

Root Cause Analysis Report

Example_Dale Earnhardt Fatality



Problem Statement

Report Number	N/A	RCA Owner	Chris Eckert
Report Date	9/4/2015	RCA Facilitator	Brian Hughes

Focal Point: Fatality - Dale Earnhardt Sr.

When

Start Date: 2/21/2001	End Date: 2/21/2001
Start Time: 5:16 PM (Eastern)	End Time: N/A
Unique Timing	After head injury during the final lap of the 2001 Daytona 500 race.

Where

Location	Daytona International Speedway, Turn 4, outer wall (point of impact)
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Actual Impact

Safety	Qualitative: Driver fatality - no others injured.	\$0.00
Public Impact	Qualitative: Massive grief and sadness at loss of very influential driver	\$0.00
Cost	Quantitative: Loss of cars (two, estimated \$125k each)	\$250,000.00
Cost	Quantitative: Cost of investigations (estimated)	\$1,500,000.00
		Actual Impact Total: \$1,750,000.00

Frequency

Frequency Note	68 NASCAR deaths (since 1948), 14 NASCAR deaths at Daytona International Speedway (since 1961), 19 total reported deaths due to basilar skull fractures.
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Potential Impact

Safety	Other drivers could have been injured and/or killed.	\$0.00
Risk Score	Risk of future fatalities determined to be Extreme	\$0.00
		Potential Impact Total: \$0.00

Report Summaries

Executive Summary

On February 19th, 2001 at approximately 5:16 PM Eastern time during the final turn of the final lap of the Daytona 500 automobile race, world-famous NASCAR driver Dale Earnhardt Sr. was killed when his car struck the outer barrier of the race track.

Earnhardt died of basilar skull fractures experienced as a result of his car hitting the concrete wall at between 157MPH and 161MPH. Earnhardt, like many other drivers, had chosen not to wear a head and neck restraining device, known as a HANS device). At the time of the 2001 Daytona 500, use of the HANS device was not mandatory.

Corrective/Preventive Actions:

1. Migrate from 5-point safety harness to 6-point safety harness to provide better driver restraint.
2. Require use of HANS restraint system to help protect against sudden neck movement.*
3. Require use of redesigned cars based on Car of Tomorrow specifications.
4. Require tracks to install SAFER barriers, which have the ability to better absorb forces of impact.

**Note: Required use of HANS did not occur until driver Blaise Alexander was killed from a similar basilar skull fracture injury four months after Earnhardt's death.*

Cause and Effect Summary

On February 19th, 2001 at approximately 5:16 PM Eastern time during the final turn of the final lap of the Daytona 500 automobile race, world-famous NASCAR driver Dale Earnhardt Sr. was killed when his car slammed into the outer barrier of the race track.

Earnhardt was negotiating the turn when he lost control after the left rear fender of his car came in contact with the right front fender of another car. It is unclear whether Earnhardt drifted into the other driver or vice versa. They were racing towards the finish in close proximity to each other and several other cars. The impact broke the rear tires of Earnhardt's car loose, sending it first to the left towards the infield, and then sharply to the right – across traffic – toward the outer barrier wall. Another racer struck his passenger door just before his car slammed into the concrete barrier.

[video of crash](#)

The sudden deceleration subjected Earnhardt's car to an estimated -68 to -48 g-forces. These forces are similar to dropping the car front-first from a height of 60' onto a slab of concrete. Earnhardt experienced basilar skull fractures – spiral fractures to the occipital and left temporal bones of his skull. This type of injury can cause sufficient damage to the adjacent brain tissues to interrupt autonomic functions such as heartbeat and breathing.

The deceleration event began when the other racer struck the passenger door of Earnhardt's car just before he hit the wall. This impact jolted his head to the right and caused the muscles of his neck to reflexively tense up. The final deceleration occurred a split second later when he hit the concrete wall at an estimated angle of 55° - 59° at a speed of 157 MPH – 161 MPH. The crush properties of the racecar (an older design) and the fact that the wall was solid

concrete meant that very little of the resulting force of deceleration was absorbed. Reflexive tension in his neck along with the substantial decelerative forces caused the bones of his skull to fracture.

Earnhardt's seatbelt was found to have failed during the crash. At first, it was thought that the failed seat belt allowed his head to hit the steering wheel causing the fatal injury. The seatbelt failure was caused by the improper installation of the belt anchor. The belt anchor should have been installed 2.5 inches away from the seat. However, in order to provide greater driver comfort, the anchor was installed approximately 5 inches away from the seat. This resulted in a suboptimal belt angle which caused the belt at the time of impact. A subsequent investigation however determined that even if the belt had not torn, Earnhardt would have still likely experienced fatal injuries of the same type and extent because his head was insufficiently restrained to prevent such an injury.

