Overturn Countermeasures for Vehicles

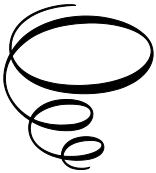
Overturn Countermeasures for Vehicles:

History of the Rollbar

By

Melvin L Myers

Cambridge Scholars Publishing



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I dedicate this book to the memory of my loving wife, Annette Bass Myers, who instilled fiction-like narration into my approach by example and provided me with time to write this book before her death in 2020, a victim of the Corona-19 pandemic.

Annette Bass Myers
December 23, 1939-December 14, 2020

"*These machines are potential death traps.*"
—O.S. Randall, MD, 1949

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PREFACE

I grew up on a farm in the Black Canyon Irrigation District near Caldwell, Idaho in the United States. My father "reclaimed" the land in 1951 from sagebrush to grow crops when I was but seven-years of age. He used a World War II Jeep and a buck rake as his first farm implements. Potatoes were one of his first crops along with alfalfa hay and wheat as a cash crop. The hay was initially used to feed our livestock, which included a couple of milk cows. It was not long until, he invested in a tractor, a Ford 8N, and soon after that, a used Ferguson tractor.

As I grew up, our acreage expanded, and I became part of the labor pool, learning to drive a tractor at 9 years of age. My initial tractor driving was always in low gear as my father loaded hay bales onto a trailer or a "slip" (boards nailed together with a tow line) pulled by the tractor. Harvesting hay, irrigation, and milking cows became part of my sunup to sundown life up through my teenage years.

Safety was an important consideration. My father would instruct me over-and-over, to never put my fingers between the guards on the sickle bar on a side mounted mowing machine (a Ferguson) where the movement of the sickle blades could cut off my fingers. When I was 12-years of age, safety became more personal. I was mowing a field of alfalfa on a farm four miles (6.4 km) from our home, and when finished with the mowing, I raised the mower sickle bar up vertically and bolted it into place for my drive home. I drove onto the gravel road and headed home. I put the tractor gear into travel mode at 12 miles-per-hour (19 kph).

Minutes down the road, the sickle bar crashed down onto the steering wheel, but it missed my head as I looked around the right side of the hood of the tractor since I was small and could better see the road that way. A sickle guard on the mower bar stabbed me in the back. I only realized this later, for I had to contend with an emergency. The tractor was still moving, and I was blocked by the bar from reaching the clutch on the left side of the tractor. The only control that I had was to hold onto the immobilized steering wheel and stand on the two brakes—one for the left rear wheel and the other for the right—on the floor ramp on the right side. I jumped up-and-down on those brakes, one for each rear wheel. The tractor veered to the left and off the road and into a ditch, where a front wheel lodged, and

the tractor motor stalled.

I got off and looked at the wreck. "*Boy! My father is going to be mad*," I thought. Then, I reached my right hand over my left shoulder to feel a wound. My hand returned wet with blood, which had soaked through the back of the white T-shirt that I was wearing. I walked home, and when I arrived, my mother took control of my care. She drove me to the doctor while my father and a hired man left to look after the tractor. I was pleased that my father was concerned about my well-being and not mad. Eight stitches later, I was home. I keep a scar as evidence of the dangers lurking on the farm. Two of the stitches were internal, and years later I was reminded of that event as plastic thread migrated out through my skin near the scar.

In those days in the 1950s, being careful was the watchword for keeping safe. I now reflect on the dangerous maneuvers that I performed as part of my work as a tractor driver. When crossing a ditch or pulling a heavy load of hay, I found that the front of the tractor could easily rear up. I turned this phenomenon to my advantage, for I could stop the rearing up in mid-air by stomping down on the clutch, then letting the tractor drop to give a boost to move the tractor's rear wheel from the ditch or get the heavy-loaded slip moving. It was only much later that I became aware of the danger of the tractor rearing up.

I graduated from the University of Idaho in 1967 with a degree in agricultural engineering. My career started as a design engineer at the Hyster Company, and then I was commissioned as an Officer in the US Public Health Service where later, I was responsible for the Surgeon General's Conference for Agricultural Safety and Health in 1991. Emerging from that conference was the need to do more about the epidemic of deaths from tractor overturns. This book focuses on overturn hazards and rollover protective structures, its history including rollbars on other vehicles, and struggles for abatement.

