

Airbags are not just a matter of air- Lessons from Takata and Toyota recall

Welcome to Toyota Showroom

“Sir, this not just another car, but a car from the veterans, who know the art and science of car making from the beginning”, the enthusiastic salesman was trying to impress Mr. Airavata and his wife, who were closely examining a Toyota car, the recently released Etios model.

“Would you mind telling us the safety features?” Airavata looked into the eyes of the salesman.

“Yes Sir, the car has all the standard safety features like braking systems, indicator for not wearing the seat belt, high speed warning indicator, and most importantly, the airbags which protect the lives of the occupants in case of a collision. In this car both the front and the rear seat passengers are provided with the protection of the airbags”.

“Wait a minute”, Airavata interrupted, “was it not the airbag that caused the Toyota car recall recently?”

“Yes, Sir, but the issue has been resolved now, and you can count on the equipment provided in the car for the safety of the passengers”, the salesman replied.

“I don’t think so”, muttered Airavata, as he had read about the Toyota car recall because of the airbag issue. (“Everything You Need to Know About the Takata Airbag Recall - Consumer Reports News,” 2015.)



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Should the airbag be a bone of contention between the buyer and the seller?

Well, it need not be. How important is an airbag to a prospective buyer is a tricky question to answer as many people while buying a car still look for features like power, seating capacity or comfort, boot space, resale value, and of course, in a country like India, the average buyer is always enamoured by the mileage or the distance a car would run for every litre of the fuel supplied to the car. Secondly, the awareness about the safety features was for a long time, observed to be low and hence the manufacturers and the dealers selling the cars, hardly touched upon them. Further, the safety features always come with an extra price tag and hence not many buyers were willing to shell down extra money on them. Hence the question, should the airbag be a serious factor to tilt the decision of buying may not find a convincing answer or consensus.

Safety of car – a designer’s imperative or a legal perspective or a driver’s nightmare?

It is a well known fact that accidents happen due to several reasons and thus the manufacturers would not be able to provide safety features to mitigate the risk under all possible situations. Car control is a term often used to indicate how much a driver can control a car while driving at different speeds, on different terrains, and under different conditions of traffic, nature, and of course, the age and maintenance related factors of the car itself. Hence the driver always thinks at least while getting into the car that he or she knows how to control the car as long as he or she is at the wheel. But sadly enough, “the driver lost the control’ is a common description in the media while describing how the accident occurred. This indicates that in spite of all the safety features provided and also the training given to the person driving the car, some unpredictable or uncontrollable factor played the role and caused the accident. Hence the car designers started looking at all possible manners of improving the safety of the occupants along with the driver such that the car can be controlled by the driver and introduced safety devices which minimize the impact

on the occupants when an accident occurs. This has historically happened wherein the safety features started getting added to the car assembly in an evolutionary manner. With the advances in technology, testing of a car has become a sophisticated laboratory experiment wherein the car is tested under all possible conditions and the impact is studied. Testing is done on the actual car or a model or through simulated experiments. This has given enormous insight into the design of safety features and thus the car design continues to be a fascinating yet challenging car as both the power capacity as well the features given in a car have increased manifold over a period of time.

At the same time, the training and education given to the driver have also been observed to change over the years as per the instructions of the traffic control authorities in particular, and the government and the car manufacturing industry in general. The driver apart from learning how to drive should also be aware of the legal liabilities and traffic rules, and has to study them as a part of the education while undergoing training. It is interesting to observe that a car manufacturer may set up a training center to teach how to drive a car using both the simulated arrangement as well the actual car. Maruti Suzuki Limited, for example in India, has set up more than 350 driving schools in different parts of the country, (<http://www.marutisuzuki.com/>).

