CONCEPT AND DEVELOPMENT OF AN ERGONOMIC BOOSTER SEAT

Erik Nilsson and Victor Wolstedt

Department of Product and Production Development, Division of Design,
Chalmers University of Technology
SE-412 96 GÖTEBORG, SWEDEN
E-mail: mi1wovi@student.chalmers.se

In collaboration with:
Caran AB
Valdemar Noréns gata 3
SE-417 55 GÖTEBORG, SWEDEN

The purpose of this study was to design a new forward facing child car seat, taking into consideration the child's comfort and safety as well as ease of use for different users. Subjective, objective and theoretical methods were used to gather information. The study resulted in a new design with improvements in ergonomics and safety as compared to present child seats. The results have been verified by means of a digital car mock-up with child dummies.

Keywords: booster seat, child car seat, child safety, seating comfort, ergonomics.

1 Introduction

A third of the deaths of Swedish children in car crashes could have been avoided if the child had been seated in an approved child seat or if the seat had been used properly (Anund et al. 2003). A study at Chalmers University of Technology resulted in ergonomic guidelines for the design of a child seat. The conclusions of the study were that a child seat must have an adjustable seat, support the child's legs, be easy to use and have clear instructions for adjustments (Ingelsten H, Johansson Å. 2005)

2 Objectives

The purpose of our recent study was to develop a new forward facing booster seat. The focus was on safety, ergonomics and ease of use. A digital mock-up of the final design was produced to verify the geometry against a car interior including child dummies of the chosen age range.

The basic idea is that good ergonomics provides safety.

3 Methods

Subjective, objective and theoretical methods were used to explore design possibilities. Subjective methods were used such as a workshop and interviews with children. Objective methods used for benchmarking, anthropometric studies, ergonomics simulations and geometric studies. Theoretical methods were used for design evaluation as well as research about ergonomics and safety.

In the first phase of the project research in the areas of ergonomics and safety was undertaken. In Dinoff's (2004) an anthropometric study of children age 3-10 years recommend six body measures that define a good seat design. These parameters parameter were chosen for further

optimization and design work. Parallel to this a benchmark arrived at using four different child seats was set. Complexity, function and geometry were evaluated and also the seats were measured. To find out the children's opinion a two a half hour workshop with a group of eight year olds was held.

Function decomposition was preformed and the main functions broken down. The purpose of this was to transfer the problem to a manageable level (Johannesson H, Person J, and Pettersson D, 2004). The different sub functions were used to generate ideas and were formed into a morphologic matrix. This was then used to generate different concepts and finally one concept was chosen after being evaluated in a Pugh's matrix (Ulrich K T and Eppinger S D, 2003). The chosen concept, described in Results below, was further developed and a CAD model developed and used to perform ergonomic simulations in a virtual car environment.

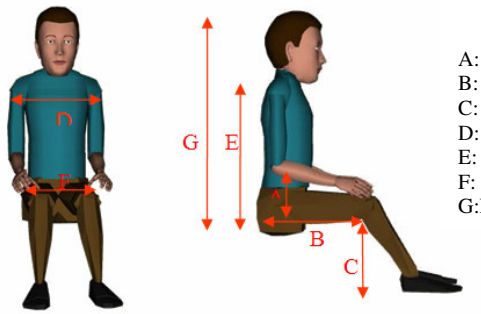
To evaluate the final design we used the ergonomics software Transom Jack together with child dummies in the ages 3, 6 and 10 together with a simple interior and exterior mock-up of a family car. The first task was to make sure that the seat would fit into the cars interior, witch is a major problem for many child seats. The second was to check that the seat would fit the chosen age range.

4 Results

The first part of the study was to define which ages we needed to target. According to Jacobsson L who has studied the use of child restraint systems, the biggest risk of injury occurs when the parents have switched from a rearward- to a forward facing system (Jacobsson L et al. 2005) One reason for this is that the parents switch too early so that the child is too small for the new system.

In the anthropometric study the key measurements for optimal comfort for the chosen population were defined, according to Dinoff M (2004). The results of this study is shown in figure 1, which shows that to fully satisfy the age range 3-10 the seat needed to be very flexible. For design reasons the seats adjustment was limited to 100mm in length and 100mm in height.

	MEASURE [mm]						
AGE	A	B	C	D	E	F	G
3 years 5 %tile	110	225	195	200	310	175	530
9 years 95%tile	230	405	380	320	490	285	750
DELTA [mm]	120	180	185	120	180	110	220



A: Elbow
B: Lower back-knee hollow
C: Knee hollow
D: Shoulder width
E: Shoulder height
F: Hip width
G:Head height

Figure 1, Key measurements (Pheasant S and Haslegrave C M 2006).

As a result of the study a new way of positioning a child was introduced. In today's seats the bottom of the child stays unchanged through out the age range so that the head of the child

changes position. In the final concept of the study the opposite has been implemented, the head is kept in the same position for the whole age range, but instead the bottom of the child is adjusted, as shown in figure 2.

This new design gives the youngest children a better view. It also helps to optimize the car's own safety systems for the whole age range. With the heads further up the smallest children can now benefit from the car's inflatable curtain more efficiently in lateral crashes.

