OPTIMIZING SEAT BELT USAGE BY INTERLOCK SYSTEMS

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ABSTRACT

Seat belts are known to be very effective, reducing the risk of injury by approximately 50% when used. Such high effectiveness is, however, based on the fact that all car occupants use the available belts. In several studies it has been shown that, in severe accidents, the seat belt use was less than 50%.

In order to increase the wearing rate more drastic solutions than information, legislation etc. have to be used. A Swedish group, representing government, research, insurance companies, car and restraint systems industry has approached the problem by proposing a smart system that will force car occupants, that normally are unbelted, to use the seat belts by systems that will interfere with the normal use of the car. Different technical approaches, which not in any way will interfere with the normal belt user, will be put forward and evaluated. The problem will also be discussed from a cost-effectiveness point of view and the potential of saving lives in an international perspective will be analyzed. It is shown that more than 6.000 lives could be saved per year in the European Union if the existing seat belts were used.

INTRODUCTION

For a couple of years there has been a concern within the Swedish road safety community about the fact that the safety potential of the seat belts is not fully used.

One of the first alarms came in a report from 1992 where fatally injured car occupants in Stockholm were studied. (Kamrén, 1992). The belt use in this group was only 40% compared to 80% in the general population.

At the last ESV Conference preliminary thoughts on a seat belt interlock system were presented by the Folksam Research Group. (Kamrén, 1994)

Another Swedish study of the belt use and the injuries showed again that the belt usage rate among severely injured was 50% in rural and 33% in urban accidents. (Bylund 1995)

In a Finnish study (Rathmayer, 1994) a clear pattern of the behavior of non-users was observed. Seat belt users committed one traffic offense in every 13 km on highways while the non-users committed one offense every 5,5 km. In urban traffic the distance between offenses was 9 km for the belted and 2,5 km for the unbelted. Non-users also drove faster and had driving histories with longer violation records than the control drivers.

Seat belt usage rates are generally observed in daylight. It can be assumed the rates are lower in darkness and in other situations where the risk for being caught without a belt is lower.

There are also a number of international research results that confirms these findings regarding the belt use and the non-user.

Being aware of that further campaigns and enforcement could only have a limited effect and that technical solutions like automatic belts were not realistic the Swedish National Road Administration last year formed a group of people representing the administration, research, insurance and car industry in order to analyze the situation and propose solutions. This paper reflects the thoughts of that group so far.

THE US EXPERIENCE

Because of various delays in introducing mandatory automatic protection in the USA in the beginning of the seventies the starter interlock requirement was introduced for the period August 15, 1973 until August 15, 1975 for vehicles without automatic protection produced during that period. These systems were connected to both front seats in such a way that if any front seat belt in an occupied seat was not locked, the starter was disabled. If a buckle was opened later a buzzer-light system was activated. All 1974 model year cars sold in the United States came with this ignition interlock except a few thousand GM models that came with airbags that met the automatic protection requirement.

In March 1974 NHTSA described the public reaction to the ignition interlock as follows:" Public resistance to the belt-starter interlock system currently required has been substantial with current tallies of proper lap-shoulder belt usage at or below the 60% level. Even that figure is probably optimistic as a measure of results to be achieved, in light of the likelihood that as time passes the awareness that the forcing systems can be disabled, and the means for doing so will become more widely disseminated,...". There were also speeches on the floor of both houses of Congress expressing the public's anger at the interlock system. On October 27, 1974 President Ford signed into law a bill that prohibited any Federal Motor Vehicle Safety Standard from requiring or permitting the use of any seat belt interlock system. NHTSA then deleted the interlock option from October 31, 1994.

Tlms the interlock systems were required in the USA for 14½ months instead of the 24 months that were originally intended. (Kratzke. 1995)

LESSONS TO BE LEARNED FROM THE US EXPERIENCE

The failure of the interlock systems in the USA 1974 can be explained by the following factors:

- Many people felt that it was an infringement of personal freedom. This is probably a typical US reaction that may not be valid for e.g. the European market.
- The voluntary seat belt use was very low.
- The belt systems that were used in the USA at that time were usually difficult to use and had a bad fit.
- The interlock system itself was too unsophisticated. It did not allow low speed maneuvers or sitting in the car with the engine idling.

NEW APPROACHES

Basic principles

Some basic principles for a new system have been established:

- The normal seat belt user shall not notice the system.
- It shall be more difficult and cumbersome to cheat on the system than using the belt.
- Permanent disconnection of the system shall be hard to make.
- The system must be very reliable and have a long lifetime.
- All seating positions in the car shall be covered by the system.
- The accident risk must not increase by any malfunctions in the system.
- Retrofit systems for old cars should be available.

Detection and processing

One input to any interaction system is the situation in the car. Which seats are occupied and are the belts properly used on these seats?

The basic sensor for an occupied seat is a contact that will detect a certain load on the seat. This concept can give false signals from e.g. luggage on the seats. Modern techniques with photocells, IR detectors, inductance, pattern recognition and load measurements on the seatback can be used to overcome most of the problems.

