COMPARATIVE INVESTIGATION OF ACTIVE SAFETY AND PASSIVE SAFETY SYSTEMS FOR N CATEGORY VEHICLES

1Shahina Khatun, 2Pankaj Chatterjee, 3Amit Kumar, 4Sumit Kanchan
1School of Mechanical Engineering, Lovely Professional University, Punjab, India.

Abstract: Since, both the safety systems in vehicles play vital role to prevent human from accidents or after-injuries in day-to-day travel, the designers and the manufacturers put their best effort to make the use of safety systems to its extent as per requirement. Both active safety system and passive safety system has their own importance in vehicles. In our research, we have selected three safety systems from each active and passive safety systems and comparative study of each safety systems is performed taking into consideration of various performance parameters. For the comparison, the three N-type vehicles selected are Mercedes Actros truck, Ford F-150 raptor and Volvo FH truck. After our study between those mentioned vehicles, Ford F-150 raptor is found to be the safest among all three vehicles.

Index Terms - Active safety, passive safety, lane change assist, hill descent control, adaptive cruise control, seatbelts, crumple zone, airbags.

1. INTRODUCTION
Safety is something that every living being seek be it an animal or human being. India falls under one of the most affected countries in the category of road accidents. The overwhelming population, heavy traffic, rash driving, poor quality of the roads, etc. are the main factors which leads to the road accidents. The safety of the driver and the passenger in the vehicle are the major concerns when it comes to the vehicle launch and sells. According to the ministry of road transport and highways transport research wing, the total number of accidents occurred in India is 4,49,002 and the total number of persons 4,51,361 in 2019. In vehicles, there are basically two categories of safety systems namely active safety system and passive safety system.

Active safety system consists of the group of features that decreases the potent of happening accidents. These systems are designed taking into consideration of different factors such as driver’s comfort and maneuverability, vehicle ergonomics, ride and handling [1] and many more. Depending on the situation and their feature installed in different active safety systems, it can be activated itself by some trigger conditions or can be activated manually by the user of the vehicle [2]. These include adaptive cruise control, brake assist system, lane change assist, lane departure warning, lane keep assist, hill descent control, park assist, tire-pressure warning, electronic stability control, etc. Hence, it is also called as crash avoidance system.

Passive safety system consists of the group of features that decreases the seriousness of the injuries and the fatalities appeared during or after the mishapening or road accidents [3]. These safety systems are designed in such a way that they are automatically activated due to sudden impacts or some triggering actions such as amount of force during collision of vehicles with any other vehicles or other objects. To sum up, we can say that these systems do not come to life until there is no call for the working. So, these systems come into action when the vehicle meet with an accident and it helps to reduce the level of injury at the time of collision [4]. These systems include seat belts, airbags, crumple zones, fuel tanks placed in correct position, fuel-pump kill switch, load-space barrier nets, etc. etc. Hence, it is also called as crash mitigation system.

2. OBJECTIVE OF OUR WORK
In this work, efforts have been made to compare the three vehicles on the basis of the active and passive safety systems employed in them on the basis of few performance parameters. The vehicles taken into consideration are Mercedes Actros truck, Ford F-150 raptor and Volvo FH truck. A comparison is made on the basis of various parameters like type of sensors used, location of the sensors on the vehicle and the working principles employed on them. The objective is to get an overall idea of effects of various parameters on the performance of passive and active safety systems.

3. RESEARCH METHODOLOGY OF OUR WORK
Under each safety systems employed in vehicles, three systems are chosen and their comparison is done using various parameters such as need, architecture and a separate table is designed to compare their performance parameters in the three different vehicles. Under active safety systems, lane change assist, hill descent control and adaptive cruise control are selected, whereas under passive safety systems, seat belt, crumple zone and air bag are taken into consideration for the comparison purpose.