Drivers had the option of using a special restraining device (called HANS – Head And Neck System) to prevent the neck from moving during a crash such as this. Even though seventeen professional drivers had been killed by basilar skull fractures up to the start of the 2001 Daytona 500, Earnhardt and many other drivers declined to use the HANS devices, saying that the protective properties did not outweigh the discomfort caused by the device. NASCAR had recommended, yet not required, the use of the HANS device. In fact, after Earnhardt's death NASCAR continued not to require the use of the device. Only after another racer was killed four months later by essentially the same type of skull fracture did NASCAR begin requiring use of the HANS device.

The medical response was adequate. However the injuries sustained were simply too great for Earnhardt to recover.

Solutions

SO-0001	Solution	Migrate from 5-point safety harness to 6-point safety harness to provide better driver restraint.	
	Cause(s)	Angle of forces on belt at time of crash	
	Note	It was not determined that a 5-point safety harness was a cause of Earnhardt's death, however this was determined to be a preventive action to help reduce risks and improve overall safety. Note: Cost is per unit.	
	Assigned		Criteria Passed
	Due		Status Validated
	Term	short	Cost \$300.00
	SO-0002	Solution	Require use of HANS restraint system to help protect against sudden neck movement.
Cause(s)		No requirements for additional protection - decision left up to driver	
Note		At first, NASCAR pulled up short of formally requiring the HANS device. However, after the death of racer Blaise Alexander from the same injury just two months after Earnhardt's death (and the sixth such fatality) NASCAR instituted a mandate to use the HANS device. At the time of the requirement, 41 of 43 racers were voluntarily using HANS devices. Note: Cost is per device.	
Assigned			Criteria Passed
Due			Status Validated
Term		short	Cost \$1,000.00
SO-0003		Solution	Require use of redesigned cars based on Car of Tomorrow specifications.
	Cause(s)	Properties of race cars involved	
	Note	These cars do not cost more than the old cars, but teams are spending more on trying to achieve gains in speed.	
	Assigned		Criteria Passed
	Due		Status Validated
	Term	long	Cost \$0.00
	SO-0004	Solution	Require tracks to install SAFER barriers, which have the ability to better absorb forces of impact.
Cause(s)		Properties of protective wall - solid concrete	

Note	Estimated cost at \$2.6 million per mile to install SAFER barriers at all NASCAR tracks. Note that this barrier is helpful for any type of car being raced - not just NASCAR. Note: Cost is for installation at every NASCAR track.		
Assigned		Criteria	Passed
Due		Status	Validated
Term	long	Cost	\$126,000,000.00

Evidence

EV-0001	<p>Evidence</p> <p>Cause(s)</p> <p>Location(s)</p> <p>Attachment(s)</p> <p>Contributor</p> <p>Type</p> <p>Quality</p>	<p>Description of HANS device (Head And Neck Safety)</p> <p>Wikipedia: https://en.wikipedia.org/wiki/HANS_device Wikipedia https://en.wikipedia.org/wiki/HANS_device</p> <p>Brian Hughes</p> <p>URL</p> <p>★★★★★</p>
EV-0002	<p>Evidence</p> <p>Cause(s)</p> <p>Location(s)</p> <p>Attachment(s)</p> <p>Contributor</p> <p>Type</p> <p>Quality</p>	<p>Dale Earnhardt Autopsy Report (opens to page 5)</p> <p>Catastrophic loss of major autonomic brain function (breathing, circulation) Spiral fractures to occipital and temporal bones of skull (basilar) Location of fractures: Proximal to areas of brain responsible for autonomic function Extent of injuries too great - recovery impossible Medical response adequate, but unable to prevent death</p> <p>http://www.thesmokinggun.com/file/dale-earnhardt-autopsy-report?page=5</p> <p>Brian Hughes</p> <p>Document</p> <p>★★★★★</p>
EV-0003	<p>Evidence</p> <p>Cause(s)</p> <p>Location(s)</p> <p>Attachment(s)</p> <p>Contributor</p> <p>Type</p>	<p>Description of Occipital Bone</p> <p>Spiral fractures to occipital and temporal bones of skull (basilar) Location of fractures: Proximal to areas of brain responsible for autonomic function</p> <p>https://en.wikipedia.org/wiki/Occipital_bone</p> <p>Brian Hughes</p> <p>URL</p>