The safety devices, all said and done, must satisfy two conditions if they have to meet the intended objective of protecting the vehicle and / or the occupants. These are: (1) the safety gadget or device must work in a mistake-proof manner exhibiting highest reliability, and (2) the driver and other occupants are fully aware of such devices and know the operating conditions. If any trigger is required by the people inside the car that should happen in the nick of the time, when an accident occurs. The safety controls can be categorized as (1) devices that protect in case of a collision, and (2) the devices that give a visual or audio warning ahead of a dangerous situation. A speed sensor that warns when the car is running at high speeds, a device that gauges the distance when reversing a car, or an indicator on the dashboard, when the fuel tank is getting empty, are all examples of such warning

devices, and as such do not provide any protection if the driver ignores the warnings. On the other hand a properly worn seat belt and an airbag are expected to provide a protection to the driver so as to prevent the body of the driver hitting the frontal portion and succumbing to serious or fatal injuries. Thus the airbag is seen as a more proactive device that automatically comes to the rescue of the driver when an accident happens.

But, the fact is, ironically enough, airbags which are supposed to be protecting the occupants in a car in case of a collision, caused more damage to the Toyota Company as they failed to protect the passengers as expected by them, (Keating, 1984). A detailed report published by <http://money.cnn.com/2014/11/20/autos/takata-airbag-victims/>, states that nearly 8 million airbags have now been recalled by National Highway Traffic Safety Administration, (NHTSA). These airbags are fitted in the cars manufactured by 14 different automakers, out of which Honda Company alone accounts for about 5 million cars.

Safety features in a car and concern by the car manufacturers

Right from the day the primitive models of the cars started rolling on the streets, safety of the people inside the car was always a question mark. With the advancement in technology, cars were designed to carry more people and also move at high speeds on different types of terrain. Further, more and more automatic controls and electronic systems started becoming the major features of the cars. This made the passenger comfort and safety related issues more and more challenging while designing the cars.

Ever since Henry Ford revolutionized the mass manufacture of cars, and more people started buying and using cars, the safety of the occupants inside the cars, became a major concern. A car being a complex assembly of parts produced in-house or procured from various sources, is not an easy product to manufacture. For a long time the car manufacturers focused more on technical issues like engine power, maximum speed, quick acceleration, seating capacity,

driving comfort, and cosmetic features. Safety of the occupants became a national debate, when unfortunate road accidents started happening across the globe and the companies took a serious note. This also prompted the Government in many countries to enact laws making it mandatory on the part of the manufacturers to install safety features in the cars. But still many manufacturers, and surprisingly many customers viewed this development as not so important as both were more conscious of the final price. Thus serious attempts to improve safety were found lacking in the third world economies with the cost of manufacturing the car, playing a major role in pricing. The manufacturers in the price sensitive markets were apprehensive about providing safety features that always attracted additional cost. Further, as long as the number of cars moving on the roads was low, the danger was not clearly perceived by the makers or the users. In addition, the changed image of a car as more a status symbol than a utility, made the manufacturers to focus on luxury and cosmetic features, and thus, safety issues became a secondary priority. Time and again several brands of cars are being recalled for poor quality and probably very few manufacturers might have saved the embarrassment of recalls, and there is no proof to say that recalls reduce the number of accidents, (Bae & Benítez-Silva, 2011, 2012). Thus the present case study has the objectives of assessing the usefulness of airbags, their design and operation, and the responsibility of the people involved including the Government, drivers, and the car makers in ensuring that device works in the intended manner to provide the required protection.

Airbags, paradox of design or of faulty design?

Airbags evolved over a period of time. In a head on collision it was commonly observed that the occupants are very likely to bang against the front metal part inside the car and thus would receive a severe injury particularly in the head, that could prove to be fatal. Airbag provides a cushion to the impacted body through a rapidly filled bag that supports and prevents the body from colliding against the dashboard or the steering. This prevents a serious injury to the occupants.

The history and development of airbags and subsequent changes in the last 70 years are well traced in <https://en.wikipedia.org/wiki/Airbag>. Citing more than 115 articles and reports, Wikipedia says that airbags became mandatory in several countries. Though originally it was customary to include airbags on the front side to protect the passenger and driver in the front seat, it became a common practice to provide airbags to the back seat passengers also. Along with this major development, the airbags were also introduced to provide safety in case of side impacts, and also to knees. It is not the intention here to provide a detailed history of airbags, but to indicate that airbags have now become a standard accessory in high end cars, and are available at an additional cost for the less expensive cars.