4. COMPARATIVE STUDY OF ACTIVE SAFETY SYSTEMS
These safety systems work for the prevention of the accidents. These systems stay active while you drive keeping you safe from accidents. Lane Change Assist, Hill Descent Control and Adaptive Cruise Control are the chosen active safety systems under this category. Most of the active safety systems are controlled by the Electronic Control Unit. The vehicles taken into consideration for the comparative study of the three above mentioned active safety systems are as follows:

- Mercedes Actros truck
- Ford F-150 raptor
- Volvo FH truck
4.1 Lane Change Assist

This assistant system informs the driver of potential hazards while changing the lane on roads and highways with several lanes. The research shows that during lane changing, more than 6% of all accidents occurs every year. Hence, it is practically important to provide lane change assistance to the drivers for their easy and safe maneuver.

4.1.1 Need

There are blind spots in every vehicle, so we are not able to see those areas which can lead to the accidents. As of the numerical data, 25% of the accidents happen while changing lanes in Germany. Radar sensors are employed in the lane change assist systems [5] to monitor the regions alongside and behind the vehicle exactly covering the blind spots. These sensors warn the driver coherently of forthcoming collision while changing lanes. This can be shown in Table 1.

4.1.2 Architecture

![Architecture of lane change assist system](image)

4.1.3 Comparison of lane change assist system employed on different vehicles at various operating parameters

Table 1. Comparison of lane change assist system employed on different vehicles at various operating parameters

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Mercedes Actros truck</th>
<th>Ford F-150 raptor</th>
<th>Volvo FH truck</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model/Manufacture</td>
<td>2019</td>
<td>2020</td>
<td>2020</td>
</tr>
<tr>
<td>Sensors</td>
<td>Lateral, full range, short range radar sensor, front stereo camera, V2V communication, Wi-fi</td>
<td>Two radar sensors on both side near the rear side of the vehicle</td>
<td>Video sensors, Laser sensors, Infrared sensors</td>
</tr>
<tr>
<td>Sensors’ location</td>
<td>Front windshield, front bumper, front top body</td>
<td>Behind the windshield</td>
<td>Video sensors: mounted behind the windshield, typically integrated beside the rear mirror Laser sensors: mounted on the front of the vehicle Infrared sensors: mounted either behind the windshield or under the vehicle</td>
</tr>
<tr>
<td>Principle</td>
<td>Radar-Echo principle, Stereo camera-Stereophotography principle</td>
<td>Radar-Echo principle, Stereo camera-Stereophotography principle</td>
<td>Hough transform and Canny edge detector to detect lane lines from real-time camera images fed from the front-end camera of the automobile</td>
</tr>
<tr>
<td>O/P actuators</td>
<td>Audible warning alarm, visual indicator, steering wheel vibrator, electronic power steering, brakes</td>
<td>Audible warning alarm, warning on instrument cluster, light blink on side mirror, electronic power steering, brakes</td>
<td>Audible warning alarm, warning on instrument cluster</td>
</tr>
</tbody>
</table>

4.2 Hill Descent Control

Hill Descent Control (HDC), is a low-speed function with enhanced engine braking. This active safety system makes it possible to increase or decrease the vehicle speed on steep downhill gradients using only the accelerator pedal, without using the foot brake [7]. It is a cruise control system where traction control technology along with anti-lock brakes is used.

4.2.1 Need

Hill descent control continuously maintains braking pressure to help prevent slippage and maintain a constant pre-set speed while going down a steep terrain. Hence, the driver can focus on the steering since there is no distraction to them for applying any brakes or downshifting the transmission. On a downhill grade, a vehicle speed between 2 and 12 mph is maintained by this safety feature [8]. Above 20 mph, the system remains activated, but the descent speed cannot be set until you are below 20 mph again. The sensors responsible for this is shown in Table 2.
4.2.2 Architecture

![Architecture Diagram]

