Seat belt

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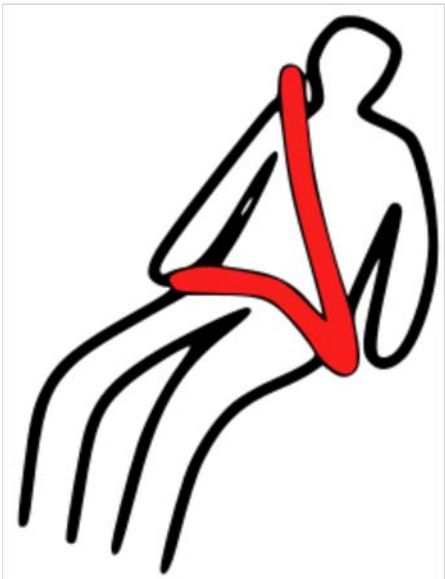
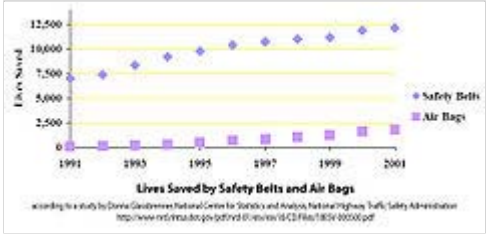
A **seat belt** or **seatbelt**, sometimes called a **safety belt**, is a safety harness designed to secure the occupant of a vehicle against harmful movement that may result from a collision or a sudden stop. As part of an overall automobile passive safety system, **seat** belts are intended to reduce injuries by stopping the wearer from hitting hard interior elements of the vehicle, or other passengers (the so-called second impact), are in the correct position for the airbag to deploy and prevent the passenger from being thrown from the vehicle. **Seat** belts also absorb energy by being designed to stretch during any sudden deceleration, so that there is less speed differential between the passenger's body and their vehicle interior, and also to spread the loading of impact on the passengers body.



A 3-point **seat belt**.

The final, so-called 'third impact' after a passenger's body hits the car interior, airbag or **seat** belts, is that of the internal organs hitting the ribcage or skull. The force of this impact is the mechanism through which car crashes cause disabling or life threatening injury. The sequence of energy dissipating and speed reducing technologies - crumple zone - **seat belt** - airbags - padded interior, are designed to work together as a system, to reduce the force of this final impact.



Lives saved by **seat** belts and airbags

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Types of seatbelt

Lap

An adjustable strap that goes over the waist. This type of **belt** is frequently found in older cars, and has been used, until recently, on some newer vehicles in **rear** or **rear** middle seats. These types of **belt** are also found on some coaches. Passenger aircraft seats also use lap **seat** belts to help prevent injuries while still allowing passengers to adopt a brace position.

A lap ("2-point") **belt** in an airplane

Sash

An adjustable strap that goes over the **shoulder**. Used mainly in vehicles during the 1960s, however they had limited benefit because it was very easy to slip out of them in a collision.

Three-point

Similar to the lap and sash belts, but has one single continuous length of **belt**. Both three-point and lap-and-sash belts help spread out the energy of the moving body in a collision over the chest, pelvis, and shoulders. Volvo introduced the first production three-point **belt** in 1959.[1] The first car with three point **belt** was a Volvo PV 544 that was delivered to a dealer in Kristianstad on August 13, 1959. The first car to feature the three point **seat belt** however was the 1959 Volvo 122 The three point **belt** was developed by Nils Bohlin who had earlier also worked on ejection seats at Saab.[2]

Until the 1980s, three-point belts were commonly available only in the front seats of cars; the back seats were only often fitted with lap or sash belts. Evidence of the potential of lap belts to cause separation of the lumbar vertebrae and the sometimes associated paralysis, or "**seat belt** syndrome", led to a revision of passenger safety **regulations** in nearly all developed countries, requiring that all seats in a vehicle have to be equipped with three-point belts. Since September 1, 2007, all new cars sold in the U.S. require a lap and **shoulder belt** in the center **rear seat**.[3]

Besides regulatory changes, "**seat belt** syndrome" has led to tremendous liability for vehicle manufacturers. One Los Angeles case resulted in a $45 million jury verdict against the Ford Motor Company; the resulting $30 million judgment (after deductions for another defendant who settled prior to trial) was affirmed on appeal in 2006.[4]

A 3-point **seat belt**

Belt-in-Seat (BIS)

