

# **DESTINED TO CRASH: FATAL CRASHES IN F1-RACING**

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# 1 INTRODUCTION

In this bachelor's thesis I am going to be studying the fatal accidents in Formula One and how they may have decreased due to different safety changes. This research area is not very broad, and my research leans a lot on my own knowledge and reasoning ability. It is also to be noted that my research contains deaths that happened during a test drive that wasn't part of any official racing event (6 out of 52) and races that weren't part of Formula One World Championship (13 out of 52). These are still part of my research as they happened while driving a Formula One car and under Formula One regulations. My research question is: How and why the deaths decreased in Formula One- racing?

## 1.1 What is Formula One?

The first Formula One race was held in 1950. Since then, the sport has taken a spot in the top pedestals of the sporting world. In recent years since Liberty Media bought Formula One, Kapur stated that the popularity has skyrocketed.<sup>1</sup> Now more people know about the sport than ever before. I find it necessary to explain and tell the basics of the sport. Formula One history in general is not widely studied.

Formula One has changed a lot over the years from the 1950s to 2020s. This is something I must take into consideration when writing about the different eras and drivers.

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<sup>1</sup> Kapur 2023.

Basics have stayed the same. They drive on a track and compete for points; these points can be acquired through multiple races during the season. At the end of the season the points are tallied and driver, and constructor, with the most points win. The series is under the control of FIA (Federation Internationale de l'Automobile, in English International Automobile Federation), which is the governing body of most motorsport series.

Nowadays racing weekends are from Friday to Sunday. On Friday, two practice sessions are held. On Saturday the third and final practice session is held. The practice isn't necessarily there for the drivers to learn the track, but to see how that year's car manages on the track with changing conditions. These conditions could contain changing weather, rain and wind, or track evolution, the more the cars drive the better the track becomes. These practice sessions are also important for discovering the perfect setup for the race weekend. Qualification is one fast lap around the track. It takes place later Saturday. In qualifying the drivers fight for pole position, the number one spot on the starting grid for the race.

The race itself is several laps driven around a track where the race weekend is held at. The number of laps is determined by the distance of one lap around the track. Drivers must drive the number of laps it takes to reach the minimum of 305 km and maximum of 321 km or two hours.<sup>2</sup> Winner is the driver that completes the racing distance the fastest. There are different situations that can affect the racing distance, such as weather. An example of this: Japanese Grand Prix in 2022<sup>3</sup> was shortened due to heavy rains and only 50 minutes of the two-hours was raced. Winner gets the most points with the rest up to tenth place following.

Big part of racing is also the strategies that the teams can implement during the race. The point of these strategies is to get the car over the finish line as fast as possible. It

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<sup>2</sup> Jones 2001, 230./ Rookie Road 2017-2023./ Tutorialspoint,"Formula One - Quick Guide".

<sup>3</sup> Japanese Grand Prix race report, F1 2022.

is also mandatory to use two sets of different tire compounds during a dry race.<sup>4</sup> When the team or driver wants to change tires, they must drive through the pit lane and perform a pitstop. The faster the pitstop, the quicker the car can make it back to the track. Perfect tire strategy can take the win in a race, but also the fastest lap which awards one point. Things like safety cars and virtual safety cars, these being safety measures, can affect the tire strategy.

Almost all from drivers to tracks has changed over the years. The physicality and fitness of the drivers was brought up in later years of the sport, think 90s and 00s<sup>5</sup>. But before that driver culture was more of a James Hunt-esque<sup>6</sup>, fast cars and lots of women. Most drivers nowadays belong to Grand Prix Driver's Association (GPDA), that operates in the same sense as a normal trade union. In tracks the layouts have changed: Spa-Francorchamps used to be roughly 12 km long, compared to 7km it is today.<sup>7</sup> Also, the safety measures have changed, barriers made from hay have fortunately changed to barriers like Armco.

“A type of crash barrier made from curved metal sheets attached to posts’, the Armco functions like a fence. The idea is to absorb or deflect impacts more progressively than other roadside furniture, such as trees.”<sup>8</sup>

These Armco barriers are used in normal roads too.<sup>9</sup>

Speed in Formula One is one the most important parts of the sport. Written multiple times was the drivers urge to be fast and compete.<sup>10</sup> The car may not be the fastest to ever been driven in competition, but they are efficient in making corners fast, making their lap time faster than the next fast car.<sup>11</sup> As it is mentioned in the article the top speed of a F1 car in a race is 360 km/h. Whereas the fastest win in 1971 Italian Grand

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<sup>4</sup> Codling 2017, 108.

<sup>5</sup> Jones 2001, 230.

<sup>6</sup> Jones 2001, 153–155.

<sup>7</sup> Jones 2001, 214.

<sup>8</sup> Codling 2017, 136.

<sup>9</sup> “ Armco Barriers in F1” 2018.

<sup>10</sup> Jones 2001, 14, 244.

<sup>11</sup> Duxbury 2022.

Prix was only that of 241 km/h.<sup>12</sup> Speed affects the crashes. As it is in a normal car crashes the severity of the crash is often determined from the speed the car was traveling. As is explained in Newton's laws.<sup>13</sup> The crashes with high speed became less deadly due to the changes implemented to the cars.<sup>14</sup>

## 1.2 Sources, methods, and ethics

Most of the sources used in the research are written by people with big connections to Formula One, for example the book *The Ultimate Encyclopedia of Formula One* by Bruce Jones (2001). It has multiple people, who are motorsport journalists, taking part in the research and writing of the book. Other times the people who have written the articles or blog posts are fans. The only somewhat neutral sources are newspaper articles, like *News in Brief*<sup>15</sup> from the Times, and studies conducted from different areas than Formula One.

This raises a question: what are the motives of the writers? Are they writing to promote the sport or discredit it or even present it in a neutral way. I have discovered that most of the fan written texts' motive is to promote the technology of the sport, not so much the sport itself. They want to highlight the engineering miracle that is the Formula One car and the sportsmanship it takes to drive the car. Fans may present bias towards a team or a driver, but usually the information they provide is unbiased.

Now with the news the goal is clear: to bring forth news of the things happening in the sport. It is very neutral and straight to the point, as there is no need to paint any pictures about the sport in hopes of highlighting it to a newer fan base. The reader

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<sup>12</sup> Jones 2001, 248.

