THE ROLE OF MOTORSPORT SAFETY

Peter G. Wright
Fédération Internationale de l'Automobile
United Kingdom
Paper Number: 98-S6-O-12

ABSTRACT

Motor sport is an activity in which accidents are expected to occur, but in which the driver and spectators expect a very high level of protection. Much of the physics and biology are the same as those involved in highway accidents, and the motorsport safety research being carried out in both Europe and the USA can make a significant contribution to road safety. Because many motorsport accidents are recorded on video, data is recorded in on-board Accident Data Recorders and detailed post accident analysis is carried out, motorsport provides an excellent environment for vehicle safety research.

The FIA has researched and implemented changes to vehicle design regulations, circuit design and circuit safety features, driver equipment, race control procedures, and medical intervention standards, to reduce the fatalities and serious injuries per accident by over 90% since the early 1970's. Its target is zero fatalities and serious injuries.

The parallels between this approach and Sweden's Vision Zero policy are clear. In both, the responsibility for road safety is taken away from the driver and handed jointly to the Administration, and to the system (vehicle and highway) suppliers. Motorsport has been carrying out a similar policy for nearly 30 years and the lessons learned could, with due care, be applied to new approaches to road safety.

INTRODUCTION

Motorsport is just over 100 years old, a few years younger than the automobile itself. For many years, apart from steps taken to protect spectators, little was done to protect participants from fatality or serious injury as a result of accidents, until the late 1960's. While drivers raced largely for the glory rather than monetary reward, and automobile manufacturers participated as part of their R&D effort rather than marketing, death and injury were accepted as part of the risk. Just as public attitudes to road safety changed in the late 1960's, it was the drivers, now professionals earning substantial incomes from motorsport, who campaigned for greater safety.

It is the nature of motor racing that drivers are encouraged to drive their vehicles at the limit of control, and both inevitable and accepted that accidents will occur. Accidents are a necessary part of motorsport providing spectator and TV entertainment. However, it is the responsibility of the governing or sanctioning body to ensure that accidents do not result in fatalities or serious injuries so an adequate level of safety is required not only for the drivers and spectators, but also for team participants and officials involved with the staging of events.

In 1994, after 11 years without a single fatality in Grand Prix events, two fatalities occurred during a single Grand Prix weekend. Because one of them involved triple World Champion Ayrton Senna and was covered world wide by live TV, the reaction of the Press, public, governments, sponsors, and even the Vatican was so adverse that it became apparent that international motorsport could be threatened unless even greater levels of safety were achieved. The FIA, as the governing body of international motorsport, immediately took wide-ranging steps to improve safety, including new regulations for car construction and circuit design, and initiated R&D into improved systems and standards for the future. It is clear that the only acceptable safety objective is zero fatalities and serious injuries.

In the USA, the major automobile manufacturers participating in the prime racing series, such as Champcar, IRL, NASCAR and IROC, are working closely with the sanctioning bodies to research and improve safety. Oval racing, with it's high speeds and rigid containment walls, provides a unique opportunity to research high delta-V, high-g impacts and to investigate human tolerance of these conditions. Impacts generating 80g frontal, 120g lateral (Ref.1.), and 135g rear have been recorded, and are under detailed investigation to determine why no g-related injuries were sustained by the drivers involved in the accidents.

Because every aspect of motor racing is so controlled, and the technology now exists to enable accidents to be monitored and analysed in detail, it presents a valuable opportunity to research automobile safety *in extremis*. The physics and biology of racing accidents and injuries are almost the same as for road car

accidents. Motorsport safety can show what is possible in terms of human protection and tolerance if there are no constraints on the level of technology applied, nor on the costs involved. While the lessons learned cannot always be directly or economically applied to the road system, much of the data and experience gathered is relevant.

Historical Aspects

In the 1960's, 1 accident in every 8 in Formula One events resulted in a fatality or serious injury (defined as an injury that prevented the driver from continuing to participate in the event or subsequent events), with some years as high as 1 in 4 (Figure 1).

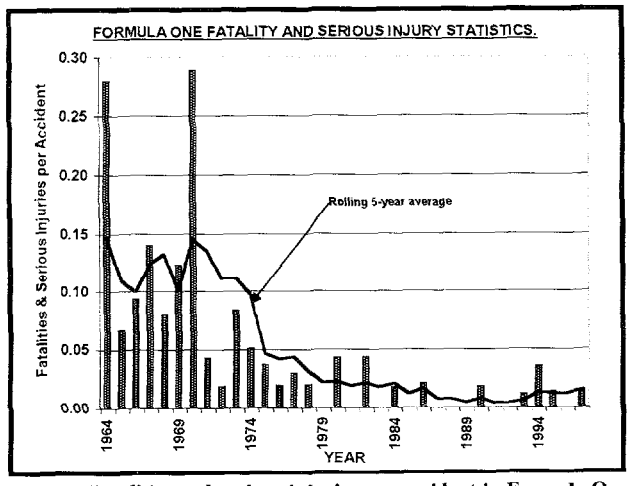


Figure 1. Fatalities and serious injuries per accident in Formula One, from 1964 to 1997.

