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## Application of quality function deployment for design improvement of car rear seat design

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### ABSTRACT

*Quality function deployment has been widely used to capture the voice of the customer and translate it into technical requirements in the development of products and services. It is a link between product or service development and technical specifications to achieve customer satisfaction. The refinement of restraints for rear seat passengers remains a developing field in automobile safety. Boosters have been shown to significantly reduce abdominal injuries caused by seatbelts. In this paper, an effort is made to use quality function deployment for increasing child safety. An opinion of customers is taken for improving the design of rear seat of a car considering child safety. A house of quality is prepared. Use of the same will be done in designing rear seat of a car.*

**Keywords:** Rear seat, Child safety, Quality function development, booster, Voice of customers

### 1. INTRODUCTION TO QUALITY FUNCTION DEPLOYMENT

It is a quality tool that helps to translate the Voice of the Customer (VOC) into new products that truly satisfy their needs. First conceptualized in 1966 as a method or concept for new product development under the umbrella of Total Quality Control, Hinshitsu Tenkai (quality deployment) was developed by Dr. Shigeru Mizuno and Yoji Akao. Yoji Akao et al. detailed methods of quality deployment in 1972. The Japan Society of Quality Control formed a research group to specifically study Quality Function Deployment (QFD) in 1978. QFD is used to translate customer requirements to engineering specifications. It is a link between customers- design engineers- competitors- manufacturing. It provides an insight into the whole design and manufacturing operation from concept to manufacturing and it can dramatically improve the efficiency as production problems are resolved early in the design phase.

It is very powerful as it incorporates the voice of the customer in the designs - hence it is likely that the final product will be better designed to satisfy the customer's needs. Moreover, it provides an insight into the whole design and manufacturing operation (from concept to manufacturing) and it can dramatically improve the efficiency as production problems are resolved early in the design phase.

### 2. CHILD SAFETY & CAR REAR SEAT

As most rear-seat occupants in the U.S. are children, the rear-seat design standards in U. S. has to consider the smaller body dimensions and different restraint needs of this population.

The protection of children in motor vehicle crashes has improved since the introduction of child restraint systems. However, car crashes are the second leading cause of death for children. Different parts of the world face different challenges with regards to protecting children in traffic. In countries like India and China, child pedestrians face considerable risks of injury and fatality, and child car occupants are rarely protected with restraints developed specifically for children.

In, for example, North America, Australia, and Europe, child restraints are mandatory for child occupants and still 32% of European road traffic fatalities for children up to 14 years of age involved car occupants. Hence there is a need to continue research, education and policy activities to enhance the safety of children in all parts of our world.

Figure 1 shows few images of normal rear car seats available in different cars.



Fig. 1: Normal Rear Car Seat

Child restraint systems are designed specifically to protect children from injuries or death in case of a car collision. The use of CRS is legally prescribed in many countries and usually, these seats are bought and installed in cars by consumers.

Child safety seats have to be corrected to be effective. However, in some cases, a correct installation is very difficult to achieve. According to several studies the misuse rates have been shown to be high, meaning that risk of injuries is increased in case of a collision. In case of families with more than one child, two or more separate CRS have to be installed, which means that the problems started before being multiplied.

In addition, in some cars, there is a very little space on the rear seats to manage well the CRS and when two separate CRS are being placed there is not enough space for a possible third occupant.



Fig. 2: Child restraint systems & its fastening to cars

As the seat belts cannot be positioned properly for children of different age groups, boosters are used for the same. There are two types of boosters. First one is backless booster which is only adjusting only the vertical distance for belt positioning. But in most current vehicles, the rear seats are not sized to accommodate children 12 and younger, who are about half of the rear-seat occupants. In one survey of vehicle second-row seats, the median rear seat cushion length was found to be 455 mm, longer than the thigh length of most rear-seat occupants of all ages.



Fig. 3: Booster types

It was come to know that people are giving importance to the child safety. But there are no stringent rules/laws made by the Indian government.

### 3. INITIAL REVIEW

Initially, discussions were held with few probable customers for the car and existing car owners about the various factors considered by them for purchasing a car. It was come to know that the child safety is one of the important factors considered by these customers.

Hence, further a detailed was carried out to know the customers' voice.

Further, a questionnaire was designed to know the "Voice of Customer" (VOC) to correctly identify the customer needs & to translate into the engineering characteristics/features. This study identified the customer needs by surveying probable customers for the car and existing car owners.

**4. DETAILED SURVEY**

A survey of more than 100 persons was carried out. The persons were mainly of 25 to 40 years ages who are likely to be customers for car manufacturers or they are already having a car. Few persons who were not belonging to this group, rather their age is more, is also taken to take the opinion of the senior persons. The survey was conducted by two methods. One is using direct online survey with the help of Google Forms. In the second method, feedback was taken directly by the respondents in hard copy. The questionnaire is having two parts. In the first part, information of respondent is taken. The second part is having an opinion about the requirements of customers.

**Questionnaire: Part- I**

1. Name of respondent: .....
2. Email Id: ..... Mobile No.: .....
3. Age: ..... Gender: .....
4. Marital status: .....No. of children: .....
5. Any other family member: .....
6. Profession: .....

**Questionnaire: Part-II**

The rear seat of a car is to be designed considering the safety of children. Please give your opinion about the following.