Figure 2. Architecture of hill descent control system

4.2.3 Comparison of hill descent control system employed on different vehicles at various operating parameters

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Mercedes Actros truck</th>
<th>Ford F-150 raptor</th>
<th>Volvo FH truck</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model/Manufacture</td>
<td>2019</td>
<td>2020</td>
<td>2020</td>
</tr>
<tr>
<td>Sensors</td>
<td>Wheel speed sensors</td>
<td>Wheel speed sensors</td>
<td>Clutch travel sensor</td>
</tr>
<tr>
<td></td>
<td>Throttle position</td>
<td>ABS module</td>
<td>Clutch switch</td>
</tr>
<tr>
<td></td>
<td>sensors (TPS)</td>
<td>Engine control module</td>
<td>Gear position sensor</td>
</tr>
<tr>
<td></td>
<td>ABS module</td>
<td>Body control unit</td>
<td>Throttle position</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Transmission control</td>
<td>sensor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>unit</td>
<td></td>
</tr>
<tr>
<td>Sensors’ location</td>
<td>In wheels, TPS-on</td>
<td>In wheels, TPS-on</td>
<td>Placed in clutch,</td>
</tr>
<tr>
<td></td>
<td>throttle valve shaft</td>
<td>throttle valve shaft</td>
<td>gear, throttle,</td>
</tr>
<tr>
<td></td>
<td>ABS module-In the</td>
<td>ABS module-In the</td>
<td>brake pedal</td>
</tr>
<tr>
<td></td>
<td>engine compartment</td>
<td>engine compartment</td>
<td></td>
</tr>
<tr>
<td>Principle</td>
<td>Wheel sensor-generator</td>
<td>Wheel sensor-generator</td>
<td>Each wheel is braked</td>
</tr>
<tr>
<td></td>
<td>principle TPS-Hall</td>
<td>principle TPS-Hall</td>
<td>to its traction limit.</td>
</tr>
<tr>
<td></td>
<td>effect or resistive</td>
<td>effect or resistive</td>
<td>The driver sets a</td>
</tr>
<tr>
<td></td>
<td>technologies</td>
<td>technologies</td>
<td>descent speed and the</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>computer takes care</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>of the rest where the</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>speed of the car is</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>calculated from</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>averaging the speeds</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>of each of the four</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>wheels.</td>
</tr>
<tr>
<td>O/P actuators</td>
<td>Brakes, throttle,</td>
<td>Brakes, throttle,</td>
<td>Brake master cylinder</td>
</tr>
<tr>
<td></td>
<td>brake master cylinder</td>
<td>brake master cylinder</td>
<td></td>
</tr>
</tbody>
</table>

4.3 Adaptive Cruise Control

In heavy traffic, radar based and camera based Adaptive Cruise Control helps the driver keep a safe distance from the vehicle in front by controlling the accelerator and all other available brakes [9]. If there is a risk of impact, the collision warning system alerts them by bulging a light onto the windscreen in the vehicle. Hence, the emergency brake automatically activates, significantly reducing the risk of severe injuries.

4.3.1 Need

Adaptive Cruise Control customs sensory technology mounted within vehicles such as lasers, cameras and radar equipment, creating an idea of how much is one car distant to another cars or objects on the driveways. Hence, this active safety system is the foundation for future car intellect. This technology allows the car to detect and warn the driver about potential forward collisions [10]. At first red lights begin to flash, and then the expression ‘brake now!’ appears on the dashboard to help the driver reduce the speed. An audible warning shall also be accompanied with the system for better warning. These features can be shown under various parameter in Table 3.
4.3.2 Architecture

Figure 3. Architecture of adaptive cruise control system

4.3.3 Comparison of adaptive cruise control system employed on different vehicles at various operating parameters

Table 3. Comparison of adaptive cruise control system employed on different vehicles at various operating parameters