The BIS is a three-point harness where the **shoulder belt** attachment is to the backrest, not to the b pillar.[5] The first car using this system in the United States was the 1990 Mercedes-Benz SL.[6] Some cars like the Renault Vel Satis use this system for the front seats. This system allegedly is safer in case of rollover, especially with 4–8 years old children,[7] though other sources dispute this claim.[8]

Experimental production car safety belts

- *Criss-cross* Experimental safety **belt** presented in the Volvo SCC. It forms a cross-brace across the chest.[9]
- *3+2 Point Seatbelt*: Experimental safety **belt** from Autoliv similar to the criss-cross. The 3+2 improves protection against rollovers and side impacts.[10]
- *Four point "**belt** and suspenders"*: An experimental design from Ford where the "suspenders" are attached to the backrest, not to the frame of the car.[11]
- *Inflatable Safety Belts*: An airbag is included within the **belt** for the **rear seat** belts.[11]

A 5-Point harness **belt**-in-**seat** on a quad bike.

Five-point harnesses

These restraints are safer but more restrictive than most other **seat belt** types. Five-point harnesses are typically found in child safety seats and in racing cars. The lap portion is connected to a **belt** between the legs and there are two **shoulder** belts, making a total of five points of attachment to the **seat**. (Strictly speaking, harnesses are never to be fastened to the **seat**—they should be fastened to the frame/sub-frame of the automobile.)

A 6-point harness in a racing car.

Six-point harnesses

These harnesses are similar to a five-point harness but include an extra **belt** between the legs, which is seen by some to be a weaker point than the other parts. These belts are used mainly in racing. In NASCAR, the six-point harness became popular after the death of Dale Earnhardt. Earnhardt was wearing a five-point harness when he suffered his fatal crash. As it was first thought that his **belt** had broken, some teams ordered a six-point harness in response.[12]

Seven-point harnesses (5+2)

Aerobatic aircraft frequently use a combination harness consisting of a five-point harness with a redundant lap-**belt** attached to a different part of the airframe. While providing redundancy for negative-g maneuvers (which lift the pilot out of the **seat**), they also require the pilot to un-latch two harnesses if it is necessary to parachute from a failed aircraft.

History

Seat belts were invented by George Cayley in the early 19th century,[13] though Edward J. Claghorn of New York, New York was granted the first patent (U.S. Patent 312,085 (http://www.google.com/patents?vid=312085) , on February 10, 1885 for a safety **belt**).[14] Claghorn was granted United States Patent #312,085 for a Safety-**Belt** for tourists, painters, fireman, etc. who are being raised or lowered, described in the patent as "designed to be applied to the person, and provided with hooks and other attachments for securing the person to a fixed object."

In 1911, Benjamin Foulois had the cavalry saddle shop fashion a **belt** for the **seat** of Wright Flyer Signal Corps 1. He wanted it to hold him firmly in his **seat** so he could better control his aircraft as he bounded along the rough field used for takeoff and landing. C-130 aircraft in South Vietnam also bounded on runways to the extent that a tight **seat belt** improved the pilot's ability to control the aircraft. It was not until World War II that **seat** belts were fully adopted in military aircraft, and even then, it was mainly for safety reasons, not improved aircraft control.[*citation needed*]

In 1946 Dr. C. Hunter Shelden had opened a neurological practice at Huntington Memorial Hospital in Pasadena, California. In the early 1950s Dr. Shelden had made a major contribution to the automotive industry with his idea of retractable **seat** belts. This came about greatly in part from the high number of head injuries coming through the emergency rooms.[15] He investigated the early **seat** belts whose primitive designs were implicated in these injuries and deaths. His findings were published in the November 5, 1955 Journal of the American Medical Association (JAMA) in which he proposed not only the retractable **seat belt**, but also recessed steering wheels, reinforced roofs, roll bars, door locks and passive restraints such as the now-and-ever-popular air bag. Subsequently in 1959 Congress passed legislation requiring all automobiles to comply with certain safety standards.[16]

American car manufacturers Nash (in 1949) and Ford (in 1955) offered **seat** belts as options, while Swedish Saab first introduced **seat** belts as standard in 1958.[17] After the Saab GT 750 was introduced at the New York motor show in 1958 with safety belts fitted as standard, the practice became commonplace.[18]