Figures 2, 3 and 4, and the following passage (Ref.2.) illustrate the conditions which gave rise to this.

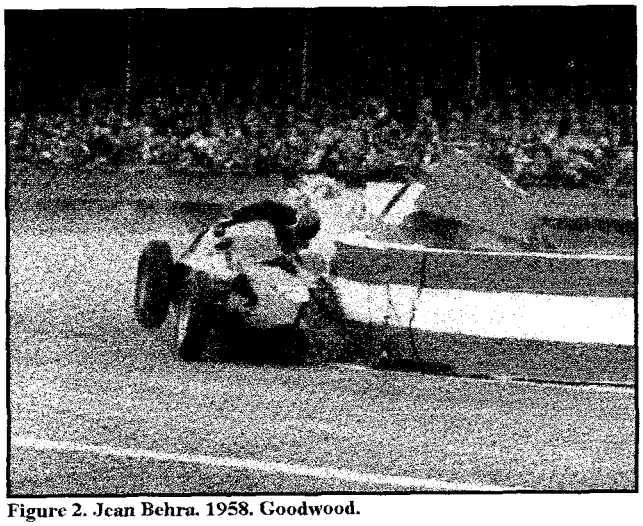


Figure 2. Jean Behra. 1958. Goodwood.

Figure 3. Tony Brooks. 1956. Silverstone.

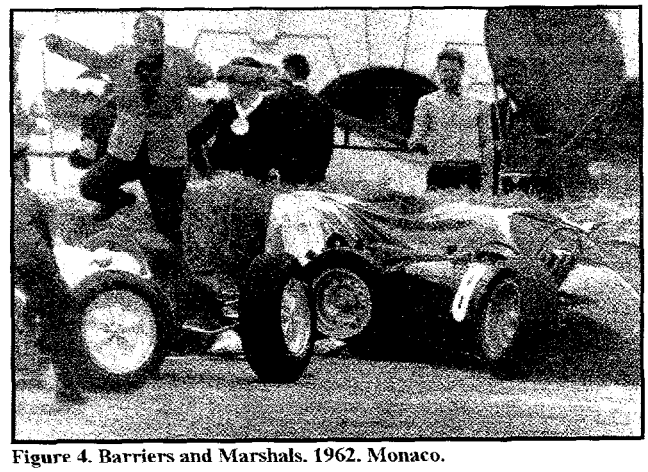


Figure 4. Barriers and Marshals. 1962. Monaco.

"In the race it began to rain heavily on the far side of the circuit, so as the leaders came down the hill to the Masta Straight, Jackie (Stewart) aquaplaned off, striking amidships a large stone buttress of an even larger and very solid stone barn, and wrapped the car round the buttress like a banana. It then bounced off into a ditch with Jackie trapped in the car with a crushed tank leaking fuel all round him. Graham (Hill) and Bondurant went off in the same area for the same reason a few seconds later but without such disastrous consequences. Just as Graham was getting back on the road he saw Jackie's car and stopped to help him. It took nearly ten minutes to get him out of the car and another 20 minutes before the ambulance arrived. He had been sitting up to his waist in petrol, so the drivers helping him stripped off his fuel-sodden clothes and wrapped him in a spectators rug."

It was this accident involving Jackie Stewart that started the driver led movement for greater safety in motor sport. The first steps taken were:

- To reduce the risk of fire.
- Establish circuit safety criteria, including arrestor areas.
- 6-point harness restraint systems and driver protective clothing.
- Standardisation of signalling and marshalling procedures.

These were followed during the 1970's by:

- Structural specifications for the cars chassis.
- Medical centres at race circuit.
- Tyre barriers.
- Graded driver licensing.

The effect of these measures was to reduce the number of accidents causing fatalities or serious injuries to an average of 1 in 40 accidents - a 5-fold improvement in less than 10 years.

Between 1980 and 1992, a further steady decline in fatalities and serious injuries per accident resulted in the rate falling to less than 1 in 250 accidents - a further 6-fold reduction.