<sup>13</sup> Thornton and Marion 2021, 49.

<sup>14</sup> Codling 2017, 25, 120.

<sup>15</sup> *The Times* 1952; *The Times* 1961; *The Times* 1970; *The Times* 1977.

space for news is usually the relaxed reader as fans likely get their news from different sources, like a magazine wholly for motorsports or the Official Formula One website.<sup>16</sup>

Now comes the professional writers, those whose job it is to know about the sport. Their motives usually depend on the publication they write for. If it's a subscription magazine like Autosport, the motive often is to write for fans that already know about the basics. It's the complete opposite for the Official Formula One website as their motive is more business sided: more fans, more money. Their writers not only cater to older fans, but also to newer fans who want to learn more. This can be best seen and heard while watching a race broadcast given by Formula One's own broadcast team. People writing books about Formula One are usually motivated by money and spreading their own knowledge to the fans but also the common reader.<sup>17</sup> The research field of Formula One is not that active in my field of study, which makes finding studies that refer to my points hard.

My research is conducted in statistical study as it uses a chart to collect information and to process it. I found this the best method for my research as the information I need is easier to use and study in chart form. It creates a spine for the study and makes things easier to understand. In my chart I have collected: the date of the accident, drivers names, age, their cause (s) of death, the circuit that the accident happened in, the event the accident happened in, their nationality and their team.

As I am researching deaths of these drivers, the ethics of this are to be brought up. My area of expertise is not philosophy or ethics, so this thesis is not going to take those points too much into consideration. Despite these points, I will try to bring up my research in an ethical way, as these are people who still might have family members alive.

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<sup>16</sup> " F1 - The Official Home of Formula 1® Racing" 2023.

<sup>17</sup> Newey 2017; Codling 2017.

So, why is this ethical? These drivers were mostly public figures, so I could argue that researching them and using them in research is the same as researching dead politicians, like John F. Kennedy, or celebrities, like Marilyn Monroe. I am also not dwelling or digging too much into their personal lives. I'd like to acknowledge that these deaths are a tragedy, but in my research, they are a way to find and make note of things changing for the better, or worse. I research them only for this thesis and highlight them only to bring forward facts of their deaths.



## 2 DEATH IN FORMULA ONE

To achieve anything in this game, you must be prepared to dabble in the boundary of disaster.

Stirling Moss<sup>18</sup>

This quote incorporates Formula One's history in the most perfect way. As in the sport, wanting to win and compete can often lead to disaster.<sup>19</sup> Going one extra kilometer per hour too fast can make all the difference in a race or a crash. The sports history is riddled with accidents where the driver barely walked away from the crash, or even died.<sup>20</sup>

### 2.1 Causes of death and notable drivers

I gathered fifty-two deaths into table<sup>21</sup>. But the main thing is that people died quite regularly in this sport.<sup>22</sup> These deaths span multiple decades and ways to die. When talking about the different ways to die I write about the time span the deaths happen

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<sup>18</sup> Balfour 2021.

<sup>19</sup> Jones 2001, 244.

<sup>20</sup> Newey 2017, 186; Williamson, *ESPN*.

<sup>21</sup> TABLE 1, part 1 and 2

<sup>22</sup> Williamson, *ESPN*.

in, and in more depth how one way to die could be divided into more categories. Some drivers have been categorized to have multiple different causes of deaths, like Luigi Musso<sup>23</sup> and Peter Collins<sup>24</sup>, with head and neck injuries and being crushed and/or flipped.

Even in normal road car driving the leading causes of death are traumatic brain injuries, spinal cord injuries and internal injuries and bleeding.<sup>25</sup> So, it isn't a surprise that in Formula One racing the leading cause for death is also head and neck injuries, red in the table, with 24 out of 52 drivers dying from it. These injuries can be placed into two subcategories: trauma and complications. Trauma here means that it is something that caused the driver to die immediately, whereas complications mean that the driver suffered something like cerebral hemorrhage.<sup>26</sup> The first death from head and neck injuries happened in 1952<sup>27</sup> and the latest in 2014<sup>28</sup>. In the 1950s 10 out of 15 died from head and neck related injuries. This was reduced in the following years with 4 out of 14 in the 1960s, 5 out of 12 in the 1970s, 3 out of 4 in the 1980s, 1 out of 2 in the 2000s and 1 out of 3 in the 2010s.

Next cause of death with most drivers categorized to have been killed from was driving into a wall, color yellow in table 1, with 16 dead. These walls could be made from concrete<sup>29</sup>, or the barriers around the track. These crashes were often described with the words "killed instantly"<sup>30</sup>. 4 drivers from 8 were killed this way from 1960 to 1962. The first time someone died this way was in 1953 and the latest in 2000. These deaths were more even throughout the years.

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<sup>23</sup> Williamson, *ESPN*.

<sup>24</sup> "Formula 1® - The Official F1® Website" 2013.

<sup>25</sup> "Common Causes of Death in Car Accidents | Morelli Law Firm".

<sup>26</sup> Williamson, *ESPN*.

<sup>27</sup> *The Times* 1952.

<sup>28</sup> DiZinno 2015.

<sup>29</sup> Williamson, *ESPN*.

<sup>30</sup> "Ricardo Rodríguez | | F1 Driver Profile | ESPN.co.uk" 2015.

13 drivers died by fire, color blue in table 1. This was a slow and painful way to go, making it the most feared way to die.<sup>31</sup> When a driver died it could go two ways: dying from the burns caused by the fire<sup>32</sup>, or to die from inhaling too much smoke.<sup>33</sup> It was said that the cars were bombs on wheels.<sup>34</sup> This was especially noticeable with cars that had magnesium in them, as magnesium is a light element that burns hot.<sup>35</sup> At least two drivers died due to their cars being made from magnesium: Jo Schlesser<sup>36</sup> in 1968 and Piers Courage<sup>37</sup> in 1970. First death caused by fire was in 1955<sup>38</sup> and latest in 1986<sup>39</sup>. Most fire caused deaths are focused to the late 1960s and early 1970s. During 1966 to 1974, 7 out of 13 deaths were caused by fire.