Glenn Sheren of Mason, Michigan submitted a patent application on March 31, 1955 for an automotive **seat belt** and was awarded US Patent 2,855,215 in 1958. This was a continuation of an earlier patent application that Mr. Sheren had filed on September 22, 1952. [19]

However, the first modern three point **seat belt** (the so-called *CIR-Griswold restraint*) used in most consumer vehicles today was patented in 1955 (US Patent 2,710,649) by the Americans Roger W. Griswold and Hugh DeHaven,[20] and developed to its modern form by Nils Bohlin for Swedish manufacturer Volvo—who introduced it in 1959 as standard equipment. Bohlin was granted U.S. Patent 3,043,625 (http://www.google.com /patents?vid=3043625) for the device.[17] Bohlin's lap-and-**shoulder belt** was introduced by Volvo in 1959, in Sweden.

In 1970, the state of Victoria, Australia, passed the first law worldwide making **seat belt** wearing compulsory for drivers and front-**seat** passengers.[21]

Technologies

Seat Belt with uncovered Inertial Reel

Most **seat** belts are equipped with locking mechanisms (or inertia reels) that stop the reel from spinning during decelerative conditions. There are two common types of locking mechanism used: 1) a centrifugal clutch which engages as the reel spins quickly, or 2) by a weighted pendulum or ball bearing: when these are deflected by deceleration or roll-over they lock into pawls on the reel. The most recent forms of inertia reels contain both of these locking mechanisms.

Types of inertia reel type seatbelts:

NLR (no locking retractor): Commonly used in recoiling lap belts

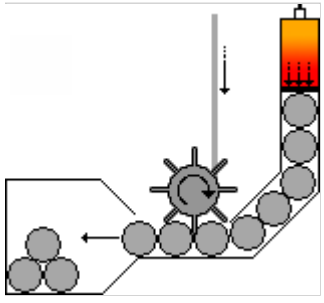
ELR V (emergency locking retractor - vehicle sensitive): Single sensitive mechanism, composed of a locking mechanism activated in an emergency by deceleration or rollover of the vehicle. Thus, the seatbelt is sensitive to the vehicle's motion.

ELR VW (emergency locking retractor - vehicle and webbing sensitive): Dual sensitive means a seatbelt retractor that, during normal driving conditions, allows freedom of movement by the wearer of the seatbelt by means of length-adjusting components that automatically adjust the strap to the wearer, with a locking mechanism that is activated by two or more of the following:

- deceleration or rollover of the vehicle,
- acceleration of the strap (webbing) from the retractor, or
- other means of activation.

A recent study by McCoy & Chou (2007) from the Ford Motor Company (Safety Test Methodology, SP-2123) demonstrated that the standard inertia reel seatbelt does not stop the head from making contact with the interior of the roof on a standard rollover test in their dynamic Rollover Component test System (ROCS). Even with modern pre-tensioning devices the head contacts the interior of the roof and the neck suffers 'visible' compression.

Pretensioners and webclamps



Pyrotechnic pretensioner

Seatbelts in many newer vehicles are also equipped with "pretensioners" and/or "Webclamps".

- Pretensioners preemptively tighten the **belt** to prevent the occupant from jerking forward in a crash. Mercedes-Benz first introduced pretensioners on the 1981 S-Class. In the event of a crash, a pretensioner will tighten the **belt** almost instantaneously. This reduces the motion of the occupant in a violent crash. Like airbags, pretensioners are triggered by sensors in the car's body, and most pretensioners use explosively expanding gas to drive a piston that retracts the **belt**. Pretensioners also lower the risk of "submarining", which is

diagram

when a passenger slides forward under a loosely worn **seat belt**. An alternative approach being looked at by major car companies is the CG-Lock technology whereby the occupant is held in position via the lap **belt** in order to prevent the passenger from coming out of position in the event of a crash.

- Webclamps clamp the webbing in the event of an accident and limit the distance the webbing can spool out (caused by the unused webbing tightening on the central drum of the mechanism) these belts also often incorporate an energy management loop ("rip stitching") which is when the lower part of the webbing is looped and stitched with a special stitching. The function of this is to "rip" at a predetermined load, which reduces the load transmitted through the **belt** to the occupant, reducing injuries to the occupant.