To determine if the belts are properly used is maybe more complicated. The US experience showed that simple systems like a switch in the buckle or measuring the amount of webbing coming out from the retractor could easily be tampered with. There is more information available from the belt system that could be used e.g. angles and forces at anchor points. Also sophisticated systems like pattern recognition or transponders in the webbing could be used.

Information from the doors, the seats and from the belt system can be combined and analyzed in such a way that the proper conclusions can be made.

Other problems that must be considered are how child restraint systems will work in this new environment and how to handle the situation when a passenger disengages his belt during travel. In that case it is probably not possible to influence the behavior of the car other than gradually and after some proper warnings to the driver.

Interaction

Several ideas for interaction could be considered, of which some are presented here.

The starter-interlock as used in the USA is the most aggressive solution. As mentioned above there are several shortcomings with this system so it is not on the agenda for the new approaches.

External visual signals is a new concept that is worth considering. By flashing the headlights or the hazard warning flashers the surrounding traffic (and the police) will notice the vehicle with non-belt users. The social pressure and the risk of being caught ought to be a good incentive to use the seat belts.

Internal light and sound warnings are used already in cars today but they can be made more aggressive and more directed to the individual non-user.

Interactions with comfort and audio systems is another approach that is discussed. This is a "soft" countermeasure but by disabling the radio, the air-condition, opening the windows etc. some users may get the message.

Throttle pedal feedback can also be used so that the force on the pedal will increase at a certain speed. This will make it possible but very tiresome to exceed that speed. Another solution may be to introduce severe vibrations in the pedal at a certain speed level.

Maximum gear level makes it impossible to put in any gear than number 1 and reverse. This takes care of one of the main faults with the US starter interlock which made it impossible to garage the car without using the seat belt. It also makes it possible to remove a stuck car from e.g. a railway crossing or a burning garage.

Maximum speed is a similar solution to the maximum gear level. The limit that is discussed so far is 30 km/h.

The final solution may be a combination of these systems i.e. the sequence can start with a visual and audible warning and then increase in intensity and finally reduce the maximum speed.

POTENTIAL EFFECTS

Sweden has got one of the highest seat belt use rates in the world with a front seat use of about 88% in observational studies. Other countries in Europe have a marginally higher use with UK in top with 91%.

In Sweden, the 88% use is to be compared to the less than 50% use among fatalities. The following table on the number of fatalities can be derived from the present situation in Sweden.

Table 1.
Seat belt use among fatally injured car occupants in Sweden 1994, based on a sample of 32 cases, and estimated number of fatalities with 100% belt use

	1994	with 100% belt use
Seat belt used	155	272
Seat belt not used	234	-
Total	389	272

	1994	with 100% belt use
Saved lives in relation to current seat belt use in Sweden (50% effectiveness)		117
Saved lives in relation to 0% seat belt use in Sweden (50% effectiveness)	155	272

The potential number of savings is 272 fatalities per year, but we have only come to a level where we have used 57% of the potential savings. This also shows that we have a higher benefit per user from the last 15% than we have had from the 85% seat belt use that we have today. This is different from other areas where the major benefits comes from the first part of an investment and with a decreasing marginal benefit. The relation between the seat belt usage rate in the population and the potential effect based on the Swedish situation can be described by the curved line in the following curve. A low usage rate gives a very limited effect since these individuals drive very safe anyway. The last 10% probably represents the most accident prone group so this is where we find the largest benefits from the belt use. The straight line describes the common belief that there is a linear correlation between the usage rate and the effect.

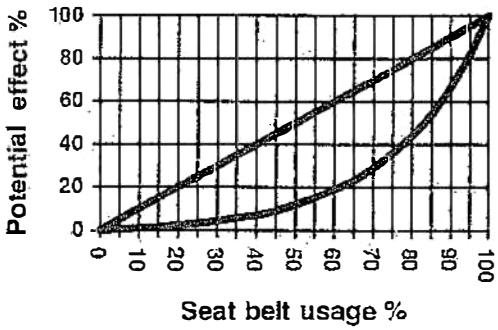

Figure 1. Correlation between seat belt usage and the potential effect on the fatalities.

If we use the Swedish figures and assume that the total European situation is not better, 15.200 belted occupants are killed every year in Europe. With a 100% seat belt use and a 50% injury reducing effectiveness, the total number of savings is around 7.600 per year. Given the Swedish situation, this is probably not an overestimation, although the potential savings may vary from country to country. It must be remembered that these figures apply only if the whole vehicle fleet is equipped with an interlock system.

A recent study from the European Transport Safety Council (ETSC) shows similar results with a potential reduction of 5.570 fatalities by a 95% belt usage rate.

Table 2.
ETSC estimations of seat belt use potential

Country	Killed car occupants 1993	Belt usage % Front seat 1991-95	Potential number of saved lives
Austria	747	70	175
Belgium	1050	55	277
Denmark	254	92	58
Finland	274	87	53
France	6168	85	1243
Germany	6128	92	1097
Greece	781	63	199
Ireland	187	53	51
Italy	3931	~55	998
Luxembourg	54	71	14
Netherlands	615	73	139
Portugal	1140	~63	234
Spain	3606	~75	834
Sweden	389	90	69
United Kingdom	1835	91	329
EU Total	27159	80	5570
USA	21987		

(IRTAD 1993) (ETSC 1996)

Only fatalities are discussed in this paper. An interlock system will of course also have a similar effect on the number of severely injured which is about 10 times larger than the number of fatalities.