Being crushed by your own car or having it take a flight around, color green in table 1, was the way to go for 9 drivers. Two drivers were crushed, and 7 drivers took a flight with their car. Most of them happened in the 1950s. First happened in 1954<sup>40</sup> and the latest in 1982.<sup>41</sup>

Other reasons for death were getting thrown out of the car, having the car's suspension broken, getting chest injuries or in Alan Stacey's case getting a bird to your face.<sup>42</sup> These deaths didn't have a specific common point, so I decided to present them in one. They could also be classified as freak accidents. First of these deaths happened in 1955 and the latest in 2014.<sup>43</sup>

Notable drivers, who died, included three-time world-champion Ayrton Senna, the only posthumous world-champion Jochen Rindt and 6-time-Grand Prix winner Gilles

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<sup>31</sup> Codling 2017, 122.

<sup>32</sup> Williamson, *ESPN*.

<sup>33</sup> "Elio de Angelis | | F1 Driver Profile | ESPN.co.uk".

<sup>34</sup> Codling 2017, 122.

<sup>35</sup> "Demonstrations - Burning Magnesium".

<sup>36</sup> "Jo Schlesser dies in experimental Honda at Rouen | On this day | ESPN.co.uk".

<sup>37</sup> Edworthy 2003.

<sup>38</sup> Williamson, *ESPN*.

<sup>39</sup> "Elio de Angelis | | F1 Driver Profile | ESPN.co.uk".

<sup>40</sup> Williamson, *ESPN*.

<sup>41</sup> "Formula 1's greatest drivers. Number 12: Gilles Villeneuve - BBC Sport" 2012.

<sup>42</sup> Williamson, *ESPN*.

<sup>43</sup> "Historic racer Denis Welch dies in Silverstone Classic accident - National - Autosport" 2018.

Villeneuve. Their deaths made headlines back then and still to this day. Senna's name always comes up in conversation when talking about the greatest F1-drivers. During the 1994 San Marino Grand Prix, Senna crashed into a wall at high-speed. He was believed to be killed by the car's front suspension. The suspension hit the side of his head causing brain injuries.<sup>44</sup> Main cause for the accident was discovered to be a snapped steering wheel column. Adrian Newey, who was the main designer on the car that Senna was driving, said it in his book.<sup>45</sup>

"But he went in, above all, with a desire to win. Ayrton was one of the fiercest, most passionate competitors the sport has known."<sup>46</sup>

Adrian Newey

After Senna's death the GPDA was reformed after a long hiatus<sup>47</sup>. He even spoke about reopening the GPDA with Alain Prost the morning before his death<sup>48</sup>.

Jochen Rindt winning the world championship even after he died, makes him a center of the discourse when talking about people dying too soon. He died from his seat belt cutting his neck after he hit a barrier<sup>49</sup>. Gilles Villeneuve never won the championship, but he is still regarded as one of the best to drive in the series. He hit another driver's car. This caused his car to go airborne. After the car hit the ground Villeneuve was flown from his car and flew into catch fencing. He had a pulse when he was rescued but was not breathing. He died later from a severe neck injury in 1982<sup>50</sup>.

As the deaths of their fellow drivers theirs too were regarded with sadness, but even to a greater degree because of their status and following.

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<sup>44</sup> Benson 2010; Jones 2001, 123; Jones 2001, 245.

<sup>45</sup> Newey 2017, 189.

<sup>46</sup> Newey 2017, 186.

<sup>47</sup> Codling 2017, 136.

<sup>48</sup> Newey 2017, 186.

<sup>49</sup> "Formula 1's greatest drivers. Number 20: Jochen Rindt - BBC Sport" 2012.

<sup>50</sup> "Formula 1's greatest drivers. Number 12: Gilles Villeneuve - BBC Sport" 2012.

## 2.2 Teams, nationalities, sessions, and tracks

When looking to categorize the drivers by their attributes even more, we can do it by teams, nationalities, session, and track. The average dying driver was 33 years old, had British nationality, drove for Lotus or Ferrari, and died during a race in Indianapolis Motor Speedway. This wasn't a surprise as teams Lotus and Ferrari are some of the teams that have been on the grid the longest, Ferrari since 1950 and Lotus from 1959 to 1994 and then again in 2012 to 2015.<sup>51</sup> Next teams with the most deaths were Kurtis Kraft with 6 and Cooper with 5. Cooper operated from 1950 to 1969<sup>52</sup> and Kurtis Kraft from 1950 to 1960<sup>53</sup>.

Kurtis Kraft is an interesting team as it only participated during the race weekend in Indianapolis, which was part of the Formula One World Championship from 1950 to 1960. Naturally moving from Kurtis Kraft to Indianapolis Motor Speedway, the track with 7 deaths, the most out of 27 different tracks that the 52 deaths took place. These deaths took place during the short period the Indianapolis 500, which was the name of the races in Indianapolis Motor Speedway, was part of F1. This track and the team Kurtis Kraft had all the things in common. During the period the Indianapolis 500 was part of the championship 15 deaths happened; 7 out of the 15 were all American and died in the Indianapolis Motor Speedway. Out of these 7 deaths 6 were with Kurtis Kraft and one with Kuzma, both American teams. Five of the deaths happened during practice, overall, most of the drivers died during a race. When Indianapolis was removed from Formula One, the deaths decreased, in American drivers, in Indianapolis Motor Speedway and in American manufactured cars. After the Indianapolis 500 left, only 3 Americans died, zero died in American manufactured cars and 2 drivers died on American soil (non-American drivers).

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<sup>51</sup> Jones 2001, 79, 85.

<sup>52</sup> Jones 2001, 78.

<sup>53</sup> "Wayback Machine" 2010.

The United States of America is the nation with the most drivers all time<sup>54</sup>, this can be pulled to the Indianapolis 500. Although the race was part of Formula One, the series' regular drivers didn't really take part in the Indy 500.

As Maurice Hamilton says in his book *Formula 1 The Official History*<sup>55</sup>:

“...it was admitted that the 500-mile race on a banked oval, for all its unique and colorful challenges, had no connection whatsoever with Formula 1.”

This was also enforced by Bruce Jones<sup>56</sup>:

“...although it was contested by an almost entirely separate set of drivers in different cars.”

Meaning that even if the USA holds the title of most drivers, they came from the Indianapolis 500 and mostly left with it. This doesn't mean American drivers disappeared, they just decreased in numbers significantly.