How an airbag works, and how it became a mandatory requirement in cars produced in the US since 1991, is well illustrated in http://web.bryant.edu/~ehu/h364proj/sprg_97/dirksen/airbags.html. Today the airbag is considered as a part of the standard equipment in a car.

Long back, an objective assessment of the airbag was made, to determine the usefulness of the airbag in case of a collision, (Will airbags cut car deaths? 1970). Further, it is clearly debated (Keating-Edh, 1984) to find out whether the airbag helps or poses a danger, and it was noticed that only a small number of car users, 14.4%, favoured the installation of airbags. Further, the airbags when installed in a new car used to increase the cost by around \$200, which did not go well with the car buyers. It was also observed that airbags along with seatbelts worn by the occupants would be more effective and airbags alone would not be much helpful. Further, airbags are of no use after the initial deployment. Thus the car buyers were less inclined towards the installation of air bags in the cars.

Later, additional health hazards were found with the use of airbags in the cars. The rapid filling of an airbag results in hearing threshold shift, making the persons less sensitive to noise because of loss of sensitivity, as propounded by Rouhana et. al. (1994). The same

observation is reported in Holt (1999), which expresses serious concern about the noise-related problem, (Air bags may damage hearing, 1999). In a similar report, researchers (Buckley, Setchfield, & Frampton, 1999) have expressed concern that the airbags may inflate unnecessarily in low speed crashes and can cause eye, face, upper limb, and chest injuries. With the help of two cases it is indicated that the airbag inflation in low speed collisions, leads to hearing loss and persistent tinnitus without any other injuries. In another study how airbags can cause eye injuries has been examined and suggested that efforts must be in full swing to mitigate the problems, (Pearlman, Eong, Kuhn & Pieramici, 2001).

Continuing on the loss of hearing ability of the occupants in case of deployment of airbags (Banglmaier & Rouhana, 2003), it was noticed that the airbags are inflated in a very short span causing excessive noise leading to loss of hearing sensitivity, described as Noise Induced Hearing Loss (NIHL). These things clearly illustrate that airbags are also responsible for creating additional health risks and hence have to be weighed against the possible benefits versus the harmful side effects on the occupants.

A comprehensive article, *What makes airbags dangerous? - Dan Newlin - Millions Recovered*. (2011) summarises how airbags themselves can become a hazard due to various reasons, Based on this article, it appears that many car users are not aware of the malfunctioning of the airbags and thus are prone to become victims should the airbags in their cars do not function properly.

However, situation seems to have improved when looked at the report by NHTSA, (Ferguson & Schneider, 2008). It is stated that the airbag crash related accidents have come down, (Special Crash Investigations—A Model for Future Corrective Action: First Generation Frontal Air Bags, 2010). This trend is illustrated in Figure 1. Strict and coordinated enforcement of rules and regulations, along with intensive educations and by public awareness programs ensured near zero fatalities in airbag crash situations.

From the literature review, it is clear that the airbags as safety devices are conceived on a good design and can definitely reduce the impact of the accident on the driver, particularly in the case of head-on collision, which is almost sure to cause instantaneous death to the front seat occupants in a car. Then why they are seen as dangerous is because they have failed in their operational effectiveness, either in terms of the timing, or in terms of inadequate inflating. It is essential that the airbags should instantaneously open up the moment a collision happens. This event is triggered by a mechanism that is built with a sensor that recognizes the impact. Airbag is deployed more because of deceleration after the hit and not based on speed. Further, even if the temperature rises beyond a certain limit inside the car or near the engine, which can be the case after driving for a long distance in hot weather, the airbag is deployed to minimize the explosion possibility, and save the occupants from getting burnt, (<http://www.crashforum.info>).