Safety Regulations

To achieve this further reduction, all aspects of motorsport that influence safety were scrutinised and measures introduced to minimise the threat to participants and spectators.

The Technical (Ref.3.) and Sporting Regulations (Ref.4) governing Formula One set the highest standard and provide a proving ground for safety measures prior to introduction into other international racing classes.

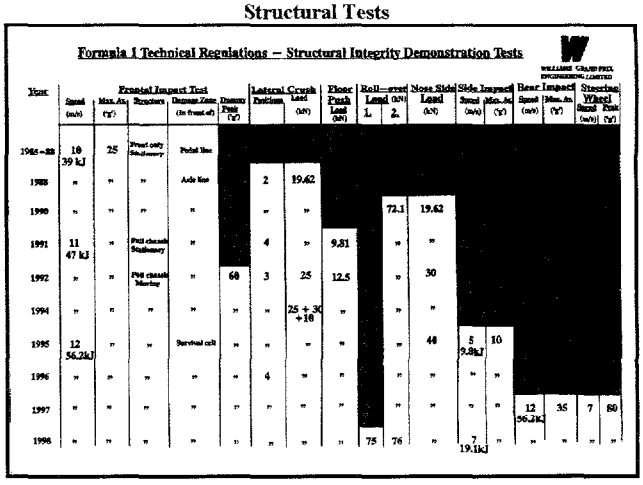
Car Construction - The prime objectives are:

1. To protect the driver from intrusion injuries.
2. To generate a deceleration pulse, in any impact direction, that can be accommodated by the driver restraint system within his deceleration and load tolerances.
3. To restrain the driver from impacting the inside of the car or any solid object or, where that is not possible, to provide a means of attenuating the resulting impact to below a level that would cause injury.
4. To avoid fires.
5. To ensure that the driver can exit the cockpit quickly and easily.

The Technical Regulations take the approach of defining a driver survival cell and stipulating a series of structural integrity demonstration tests, rather than laying down construction methods and materials.

The chronological development of the structural tests is shown in Table 1.

Table 1.
Chronological Development Of Formula One Survival Cell Structural Tests



Figures 5 and 6 illustrate the current tests.

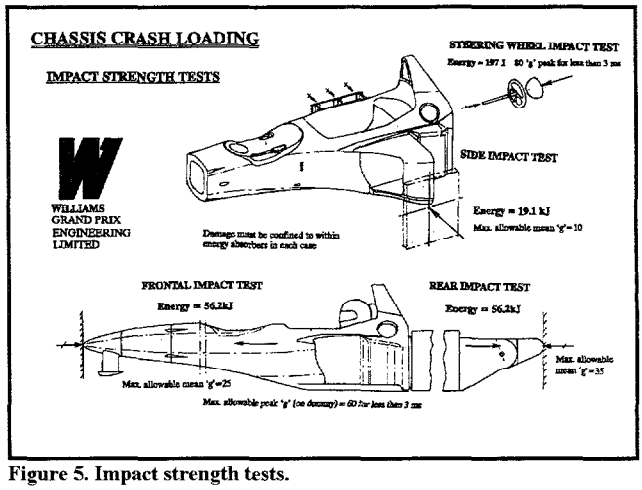


Figure 5. Impact strength tests.

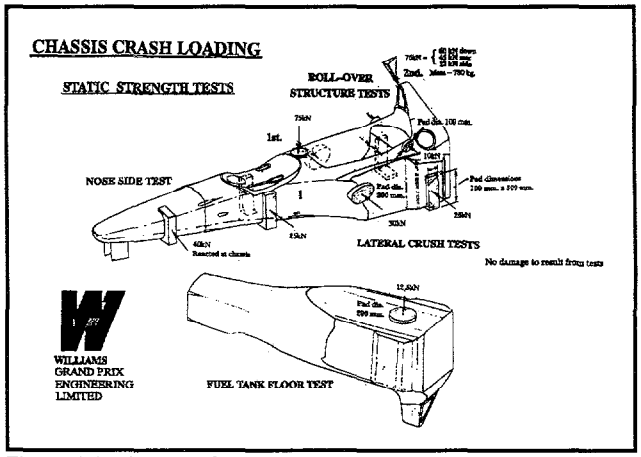


Figure 6. Static strength tests.

The driver must wear a 6-point harness employing 75 mm wide webbing. Parts of the safety cell that may be struck by the driver's head are padded with energy absorbing foam.

Drivers must demonstrate that they can get out of the car within five seconds, wearing full racing equipment and unaided.

Detailed specifications relating to fuel systems and fire extinguishing equipment are set down, as is the location of the fuel tank in the centre of the car.

