A Comparative Study Between Different NCAPs and The Future of BNVSAP

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Abstract. India is the third largest road network which is used by one percent of the world’s total vehicle population. On this road network six percent of the total of global road traffic accidents occur. India is the sixth-largest car market in the world but is still the only country amongst the global top 10 car markets to not have a testing program. To reduce the number of road traffic accidents, many countries have come up with safety programmes such as Euro NCAP (New Car Assessment Program), US NCAP, Latin NCAP, etc. In 2014, Indian government proposed a similar safety assessment program called as Bharat New Vehicle Safety Assessment Program (BNVSAP) but it is since delayed in its implementation due to a number of reasons. The aim of this study is to compare existing NCAPS and the new BNVSAP and propose some improvements in it by studying the experiences gained by the older NCAPs and observing the difference in the situation of road traffic in India and in other countries by analysing real world accident data.

1. Introduction
India being a developing country doesn’t have a strong infrastructure to enforce traffic rules (such as speed cameras, traffic monitors, etc.). There were about three million new car registrations in the country with the customers not knowing about the safety ratings of their vehicles. The consumers aren’t aware nor are educated about the importance of safety ratings for cars. Therefore, the start of a new crash assessment programme as soon as possible is a must. In 2019 almost 154 thousand people died in road accidents with over-speeding being one of the main causes. To bring the cost down automakers oftendon’t include airbags in their low budget offerings or just one in front of the driver which is the reason why most Indian cars tested abroad failed to pass the crash tests. A successful evaluation programme must be able to adapt to changes and new developments. Experiences from older programmes such as US NCAP and Euro NCAP should be studied and used to improve existing plans. Different NCAPs have different circumstances which should be taken into consideration. Said circumstances include real- world accident data, financial status of area, consumer market, etc.

Dummy readings are used to evaluate risk factors that help replicate real-world accidents. An effective evaluation programme must be easily accessible to all consumers. Any customer in the market looking for a new vehicle must have access to authentic ratings. Social awareness through publication mediums (such as magazines and newspapers) and on the internet.
2. Literature Review

A reliable tool for depicting crash tests on automobiles are computer software. They have a great effect on crashworthiness of a car as they decrease the time and cost spent in development of the automobile. Simulations are done on computer software to decrease the number of tests and to optimize the design of the automobile. This kind of simulation is done by Ambati et al. [1] in their research paper. They took a model of Chevrolet C1500 pick-up truck and simulated it for frontal impact crash tests. The computer software they used was LS-DYNA. They validated the results from the actual test performed by National Crash Analysis Centre (NCAC). They found that almost half of the energy of the impact is absorbed by the engine, bumper and rails in 0.04 sec after the initiation of the crash. They also noticed that there is minimum intrusion of components in the cabin and minimum deformation of the cabin.

The physical tests are done to validate the performance of an automobile in terms of its crashworthiness. In crashworthiness engineering, there are useful techniques called as state of art technique which use FEA (finite element analysis) and lumped parameter models or full car and component tests. U.N. Gandhi [2] put forward an analytical model which consists of two parts: a transfer function part which consists of ARMA (Autoregressive moving average) of white noise and the second part is a differential equation which consists of stiffness, damping characteristics and mass. The lumped parameters which are present in the model are time varying and they correlate with the structural characteristics involved during crash test. The important of this technique is seen by its ability to predict structural parameters from frontal and side impact test data.

Similar to the gasoline vehicles, the crash testing of electric vehicles is also very interesting. They are also tested by the NCAP. Therefore, in their study Z. Zhang et al. [3] differentiated the safety tests of electric automobiles with that of gasoline automobiles. They researched the crash test procedure, crash standards of electric vehicle. They collected the data from both sets of tests and differentiated the gasoline automobiles with that of electric automobiles.

One of the most fatal injuries involved in car crashes are head injuries. Therefore, it becomes very important to study the biomechanical limits of human organisms. Erika et al. [4] researched the same and prepared an article in which they proposed a material which protect solid parts of the construction from damaging from collisions and simultaneously it should be light in weight. They found that DIN 1.4301 steel was the optimum material as it can resist a collision at 24 km/h and the strain member completes RCAR requirements. Not only the strength and stiffness of the car was improved but it was light in weight and more fuel efficient.