Regarding the timing is concerned, airbag must come into action in a tiny fraction of time, and for this the trigger has to be rapid and the inflating mechanism should act fast. This depends on the sensor on one hand and on the other on many parameters including the stature of the person, the extra weight carried by the seat, the crash severity, and the design factors like single stage inflating, or multistage inflating. Hence if the trigger mechanism doesn't function properly the activation of the airbag will always be affected, which is essentially what happened in the of Takata airbags deployment case.

Is the supplier at fault? Takata, the airbag manufacturer and supplier

Takata Kojo Corporation started manufacturing seat belts in 1952 and since then has become a global supplier of safety products for the purpose of saving the lives of the driver and passengers, in case of a collision. The company has the motto of saving human lives anywhere in the world, with their safety equipment fitted in the cars.

As stated by Takata Corporation, Japan, <http://www.takata.com/en.>, the objective of the company is as follows

- “At Takata, we dream of a “world with zero fatalities from traffic accidents.” We understand the importance of every individual, and hope to one day experience a global community where everyone recognizes the true value of human life”.



Figure 1 : Air bag related fatalities over the years

From the data related to Figure 1, the following estimates are made:

Average number of fatalities = 15.8 per year.

What is more relevant is to observe how the airbags were able to save lives, as over a period of 10 years the fatalities came down from 42% to 36%, (<https://crashstats.nhtsa.dot.gov>). This improvement is attributed to the deployment of airbags, though the role of other safety measures is not discounted.

Keeping this in mind the Takata company started expanding its production and operations from 1980's and started setting up units in many countries in Americas, Europe, and Asia. Particularly in those

countries where the production of cars started zooming up because of the increase in demand, for example in India, Takata established their unit, and thus today has 57 plants in 22 countries around the world. This has helped the company in understanding the local markets, climatic conditions, driving styles, regulations, and also the customers' preferences, thus enabling the company to customize their products. As mentioned earlier, an airbag offers better protection when seat belt is also worn by the person, and thus the company produces an array of seat belts and airbags to suit many vehicles. Starting from the eighties, the company has set up labs and testing units to ascertain the quality of the products.

Takata states that it aims towards total safety system with the safety of both the persons inside the car as well those outside it, thereby minimizing the overall impact on the society. Based on their research and development efforts, the Takata Company is moving towards developing overall safety solutions, as depicted in Figure 2, which illustrates both current Takata products and products under development.

Takata has not restricted itself to manufacture only seat belts and airbags, but is also manufacturing steering wheels and other products. But airbags continue to be the company's major product in terms of sales as seen in Figure 3. The company aims to become a world leader in providing safety solutions across a range of vehicles and tries to save lives of people or minimize the danger in case of a collision.

Figure 2. Takata Total Safety System

(Source: <http://www.takata.com/en/about/development.html>)

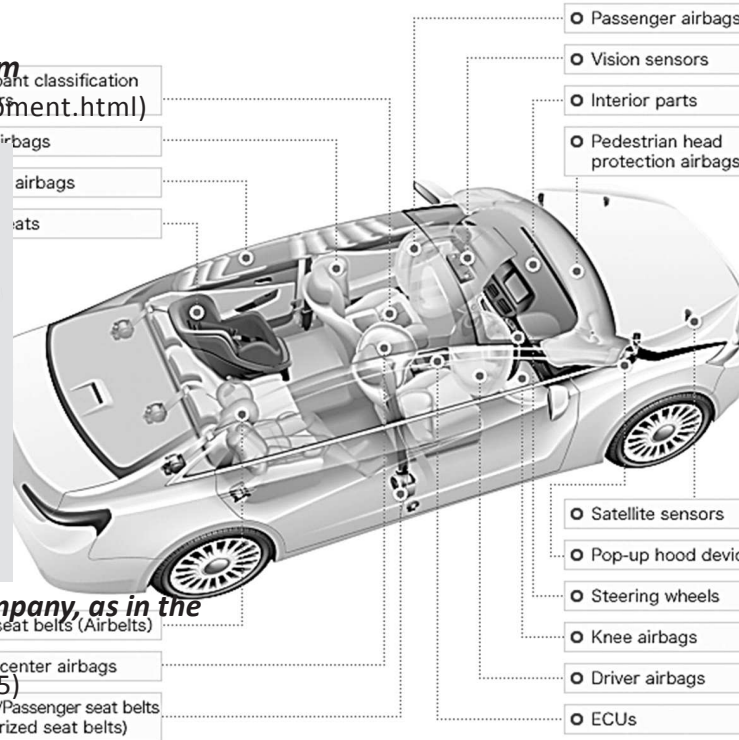
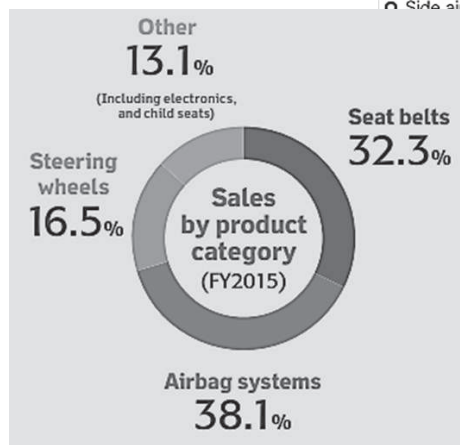


