assess crash severity and turn on a light that alerts medical and safety workers to a high G impact having the potential to produce injury. Chassis decelerations exceeding 50G's for 10 ms are considered severe and turn on the light.

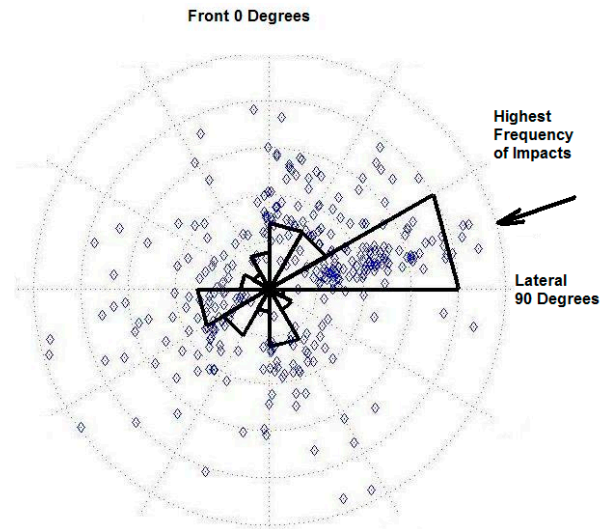
NASCAR

The IWI recorder was adopted in NASCAR in late 2002. The specifications for the IWI recorder are shown in Table 2 and in Appendix 1. NASCAR has several thousand incidents in their database.

In the yearly driver's safety meeting the data is summarized along with the other safety advances. The NASCAR safety has benefited by understanding the forces and the principal direction of force (PDOF) determined from the crash recording.

The design of the Car of Tomorrow (CoT) benefited from the wealth of crash data available to determine the angles of impact and the highest frequency of "hits" could be expected. Lateral impacts are the highest percentage.

A generic polar diagram of the impacts is shown in Fig 6. Note that while the series and magnitudes of the impacts have been left blank, the direction of the impacts is predominately lateral right side impacts.



Polar Plot of the Magnitudes and Direction of Force in NASCAR Incidents

Figure 6

The reinforced seat that NASCAR has developed, and continues to research, could not have been possible without crash recorder data.

NHRA

Crash recorders were first introduced to drag racing in the NHRA Sport Compact Series in 2002 as part of a GM factory effort.

Beginning in 2007, NHRA began a program to introduce crash recorders to drag racing after the crash that took the life of Funny Car driver Eric Medlen at Gainesville. Ford Racing working with Delphi installed the Delphi ADR-3 full function ADR (Appendix 3) on all Top Fuel and Funny Cars. The recorders were made mandatory for the first points race at Pomona in 2008. The full function ADR-3 recorder on the fuel cars was able to take information from externally mounted tri-axial accelerometers to help understand the motion of the chassis during high frequency events caused by tire shake and tire failure.

On the Pro Stock side, NHRA began a program to introduce crash recorders with GM Racing and Delphi. The Delphi ADR-3 min-function (Appendix 3) recorder installation is shown in Figure 4.

ALMS

The Corvette C6.R has used the Delphi ADR-2 and ADR-3 recorders since 2001. The placement of the recorder in the car is shown in Figure 5.

Figure 7 shows the ADR-2 Pi data from a C5R Corvette impact with a concrete jersey barrier on a street course. The barrier moved at the peak G load providing a double

hump deceleration trace. The resulting damage to the car can be seen in Figure 7.

Formula One

Formula One played an important part in the development of the Delphi ADR-1 recorder.

The following excerpts are taken from Formula One sources:

....." it has been compulsory since 1999 for every Formula One car to be fitted with an accident recorder? The device resembles the black box in an aircraft and records all the speed and deceleration data, which provide the basis for further safety improvements."(8)

"The FIA has developed the Circuit Safety Analysis System (CSAS) to enable the analysis of speeds at any part of a circuit allowing the calculation and visualization of run-off areas and energy dissipating barrier systems. The data for this analysis is collected from Accident Data Recorders installed in-car." (9)

A report on the CSAS (10) describes use of the crash recorder in making safer road circuits for Formula One.

The early experience with the crash recorder and efforts to establish a Severity Index Coefficient (SIC) to determine the risk of injury to the driver due to crash deceleration magnitudes is documented by Wright. (11)

IROC

The International Race of Champions (IROC) started using the IST EDR-3 recorder supplied by GM in 1997 (Table 1).

An incident recorded at Talladega in 2001 is shown in Figure 8 with the type of plot that was created. The IST Dynamax software integrated the longitudinal acceleration (peak 35.3 G's) to yield a delta-V of 28.3 MPH.

IROC was one of the first series to incorporate a crash recorder and used them though their 2006 (last) season.