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Mercedes Actros truck</th>
<th>Ford F-150 raptor</th>
<th>Volvo FH truck</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model/Manufacture</td>
<td>2019</td>
<td>2020</td>
<td>2020</td>
</tr>
<tr>
<td>Sensors</td>
<td>Accelerator and brake pedal position sensor Radar sensor Ultrasonic sensor</td>
<td>Radar sensor Camera</td>
<td>Accelerator and brake pedal position sensor Radar sensor Ultrasonic sensor</td>
</tr>
<tr>
<td>Sensors’ location</td>
<td>Front windshield, front and rear bumper</td>
<td>Front windshield, front and rear bumper</td>
<td>Front windshield, front bumper</td>
</tr>
<tr>
<td>Principle</td>
<td>Radar-echo principle Ultrasonic sensors-emits and receives signal to calculate distance</td>
<td>Radar-echo principle Ultrasonic sensors-emits and receives signal to calculate distance</td>
<td>Radar-echo principle Ultrasonic sensors-emits and receives signal to calculate distance</td>
</tr>
<tr>
<td>O/P actuators</td>
<td>Vehicle acceleration, steering, speed</td>
<td>Vehicle acceleration, steering, speed</td>
<td>Vehicle acceleration, steering, speed</td>
</tr>
</tbody>
</table>

5. COMPARATIVE STUDY OF PASSIVE SAFETY SYSTEMS

Passive safety systems do not come to life until there is no call from the system work so, these systems come to life when the vehicle meets with an accident and it helps to reduce the level of injury at the time of collisions. Seat belt systems, Crumple zones and Air bags are the chosen passive safety systems under this category. The passive safety systems are deployed automatically when the car faces collision to certain impact. The vehicles taken into consideration for the comparative study of the three above mentioned passive safety systems are as follows:

- Mercedes Actros truck
- Ford F-150 raptor
- Volvo FH truck

5.1 Seat Belts

It is a safety device made to securely hold the driver or the passenger during emergency braking or during a collision. It reduces the chances of head injury and prevent the person to fall out of the vehicle.

Seat belt is a safety device that reduce the risk of the injuries at the time of road accident \[^{11}\]. It is designed to absorb the force of the impact and to hold the driver or the passengers. The seat belt comprises of polyester strip, retractors, seat belt buckles, seat belt tongues and seat belt pillar loops. The different types of seat belts found in vehicles are as follows:

- Two-point seat belt
- Lap belt
- Sash belt
- Three-point seat belt

Figure 4. Data showing number of persons killed due to non-wear of seat belts
Figure 4 is the data taken from MORTH official website where the number of persons killed due to non-wear of seat belts and its change in to number of deaths in percentage is shown.

5.1.1 Need
The safest way to derive a vehicle is to buckle up the seat belt. According to the MORTH, as shown in figure 4, the number of persons killed due to non-wear of safety belts during 2019 is 20,885 which is about 14.5% less than that of 2018 [12]. From the data above, it is clear that the use of seatbelts plays vital role in saving thousands of lives every year.

5.1.2 Architecture

![Architecture of seat belt](image)

5.1.3 Comparison of seat belt system employed on different vehicles at various operating parameters

Table 4. Comparison of seat belt system employed on different vehicles at various operating parameters

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Mercedes Actros truck 2019</th>
<th>Ford F-150 raptor 2020</th>
<th>Volvo FH 16 truck 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model/Manufacture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated seat belt Hight</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>adjustment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Automatic locking mode</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Safety belt warning light</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>and chime</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crash sensors and monitoring system with readiness indicator</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Inflatable Seatbelt</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Supplementary Restraint</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>System (SRS) mechanism</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seat belt material</td>
<td>Polyester</td>
<td>Polyester</td>
<td>Polyester</td>
</tr>
</tbody>
</table>

5.2 Crumple Zone
Crumple zone is also known as crush zone [15]. From the name, it clearly signifies that it is designed to crush when the vehicle suddenly collides with significant amount of force with objects like other vehicles, house, etc. Thus, it acts as a cushion that extends the deceleration time of the vehicle transferring less impact to the driver and the passengers.

5.2.1 Need:
During an accident, crumple zone preserves to convert the kinetic energy of the vehicle into controlled deformation. It helps the vehicle to take more time for deceleration due to which the effect of the impact force is decreased, hence increasing the possibility of the driver’s and passenger’s survival [16].