Figure 3. Sales by product category of Takata Company, as in the year 2015.

(Source: Takata Corporation Corporate Brochure 2015)

The Explosion – Massive recall of airbags

The recall of vehicles because of airbags became international news, (“Takata Airbag Recall - Everything You Need to Know”, 2016), and the list of vehicles released in the media included the top brands in the field of automobile manufacturers. It was mentioned that cars made by 14 different automakers have been recalled to replace frontal airbags on the driver’s side or passenger’s side, or both. NHTSA has called this incident as “the largest and most complex safety recall in U.S. history.” It was also found that the airbags fitted in the models from the year 2002 to 2015, were all supplied by Takata. This sent a panic wave across the globe because the sheer number of airbags to be recalled was in millions. The total number of vehicles recalled due to faulty airbags was around 34 million vehicles in the United States, and another 7 million worldwide, (Blackwell, 2016). The news also said about at least 10 deaths and more than 100 injuries because of faulty air bags, in the US alone. Accurate picture of airbag disaster across the globe is not available, though one can argue about the role of airbags seen both as a life saver and as a life pruner. Because, it is claimed that the Department of Transportation estimates that between 1987 and 2012, frontal airbags have saved 37,000 lives. This further fuelled the debate about the role played by the airbags, with no clarity on the continuance of the installation of airbags, which may help or harm the users, given the precarious consequences namely death or injuries.

Cloud of mystery behind the Takata airbags

As mentioned earlier, 14 top auto makers producing high end models and luxury vehicles, initiated recalls to ensure that the airbags supplied by Takata are found in proper order or not. The list of auto companies is given in Table 1. It may be noted that out of these companies 14 companies were prioritized based on the volume requirement.

Table1

Automobile manufacturing companies who initiated recalls due to airbags

Acura	General Motors	Nissan
Audi	Honda	Scion
BMW	Infiniti	Subaru
Chrysler	Lexus	Toyota
Ferrari	Mazda	Volkswagen
Ford	Mitsubishi	Jaguar/Land Rover

As reported in the media, both Honda and Takata companies knew about the problem with the airbags (Atiyeh, 2016), as early as in 2004, but neither of them shared the data with the concerned authorities nor informed the other automakers, perhaps because the incident was not seen as gruesome or thought as inviting investigation or expecting public ire. However, the newspaper which carried the news, reported that a review of federal documents revealed that the airbags have caused two deaths and 30 injuries in Honda vehicles and no less than 139 reported injuries across all automakers. Honda resorted to a tiny recall in 2008 in which 4205 cars were taken back and the action was repeated eight times. Shockingly, Honda had not informed the National Highway Traffic Safety Administration that the airbags had actually ruptured or were linked to injuries and deaths. Also in 2007, Honda took back airbag parts during dealer service visits without notifying owners and shipped the parts to Takata for analysis. Though NHTSA started investigating in November 2009 closed it after six months, ignoring the information that was available with Takata.