Inflatable Seatbelts

Inflatable seatbelts have tubular inflatable bladders contained within an outer cover. When a crash occurs the bladder inflates with a gas to increase the area of the restraint contacting the occupant and also shortening the length of the restraint to tighten the **belt** around the occupant, improving the protection.[22] The inflatable sections may be **shoulder**-only or lap and **shoulder**. The system supports the head during the crash better than a web only **belt**. It also provides side impact protection. The inflatable seatbelt was invented by Donald Lewis and tested at the Automotive Products Division of Allied Chemical Corp. Ref an early patent US 3,841,654 filed in 1972

Automatic seat belts

Seatbelts that automatically move into position around a vehicle occupant once the adjacent door is closed and/or the engine is started were developed as a countermeasure against low usage rates of manual **seat** belts, particularly in the United States of America. The first car to feature Automatic **Shoulder** belts as standard equipment was the 1981 Toyota Cressida, but the history of the belts go back further.[23]

Automatic **seat belt** in a Honda Civic

The 1972 Volkswagen ESVW1 Experimental Safety Vehicle presented passive **seat** belts.[24] Volvo tried to develop a passive three point seatbelt. In 1973 Volkswagen announced they had a functional passive **seat belt**.[25] The first commercial car to use automatic **seat** belts was the 1975 Volkswagen Rabbit.[26]

Automatic **seat** belts received a boost in the United States in 1977 when Brock Adams, United States Secretary of Transportation in the Carter Administration, mandated that by 1983 every new car should have either airbags or automatic **seat** belts.[27][28] despite strong lobbying from the auto industry.[29] Adams was attacked by Ralph Nader, who said that the 1983 deadline was too late.[30] Soon after, General Motors began offering automatic **seat** belts, first on the Chevrolet Chevette,[31][32] but by early 1979 the VW Rabbit and the Chevette were the only cars to offer the safety feature,[30] and GM was reporting disappointing sales.[33] By early 1978, Volkswagen had reported 90,000 Rabbits sold with automatic **seat** belts.[26] A study released in 1978 by the United States Department of Transportation claimed that cars with automatic **seat** belts had a fatality rate of .78 per 100 million miles, compared with 2.34 for cars with regular, manual belts.[34] In 1981, Drew Lewis, the first Transportation Secretary of the Reagan Administration, influenced by studies done by the auto industry,[35]

"killed"[36] the previous administration's mandate;[37] the decision was overruled in a federal appeals court the following year,[38] and then by the Supreme Court.[36] In 1984, the Reagan Administration reversed its course,[39] though in the meantime the original deadline had been extended; Elizabeth Dole, then Transportation Secretary, proposed that the two passive safety restraints be phased into vehicles gradually, from vehicle model year 1987 to vehicle model year 1990, when all vehicles would be required to have either automatic **seat** belts or driver side air bags.[36] Though more awkward for vehicle occupants, most manufacturers opted to use less expensive automatic belts rather than airbags during this time period.

When driver side airbags became mandatory on all passenger vehicles in model year 1994, most manufacturers stopped equipping cars with automatic **seat** belts. Exceptions include the 1995-1996 Ford Escort/Mercury Tracer and the Eagle Summit Wagon which had automatic safety belts along with dual airbags.[*citation needed*]

Automatic belt systems

- **Manual lap belt with automatic motorized shoulder belt** — When the door is opened, the **shoulder belt** moves from a fixed point near the **seat** back on a track mounted in the door frame of the car to a point at the other end of the track near the windshield. Once the door is closed and the car is started, the **belt** moves rearward along the track to its original position, thus securing the passenger. The lap **belt** must be fastened manually.
- **Manual lap belt with automatic non-motorized shoulder belt** — This system was used in American-market vehicles such as the Hyundai Excel and Volkswagen Jetta. The **shoulder belt** is fixed to the aft upper corner of the vehicle door, and is not motorized. The lap **belt** must be fastened manually.
- **Automatic shoulder and lap belts** — This system was mainly used in General Motors vehicles, though it was also used on some Honda Civic hatchbacks and Nissan Sentra coupés. When the door is opened, the belts go from a fixed point in the middle of the car by the floor to retractors on the door. Passengers must slide into the car under the belts. When the door closes, the **seat belt** retracts into the door. The belts have normal release buttons that are supposed to be used only in an emergency, but in practice are routinely used in the same manner as manual **seat belt** clasps.[*citation needed*]