Next track with the most deaths was Nürburgring with 5 and Silverstone with 4. Both tracks had a multi-year run in Formula One, with Silverstone still being part of the race calendar to this day. First death in Nürburgring was in 1954 and latest 1969, though it is remembered best because of Niki Lauda's near fatal accident in 1976<sup>57</sup>. Silverstone's deaths were a bit more spread out with the first in 1960 and the latest in 2014.

Overall, there aren't many connecting factors between the deaths that happened at certain tracks. I studied all the tracks that have more than one death, trying to find anything connecting the deaths. In Autodromo di Modena all the drivers had connections to Italy; out of the 3 dead drivers, 2 drove for Ferrari and 2 were Italian. In Circuit Park Zandvoort 2 of the three drivers that died driving for March Engineering, died there. In Circuit de Spa- Francorchamps and in Autodromo Enzo e Dino Ferrari, two

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<sup>54</sup> " Nations With the Most Drivers in Formula 1 History • MOSTLY F1".

<sup>55</sup> Hamilton 2022, 17.

<sup>56</sup> Jones 2001, 14.

<sup>57</sup> Jones 2001, 41, 115.

out of the two that died in both tracks happened during the same race weekend. Spa-Francorchamps in the 1960 race with Chris Bristow and Alan Stacey. And in Enzo e Dino Ferrari during the 1994 weekend, Roland Ratzenberger in qualification and Ayrton Senna in the race.

Kyalami Racing Circuit offered catastrophe for the Shadow Racing Cars as their only deaths both happened in this track, Peter Revson during a test in 1974 and Tom Pryce in a race during the 1977 season. Watkins Glen International was the only circuit out of the studied tracks that had both of its deaths die from the same type of injury: head and neck injuries. Francois Cevert had his body cut in half during the 1973 qualification<sup>58</sup> and Helmuth Koinigg died from decapitation during the 1974 race.<sup>59</sup>

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<sup>58</sup> Hill 2010.

<sup>59</sup> Katz 1974.

### 3 HISTORY OF SAFETY CHANGES

As it is clear now the deaths did decrease. We can begin to tie the decrease to safety features being introduced and evolved.

#### 3.1 Head, neck, and fire safety

Main safety change to affect the decrease of deaths from head and neck related injuries was the full-face helmet. Crash helmets akin to riding helmets were made mandatory in 1952, mostly due to Luigi Fagioli's death in a sports car race.<sup>60</sup> Full-face helmets were first introduced to F1 by American driver Dan Gurney in the 1968 German Grand Prix. It was not popular among drivers, until Jochen Rindt started using one.<sup>61</sup> These helmets not only protected the head but also drivers' ears from motor sounds and wind. They are made of carbon fiber. Helmets nowadays must face a strict list of requirements. They must be full-faced, and its lining must be made with materials that will absorb the most energy in an accident. The visor is covered with tear-offs that combat dirt and oils that may alter or block drivers' vision. They are fitted with a drinks bottle and radio mouthpiece.<sup>62</sup>

After the introduction of the full-face helmet in the 1968 German Grand Prix, 3 out of the 10 head and neck injury deaths, died from helmet-related problems. Tom Pryce

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<sup>60</sup> Codling 2017, 120.

<sup>61</sup> Codling 2017, 135.

<sup>62</sup> Jones 2001, 230.



and Jules Bianchi died from causes relating straight to helmets. Pryce's helmet sharply pulled upwards killing him instantly and Bianchi had his helmet lodged under a safety vehicle and died after being in a coma. Mark Donohue died from cerebral hemorrhage after crashing into the barriers. We can clearly state that the full-faced helmet did decrease deaths from classical head injuries.

The HANS device came in 2003, to help drivers' necks and heads even more. As the name suggests (Head and neck support), its job is to limit the movement of the head in the car. HANS connects to the drivers' helmet and helps with the threat of hyper-extending, leading cause of death in racing, when it results in a basal skull fracture<sup>63</sup>. It can also reduce the risk of whiplash<sup>64</sup>. As most of the safety changes this too was faced with criticism in its debut. HANS too as the helmet before became a staple in motorsports. After the introduction of the HANS device one death can be counted for to be due to it not working. But as this death happened during a race that wasn't part of the Formula One Grand Prix races, it could be that there wasn't regulation to use the HANS device as it was in the series.

Racing suits were made mandatory in the 60s, but they weren't fireproof until 1975. Nowadays they are made with light and breathable material with Nomex coating. Nomex is the same thing firefighters use in their suits<sup>65</sup>. Racing outfit for the drivers contains: one-piece overall, that has a high neck and elasticated cuffs at the wrists and ankles. The driver's underwear, socks and balaclava are also made from Nomex<sup>66</sup>. Every element of the suit is tested rigorously, so that they protect the drivers in case of a fire<sup>67</sup>. The suits must always meet FIA safety requirements. Racing suits didn't save lives per se, but they increased the general safety by a huge margin.

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<sup>63</sup> Duxbury 2022.

<sup>64</sup> Codling 2017, 136.

<sup>65</sup> Duxbury 2022.

<sup>66</sup> Jones 2001, 230.

<sup>67</sup> Duxbury 2022.

At first refueling was banned from 1984 to 1994, and again from the 2010s onwards<sup>68</sup>. The first ban was introduced due to safety concerns, as the fuel used <sup>69</sup>and some materials, such as magnesium were highly flammable<sup>70</sup>, magnesium sheet thickness was regulated more in the 1972 <sup>71</sup>after two deaths relating to magnesium<sup>72</sup>. The refueling ban was safer for F1 as during the time (1994-2009) it was not in use there were accidents that highlighted the risk of fueling. For example, Jos Verstappen in 1994, the fuel hose sprayed Verstappen and his crew with fuel and resulted in a fiery blaze, with Verstappen suffering from mild burns<sup>73</sup>, and Kimi Räikkönen in 2009, where he was doused with fuel from Heikki Kovalainen's attached fuel hose, that he dragged down the pitlane<sup>74</sup>.