Circuits - Closed-circuit racing tracks are licensed by the FIA according to the classes of cars to be raced on them. Circuits are inspected according to the FIA Internal Guidelines for Motor Racing Course Construction and Safety (Ref. 5.), which lays down standards and guidelines for all aspects of circuit construction, including:

- Track design and construction
- Run-off areas and kerbs.
- Deceleration and arrestor areas.
- Barriers - guard rail, concrete walls, tyre barriers, spectator protection fences.
- Service and access roads
- Marshalling and signalling posts and equipment
- Track-side signs and all other potential obstacles

Drivers - Drivers are licensed to participate in racing classes according to their experience. The licensing system also provides a means of sanctioning drivers for actions that are considered prejudicial to safety.

Standards for driver equipment, including helmets and overalls, are set and regularly checked.

Medical - The philosophy behind the medical service standard laid down by the FIA, is based on providing timely and expert medical attention within seconds of an accident occurring, through to transfer by helicopter of an injured driver or other participant to an approved receiving hospital.

Much has been written about the critical "golden hour" in the treatment of trauma but it is intervention, reduced to minutes or even seconds in Grand Prix racing, that is deemed most important (Ref.6.). Rapid response in the event of an accident is provided by fully equipped, rapid intervention medical cars stationed around the circuit and able to reach the scene of any accident within 30 seconds. These are backed up by doctors and paramedics on foot, stationed at intervals around the circuit. At a circuit such as Monaco where access is difficult, 3 intervention cars backed up by 100 doctors and paramedics are required to provide this level of intervention performance.

In a number of accidents in the last few years, rapid intervention undoubtedly saved the lives of drivers with obstructed airways.

At every circuit there are also two or three trained extraction teams, equipped to extract a driver with possible spinal injuries from a damaged car. These teams practice on actual Formula One cars and familiarise themselves with potential problem features. Following extraction and stabilisation, and injured driver will either be taken to the Medical Centre by ambulance, or direct to the receiving hospital by helicopter.

FIA regulations demand a high level of equipment at the circuit Medical Centres. Staffing levels are a minimum of two consultant anaesthetists, a consultant general and orthopaedic surgeon, a spinal or neurosurgeon and a burns specialist. Intensive resuscitation rooms and an operating theatre equipped to University Hospital standards are a minimum requirement. Only when the injured person is deemed stable enough to travel to the receiving hospital for more specialist treatment or care are they transferred.

Driver fitness is monitored, particularly post-accident. Random drug tests to IOC standards are carried out regularly.

Race Control - A permanent FIA Race Director controls the running of major international motorsport events. Race Control is in radio contact with all medical facilities, race officials, marshals, and signallers, and is able to survey the whole track and Pit Lane via closed circuit TV. The Race Director is thus able to assess the seriousness of an accident and either stop other cars running or control their pace using the Safety Car. These measures enable medical intervention teams to gain unencumbered and safe access to the scene of the accident. If the driver is not injured, his stationary car can be removed from an exposed position without putting track marshals in danger.

Race Control also monitors the speed of cars in the Pit Lane and reports offenders to the Stewards of the Meeting, who administer penalties to those who exceed the limits set down on safety grounds.

Future Developments - In 1992 the safety record of Formula One approached zero fatalities and serious injuries per accident, a level where individual incidents have a disproportionate effect on the statistics. The events of 1994, when two drivers were killed and one seriously injured, focused sharply on this effect. The FIA responded by initiating a series of R&D programmes to investigate where further safety measures could be effective. The objective of meeting and maintaining the target of zero fatalities and serious injuries was

confirmed. Programmes which have been carried out or are currently under way include:

- Investigations into measures to control the speed of the cars, particularly in high speed, high lateral acceleration corners carried out in co-operation with the participating teams. A number of restrictions on aerodynamic downforce, power and tyre grip have been introduced.
- Head protection around the sides and behind the driver's helmet has been made mandatory.
- Increased severity structural tests have been introduced for the driver's survival cell, which has also been increased in size.
- A mandatory Accident Data Recorder, to provide both impact data and information on the performance of circuit safety features (gravel arrestor beds, kerbs etc) was introduced in 1997.
- Research is being carried out into the performance of existing, proprietary and increased performance impact barriers.
- A major R&D programme is underway into restraint systems for the protection of the drivers head and neck in a frontal impact.
- More severe crash helmet test specifications are being developed.
- Accident reconstruction, using helmet damage for correlation, is performed on accidents in which injuries have occurred.
- Close co-operation with national motorsport safety researchers in different countries is being undertaken.
- In-cockpit signalling systems are being developed.
- Wheel retention systems are being investigated.
- Minimum safety standards for private testing have been established.
- Software for the analysis of safety features on proposed new circuits and changes to existing circuits, are being further developed.