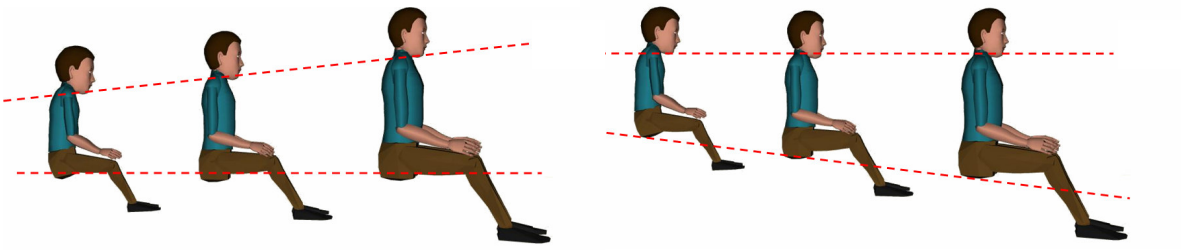


Figure 2, Comparison between today's seat and "Step Safety".

The final concept for the child seat is called "Step safety". The design is intended to be as simple as possible to avoid improper use. The placement of the belt must be self-evident so that there is only one way to place it over the seat and the child. If this is not done feed back must be immediate.

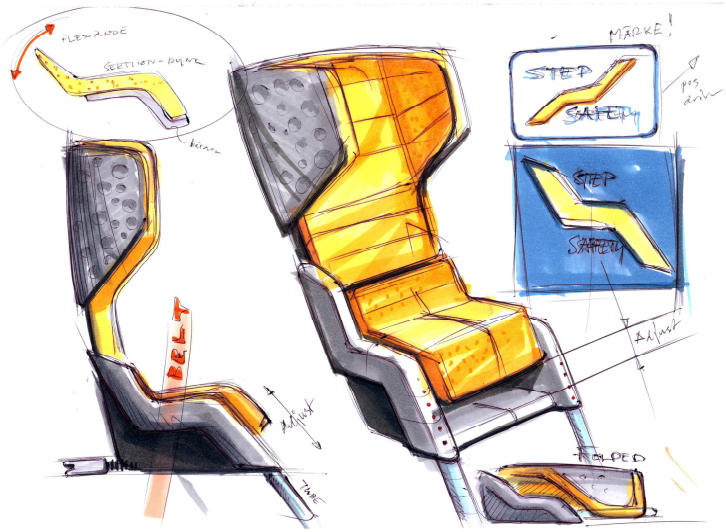


Figure 3, Concept sketch of "Step safety".

To give the child more stability, the chair is equipped with a footrest that can easily be adjusted the proper length. This helps relive pressure on the back of the thighs, which can reduce blood circulation and so cause discomfort.

To adjust the seat as the child grows the seat cushion is moved diagonally to cover the length of the back and at the same time adjust the thigh length, as seen in figure 4. The cushion is adjusted by first pulling a handle at the front of the cushion and then just sliding up or down. To let the parents know when the seat is adjusted correctly, a silhouette head on the headrest indicating the correct position.

Figure 4, Adjustments for the seat and footrest.

To further secure the seat, it is equipped with isofix claws. These help the seat to remain in the same position during a crash, especially in a lateral collision. It will also keep the seat more stable and hence more comfortable and secured in its position while not in use to avoid the risk of loose objects in the compartment during a crash.

When the child seat is not in use it folds easily the backrest which makes the seat compact and easier to handle and store. As seen in figure 5 the back has been folded and the foot rest used as handle.

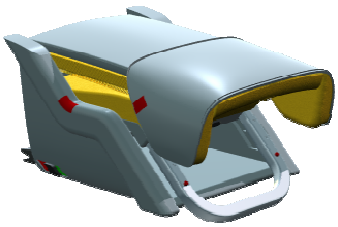


Figure 5, Backrest is foldable to facilitate storage.

5 Conclusions

- A new design for a child seat with ergonomics and safety taking into consideration. The higher position gives the child a better view.
- A diagonal adjustment of the seat improves the child's seating comfort and ease of use for the parents.
- A head silhouette on the backrest helps the parent to position the child correctly.
- Folding the backrest makes the seat easier to store.
- Isofix provides extra safety.
- A footrest helps to relive pressure from the thighs.

6 Discussion

To fit the child seat into a car seat taking into consideration different age groups of children turned out to be the biggest challenge during the project.

The seat is designed for children 3-10 years old. The recommendation from the Swedish road administration is to use rearward facing seats up to the age of 4 as the neck and pelvis are still

developing and the head is proportionally large. However as seen in Jacobsson L´s research parents tend to switch systems much earlier than recommended. This gave us the choice to either accept the recommendation or adapt the system to how we believe it will be used. The seat is designed to fit and protect younger children then 4 years, meanwhile we still believe that the Swedish road administrations recommendation should be followed.

In this study no real crash tests or studies with humans have been preformed. The improvements mentioned in the report are therefore only expected benefits and the next step as we see it is to produce a prototype to be used for ergonomics evaluation and to perform crash tests.

7 References

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