One of the emerging topics in the field of safety in traffic accidents is high voltage safety in electric vehicle. This field includes the study of design of high and low voltage cables in automobiles, integrity of high voltage components of the vehicle after its crash, high voltage cut-off safety, crashworthiness of automobiles. Lian et al. [5] provided a solution to improve the HV safety performance in a rear impact type collision. They also made possible that the high voltage safety requirements of the vehicle are met according to Chinese regulations and FMVSS (US Federal Motor Vehicle Safety Standard) 305 for a rear impact at a speed of 80 km/h.

Nowadays, many safety systems are equipped with automobiles to decrease the number of crashes and personal injuries, more importantly fatal injuries. One such popular safety system is ESC or ESP (Electronic Stability Control). The major production of this feature started in 1998. The role of this system is to hold on the automobile in control in difficult maneuvering conditions such over- steer or under-steer through braking wheels separately and/or by regulating engine power [6]. Tingvall et al. [7] took the data of car crashes happening in Sweden in between 1998 to 2004 and showed the positive impacts of this system on real life crashes. They did a statistical analysis on the data and found that the effectiveness of ESC on all kinds of crashes was 16.7 ± 9.3% and the effectiveness of crashes with injured occupants was 23.0 ± 9.2%. This shows how effective it is in reducing car crashes and fatal injuries.
3. Analysis of road accident scenario at national level

According to a report in 2018 by WHO, India comes first in terms of the number of road accidents occurring in a year. Even the most populous country, China, is behind India in this situation. Current situation of road traffic accidents in India is very concerning as it is worsening each year instead of improving which is generally the case in most countries. According to the latest data of the year 2019 provided by NCRB (National Crime Records Bureau) [8], a total of 4,37,396 road accidents were reported in 2019 in which 4,39,262 were injured and 1,54,732 people died. As a result, the rate of deaths per thousand vehicles has increased from 0.6 in 2018 to 0.61 in 2019 (See Table 1). A large percentage of about 13.7% of the total road accidents deaths were due to car accidents.

The state wise distribution reveals that the highest share of the total fatalities was of Uttar Pradesh with 15.8% (3,355 out of 21,196). According to the distribution by month, the highest road accidents occurred in the month of January with 40,548 and least in the month of September with 31,441. By distributing the total road accidents time-wise it is observed that between 18:00 hrs to 21:00 hrs, 19.0% of the total number of road accidents occurred (83,097 out of 4,37,396) which is highest followed by 17.4% during 15:00 hrs to 18:00 hrs and 15.3% during 12:00 hrs to 15:00 hrs. When distributed cause-wise, it shows that one of the major causes of road accidents deaths is due to defect in mechanical condition of motor vehicle and it accounts for 1.3% (2045 out of 1,54,732) [9].

| Sl. No. | Year | Road accidents (In thousands) | Persons Injured (In thousand) | Persons Killed (In Nos.) | No. of Vehicles (In Nos.) | Rate of Deaths per thousand Vehicles (COL.7/COL.9) |
|--------|------|-------------------------------|------------------------------|-------------------------|--------------------------|-----------------------------------------------|
| 1      | 2015 | 464.7                         | 482.4                        | 1,48707                 | 2,10,023                 | 0.71                                          |
| 2      | 2016 | 473.0                         | 485.5                        | 1,51,801                | 2,30,031                 | 0.66                                          |
| 3      | 2017 | 445.7                         | 456.2                        | 1,50,093                | 2,53,311                 | 0.59                                          |
| 4      | 2018 | 445.5                         | 446.5                        | 1,52,780                | 2,53,311                 | 0.60                                          |
| 5      | 2019 | 437.4                         | 439.2                        | 1,54,732                | 2,53,311                 | 0.61                                          |

Table 2. Annual summary of road accidents in Great Britain [10].