ALTERNATIVE MEASURES

Preliminary calculations of the cost-effectiveness of an interlock system show that this is a very effective measure compared to some other ones.

By using the Swedish calculations of the willingness-to-pay for risk reductions, it is possible to calculate the possible economic benefits for an interlock system. It can be estimated that the savings from interlock in Sweden is in the region of more than 5 billion SEK/year (~700 million US$/year). With the medium age of cars that we have in Sweden for the moment, the cost that can be spent on each car for an interlock system is therefore approximately 20.000 SEK (~3.000 US$). With an anticipated cost of 200 SEK (~30 US$) per car for an interlock system, the ratio between benefit and cost is 100:1, which by margin is higher than for any other known safety measure. As an example, a 100% fitting of airbags from now on in Sweden would save approximately 50-60 lives annually, but for a cost that is ten times higher than for the interlock, still leaving us with a positive balance between cost and benefit, but serving as an indicator of the extreme benefits of interlock.

ATTITUDES

Preliminary results from a study made by the Swedish National Road Administration in 1995 based on interviews with 5914 persons aged 15-84 years show that there, in general, is a positive attitude for introducing interlock systems.

Table 3.
Swedish interviews

Do you agree or disagree that cars should not be able to run faster than 30 km/h if the driver is not using the seat belt?

%	Male	Female	Total
Strongly agree	24,1	36,6	30,2
Agree	17,7	19,8	18,7
Neither / or	14,1	15,1	14,6
Disagree	19,4	13,7	16,6
Strongly disagree	24,8	14,8	19,9
Total	100,0	100,0	100,0

Table 4.
Swedish interviews

Do you agree or disagree that cars should be equipped with buzzers and lights to warn that someone is not using the seat belt?

%	Male	Female	Total
Strongly agree	37,1	51,8	44,5
Agree	25,4	26,4	25,9
Neither / or	13,4	9,4	11,4
Disagree	12,5	7,2	9,8
Strongly disagree	11,6	5,3	8,4
Total	100,0	100,0	100,0

These two tables show that women are more positive than men and that the less aggressive buzzer-light system is preferred.

This investigation also shows that older persons are more positive to interlock systems than younger persons.

An alarming fact is that of those who state that they seldom or never buckle up in the front seat on rural roads we can find that 77% disagree or strongly disagree on a 30 km/h speed limiting interlock. 55% of this group are also against the buzzer and light warning system. This is actually our target group so we need to find out how to change their attitudes and how to prevent them from disconnecting the interlock system.

INCENTIVES FOR INSTALLATION

Since a legislation on a national level is difficult or impossible after Sweden has become a member of the European Union, other ways to have these systems installed in new and existing cars have been discussed.

- A majority of new cars in Sweden are bought as company cars. There is a possibility to lower the tax

liability of the benefit in kind on cars if they are equipped with interlock systems.

- The general vehicle tax can also be moderated depending on the safety equipment of the car.
- Insurance companies are discussing to adopt the premiums along these lines.
- Another proposal is that drivers that are caught without using the belt will be obliged to install an interlock device in their cars.

FUTURE ACTIVITIES

Attitudes

During the spring of 1996 a survey of non-users will be made in Sweden. In cooperation with the police, non-users will be stopped and interviewed at 11 locations spread over Sweden. The interviews will concentrate on seat belts in general and reasons for non-wearing in particular.

System specification

A technical specification, probably in the format of a draft ECE-Regulation will be made during 1996. This draft will allow the car manufacturers to use different options but the goal will be a 99% belt use rate. Also retrofit systems for existing cars will be considered.

An interesting alternative to have detailed technical specifications is to measure the actual belt use rate in traffic for the different cars model years. The tax and other benefits could then be applied with about a one year delay from the introduction of a new car. This alternative will give the vehicle manufacturers free hands to do whatever they want to increase the use in their vehicles. If the coupling between the usage rate and the benefits for the car industry and the car user are strong enough this approach could lead also to a voluntary installation of interlock systems in the existing car fleet.

Implementation

Since this concept has been very positively accepted by the Swedish Ministry of Transport, discussions will go on in order to find the proper tax and other incentives to have some kind of system implemented on the Swedish market as soon as possible.

The car industry may object to this since they do not want to have different equipment on different markets. An international standard would of course be better for everybody but considering the time it will take - and the number of unbelted people killed during that time - our position is that we ought to do something wherever it is possible to get something done quickly in this field.

CONCLUSIONS

At least 6.000 lives can be saved in the European Union annually if the seat belts that are already in the cars are used by 100% of the occupants. The only way to reach this level is to have a technical solution that will make it impossible or very cumbersome to use the car without using the seat belts. There are several technical solutions available that could be implemented in a short time. The main obstacle to reach this goal is probably of a political nature.

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