Quality ★★★★★

EV-0004 **Evidence** Description of Temporal Bone
Cause(s) Spiral fractures to occipital and temporal bones of skull (basilar)
Location of fractures: Proximal to areas of brain responsible for autonomic function
Location(s) https://en.wikipedia.org/wiki/Temporal_bone
Attachment(s)
Contributor Brian Hughes
Type URL
Quality ★★★★★

EV-0005 **Evidence** Article from Hot Rod
Cause(s) Catastrophic loss of major autonomic brain function (breathing, circulation)
Location of fractures: Proximal to areas of brain responsible for autonomic function
Deceleration of estimated -68 to -48 G (42–44 mph [68–71 km/h])
Speed at time of contact > 161 mph
Trajectory angle = 13.6° (slope of track & wall)
Angle of impact = 55° - 59° off centerline of Earnhardt's car
Speed at impact = 157 to 161 mph (253 to 259 km/h)
Properties of protective wall - solid concrete
Properties of race cars involved
Force components of impact
Angle of forces on belt at time of crash
Belt installation not per manufacturers specification (too far back)
Driver request due to added comfort
Medical response adequate, but unable to prevent death
Forces (tension) of neck muscles (opposite direction of deceleration forces)
Reflexive response
Capability of skull to withstand forces
Location(s) <http://www.hotrod.com/news/nascar-accident-report-dale-earnhardt/>
Attachment(s)
Contributor Brian Hughes
Type URL
Quality ★★★★★

EV-0006 **Evidence** Video of Crash (5:00 shows entire sequence)

Cause(s)	Earnhardt's race car impacted protective wall Second race car impacted Earnhardt's car Earnhardt's car veered into pathway of second race car Contact between left rear of Earnhardt's car and another race car Slight movements by either driver Proximity of cars Earnhardt's car traveled toward protective wall Protective wall in path Second race car traveling forward down the track
Location(s)	https://www.youtube.com/watch?v=rXGKys62TXw
Attachment(s)	
Contributor	Brian Hughes
Type	Photo
Quality	★★★★★

EV-0007	Evidence	Daytona Track Facts
	Cause(s)	
	Location(s)	http://www.daytonainternationalspeedway.com/Track-Info/Track-Facts.aspx
	Attachment(s)	
	Contributor	Brian Hughes
	Type	URL
	Quality	★★★★★

EV-0008	Evidence	Sun Sentinel Article
	Cause(s)	Failed seat belt - allowed forward movement of driver Catastrophic loss of major autonomic brain function (breathing, circulation) Location of fractures: Proximal to areas of brain responsible for autonomic function Deceleration of estimated -68 to -48 G (42–44 mph [68–71 km/h]) Force components of impact No supplemental neck protection Driver's choice - believed protective properties did not outweigh discomfort caused by device No requirements for additional protection - decision left up to driver Angle of forces on belt at time of crash Belt installation not per manufacturers specification (too far back) Driver request due to added comfort
	Location(s)	http://articles.sun-sentinel.com/2001-04-10/news/0104100290_1_earnhardt-s-head-earnhardt-s-fatal-injury-high-speed-frontal-crash

	Attachment(s)	
	Contributor	Brian Hughes
	Type	URL
	Quality	★★★★★

EV-0009	Evidence	Estimated cost of NASCAR stock car
	Cause(s)	
	Location(s)	http://auto.howstuffworks.com/auto-racing/nascar/nascar-basics/nascar-race-car-cost1.htm
	Attachment(s)	
	Contributor	Brian Hughes
	Type	URL
	Quality	★★★★★

EV-0010	Evidence	List of NASCAR fatalities
	Cause(s)	
	Location(s)	
	Attachment(s)	
	Contributor	Brian Hughes
	Type	URL
	Quality	★★★★★

EV-0011	Evidence	Wikipedia entry Dale Earnhardt crash
	Cause(s)	Deceleration of estimated -68 to -48 G (42–44 mph [68–71 km/h]) Speed at time of contact > 161 mph Trajectory angle = 13.6° (slope of track & wall) Angle of impact = 55° - 59° off centerline of Earnhardt's car Speed at impact = 157 to 161 mph (253 to 259 km/h) Properties of protective wall - solid concrete Properties of race cars involved Force components of impact
	Location(s)	
	Attachment(s)	
	Contributor	Brian Hughes
	Type	URL
	Quality	★★★★★

EV-0012	Evidence	Wikipedia entry on SAFER barriers
	Cause(s)	