1. For how many children, safety arrangement should be done in the rear seat?
2. What orientation of rear seat would you like? a) Front facing b) Rear facing
3. Children of what age should be considered for safety consideration in the design of rear seat of a car?
4. Whether the seat should be solely designed for children or it should be designed for both children and adult persons also?
5. If for adults also, whether space below the rear seat should be used for the arrangements?
6. What would be the time in seconds within which seat should be converted from adult to children or vice versa?  
.....Seconds
7. Other suggestions (if any) .....

The opinion of the respondents is summarized in Table 1.

**Table 1: Summary of the opinion of respondents**

| Sr. No. | Questions  | Mostly appearing answer                  | Frequency |
|---------|--|--|-----------|
| 1       | For how many children, safety arrangement should be done in the rear seat?   | 2  | 85        |
| 2       | What orientation of rear seat would you like?<br>a) Front facing b) Rear facing  | Front facing                             | 88        |
| 3       | Children of what age should be considered for safety consideration in the design of rear seat of a car?                    | Up to 12 years                           | 90        |
| 4       | Whether the seat should be solely designed for children or it should be designed for both children and adult persons also? | For both children and adult persons also | 86        |
| 5       | If for adults also, whether space below the rear seat should be used for the arrangements?                                 | Yes                                      | 88        |
| 6       | What would be the time in seconds within which seat should be converted from adult to children or vice versa?              | 120 Seconds<br>(2 minutes)               | 89        |

**5. HOUSE OF QUALITY**

After taking the opinion of different persons during the survey, various factors related to design were reviewed. The House of quality is prepared for the design of the rear seat of the car considering the child safety.

**Table 2: Legend**

|    |   |   |
|----|---|---|
| ⊕  | Strong relationship                       | 9 |
| φ  | Moderate relationship                     | 3 |
| ∅  | Weak relationship                         | 1 |
| ++ | <b>Strong positive correlation</b>        |   |
| +  | <b>Positive correlation</b>               |   |
| -  | <b>Negative correlation</b>               |   |
| ∇  | <i>Strong negative correlation</i>        |   |
| ∇  | <i>Objective to minimize</i>              |   |
| ↑  | <i>Objective to maximize</i>              |   |
| ×  | <i>The objective is to hit the target</i> |   |

|   |                                |                 |                   | Column No.  | 1                | 2            | 3       | 4       | Competitive analysis (0=Worst, 5=Best)      |  |  |  |  |
|---|--------------------------------|-----------------|-------------------|---|------------------|--------------|---------|---------|---|--|--|--|--|
|   |                                |                 |                   | Quality Characteristics ("Functional requirements" or "Hows" →) | No. of accidents | No. of parts | Weight  | Volume  | All existing cars in India                  |  |  |  |  |
| Row No.   | Max. Relationship Value in row | Relative weight | Weight/Importance | Demedanded Quality ("Customer requirements" or "Whats") ↓       |                  |              |         |         |   |  |  |  |  |
| 1   | 9                              | 25              | 5                 | Correct installation  | ⊕                | ⊖            | ⊖       | ⊖       | No such features available in present cars. |  |  |  |  |
| 2   | 9                              | 15              | 3                 | Ease of installation  | ⊖                | ⊕            | ⊕       | ⊖       |   |  |  |  |  |
| 3   | 9                              | 15              | 3                 | Space remaining after installation                              |                  | ⊖            |         | ⊕       |   |  |  |  |  |
| 4   | 9                              | 20              | 4                 | Flexible for age groups   |                  |              | ⊖       | ⊕       |   |  |  |  |  |
| 5   | 9                              | 25              | 5                 | Foldable/convertible to normal seat                             |                  | ⊕            | ⊖       |         |   |  |  |  |  |
|   |                                | <b>100</b>      | <b>20</b>         |   |                  |              |         |         |   |  |  |  |  |
| Target or Limit value   |                                |                 |                   |   | Minimum          | Minimum      | Minimum | Minimum |   |  |  |  |  |
| Difficulty (0 = Easy to accomplish, 10 = Extremely difficult) |                                |                 |                   |   | 7                | 4            | 5       | 5       |   |  |  |  |  |
| Max. relationship value in column                             |                                |                 |                   |   | 9                | 9            | 9       | 9       |   |  |  |  |  |
| Weight/importance   |                                |                 |                   |   | 240              | 450          | 255     | 355     |   |  |  |  |  |

Fig. 4: House of quality

### 6. CONCLUSIONS

After taking a review of the various parameters for the design of rear seat of car & Quality Function Deployment, an effort is made towards implementation of Quality Function Deployment for the new design of rear seat of the car.

Following are the conclusions:

- Most of the customers want the child safety arrangement to be done for two children.
- Even though rear facing of the seat is safer than front facing, customers prefer a front facing seat only. This might be due to the emotional attachment to their children.
- Customers want the safety arrangement for their children of different age groups.
- Customers want the rear seat to be used for both their children & their parents (adults).
- Customers are ready to allow the use of luggage space below the rear seat to increase child safety.
- As per the customers, rear seat for child safety should be of quick change type requiring less time for the arrangement.
- Quality Function Deployment is a good tool to improve the existing products or systems considering customers' need.

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