5.2.2 Architecture:

![Architecture of crumple zone in vehicles](image)
5.2.3 Comparison of crumple zone system employed on different vehicles at various operating parameters

Table 5. Comparison of crumple zone system employed on different vehicles at various operating parameters

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Mercedes Actros2644 LS truck</th>
<th>Ford F-150 raptor</th>
<th>Volvo FH 16 truck</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model/Manufacture</td>
<td>2019</td>
<td>2020</td>
<td>2020</td>
</tr>
<tr>
<td>Chassis type</td>
<td>Ladder frame chassis</td>
<td>Ladder frame</td>
<td>Ladder frame chassis</td>
</tr>
<tr>
<td>Material used</td>
<td>Steel frame</td>
<td>High strength steel frame</td>
<td>Steel frame</td>
</tr>
<tr>
<td>Length of chassis</td>
<td>6867mm</td>
<td>220 inches</td>
<td>6700mm</td>
</tr>
<tr>
<td>SOS Post-Crash Alert System</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

5.3 Air Bag

Air bags are proven to be the quickest life-saving passive safety system that is designed so efficiently that they inflate and deflate with in no time during the collisions to save the passengers from major damage \(^{[15]}\). These air bags work their optimum when combined with seat belts. It consists of a fabric bag, inflation module, and an impact sensor.

5.3.1 Need:

According to the NHTSA report, from the year 1987 to 2018 \(^{[16]}\), frontal air bags have saved 50,459 lives. When an accident is occurred, the impact sensor transfers the signal to the ECU and from there, the signal is transferred to the air bag and due to that, the air bag inflates with in few milliseconds or less than 1/20\(^{th}\) of a second and deflates very rapidly. If a problem is occurred in the inflation of the air bag, it could lead to death of the fatalities.

5.3.2 Architecture:

![Architecture of air bag employed in vehicles](image)

5.3.3 Comparison of air bag system employed on different vehicles at various operating parameters

Table 6. Comparison of air bag system employed on different vehicles at various operating parameters

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Mercedes Actros2644 LS truck</th>
<th>Ford F-150 raptor</th>
<th>Volvo FH 16 truck</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model/Manufacture</td>
<td>2019</td>
<td>2020</td>
<td>2020</td>
</tr>
<tr>
<td>Number of air bags in the vehicle</td>
<td>2</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Chemical used (Reactants)</td>
<td>NaN3, KNO3, SiO2</td>
<td>KNO3, SiO2, NaN3</td>
<td>SiO2, KNO3, NaN3</td>
</tr>
<tr>
<td>Opening time</td>
<td>1/20(^{th}) of a second</td>
<td>1/20(^{th}) of a second</td>
<td>1/20(^{th}) of a second</td>
</tr>
</tbody>
</table>

6. PATENTS

6.1 Patents Under Passive Safety Systems

6.1.1 seat Belt

I. US6955403B1: Seatbelt routing and restraint system (Mary A. Weaver) 2007
   - A set of belt adjustments are found between the mid-section and the upper edge of the rectangular sheet for varying the location from where the shoulder-belts extend from the rectangular sheet.
   - A set of belt adjustments include loops that accept the shoulder-belt which are attached to rectangular sheet.

II. US6767055B1: Vehicle seat frame and belt assembly (C. Michael Sparks) 2007
   - The vehicle seat and restraint assembly and forwardly and rearwardly facing abutments of struts are flashily mating when in engaged position.
   - The first strut is fixed at an angle of about 55 degrees relative to seat frame, and second strut is fixed at an angle of about 35 degrees relative to back frame.

   - This seating system includes a seat back with one or more plastic panels that extend across a lateral distance of the seat back.
   - The seat back mostly consists of more than one path forming ribs.
IV. US6871876B2: Seat belt restraint system with double shoulder belts (Zhaoxia Xu) 2004
   - The upper end of shoulder belt is extendable and retractable to the upper portion of seatback adjacent the occupant's shoulder.
   - The mechanism interlocks the lower ends of both shoulder belts and the first end of middle portion belt.
V. WO2008054485A1: Seat belt system for a vehicle (John Bell, Martyn Palliser, George Gordon Milton Smith) 2002
   - The lower limit of the strap defines a stop comprising a protrusion of thickness greater than the width of the first slot of the adjustable webbing guide on the strap.
   - To lock the adjustable webbing guide, vertically spaced apart holes is created to the strap such that retractable projection inserts through those holes.