I wish to acknowledge my many co-authors in other writings about this issue. Foremost, I wish to thank Henry P. Cole, my colleague at the University of Kentucky with whom I conducted much research and where I was also joined by Susan C. Westneat. Other colleagues in the research included Joan Mazur, Mark A. Purschwitz, and Daniel M. Saman. Research related to tractor use on fish farms involved my colleague from Kentucky State University, Robert M. Durborow, and at the Mississippi State University, Greg A. Ibendahl and Walter B. Stephens.

One of my first publications regarding the tractor overturn hazard was shared with my senior author from the National Institute for Occupational Safety and Health (NIOSH), John R. Etherton. I collaborated with Rene

Pana-Cryan at NIOSH in cost-effectiveness research regarding rollover protection on tractors and also at NIOSH with John R. Myers in a study of tractor rollover protection prevalence on catfish farms. He also shared in the planning and proceedings of the *Surgeon General's Conference on Agricultural Safety and Health*, which highlighted the problem of tractor overturns and the known solution, the rollover protective structure. We were joined in that effort by Robert F. Herrick, Steve A. Olenchock, Jack E. Parker, and David L. Hard, all of NIOSH, as well as Katherine Wilson of the Centers for Disease Control and Prevention. I participated with Kelly Donham, David Osterburg, and Carol Lehtola in a meeting at the University of Iowa and the publication of *Tractor-Risk Abatement and Control: A Policy Conference.* I also thank my recent collaborators Timothy Kelsey of Penn State and Pamela J. Tinc, Julia A. Sorensen, and Paul Jenkins of the New York Center for Agricultural Medicine and Health in the stimulation of ROPS (rollover protective structure) retrofits on older tractors and Farzaneh Khorsandi of the University of California and Paul Ayers of the University of Tennessee to bring attention to rollover protection on all-terrain vehicles (ATVs). I also want to acknowledge David V. MacCollum (now deceased) of Arizona, a pioneer in rollover protection and his insights about rollbars on off-road vehicles other than farm tractors. In addition, I acknowledge my friend, David Robertson in Australia, for his insights into crush protection related to ATV rollovers.

Each chapter and section of the text begins with a pithy quote (an epigraph) as a thematic introduction to what follows.

PART I

SILENT EPIDEMIC

The hazardous characteristics of certain products are obvious, but their consequences are often ignored.
—Leon S. Robertson, 1998

In this part of the book, I deal with a century-long emerging epidemic of deaths and injuries associated with vehicle overturns, emphasizing the agricultural tractor and other off-road vehicles, but with later chapters devoted to motor sports, small quadricycles, and automobiles. In this part of the book, I describe the common cause of a growing and silent epidemic of vehicle overturn-related deaths and serious injuries up through the 1940s: The US Centers for Disease Control and Prevention defines an epidemic as follows: (CDC 2011)

"an occurrence of more cases of disease, injury, or other health condition than expected in a given area or among a specific group of persons during a particular period. Usually, the cases are presumed to have a common cause or to be related to one another in some way."

When vehicles are a common cause of injury, whether off-road or on-road, and topple over and crush or squeeze the life from thousands of people, an epidemic occurs; at first, a silent epidemic of death, but when recognized, pretexts emerge to keep the status quo and thus stall preventive action (the wicked problem). Early on, a decades-long emphasis on automobile collisions regarding pedestrian and driver behavior and roadway design diverted much attention from vehicle design and overturns until the 2000s.

The first five chapters set the stage to understand the cause of vehicle overturns, associated serious and fatal injuries, and the engineering approach that battles future pretexts for inaction. Chapter 1 reveals the century-long epidemic and the problem of vehicle instability and gives an overview for the book. Chapter 2 explains the problem of blaming the victim and engineers' shift to injury prevention by design starting in the 1910s. Chapter 3 examines the special problem of rear flip-overs of tractors in the 1920s, and Chapter 4 describes the causes of tractor rollovers to the side and

the rise of the farm safety movement into the 1930s and 1940s. Chapter 5 covers the 1940s and early 1950s and the role of falling object protection as a step toward “rollbar” use on large off-road vehicles such as crawler tractors employed in logging and construction. Falling object protections also extend to industrial lift trucks to guard against injury to the machine operators. Part 2 follows these first five chapters and addresses the worldwide evolution of rollbar protection of operators (or drivers) from fatal and serious nonfatal injuries in the event of an off-road vehicle overturn and ending with speed-related race car “summersaults” or “barrel-rolls.”