	Location(s)	
	Attachment(s)	
	Contributor	Brian Hughes
	Type	URL
	Quality	★★★★★
EV-0013	Evidence	Wikipedia entry on Car of Tomorrow (CoT)
	Cause(s)	
	Location(s)	
	Attachment(s)	
	Contributor	Brian Hughes
	Type	URL
	Quality	★★★★★
EV-0014	Evidence	Estimated cost of SAFER barrier installation at all NASCAR tracks
	Cause(s)	
	Location(s)	http://www.nascar.com/en_us/track-landing-page.html
	Attachment(s)	
	Contributor	Brian Hughes
	Type	Spreadsheet
	Quality	★★★★★
EV-0015	Evidence	How the HANS device works (from Car and Driver)
	Cause(s)	
	Location(s)	http://www.caranddriver.com/features/the-physics-of-how-the-hans-device-saves-lives-feature
	Attachment(s)	
	Contributor	Brian Hughes
	Type	URL
	Quality	★★★★★

Notes

NO-0001	Note	Note: Even if the seat belt had functioned properly, Earnhardt still likely would have suffered fatal injuries. This cause path was added due to speculation that his death was caused by a failed seatbelt.
	Cause(s)	Failed seat belt - allowed forward movement of driver

★ Fatality - Dale Earnhardt Sr.

T Catastrophic loss of major autonomic brain function (breathing, circulation)

T Spiral fractures to occipital and temporal bones of skull (basilar)

T Deceleration of estimated -68 to -48 G (42-44 mph [68-71 km/h])

N Force components of impact

T Second race car impacted Earnhardt's car

T Earnhardt's race car impacted protective wall

T Earnhardt's car traveled toward protective wall

N Protective wall in path

Connects To:
a Earnhardt's car veered into pathway of second race car

Terminated Because:
Desired State

T Earnhardt's car veered into pathway of second race car

T Contact between left rear of Earnhardt's car and another race car

T Slight movements by either driver

Terminated Because:
Other causal paths more productive

N Proximity of cars

Terminated Because:
Other causal paths more productive

N Speed at time of contact > 161 mph

Terminated Because:
Other causal paths more productive

N Second race car traveling forward down the track

Terminated Because:
Other causal paths more productive

N Trajectory angle = 13.6° (slope of track & wall)

Terminated Because:
Other causal paths more productive

N Angle of impact = 55° - 59° off centerline of Earnhardt's car

Terminated Because:
Other causal paths more productive

N Speed at impact = 157 to 161 mph (253 to 259 km/h)

Terminated Because:
Other causal paths more productive

N Properties of protective wall - solid concrete

Terminated Because:
Potential for additional investigation

Solutions
Require tracks to install SAFER barriers, which have the ability to better absorb forces of impact.
Criteria Pass Status Validated
Estimated cost at \$2.6 million per mile to install SAFER barriers at all NASCAR tracks. Note that this barrier is helpful for any type of car being raced - not just NASCAR. Note: Cost is for installation at every NASCAR track.

N Properties of race cars involved

Terminated Because:
Potential for additional investigation

Solutions
Require use of redesigned cars based on Car of Tomorrow specifications.
Criteria Pass Status Validated
These cars do not cost more than the old cars, but teams are spending more on trying to achieve gains in speed.

T Driver's choice - believed protective properties did not outweigh discomfort caused by device

Terminated Because:
Other causal paths more productive

N No supplemental neck protection

N No requirements for additional protection - decision left up to driver

Terminated Because:
Other causal paths more productive

Solutions
Require use of HANS restraint system to help protect against sudden neck movement.
Criteria Pass Status Validated
At first, NASCAR pulled up short of formally requiring the HANS device. However, after the death of racer Blaise Alexander from the same injury just two months after Earnhardt's death (and the sixth such fatality) NASCAR instituted a mandate to use the HANS device. At the time of the requirement, 41 of 43 racers were voluntarily using HANS devices. Note: Cost is per device.

N Capability of skull to withstand forces

Terminated Because:
Other causal paths more productive

N Forces (tension) of neck muscles (opposite direction of deceleration forces)

T Reflexive response

Terminated Because:
Other causal paths more productive

T Failed seat belt - allowed forward movement of driver

N Angle of forces on belt at time of crash

T Belt installation not per manufacturers specification (too far back)

T Driver request due to added comfort

Terminated Because:
Other causal paths more productive

Solutions
Migrate from 5-point safety harness to 6-point safety harness to provide better driver restraint.
Criteria Pass Status Validated
It was not determined that a 5-point safety harness was a cause of Earnhardt's death, however this was determined to be a preventive action to help reduce risks and improve overall safety. Note: Cost is per unit.

N Location of fractures: Proximal to areas of brain responsible for autonomic function

Terminated Because:
Other causal paths more productive

N Extent of injuries too great - recovery impossible

Terminated Because:
Other causal paths more productive

T Medical response adequate, but unable to prevent death