6.1.2 Air Bag
   - An inflatable curtain has a first chamber and a second chamber that inflates toward the front of the first chamber.
   - The second chamber has a height above the height \( \text{[17]} \) of the first chamber so that the lower part of the second chamber is pressed downward while being adjacent to a door of a vehicle.
II. JP6294963B2: Wrapped side impact airbag system and method (Ma Dae Hyong) 2014
   - In the airbag assembly, the deployed configuration has the lower segment angled on the lower segment such that the outer surface of the inner fabric layer faces upward.
   - In the deployed configuration, the second chamber is typically positioned between the vehicle occupant's head and an occupant area occupied by at least one of the vehicles.
   - The airbag module comprises of an airbag cushion to be inflated by means of a gas generated by a connected inflator and thereby to be deployed from the airbag module.
   - An airbag deployment guide takes the form of a vehicle installed \( \text{[18]} \) airbag module which is provided with an inflator to the inflatable airbag cushion in the vicinity of a cavity.
IV. EP1583675B1: Airbag system (Dirk Meissner, Sami Al-Samaaree) 2003
   - In this paper, there is minimum combination of one supplementary and main bags respectively.
   - That supplementary airbag has a lower volume in order to increase the depth of deployment and/or to alter the direction of deployment of the main airbag.
   - The thickness of the airbag is made to be between 2mm-25 mm when it is uninflated.
   - An attachment mechanism may also be attached to the airbag designed to attach the airbag to the vehicle door.
VI. US7063350B2: Dual chamber side airbag apparatus and method (Daniel L. Steinke, Brian M. Lighthall) 2003
   - The airbag module has a cushion with a pelvic chamber \( \text{[19]} \) and a thoracic chamber.
   - The housing has an aperture disposed within each of the chambers such that when the inflator deploys, the pelvic chamber is inflated to a relatively higher pressure \( \text{[21]} \).

6.1.3 Crumple Zone
   - The beam member includes a weak portion configured to be weak against a load inputted in a vehicle longitudinal direction.
   - An extension portion is configured to prevent the steering member receiving the input load from sliding toward the passenger-seat side by contacting the hinge pillar \( \text{[22]} \).
II. AU2012216535B2: Support structure including a unidirectional crumple zone (Luke Adrian Mcloughlan, Gregory Nagel) 2012
   - A unidirectional crumple zone is attached to the frame between the attachment end and the distal end, and defines a crumple zone face substantially orthogonal to the compression axis.
   - An anvil member, such as a spacer block covers only a portion of the crumple zone face and has an edge substantially parallel to the crumple zone face.
III. US7699347B2: Method and apparatus for a shared crumple zone (Stephen D. Shoap) 2008
   - A first bumper is connected to the distal end of the first elongated member whereas a second elongated member has a proximate end and a distal end.
   - The proximate end is proximate and approximately perpendicular to a second face of the container and a long axis of the second member intersects the second face.
IV. DE102006041092B4: Crumple zone of a body of a motor vehicle (Martin Kruse, Ralf Grosser, Jürgen Stegmaier, Andreas Graf) 2006
   - In crumple zone, the cross member designed as a connecting component of the safety passenger compartment is assigned to the motor vehicle.
   - Crumple zone contains the hollow chambers of the body component extended in the vehicle vertical direction.
   - The plate member is having a multi-stage U-shaped cross-section which acts as the vehicular shock absorbing front bumper device.
   - The multi-stage U-shaped cross-section is characterized by a three-stage U-shaped cross-section, the vehicular shock absorbing front bumper equipment.
VI DE4414432A1: Vehicle with integral crumple zone (Albrecht Dr Ing Hartmann, Joerg R Bauer) 1994
- The outer shell encloses the vehicle's front bumper and at least a greater part of a section forming the front of the vehicle from the bumper to the lower edge of the windscreen.
- The vehicle has side panels integrated into the door panels. Between the extended panels and the chassis structure is located at least part of an air-bag.