With the first ban ending in 1994, the safety for refueling and fueling in general did not end. 1994 fire protection clothing for refueling crews became mandatory. This was followed with the refueling connector to be covered from 1998 onwards<sup>75</sup>. In 2004 Refueling rigs were allowed during the first part of qualifying if everyone wore suitable clothing and photographers were restricted<sup>76</sup>.

The second ban was reintroduced in 2010. This time the reason is more financial than that of safety, as it was quite expensive to move heavy fueling equipment around the world with the series. The ban introduced a new strategy point in fuel having to make it to the finish line. This put more pressure towards practice sessions as the need to see how much fuel the track and driver style took. Different tracks took different fuel loads, the same with different driver styles. With the ban pitstops became faster, safer, and easier<sup>77</sup>.

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<sup>68</sup> Duxbury 2022.

<sup>69</sup> " These Formula 1 Safety Features Keep Drivers Alive" 2022.

<sup>70</sup> " Demonstrations - Burning Magnesium".

<sup>71</sup> " Safety Improvements in F1 Since 1963", AtlasF1.

<sup>72</sup> " Jo Schlessler dies in experimental Honda at Rouen | On this day | ESPN.co.uk"; Edworthy 2003.

<sup>73</sup> Duxbury 2022.

<sup>74</sup> Duxbury 2022.

<sup>75</sup> " Safety Improvements in F1 Since 1963", AtlasF1.

<sup>76</sup> " F1 rules and stats 2000-2009 - F1technical.net".

<sup>77</sup> Braybrook 2023.

The fire safety did not stop with refueling bans and adequate racing suits, these were only the start. As stated earlier the fuel used was highly flammable, and during the ban of 2010 each car could carry around 100 kilograms of fuel<sup>78</sup>. This made it important that the fuel wouldn't migrate from the tank and worsen accidents. The car also ran incredibly hot during races.

If fire comes to play the driver extraction becomes difficult, leading to marshals taking longer to get the driver out of the car. What if the driver couldn't get out on their own? This made the racing suit, and the cars own fire safety mechanisms a matter of life and death. The cars are equipped with fire extinguishers and fire-resistant fuel tanks<sup>79</sup>. These fuel tanks are made of military grade Kevlar, the same material used in bullet-proof vests. They are also reinforced with rubber to prevent the fuel from leaking or catching fire due to the heat<sup>80</sup>.

### **3.2 Crashing and car safety**

In Formula One the seat belt has been an interesting discussion. Before its arrival to the F1 car, it was viewed mostly in a negative light; it was better to fly out of the car than be tied down by the seat belt during a fiery accident<sup>81</sup>. In 1991 The seat belt became part of FIA testing<sup>82</sup>. Currently the drivers use a strong six-point safety harness<sup>83</sup>. The seatbelt is inspected before every race to make sure it is safe and usable during the race, even a slight tear renders it unusable<sup>84</sup>.

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<sup>78</sup> " These Formula 1 Safety Features Keep Drivers Alive" 2022.

<sup>79</sup> Skill-Lync.

<sup>80</sup> Codling 2017, 117.

<sup>81</sup> Codling 2017, 120.

<sup>82</sup> " Safety Improvements in F1 Since 1963".

<sup>83</sup> Jones 2001, 228.

<sup>84</sup> " The Race for F1 Safety: The Six-Point Seatbelt" 2021.

After its introduction in 1972, only one driver's death can be blamed to the seatbelt not fully working: Gilles Villeneuve. Villeneuve's death was investigated in greater detail in the chapters before. In general, the seatbelt did its job in F1 and in the world of normal vehicles.

The place where the driver is seated has had many changes towards its safety. Most notably being called the monocoque and made to withstand (and absorb) immense forces during a crash to make sure the driver is safe<sup>85</sup>. The monocoque is made of carbon fiber, Kevlar, and other ultra strong man-made fibers<sup>86</sup>. It is designed to be the last line of defense between the driver and the track<sup>87</sup>. The monocoque must be fitted with its own fire suppression system that is driver activated, this sprays fire retardant foam around the monocoque and engine<sup>88</sup>.

Reinforced "survival cell" (monocoque) was introduced in 1981. Static crash test was introduced in 1988, and the side test in 1995. In 1998 the monocoque got bigger and the tests conducted towards it got stronger. This learning curve grew in the 2000s and the test became more rigorous and demanded more of the monocoque<sup>89</sup>. Nowadays the monocoque is made to withstand even the most dramatic of crashes<sup>90</sup>. Though the monocoque is considered the frontline of safety in the F1 car, it has not always been like that. Ayrton Sennas death can be partially blamed on the weak structure of the monocoque, as it allowed the front suspension to hit his head. On the other hand, the modern monocoque can be credited in being a part of saving the life of Romain Grosjean in 2020 Bahrain Grand Prix.

The Halo or secondary roll structure was introduced in 2018. All the accidents and deaths across motorsport called for and accelerated the research for a safety feature to

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<sup>85</sup> Duxbury 2022.

<sup>86</sup> Jones 2001, 228.

<sup>87</sup> Duxbury 2022.

<sup>88</sup> Skill-Lync.

<sup>89</sup> " Safety Improvements in F1 Since 1963".

<sup>90</sup> Duxbury 2022.

protect the head. It was first timed for the 2017 season but moved to the 2018 season due to the concerns that it was not tested enough and properly. In the beginning it was heavily criticized: it was against the DNA of single-seater racing, and it raised concerns towards driver visibility<sup>91</sup>. As these died down, the appreciation towards the Halo began to show. It protects the drivers from large pieces of debris, as well as if the car ends up on top of another car, or under a safety vehicle like Jules Bianchi. It has been seen in action with Romain Grosjean's fiery accident in Bahrain.

"The halo above Grosjean's head had forced the metal apart and, in the process, saved the driver's life."

Maurice Hamilton

The barriers and run-off areas are the most vital part of racetrack safety to exist. They have existed since the start of the series, but worked mostly as a reminder where the track went. It started as hay bales for barriers<sup>92</sup> and grass for run-off areas. It has evolved in the 2000s to standardized tire barriers that can more effectively absorb the energy of the crash<sup>93</sup>. They have improved since every accident to be better to the specificity of the track and speeds. Barriers consist of a steel fence (Armco barrier) as a last resort, in front of those there are usually barriers made of materials that can absorb large amounts of energy, like tires. Before the barriers there are run-off areas that are designed to slow the car as much as possible. After the Imola weekend in 1994, where Rolan Ratzenberger and Ayrton Senna lost their lives, the eyes of safety were also moved to run-off areas, decreasing the dangers of fast corners. New tracks had large asphalt run-offs that worked better at stopping the car than grass or gravel<sup>94</sup>. In 1996 tracks could only hold two corners that were deemed dangerous<sup>95</sup>. This was

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<sup>91</sup> Hamilton 2022, 245–246.