CHAPTER 1

LIFE IN THE BALANCE

On January 27, 2015, Katie, my 19-year-old granddaughter, was a passenger in a Jeep on a US Interstate Highway. The young driver of the Jeep over-corrected when dodging another vehicle and went off the side of the road, and the Jeep tumbled over upside down. The Jeep had a rollbar, and Katie hung down from her seatbelt. She was okay except for some discomfort from the fall as she released her seatbelt, but she and the driver survived the rollover thanks to a rollbar. (See Fig. 1-1)

1.1. Introduction

"He stood on the edge of the cliff, his life in the balance. With his fortune in the balance, John rolled the dice."—An American Idiom (McGraw-Hill, 2000)

Fig. 1-1. The Jeep that overturned. Photo by Katherine Brown (author's granddaughter).

Vehicle overturns can be deadly. During the period 1910-2017, automobile crashes killed 3.7 million people in the United States. Research found that overturns caused an estimated one-third of these deaths. (Public Citizen, 2003) In 1971, Deere & Company engineer James F. Arndt claimed that over the previous 50 years, 30,000 tractor operators had been fatally crushed from rollovers. (Arndt 1971) Deere & Company, an acknowledged leader in the development of rollover protection to prevent crush-related injuries from agricultural tractor rollovers, related crush-related injuries in 1974 to entrapment "between two objects" (e.g., the tractor and the ground) "moving together with force or speed," with an example of a tractor that flipped over backwards and "crushed" a woman to death. It also stated that more than half of tractor-related deaths result from overturns, but chances of survival are improved with a rollover protective structure (ROPS).

(Bittner et al. 1974) Earlier in 1967, R.C. Williams reflected on the history of the tractor and referred to the overturn as a "death trap." (Williams 1987)

While rollover protection as a priority for automobile occupants stalled for nearly a century, in the late 1910s, farmers started to recognize the hazard of tractor overturns, and in the 1920s, engineers studied the cause of overturns. The history of the rollbar emerged initially in the sport, "auto-polo," and in 1917 as a protective cab on a race car (described in Chapter 10). Then rollbars took hold as a protective device in its use on crawler tractors in the 1940's as an offshoot of brush guards and falling object protective canopies used in logging. As tractors overtook horses and mules for motive power on farms, an epidemic of death from tractor overturns focused attention from many quarters on rollover prevention and protection in the 1950s. Proof of success of rollbars on tractors came from Sweden, New Zealand, and the highway department in the State of North Dakota. Rollover protection on race cars began in earnest in the 1960s and Formula 1 racing in 1991.

This book is about the fits and starts in a history of the rollbar as protection in the event of a vehicle overturn. Rollbars are part of many vehicles including race cars, construction equipment, tractors, lift trucks, and commercial lawnmowers. Some convertibles have automatically deployable rollbars, and automobiles evolved with crashworthy roofs and protective interiors, but legacy tractors and all-terrain vehicles (ATVs), with few exceptions, lack rollbars denying life to thousands. What follows is a century-long story of a struggle to protect people's lives from vehicle overturns that first emerged with attention to the farm tractor and on logging and earthmoving equipment.

The current chapter describes the underpinnings of vehicle overturn dangers with three vignettes about motorized vehicle overturns and early protective technology on automobiles and tractors, a description of the epidemic of rollover-related deaths, and an explanation of the physics of vehicle overturns. It concludes with an overview of the book.