Further, another dimension was added to the airbag explosion in an article (Anon. 2016) which states that there are two elements involved in an airbag rupture, one is the inflator and the other is the propellant. Based on the tests conducted by Takata and other independent entities, degradation in propellant can cause rupture in the airbag because of the varying configuration of the propellant and inflator. This further results in exploding of the inflator parts during the airbag

rupture causing severe injuries to the occupants. Hence it also argued that the issue is related to the airbag inflator and not the actual airbag fitted inside a car. Further, different airbags might have received different inflators from different suppliers and thus the whole issue cannot be attributed to airbags alone. It is quite possible that in the same car, different airbags and inflators supplied by different vendors might have been fitted. It is also likely that different suppliers might have provided different airbags fitted on the front and side of the passengers. These observations have made the process of investigation, a more challenging proposition, as multiple parties are involved and the issues are interconnected to result in misleading conclusions. But, what needs to be observed here is the Takata Company has singlehandedly taken the responsibility of recalls and replacement, thereby indicating the company stands for voluntary adherence to quality standards. But because the information was not made public by Honda and Takata Companies, even though they knew the issue, can they be seen as professionally unethical is also a question not easy to answer, because the number of death or injuries was too small. Only when the recalls started off in big numbers, the responsibility was accepted by Takata.

Toyota Motor Corporation and Recalls

Though many companies got affected, only one company namely Toyota is discussed here. The reason is, Toyota all these years is seen as an epitome of quality and stands apart from the rest because of excellent quality principles the company has been advocating all these days. Hence the heading may look like an oxymoron given the fact that the Toyota Company is historically known for high quality of the products it makes and recognized world over as a pioneer in the manufacture of cars. Like many other Japanese companies, Toyota has put quality at the top of the agenda. Their legendary production system known as the Toyota Production system, is the envy of operations managers all over the world, as illustrated by many authors for example, Benders & Morita (2004), Black (2007), New (2007), O'Connell, (1988). Marksberry (2013), and Nortje & Snaddon (2013). As of

2008, 48 books, in English, and 382 in Japanese, have been published about the Toyota Company, out of which 24 and 97 books in the two languages respectively have focused on Toyota Production system, (Osono, Shimizu, & Takeuchi, 2008). In fact, Toyota itself rigorously follows the continuous improvement technique, popularly called as “kaizen” in Japanese, (Liker & Franz, 2011).

In the history of automobiles, recalls are not new or infrequent. Several companies including the legendary Ford Company of US, have experienced a series of recalls. But the impact of recalls may not be devastating as sufficient evidence may still not be available for banning the product. This usually happens with all the recalls, as people are also likely to forget the recalls and move on with their buying decisions, as evidenced by early researchers, Grafton, Hoffer & Reilly (1981), and Reilly & Hoffer (1983).

No doubt it is the reputation of a company that is first affected in the case of recall, as researched by several authors, like Rhee & Haunschild (2003, 2006), and Rupp & Taylor (2003). What is interesting here is Toyota in spite of all the quality systems in place, could not escape the quality related issues commonly encountered by other manufacturers. In an earlier instance, malfunctioning devices causing the death of the occupants inside the car, made the company to compulsorily recall their cars, described and debated by several authors, for example, Auffermann (2010), and Heechang, Robert, & Oredola (2012), and Hammond (2013). A visible impact of recalls is reflected in the sales, as reported by Shin, Richardson, & Soluade (2014), who have specifically examined the loss of sales of Toyota cars in the wake of the recalls.

Here is the excerpt that shook the car owners and drivers, (Everything You Need to Know About the Takata Airbag Recall - Consumer Reports News, 2015).