<sup>92</sup> Codling 2017, 120.

<sup>93</sup> Duxbury 2022.

<sup>94</sup> Duxbury 2022.

<sup>95</sup> "Safety Improvements in F1 Since 1963".

made in effort to prevent the likes of Imola again. Asphalt is preferable for run-off, since it doesn't punish the cars as much as gravel or grass, where cars can get stuck<sup>96</sup>.

Biometric gloves were introduced in 2018, and their main job is to give even more information to the medical team about drivers' state during an accident. The gloves transmit the pulse and blood oxygen levels of the drivers to race control at all times. They are used to knowing how fast the extraction of the driver can be in case of an accident where the driver can't get out on their own<sup>97</sup>. The FIA Formula 1 technical regulations state that the biometric gloves are mandatory and must be manufactured in a specification supplied by the FIA, by a manufacturer specified by FIA<sup>98</sup>.

Marshals are one of the key elements of a successful race and not just in the sense of safety. They have been a part of Formula One since its first year in 1950. They are unpaid volunteers, usually from the country where the race takes place. In racing today, they are the first responders, trained in first aid, fire safety and accident handling<sup>99</sup>. They are also responsible for waving different flags to signal to drivers of accidents, debris, track conditions and when the problem is clear.

Most important flags to F1 racing are red (drivers must return to pitlane, be prepared to stop and the session is stopped), yellow (warns of hazards ahead, no overtaking, and to be prepared to slow) and checkered (end of session)<sup>100</sup>. Flag signaling code was introduced in 1963. In 1998 the signaling was also directed to full light sets and in 1999 pitlane exit was controlled with green and red lights<sup>101</sup>. Although marshals still wave flags the meaning was also transferred to light panels.

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<sup>96</sup> Duxbury 2022.

<sup>97</sup> Duxbury 2022.

<sup>98</sup> " FIA 2024 Formula 1 technical regulations-issue 2-2023-08-31".

<sup>99</sup> Duxbury 2022.

<sup>100</sup> Jones 2001, 230-232.

<sup>101</sup> " Safety Improvements in F1 Since 1963".

As mentioned earlier in firefighting, marshals were relatively inexperienced when it came to cars catching fire. It improved not only in the ways mentioned earlier, but from better training and learning from accidents, why they couldn't help. In 1975 marshal posts became a thing and in 1999 every car was fitted with a panel to show marshaling information.

At first, they couldn't save people in racing accidents, but as they evolved the first response became more powerful, and nowadays they are one of the most important features when it comes to driver rescue and ensuring the track is clear for other drivers.

Safety car was first used in 1973 in the Canadian Grand Prix but became permanently part of the series in 1993<sup>102</sup>. It is a key to safer racing. It comes out in case of an accident (a lot of debris or the car is in an unsafe place), or bad weather. Its job is to keep the speeds down and stopping overtaking and showing a safe route for the car in case of debris. It was standardized in 1996, along with the FIA medical car, and it was made more powerful a year later<sup>103</sup>.

Virtual safety car is a version of a safety car for accidents where action must be taken fast, or the accident was minor. When in effect the drivers cannot overtake one another, and they must follow electronically monitored speed limit<sup>104</sup>. As the safety cars target the focus and limiting the speeds, they are essential to racing safety, and deploying either the virtual or the real one is a must feature to ensure safety for the driver stopped and the driver racing.

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<sup>102</sup> Duxbury 2022.

<sup>103</sup> " Safety Improvements in F1 Since 1963".

<sup>104</sup> Codling 2017, 137.

## 4 CONCLUSIONS

So, how, and why the deaths decreased in Formula One-racing? Simple answer: old safety features evolved and new were introduced. It can be said with confidence that safety couldn't have evolved without the human emotion of getting tired of seeing your colleagues, family members or employees dying. Safety in Formula One, like in real working life, is written with blood. It took people dying multiple times to have something done to the dangerous elements of the sport. After safety changes the sport is safer than ever, but it doesn't give the reason to stop now. I believe it to be the most important part of any job that it is the safest it can be. No one should lose their life because of inadequate safety, or disregard for it.

In this research we first establish groundwork for the state of dying and how or why people were killed in Formula One. I go through all the ways to die, how they are placed in the history of the sport. The point is to show what death was and were, or how, it happened, so that we later can show how or why it decreased. I also show three notable driver cases in detail. Jochen Rindt, Gilles Villeneuve and Ayrton Senna were picked because of their skill level, status, and their status in the eyes of fans. My point in this is to show that even beloved and world-famous drivers can succumb to death. That even the most skilled can die and why the safety changes gained a lot more traction after these three deaths.



After laying down the ways to die, I investigate similarities in the deaths. Was there a track or event more deadly than others? Did drivers die in a similar matter in the same track or event? The most important discovery was the Indianapolis deaths. This shaped my whole understanding to a different level. As Indianapolis left Formula One in 1960, deaths decreased. I also found out that many of the deaths had nationalities in common. As I explained in chapter 2.2, American driver deaths decreased, as did deaths with American manufactured cars. This was a big discovery that led to a whole new point in my research.

Now we go through safety changes, how they affected the safety, or were shown in table 1. These changes massively changed the sports rules, how it looked and how people looked at it. These are the main points of this research. I found that there are many ways that these safety changes affected to the decrease of deaths. I had accomplished my goal in showing how and why the deaths decreased in Formula One-racing.

In the future the sport will continue to evolve, with hopefully the safety evolving with it. As regulation changes and aims for a more carbon neutral future, I like to think safety comes with. I believe that losing drivers is more expensive for the series than changing things for safety. I also think that many of the current drivers have had tight connections to drivers that have died in racing. This means they are more actively changing the sport for better as death has been a close thing.