Disadvantages

Automatic **belt** systems generally offer inferior occupant crash protection.[40][41] In systems with belts attached to the door rather than a sturdier fixed portion of the vehicle body, a crash that causes the vehicle door to open leaves the occupant without **belt** protection. He or she will in that case be thrown from the vehicle and suffer greater injury or death.[41] Because many automatic **belt** system designs compliant with the US passive-restraint mandate did not meet the safety performance requirements of Canada—which were not weakened to accommodate automatic belts—vehicle models which had been eligible for easy importation in either direction across the US-Canada border when equipped with manual belts became ineligible for importation in either direction once the US variants got automatic belts and the Canadian versions retained manual belts. Two such models were the Dodge Spirit and Plymouth Acclaim.[42][43]

Automatic **belt** systems also present several operational disadvantages. Motorists who would normally wear **seat** belts must still fasten the manual lap **belt**, thus rendering redundant the automation of the **shoulder belt**. Those who do not fasten the lap **belt** wind up inadequately protected by only the **shoulder belt**; in a crash without a lap **belt** such a vehicle occupant is likely to "submarine" (be thrown forward under the **shoulder belt**) and be seriously injured. Motorized or door-affixed **shoulder** belts hinder access to the vehicle, making it difficult to enter and exit—particularly if the occupant is carrying items such as a box or a purse. Vehicle owners tend to

disconnect the motorized or door-affixed **shoulder belt** to alleviate the nuisance of entering and exiting the vehicle, leaving only a lap **belt** for crash protection. Also, many automatic **seat belt** systems are incompatible with child safety seats, or compatible only with special modifications.

Use of seat belts by child occupants

*Main article: Infant car **seat***

As with adult drivers and passengers, the advent of **seat** belts was accompanied by calls for their use by child occupants, including legislation requiring such use. Generally children using adult **seat** belts suffer significantly lower injury risk when compared to non-buckled children.

The UK extended compulsory seatbelt wearing to child passengers under the age of 14 in 1989. It was observed that this measure was accompanied by a 10% *increase* in fatalities and a 12% *increase* in injuries among the target population.[44] In crashes, small children who wear adult seatbelts can suffer "**seat-belt** syndrome" injuries including severed intestines, ruptured diaphragms and spinal damage. There is also research suggesting that children in inappropriate restraints are at significantly increased risk of head injury,[45] one of the authors of this research has been quoted as claiming that "The early graduation of kids into adult lap and **shoulder** belts is a leading cause of child-occupant injuries and deaths."[46] As a result of such findings, many jurisdictions now advocate or require child passengers to use specially designed child restraints. Such systems include separate child-sized seats with their own restraints and booster cushions for children using adult restraints. In some jurisdictions children below a certain size are forbidden to travel in front car seats."[47]

In rear seats

In 1955 (as a 1956 package) Ford offered lap only **seat** belts in the **rear** seats as an option within the *Lifeguard* safety package. In 1967 Volvo started to install lap belts in the **rear** seats. In 1972 Volvo upgraded the **rear seat** belts to a three point **belt**.[48]

In crashes, unbelted **rear** passengers increase the risk of belted front **seat** occupants' death by nearly five times.[49][50]

Reminder chime and light

Examples of warning lights on a car dashboard.

In North America, cars sold since the early 1970s have included an audiovisual reminder system consisting of a light on the dashboard and a buzzer or chime reminding the driver and passengers to fasten their belts. Originally, these lights were accompanied by a warning buzzer whenever the transmission was in any position except park if either the driver was not buckled up or, as determined by a pressure sensor in the passenger's **seat**, if there was a passenger there not buckled up. However, this was considered by many to be a major annoyance, as the light would be on and the buzzer would sound continuously if front-**seat** passengers were not buckled up. Therefore, people who did not wish to buckle up would defeat this system by fastening the seatbelts with the **seat** empty and leaving them that way.

By the mid-1970s, auto manufacturers modified the system so that a warning buzzer would sound for several seconds before turning off (with the warning light), regardless of whether the car was started. However, if the driver was buckled up, the light would appear, but with no buzzer. New cars sold in the United States in 1974

and the first part of the 1975 model year were sold with a special "ignition interlock", whereby the driver could not start the car until the **seat belt** was fastened; however, this system was short-lived.

Today, the **belt** warning light may stay on for several minutes after the car is started if the driver's **seat belt** is not fastened.