Safety Regulation - The FIA governs international motorsport through the World Motor Sport Council. This body is assisted in its tasks by specialised Sporting Commissions and Working Parties. Those relevant to safety are:

- Medical Commission
- Technical Commission
- Circuit and Safety Commission
- Formula One Safety Commission

plus a number of Working Groups that involve technical experts from the teams, circuits, the medical profession and organising bodies.

It is through this system of close co-operation between the FIA and all those involved in organising and participating in motorsport, that fast responses to new safety issues are possible. Safety measures can, if necessary, be introduced within weeks.

Road car safety legislation in Europe lags many years behind best available technology. For this reason, the FIA became a founder member of EuroNCAP in order to provide motorists, who are members of associated motoring clubs, with up to data safety information and to put pressure on all manufacturers to sell cars that demonstrate state of the art safety performance.

Vision Zero - The Swedish Ministry of Transport and Communications has proposed a radical Vision Zero road safety strategy which was approved by the Swedish Parliament in 1997. Vision Zero is conceived from the ethical base that it can never be acceptable that people are killed or seriously injured when moving within the road transport system. It is the long term goal is that no-one will be so affected. (Ref.7.)

For many years, the emphasis in traffic safety work has been in trying to encourage the road user to respond in an appropriate way, typically through licensing, testing, education, training and publicity, to the many demands of a man-made and increasingly complex traffic system. Traditionally the main responsibility for safety has been placed on the user to achieve this end, rather than on the designers of the system.

The Vision Zero approach involves an entirely new way of looking at road safety and of the design and functioning of the road transport system. It involves altering the emphasis away from enhancing the ability of the individual road user to negotiate the system to concentrating on how the whole system can operate safely. Also, Vision Zero means moving the emphasis away from trying to reduce the number of accidents to eliminating the risk of chronic health impairment caused by road accidents.

Vision Zero accepts that preventing all accidents is unrealistic. The aim is to manage them so they do not cause serious health impairment. The long term objective is to achieve a road transport system which allows for human error but without it leading to serious injury.

While the concept envisages responsibility for safety amongst the designers and users of the system, the designer has the final responsibility for 'fail-safe' measures:

- System designers are responsible for the design, operation and the use of the road transport system and are thereby responsible

for the level of safety within the entire system.

- Road users are responsible for following the rules for using the road transport system set by the system designers.
- If the users fail to comply with these rules due to a lack of knowledge, acceptance or ability, the system designers are required to take the necessary further steps to counteract people being killed or injured.

CONCLUSION

The parallels with the way in which motorsport safety is managed and the strategy of Vision Zero are many. While accidents in motorsport are accepted as being part of motor racing, they will always be actively discouraged on the road. However, in both approaches prime responsibility for accidents occurring and the resulting fatalities or injuries, is taken away from the vehicle drivers. In its place the administration takes responsibility and sets down standards of safety performance for the vehicle manufacturers and highway (circuit) operators to achieve. It also ensures that users obey regulations concerning use of the system.

Close co-operation between the parties involved is essential for the fast introduction of safety initiatives and the monitoring of the effects of safety measures. Motorsport has demonstrated that if this close co-operation exists, significant reductions in fatalities and serious injuries can be achieved within a short time scale. Vision Zero is a state of mind. Within motorsport it is foreseeable that a sustained record of zero fatalities and serious injuries is achievable in the near future. On the way to this target motorsport can demonstrate many techniques and procedures that can contribute to achieving the same goal on the road.

ACKNOWLEDGEMENTS

The author is grateful for the assistance of Max Mosley, President of the FIA, and Prof. Sid Watkins, President of the FIA Medical Commission, in preparing this paper.

REFERENCES

1. Melvin, John, "Investigation of Indy Car Crashes Using Impact Recorders". Motorsports Engineering Conference Proceedings. Volume 1. 1996.pp. 127-143.

2. Rudd, Anthony, "It was Fun!". Patrick Stephens Ltd. 1993.

3. "FIA Formula One Technical Regulations". Fédération Internationale de l'Automobile. 1998.

4. "FIA Formula One Sporting Regulations". Fédération Internationale de l'Automobile. 1998.

5. "FIA Internal Guidelines for Motor Racing Course Constructions and Safety".

6. Watkins, Sid, "An Application of EMS Lessons: Formula One Grand Prix Racing". Trauma Care. HEMS. London. 1997.
7. European Transport Safety Council. Newsletter. July 1997.