1.2. Gasoline Buggies

> *"It* (Car No. 5,000,000; 1921) *is out in my museum along with the gasoline buggy that I began work on thirty years before and first ran satisfactorily along in the spring of 1893."*—Henry Ford, 1923

In the 1800s, steam power took over many tasks previously provided by horsepower. An external fuel source of wood or coal burning for this power heats an enclosed chamber of water to produce steam under pressure to move machines such as traction engines to pull plows. In 1892, John

Froelich built the first mechanically successful gasoline powered tractor. (Williams 1996) This innovation stimulated the rise of the motor car, modern tractor, and airplane that benefited society immensely. Many early innovators kick-started a century that produced rollover protection.

The Horseless Carriage

"A later version of that engine powered his first automobile—essentially a frame fitted with four bicycle wheels (in 1896)."—Anonymous, 2003

On the eve of the Centennial of the United States in 1875, at 12 years of age, Henry Ford saw a road steam engine pulling a coal cart. This etched into his mind a way to remove the drudgery that he experienced of holding a plow pulled behind a horse. Four years later, he became a mechanic working on the same steam-powered vehicles that he had seen earlier. He focused on smaller steam traction engines for the small farmer who could ill afford outsized traction engines. Then his interest shifted to the internal combustion engine that he built along with a two-seat "gasoline buggy." Residents saw the buggy as the first horseless carriage on the streets of Detroit, Michigan, and Ford realized a market for the automobile rather than the tractor as the new century began. (Ford 1923)

Ford built two 80-horsepower race cars in 1903. In a three-mile race, one of his cars beat the competition by a half mile. Immediately, the public saw Ford as a man who could build fast cars. He sold the second car to bicyclist Tim Cooper. The car was painted fire engine red with the number 999 on it after a train with that number that made a record run from Manhattan to Chicago. Ford said, "*It was built for speed alone*." Cooper aimed to enter it into a 5-mile race, and he enlisted fellow bicyclist, Berna Eli (Barney) Oldfield as the driver. Oldfield never drove a car before and called it "*a bedframe on wheels*." He was fearless and immediately took the lead and won the race. "*The race changed my life*," he said. Eight months later he drove Ford's car to break the mile per minute limit (60 mph/97 kph), and soon became known as the speed king. He put the "999" on every car he raced thereafter. (Leerhsen, 2011, p. 55)

Ford formed the Ford Motor Company in 1903, and by 1904, he built the "Model A" runabout. In his first year, he sold 1,708 cars at $850 each. Eight models followed until he standardized on the "Model T" in 1909 with the help of the Dodge brothers and incorporated the assembly line into his manufacturing process in 1913. (Ford 1923) Early on, Ford dominated the car manufacturing business.

Strength and Safety

"(Edward) Budd's first customers were John and Horace Dodge, who founded Dodge Brothers in 1914. Budd persuaded them to use the all-steel body his engineers had designed, and the Dodge Touring Car was an instant success."—Editors, *Auto News*, 1996

The Dodge brothers, John and Horace, mechanics by trade, made parts for automobile manufacturers in the early 1900s, manufactured the Oldsmobile automobile, and helped a bankrupted Henry Ford to produce the Model T automobile in 1909. When Ford constructed his own manufacturing plant three years later, they cashed in their 10% share in the Ford enterprise for $15 million and launched their own automobile company.

Fig. 1-2. Dodge Brothers Advertisement, all-steel body, 1926, Courtesy Library of Congress

In 1914, the Dodge car designs were informed by railroad car designs by engineer Edward Gowan Budd and his development of pressed body steel. The Dodge brothers manufactured cars with all steel bodies that protected the occupant against crushing injuries with a substantial frame and roof. Budd was also a leading developer of arc welding that replaced riveting. (Editors 1996) In 1919, the brothers promoted in films the car rolling over with the all-steel frame enclosure that could protect its occupants from injury, but in 1920, the Spanish flu killed them both. The Dodge Brothers Company continued safety messaging, as shown in Fig. 1-2. It sold a million cars by 1923; the pressed steel bodies also improved the appearance of saloons, e.g., sedans. (Latham & Agresta 1989, Setright 2002, YouTube) The saloon (sedan) nomenclature came from railroad passenger cars and refers also to passenger cars that seat four people.

The safety messaging continued until the family sold the company to an intermediary and the Chrysler Corporation in 1928. All-steel bodies in all automobiles would not be realized until the 1930s, and the use of a roll-cage on race cars would be deferred until the 1970s.