| Year | Fatality | Serious injury | Slight injury | Total injury |
|------|----------|----------------|---------------|--------------|
| 1980 | 5,953    | 60,000         | 275,000       | 323,000      |
| 1990 | 5,217    | 32,000         | 275,000       | 336,000      |
| 1997 | 3,599    | 32,000         | 275,000       | 324,000      |
| 1998 | 3,421    | 41,000         | 281,000       | 322,000      |
| 1999 | 3,423    | 39,000         | 278,000       | 317,000      |
| 2000 | 3,409    | 38,000         | 279,000       | 317,000      |
| 2002 | 3,431    | 36,000         | 263,000       | 299,000      |
| 2004 | 3,221    | 31,000         | 245,000       | 278,000      |
| 2006 | 3,172    | 29,000         | 226,559       | 255,000      |
| 2008 | 2,538    | 26,000         | 202,333       | 228,000      |
| 2010 | 1,857    | 20,803         | 185,995       | 206,798      |
| 2012 | 1,754    | 23,039         | 170,930       | 193,969      |
| 2014 | 1,775    | 22,807         | 169,895       | 194,477      |
| 2016 | 1,792    | 24,101         | 155,491       | 179,592      |
| 2018 | 1,782    | 25,484         | 133,112       | 160,378      |
| 2019 | 1,870    | 27,820         | 129,820       | 157,630      |
Table 2. shows the gradual decrease in fatalities caused by road accidents after the formation of Euro NCAP in 1996. There are various other factors affecting the statistics such as stricter traffic rules, technological advancements, etc. but gives great hope.

4. Comparison between different NCAPs

4.1. US NCAP

National Highway Traffic Safety administration (NHTSA) first carried out safety evaluating crash tests in 1979. Initially only frontal crash was evaluated but with time new tests were introduced including the side crash test in 1997. The tested cars are awarded with ratings between one star to five stars to illustrate the results conveniently to the consumers. US NCAP assessments comprises of four broad areas [11]:

- Adult Occupant Protection (for the front occupants);
- Child Occupant Protection;
- Pedestrian Protection
- Safety Assist, which evaluates driver-assistance and crash-avoidance technologies.

Our focus will be on the adult occupant protection which include the following tests:

4.1.1. Frontal Crash Test

The test vehicle is driven into a rigid barrier with full overlap with a test speed of 56 km/h. The car has an average-sized male dummy in the driver seat and a female dummy of small size in passenger seat with both dummies being secured with seat belts. Car structures need to be stiff to reduce lower leg and head injuries. This test also assesses the restraint system of the car, such as airbags and seatbelts.

4.1.2. Side Barrier Crash Test

To represent an intersection type accident a 3015 lb. (1367 kg) moving barrier at a speed of 38.5 mph (62 km/h) is crashed into the standing test vehicle. The aim of this test is to evaluate the injuries to the head, abdomen, chest and pelvis.

4.1.3. Side Pole

This test involves launching the vehicle at 75-degree angle at 32km/h towards a rigid and narrow pole in the vicinity of the driver. Head protection is of utmost importance in this test. This test is formalized to test the car’s capability to guard the driver’s head, chest and pelvis on impact.

4.2. EURO NCAP

Europe’s car safety assessment programme also known as Euro NCAP was formed in 1996 for safer cars. It is a voluntary non-profit to provide consumers with apt safety information of new cars available in the market. This programme includes various tests like frontal and side impact crash test to evaluate the car and give a star rating out of five. It is not compulsory for manufacturers to get their vehicles tested. The vehicle models chosen for testing are either selected by Euro NCAP or sponsored by manufacturer. Euro NCAP also assess the potential risks to vulnerable pedestrians on collision with the vehicle at city speeds. Head, lower leg and upper leg impact on the bumper and bonnet are tests using dummy. They give extra points for effective pedestrian collision prevention [12]. Adult occupant protection tests are:

4.2.1. Mobile progressive deformable barrier

The test vehicle is launched at 50 km/h towards a deformable moving barrier mounted on an oncoming trolley of weight 1400kg, also moving at 50 km/h with a 50% overlap. The aim of the test is to evaluate the crumple zones and the compatibility of the test vehicle.
4.2.2. Side mobile impact barrier
Same setup as US but speed is again reduced from 62 km/h to 50km/h. Since there is little energy absorbing space on the side of the vehicle, this test has encouraged stronger B-pillars and side airbags.