Future of this area of research is only beginning. My work is but a modest presentation of a fan wanting to bring her connection to the sport known. I also believe fiercely in work safety so to bring forward my take on it is an existing thing. I can only hope more people gain interest towards Formula One in the eyes of research.

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# APPENDICES

## TABLE 1

date of acci	name	age	cause of death	cause of death	cause of death	circuit
18.6.1952	Cameron Earl	8.5.1923 (29)				MIRA test track
15.5.1953	Chet Miller	19.7.1902 (50)				Indianapolis Motor Speedway
18.9.1953	Charles de Tornaco	7.6.1927 (26)				Autodromo di Modena
31.7.1954	Onofre Marimon	19.12.1923 (30)				Nurburgring
11.4.1955	Mario Alborghetti	23.10.1928 (26)				Circuit de Pau-Ville
16.5.1955	Manny Ayulo	20.10.1921 (33)				Indianapolis Motor Speedway
30.5.1955	Bill Vukovich	13.12.1918 (36)				Indianapolis Motor Speedway
14.3.1957	Eugenio Castellotti	10.10.1930 (26)				Modena Autodrome
15.5.1957	Keith Andrews	15.6.1920 (36)				Indianapolis Motor Speedway
30.5.1958	Pat O'Connor	9.10.1928 (29)				Indianapolis Motor Speedway
6.7.1958	Luigi Musso	28.7.1924 (33)				Circuit de Reims-Gueux
3.8.1958	Peter Collins	6.11.1931 (26)				Nurburgring
19.10.1958	Stuart Lewis-Evans	20.4.1930 (28)				Circuit d'Ain Diab
2.5.1959	Jerry Unser Jr.	15.11.1932 (26)				Indianapolis Motor Speedway
19.5.1959	Bob Cortner	16.4.1927 (32)				Indianapolis Motor Speedway
13.5.1960	Harry Schell	29.6.1921 (38)				Silverstone Circuit
19.6.1960	Chris Bristow	2.12.1937 (22)				Circuit de Spa-Francorchamps
19.6.1960	Alan Stacey	29.8.1933 (26)				Circuit de Spa-Francorchamps
1.6.1961	Shane Summers	1.6.1936 (24)				Brands Hatch
15.6.1961	Giulio Cabianca	19.2.1923 (38)				Autodromo di Modena
10.9.1961	Wolfgang von Trips	4.5.1928 (33)				Autodromo Nazionale di Monza
1.11.1962	Ricardo Rodriguez	14.2.1942 (20)				Autodromo Magdalena Mixiucha
21.12.1962	Gary Hocking	30.9.1937 (25)				Westmead Circuit
1.8.1964	Carel Godin de Beaufort	10.4.1934 (30)				Nurburgring
7.8.1966	John Taylor	23.3.1933 (33)				Nurburgring
7.5.1967	Lorenzo Bandini	21.12.1935 (31)				Circuit de Monaco
14.8.1967	Bob Anderson	19.5.1931 (36)				Silverstone Circuit
7.7.1968	Jo Schlesser	18.5.1928 (40)				Circuit de Rouen-les-Essarts
1.8.1969	Gerhard Mitter	30.8.1935 (33)				Nurburgring
25.5.1970	Martin Brain	22.12.1932 (37)				Silverstone Circuit
21.6.1970	Piers Courage	27.5.1942 (28)				Circuit Park Zandvoort
5.9.1970	Jochen Rindt	18.4.1942 (28)				Autodromo Nazionale di Monza
24.10.1971	Jo Siffert	7.7.1936 (35)				Brands Hatch
29.7.1973	Roger Williamson	2.2.1948 (25)				Circuit Park Zandvoort
6.10.1973	Francois Cevert	25.2.1944 (29)				Watkins Glen International
22.3.1974	Peter Revson	27.2.1939 (35)				Kyalami Racing Circuit
6.10.1974	Helmuth Koinigg	3.11.1948 (25)				Watkins Glen International
17.8.1975	Mark Donohue	18.3.1937 (38)				Österreichring
5.3.1977	Tom Pryce	11.6.1949 (27)				Kyalami Racing Circuit
29.8.1977	Brian McGuire	13.12.1945 (31)				Brands Hatch
10.9.1978	Ronnie Peterson	14.2.1944 (34)				Autodromo Nazionale di Monza
1.8.1980	Patrick Depailler	9.8.1944 (35)				Hockenheimring
8.5.1982	Gilles Villeneuve	18.1.1950 (32)				Circuit Zolder
13.6.1982	Riccardo Paletti	15.6.1958 (23)				Circuit Gilles Villeneuve
14.5.1986	Elio de Angelis	26.3.1958 (28)				Circuit Paul Ricard
30.4.1994	Roland Ratzenberger	4.7.1960 (33)				Autodromo Enzo e Dino Ferrari
1.5.1994	Ayrton Senna	21.3.1960 (34)				Autodromo Enzo e Dino Ferrari
24.6.2000	John Dawson-Damer	1941 (59)				Goodwood Hillclimb
14.7.2002	Fritz Glatz	21.7.1943 (58)				Autodrom Most
27.7.2014	Denis Welch	Aged 69				Silverstone Circuit
5.10.2014	Jules Bianchi	3.8.1989 (25)				Suzuka International Racing Course
7.9.2017	David Ferrer	aged 62				Circuit Park Zandvoort

TABLE 1, part 1. Red: head and neck injuries; yellow: drove to/hit a wall; green: crushed/flipped; blue: fire; purple: other