6.2 Patents Under Passive Safety Systems

6.2.1 Lane Change Assist
I. US9415776B2: Enhanced lane departure system (Oliver Schwindt, James Kim, Bhavana Chakraborty, Kevin Buckner, Brad Ignaczak) 2014
- This highlights the positions of the sensor on the host vehicle considering the parameters affecting the performance of lane departure system.
- It explains the working of the control system [23].
II. DE102014116225B4: Lane change assistance apparatus and method of operation therefor (Soon Jong Jin) 2014
- It tells us about the apparatus used in cars/vehicles.
- It tells us about the operation of different type of sensors and cameras.
III. EP1598233B1: Lane change assist system (Hikaru Nishira, Taketoshi Kawabe) 2004
- This highlights about the working of the lane change assist system
- It explains about the processing going on inside the system so that it can help the host to turn the vehicle and at a desire speed [24].

6.2.2 Hill Descent Control
I. US10597032B2: Vehicle speed control system (James Kelly, Andrew Fairgrieve, Daniel Woolliscroft) 2018
- It comprises more than one ECUs that applies torque to the required vehicles and provides the signal to locate the position of slip in the wheels.
- The ECUs further receive the target speed input from the user and maintain the speed by adjusting amount of torque and slip detection.
II. US10155513B2: Methods and systems for a vehicle driveline (Gregory Michael Pietron, Adam Nathan Banker, Dennis Craig Reed, Seung-Hoon Lee, James William Loch McCallum) 2017
- The manual input of engine stop conditions in a hill descent mode is allowed in the method.
- The manual input of driveline disconnects clutch operating mode conditions in a hill descent mode.
III. EP2139740B1: Assistance system for driving in slopes for automobiles (Philippe Blaise, Emmanuel Charpin, Damien Joucgoux) 2008
- It includes sensors for driving assistance and correcting path for electronic calculators.
- Hill Assist Module (HAM) and Hill Descent Control Module (HDCM) falls under Hill Assist Descent Control Module (HADCM).

6.2.3 Adaptive Cruise Control
- It maintains a pre-set speed input by the user relieving the load of braking.
- If the other vehicle comes near the vehicle, the driver needs to decelerate himself.
- The system controls the regenerative braking system to reduce the speed of the wheels of the vehicles.
- The system itself controls the activation and deactivation of braking according to the traffic lights changes confronted by the vehicles.
III. EP3052961B1: Adaptive cruise control with on-ramp detection (Freddy RAYES) 2014
- The system mechanically performs control of a mass vehicle longitudinally to account for merging vehicles.
- This provides techniques to automatically detect the ramp on the way of the vehicles and find a relative speed.

7. CONCLUSION
- According to WHO report, the number of deaths just because of the road accidents is nearly about 1.35 million per year. This huge number of deaths make safety issues to be the prominent one while purchasing vehicles.
- Both active safety system and passive safety system are equally important as former one alert the driver before mis-happening whereas the latter one protects the driver as well as passengers from major injuries after the accident is occurred.
- In this review study, we have discussed some of the different safety systems provided by the N-type vehicles and compared their performance parameters with three different vehicles of N-type. In active safety systems, comparing the three systems i.e. Lane change assist, Hill descent control and Adaptive cruise control of the three vehicles, all the vehicles were having almost same parameters of performance.
- In passive safety systems, comparing the vehicles on the basis of systems as seat belts, crumple zone and airbags, Ford F-150 raptor has more features accompanied in the systems like inflatable seat belts, SRS mechanism, more number of airbags in the vehicle, etc.
- Therefore, our comparative study shows clearly that Ford F-150 raptor is the safest among all three vehicles we have chosen to compare on the basis of their various safety features.
REFERENCES