4.3. LATIN NCAP
Latin New Car Assessment Program was founded in 2010 to assess the safety levels of new cars for the Latin America and Caribbean. Latin NCAP awards vehicles with a safety rating between 0 and 5 stars. This programme provides safety ratings based on the assessment of adult occupant protection, child occupant safety, pedestrian and liable road user’s protection and safety assistance systems offered by the various vehicle models. The adult occupant protection includes the following 3 major crash tests:

4.3.1. Frontal Impact Test
The frontal impact test is performed at 64 km/h where the car is crashed into a deformable barrier with 40% of its width front on the driver side (offset). Results obtained from the crash test dummies are used to assess safety provided to adult occupants in the front seat. This test encourages manufacturers for prevent excessive Intrusion in the cabin and to install advanced restraint system.

4.3.2. Side Impact Test
Vehicles are tested with the same setup as the Euro NCAP’s Side mobile impact barrier test.

4.3.3. Side Pole Impact Test
This test involves launching the vehicle laterally at 29 km/h towards a rigid and narrow pole. Head protection is of utmost importance in this test.

Additionally, new technologies include the Autonomous Emergency Braking (AEB) low-speed system which uses forward-looking radar, cameras or optical sensors or a combination of these to help quickly and accurately detect vehicles, pedestrians or other potential obstacles and the apply the brakes in low-speed situations.

5. The proposed NCAP for Indian market: BNVSAP
Bharat New Vehicle Safety Assessment Programme (BNVSAP) is a proposed NCAP for the Indian market which was initially expected to begin mid-2014 but is since postponed. The tested cars will receive star ratings based on their performance in various tests with credits given for inclusion of features such as ABS, ESC, EBD, etc. [13]. This will also help boost the number of cars exported to foreign markets. The proposed crash tests are:

5.1. Frontal Impact Test
The frontal impact test is performed at 56km/h where the car is crashed into a deformable barrier with 40% of its width front on the driver side (offset). Results obtained from the crash test dummies are used to assess protection given to adult occupants in the front seat. This test encourages manufacturers to prevent excessive Intrusion in the cabin and to install advanced restraint systems.

5.2. Side Impact Test
A barrier which is deformable is attached to a trolley which is propelled with a speed 50 km/h towards the static test vehicle at right angles. This has driven the development of stronger B-pillars with energy-absorbing structures in door panels and the addition of curtain airbags in cars.

Gradually cars will be required to meet tougher regulations and as time progresses more features will be made compulsory like airbags and anti-lock braking system. Some new safety features include automatic emergency braking at low speed, hill descent assist, side crash avoidance, etc. but can currently only be found in expensive options. Global NCAP is a charity project, which serves as a harmonization tool between various NCAPs. Today’s car market is globalized, where companies sell...
the same vehicles and vehicle platforms in different parts of the world [14]. Global NCAP aims to bring technical knowledge and support to emerging car markets. Their aim also includes promotion of information exchange between various NCAPs and social awareness [15].

6. Conclusion
A successful evaluation programme must be able to adapt to changes and new developments. Experiences from older programmes such as US NCAP and Euro NCAP should be studied and used to improve existing plans. Due to the late arrival of BNVSAP, the addition of new tests (such as side pole test) and technologies as quickly as possible is a must to maintain a global standard. Different NCAPs have different circumstances which should be taken into consideration. Said circumstances include real-world accident data, financial status of area, consumer market, etc. These tests encourage manufacturers to build safer vehicles for passengers and lead to development of new technologies to avoid accidents. Companies boast their car’s ratings if they have successful crash tests through advertisements which encourages other competing companies to introduce safer alternatives. Nowadays manufacturers use a combination of materials in their chassis such as steel, aluminium and carbon fiber to find the required combination of strength, rigidity and lightness. Low Young’s modulus and energy absorbing materials should be selected for B-pillars, etc. Steel and aluminium are the most common materials used in commercial vehicles today.

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