- “More than 30 million vehicles in the United States, made by 10 different automakers, have been recalled to replace frontal

airbags on the driver's side or passenger's side, or both. The airbags, made by major parts supplier Takata, were mostly installed in cars from model year 2002 through 2008, although it has been expanded through 2014 in some cases. Some of those airbags could deploy explosively, injuring or even killing car occupants. At the heart of the problem is the airbag's inflator, a metal cartridge loaded with propellant wafers, which in some cases has ignited with explosive force. If the inflator housing ruptures in a crash, metal shreds from the airbag can be sprayed throughout the passenger cabin—a potentially disastrous outcome from a supposedly life-saving device.”

Questions and more questions

The uncertainty of replacement in case of a faulty airbag looms large over the minds of the customers, because, the number of airbags recalled exceeds 34 million. Sensing the demand exerted on their production system, Takata has ramped up their production capacity, but still the time required for production is a major concern. This may take months and even years given the huge quantity of production. Sensing the danger of running out of time, Takata has contacted the other manufacturers of airbags for help. These rival manufacturers include companies like AutoLiv, TRW, and Daicel (“Takata Airbag Recall - Everything You Need to Know”, 2016). These competitors have agreed to use their capacity to produce the airbags to be used for replacement purpose.

However, a thorough investigation by NHTSA has found the root cause of the problem. It is observed that ammonium nitrate based propellant used in airbags, which is subjected to environmental moisture, high temperature, and age, is likely to cause improper inflating of the airbags thus leading to death or injuries to the occupants of the passenger car. Hence, the number recalled has tripled in size over the past year, because of public announcements and currently more than 100 million vehicles worldwide with airbag inflators are in need of replacement before 2019. (“Takata Airbag Recall - Everything You Need to Know”, 2016). A herculean task indeed!

Whose responsibility it is?

Airbags are not considered as primary safety devices but are called supplemental devices. Because they will be fully effective only if:

- The driver and the front seat occupants are wearing seat belts
- The airbag On – Off switch is turned “on”.
- The positioning of the person is quite conducive for protection by the airbag in terms of the stance (position or inclination of the person)
- The distance between the passenger’s body and the front dashboard is maintained at 10 inches.
- Airbags have been replaced after deployment.

These conditions clearly show that the responsibility of the front seat occupants including driver is the maximum if they have to derive the benefit of the airbag. Next comes the effectiveness of the trigger mechanism which is battery operated, in deploying the airbag in case an accident occurs. This makes it imperative that the battery is properly charged and the mechanism is in good condition. Only then the airbag provides the necessary protection and saves the lives. If these conditions are not in place, the airbags fail to discharge their duty and further, may get triggered under false alarm causing more damage to the occupants.

The following suggestions are worth implementing by the concerned agencies to save lives:

- a) While teaching how to drive, the driving schools should also teach about the airbags and the necessary instructions to be followed
- b) The airbag manufacturers and the vendors who supply the constituent parts must certify that they have complied with the prevailing rules and adhere to the regulations as imposed by the Government or such authorities

- c) Thorough testing of the airbags must be done under different crash conditions and their reliability should be ascertained
- d) Car manufacturers should insist on the buyers to go for air bag installation as a standard fitment, rather than showing them as under extra charge, which would deter the car buyers from going for airbags
- e) Preferred to have the cost of airbags built into the total cost by considering the airbags as standard and mandatory safety devices and not showing them as luxury features
- f) Drivers and the front seat occupants should strictly follow the guidelines issued by the safety authorities.
- g) Aged persons and children under the age of 12 years, must avoid being seated in the front.

All these suggestions indicate that safety to be derived from the safety features fitted in a car are realized only by collective responsibility of all concerned and more by the drivers.

Epilogue

Airbags per se are not at all fault if they fail to perform or wrongly perform. Buyers need to understand the big picture and not to hold only the manufacturer as responsible for the safety of the occupants.

Will Mr. Airavata continue to wait for his Toyota car, thinking that better devices coupled with stringent inspection will be offered to the customers? Will he shift his choice to another model or make? Perhaps it is possible to answer these questions by 2019, hoping that the Takata Company would have completed the replacement of all the airbags, before or by that time.

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