In Europe and some other parts of the world, most modern cars include a **seat-belt** reminder light for the driver and some also include a reminder for the passenger, when present, activated by a pressure sensor under the passenger **seat**. Some cars will intermittently flash the reminder light and sound the chime until the driver (and sometimes the front passenger, if present) fasten their seatbelts.

Legislation

*Main article: **Seat belt** legislation*

Observational studies of car crash morbidity and mortality,[51][52][53] experiments using both crash test dummies and human cadavers indicate that wearing **seat** belts greatly reduces the risk of death and injury in the majority of car crashes.

This has led many countries to adopt mandatory **seat belt** wearing laws. It is generally accepted that, in comparing like-for-like accidents, a vehicle occupant not wearing a properly fitted **seat belt** has a significantly and substantially higher chance of death and serious injury. One large observation studying using US data showed that the odds ratio of crash death is 0.46 with a three-point **belt**, when compared with no **belt**.[54] In another study that examined injuries presenting to the ER pre- and post-**seat belt** law introduction, it was found that 40% more escaped injury and 35% more escaped mild and moderate injuries.[55]

The effects of **seat belt** laws are disputed by those who observe that their passage did not reduce road fatalities. There was also concern that instead of legislating for a general protection standard for vehicle occupants, laws that required a particular technical approach would rapidly become dated as motor manufacturers would tool up for a particular standard which could not easily be changed. For example, in 1969 there were competing designs for lap and 3-point **seat** belts, rapidly-tilting seats, and air bags being developed. But as countries started to mandate **seat belt** restraints the global auto industry invested in the tooling and standardized exclusively on **seat** belts, and ignored other restraint designs such as air bags for several decades[56]

Risk compensation

Some have proposed that the number of deaths was influenced by the development of risk compensation, which says that drivers adjust their behavior in response to the increased sense of personal safety wearing a **seat belt** provides.

In one trial subjects were asked to drive go-karts around a track under various conditions. It was found that subjects who started driving unbelted drove consistently faster when subsequently belted.[57] Similarly, a study of habitual non-seatbelt wearers driving in freeway conditions found evidence that they had adapted to seatbelt use by adopting higher driving speeds and closer following distances.[58] Similar responses have been shown in respect of anti-lock braking system, airbags, and, more recently, the electronic stability control system. [*citation needed*]

A 2001 analysis of US crash data aimed to establish the effects of seatbelt legislation on driving fatalities[59] and found that previous estimates of seatbelts effectiveness had been significantly overstated. According to the

analysis used, seatbelts were claimed to have decreased fatalities by 1.35% for each 10% increase in seatbelt use. The study controlled for endogenous motivations of **seat belt** use, which it is claimed creates an artificial correlation between **seat belt** use and fatalities, leading to the conclusion that seatbelts cause fatalities. For example, drivers in high risk areas are more likely to use **seat** belts, and are more likely to be in accidents, creating a non-causal correlation between seatbelt use and mortality. After accounting for the endogeneity of seatbelt usage, Cohen and Einav found no evidence that the risk compensation effect makes seatbelt wearing drivers more dangerous, a finding at variance with other research.

Increased traffic

Other statistical analyses have included adjustments for factors such as increased traffic, and other factors such as age, and based on these adjustments, a reduction of morbidity and mortality due to **seat belt** use has been claimed.[51] However, Smeed's law predicts a fall in accident rate with increasing car ownership and has been demonstrated independently of **seat belt** legislation.

Use in vehicles other than cars

Buses

*Further information: **Seat** belts in school buses*

Pros[60][61] and cons[62][63][64][65] had been alleged about the use of seatbelts in school buses.

In the European Union, all new long distance buses and coaches must be fitted with **seat** belts.[66]

Trains

Use of seatbelts in trains has been investigated. Concerns about survival space intrusion in train crashes and increase of injuries to unrestrained or incorrectly restrained passengers led the researches to discourage the use of **seat** belts in trains.

> *It has been shown that there is no net safety benefit for passengers who choose to wear 3-point restraints on passenger carrying rail vehicles. Generally passengers who choose not to wear restraints in a vehicle modified to accept 3-point restraints receive marginally more severe injuries.*[67]

Airplanes

The "Father of Crash Survivability", Hugh DeHaven, was a plane pilot. His interest in crash survivability was sparked by his surviving a plane crash during the First World War.

See also

- Air bags
- Automobile safety
- Baby transport
- Passive safety device
- **Seat belt** use rates by country

- **Seat belt** use rates in the USA

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