nationality	team	session	event	
British	ERA	test	test	Orange
American	Kurtis Kraft	practice	Indianapolis 500	
Belgian	Ferrari	practice	Modena Grand Prix	Turquoise
Argentine	Maserati	practice	German Grand Prix	
Italian	Maserati	race	Pau Grand Prix	Turquoise
American	Kurtis Kraft	practice	Indianapolis 500	
American	Kurtis Kraft	race	Indianapolis 500	
Italian	Ferrari	test	test	Orange
American	Kurtis Kraft	practice	Indianapolis 500	
American	Kurtis Kraft	race	Indianapolis 500	
Italian	Ferrari	race	French Grand Prix	
British	Ferrari	race	German Grand Prix	
British	Vanwall	race	Moroccan Grand Prix	
American	Kuzma	practice	Indianapolis 500	
American	Kurtis Kraft	practice	Indianapolis 500	
American	Cooper	practice	BRDC International Trophy	Turquoise
British	Cooper	race	Belgian Grand Prix	
British	Lotus	race	Belgian Grand Prix	
British	Cooper	practice	Silver City Trophy	Turquoise
Italian	Cooper	test	test	Orange
German	Ferrari	race	Italian Grand Prix	
Mexican	Lotus	practice	Mexican Grand Prix	Turquoise
Rhodesian (current Zimbabwe)	Lotus	practice	Natal Grand Prix	Turquoise
Dutch	Porche	practice	German Grand Prix	
British	Brabham	race	German Grand Prix	
Italian	Ferrari	race	Monaco Grand Prix	
British	Brabham	test	test	
French	Honda	race	French Grand Prix	
German	BMW	practice	German Grand Prix	
British	Cooper	race	Nottingham Sports Car Club meeting	Turquoise
British	De Tomaso	race	Dutch Grand Prix	
Austrian	Lotus	qualifying	Italian Grand Prix	
Swiss	British Racing Motors team	race	World Championship Victory Race	Turquoise
British	March Engineering	race	Dutch Grand Prix	
French	Tyrell	qualifying	United States Grand Prix	
American	Shadow Racing Cars	test	test	Orange
Austrian	The Surtees Racing Organisation	race	United States Grand Prix	
American	March Engineering	practice	Austrian Grand Prix	
British	Shadow Racing Cars	race	South African Grand Prix	
Australian	McGuire	practice	Shellsport International series round 11	Turquoise
Swedish	Lotus	race	Italian Grand Prix	
French	Alfa Romeo	test	test	Orange
Canadian	Ferrari	qualifying	Belgian Grand Prix	
Italian	Osella	race	Canadian Grand Prix	
Italian	Brabham	test	test	Orange
Austrian	Simtek	qualifying	San Marino Grand Prix	
Brazilian	Williams	race	San Marino Grand Prix	
British	Lotus	run	Goodwood Festival Of Speed	Turquoise
Austrian	Footwork team	race	Czech Superprix	
British	Lotus	race	Jack Brabham memorial trophy	Turquoise
French	Marussia	race	Japanese Grand Prix	
French	March Engineering	race	Historic Grand Prix	Turquoise

TABLE 1, part 2. Orange: a test drive that wasn't part of any official racing event; turquoise: race that wasn't part of Formula One World Championship

**TABLE 2**

	people died	nationalities	teams	tracks and event	
1950s	15	American	7 Kurtis Kraft	6 Indianapolis Motor Speedway; Indianapolis 500	7
		British	3 Ferrari	4 Nurburgring; German Grand Prix	2
		Italian	3 Maserati	2 Autodromo di Modena; Modena Grand Prix, test	2
		Belgian	1 ERA	1 MIRA test track; test	1
		Argentinian	1 Vanwall	1 Circuit de Pau-Ville; Pau Grand Prix	1
			Kuzma	1 Circuit de Reims Gueux; French Grand Prix	1
				Circuit d'Ain Diab; Moroccan Grand Prix	1
1960s	14	British	5 Cooper	4 Nurburgring; German Grand Prix	3
		Italian	2 Lotus	3 Silverstone Circuit; BRDC International Trophy, test	2
		German	2 Ferrari	2 Circuit de Spa-Francorchamps; Belgian Grand Prix	2
		American	1 Brabham	2 Brands Hatch; Silver City Trophy	1
		Mexican	1 Porche	1 Autodromo di Modena; test	1
		Rhodesian	1 Honda	1 Autodromo Nazionale di Monza; Italian Grand Prix	1
		Dutch	1 BMW	1 Autodromo Magdalena Mixiucha; Mexican Grand Prix	1
		French	1	Westmead Circuit; Natal Grand Prix	1
				Circuit de Monaco; Monaco Grand Prix	1
				Circuit de Roven-les-Essarts; French Grand Prix	1
1970s	12	British	4 Lotus	2 Circuit Park Zandvoort; Dutch Grand Prix	2
		Austrian	2 March Engineering	2 Autodromo Nazionale di Monza; Italian Grand Prix	2
		American	2 Shadow Racing Cars	1 Brand Hatch; World Championship Victory Race, Shellsport Internationala Series Round 11	2
		Swiss	1 British Racing Motors Team	1 Watkins Glen International Circuit; United States Grand Prix	2
		French	1 Tyrrell	1 Kyalami Racing Circuit; test, South African Grand Prix	2
		Australia	1 The Surtees Racing Organisation	1 Silverstone Circuit; Nottingham Sports Car Club meeting	1
		Swedish	1 McGuire	1 Österreichring; Austrian Grand Prix	1
			Cooper	1	
			De Tomaso	1	
1980s	4	Italian	2 Alfa Romeo	1 Hockenheimring; test	1
		French	1 Ferrari	1 Circuit Zolder; Belgian Grand Prix	1
		Canadian	1 Osella	1 Circuit Gilles Villeneuve; Canadian Grand Prix	1
			Brabham	1 Circuit Paul Ricard; test	1
1990s	2	Austrian	1 Simtek	1 Autodromo Enzo e Dino Ferrari; San Marino Grand Prix	2
		Brazilian	1 Williams	1	
2000s	2	British	1 Lotus	1 Goodwood Hillclimb; Goodwood Festival of Speed	1
		Austrian	1 Foorwork Team	1 Autodrom Most; Czech Superprix	1
2010s	3	French	2 Lotus	1 Silverstone Circuit; Jack Brabham Memorial Trophy	1
		British	1 Marussian	1 Suzuka International Racing Course; Japanese Grand Prix	1
			March Engineering	1 Circuit Park Zandvoort; Historic Grand Prix	1

TABLE 2, part 1


























1950s	session		reasons of death	
	practice	7		10
	race	6		4
	test	2		4
				2
				1
1960s	race	6		5
	practice	6		4
	test	2		3
				3
				2
1970s	race	7		5
	practice	2		5
	qualificatic	2		3
	test	1		2
1980s	test	2		3
	race	1		1
	qualificatic	1		1
				1
1990s	qualificatic	1		1
	race	1		1
2000s	run	1		1
	test	1		1
2010s	race	3		1
				1
				1

TABLE 2, part 2