SAFER Barrier

The SAFER barrier has improved driver safety by reducing the G load of the impact. The development of the barrier and the "In-Service Performance Evaluation of the SAFER Racetrack Barrier", described in SAE 2004-01-3526, required the use of the crash recorders. In that report the SAFER barrier is credited with reducing the G load at impact from 30 to as high as 80 percent.

Conclusions

Crash recording has been done for 15 years in racing.

The information has allowed researchers to learn more about the loads on the race car and the driver.

Improvements in restraints, seats, interior padding, car structures and the SAFER barrier would not have been possible without the crash recorder.

The data from crash recorders has aided medical personnel treat the driver after an incident. The combination of medical data and crash recorder data has provided new insights into the biomechanics of crash occupant protection. This data may be the most important single contribution of racing to the public.

Future

The crash recorder will become more common-place in racing. More data will be obtained from the driver and restraint system with the ultimate goal of knowing all the loads on the driver during an incident.

More data will be shared between sanctioning bodies to improve safety for all.

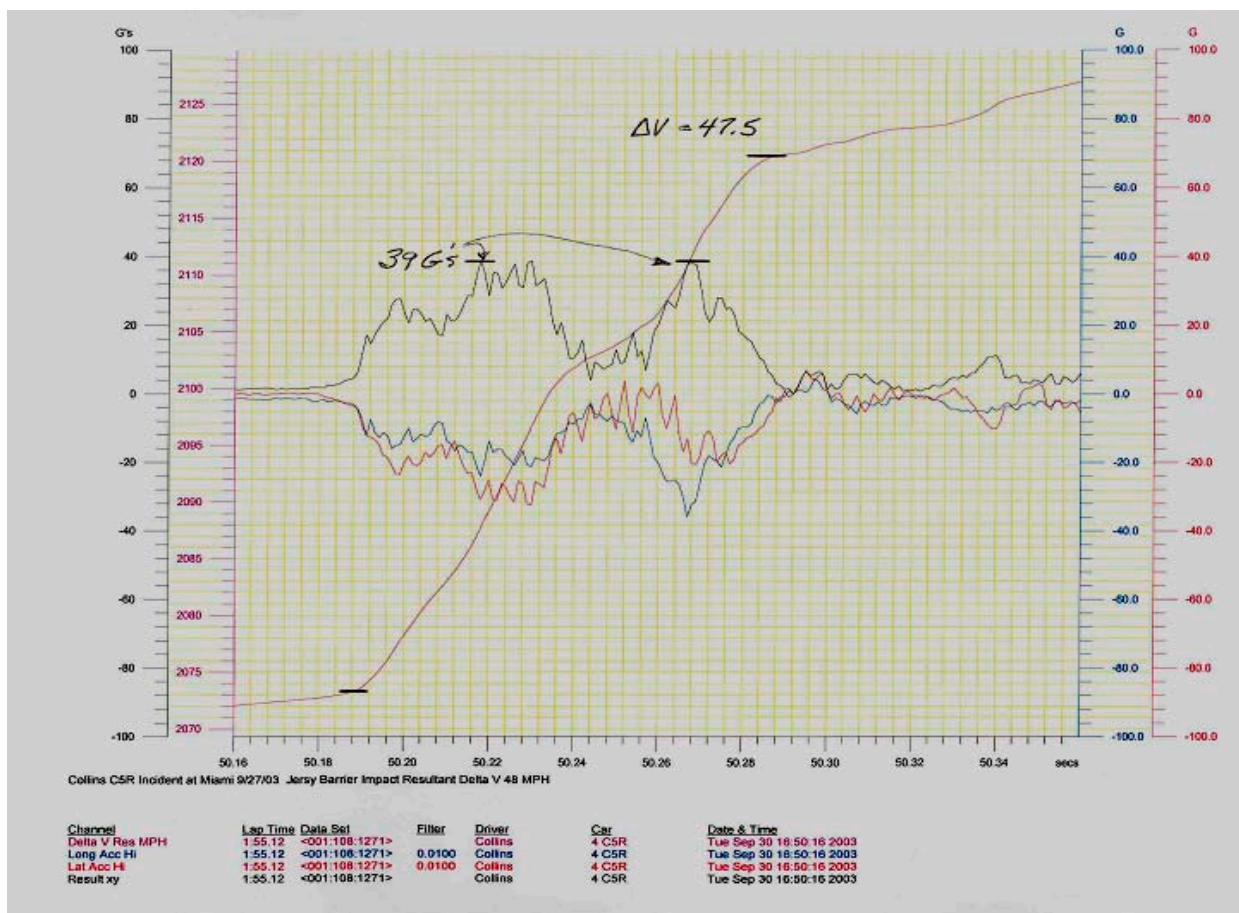
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ADR-2 Pi Trace from Impact with C5R Corvette and a Concrete Jersey Barrier

Figure 7