The reliability of ABS and airbag systems with respect to periodic testing: a cost benefit analysis

by R S Bartlett, ICP Simmons and Miss TL Smith

PR/SE/439/02

TRL LIMITED

PROJECT REPORT PR/SE/439/02

THE RELIABILITY OF ABS AND AIRBAG SYSTEMS WITH RESPECT TO PERIODIC TESTING: A COST BENEFIT ANALYSIS

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Prepared for: **Project Record:** **CITA Working Group 7**
Client: **Mr J David**

	Approvals
Project Manager	
Quality Reviewed	

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EXECUTIVE SUMMARY

A major project to examine the potential of expanding current periodic roadworthiness testing of passenger cars has been carried out under the direction of CITA Working Group 7. This work has included a detailed reliability study, an investigation into potential ABS test methods and an investigation into airbag system test methods. This report describes a cost benefit analysis designed to examine the potential benefits of introducing additional testing for ABS and airbag systems.

Detailed reliability data for vehicle electronic systems has been collected in the UK from a roadside call-out organisation and a major vehicle leasing company. This has been supported by data from Germany and Sweden. This information has been combined with data on the cost of breakdowns and road traffic accidents to estimate the potential benefits of introducing additional periodic testing. Most of the analysis has been based upon data for the UK but we have attempted to extend the analysis to the wider European arena to provide a more comprehensive estimate.

There are two key benefits that would result from additional testing:

- The reduction of accident related costs which includes potential reduction in injury severity.
- The reduction of the breakdown/repair costs.

Results from the reliability study estimated that about 85,000 airbag faults and 107,000 ABS faults occurred in the UK for the year 2000. These are significant numbers of faults and their potential consequences could result in significant numbers of breakdowns and road traffic accidents. In the cost benefit analysis it has been attempted to estimate these potential consequences from actual breakdown and repair costs together with the potential benefit of reducing accident costs including reducing the injury severity level.

In the UK, the typical potential reduction in the cost of breakdowns alone related to airbag faults was 600,000 Euros whilst for ABS this was 2,600,000 Euros. Similarly the cost benefits from accidents were 33,000,000 Euros for airbags and 15,500,000 Euros for ABS.

As the number of fatal passenger car accidents is significantly higher in France, Germany and Italy compared to the UK, then the potential benefits of introducing additional vehicle testing in these countries is likely to be higher. Furthermore the fitment rate of electronic systems also varies between the European countries. However, it has been estimated that if the introduction of additional testing for ABS and airbags were introduced then the potential benefit would typically be about 6 Euros per vehicle. Hence the cost benefit analysis will show a balance point when the cost of testing is increased by 6 Euros.

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ABSTRACT

A study of the reliability of vehicle electronic systems fitted to passenger cars has been completed. Data was collected from the UK, Germany and Sweden. Studies to develop potential periodic testing for ABS and airbags have also been completed. This report describes a cost benefit analysis to determine the potential benefits of introducing such tests on the consequences of failures. This includes potential benefits in reducing the number of roadside breakdowns and severity of road traffic accidents. Whilst most of the data has been provided by the UK, the results have been considered on a broader European perspective.

1. INTRODUCTION

As part of a major European study to examine the potential of expanding current annual vehicle roadworthiness testing, reliability data has been collected on vehicle electronic systems from sources in Germany, Sweden and the UK (not including Northern Ireland). The majority of the data was sourced from the UK and included detailed reliability data from a roadside call-out organisation and a major vehicle fleet leasing company.

Until now, there has been little data available concerning how reliable electronically controlled systems are or how they could be checked for correct function. This collaborative programme of research aims to address this issue by identifying current and near market systems and examining their performance, identifying whether a need exists to carry out periodic inspections of the systems identified and developing test procedures for use in periodic and other inspections where necessary.

Other work within the study is examining potential test methods that could be used for annual testing. This work has concentrated on ABS and airbags as these represent current safety critical systems fitted to large numbers of vehicles.

This report presents an initial cost benefit analysis of such an annual test procedure, if one were in place. The report focuses on potential benefits, not on the costs of a system, so in this sense provides only a partial analysis. The report covers the potential benefits of ABS and airbag systems only.

2. ABS AND AIRBAG DATA

The ABS and airbag data was obtained from the UK roadside call-out organisation and the vehicle leasing company as follows:

- Breakdown records from membership of 2 million
- Lease company fleet of 140,000 vehicles

The recovery organisation had approximately two million members during the period covered by the database. If it is assumed that each member had one vehicle then this sample of vehicles represented approximately 10 percent of the UK vehicle fleet. This data relates to failures in service and does not include faults found during routine maintenance.

The leasing company is one of the UK's largest vehicle leasing organisations (who lease vehicles up to 4 years old). Within this organisation, a record is entered into their database for each individual vehicle repair for all vehicles in their fleet; in this way, the database includes all repairs from routine servicing, major overhauls and garage repairs after a roadside breakdown. This database differs from that provided by the breakdown organisation in that it does not solely cover incidents where a vehicle broke down by the side of the road.

The information contained in each record, in both databases, includes the type of failure, coded in a 3-digit code (ie identifying the component which failed with a reasonable degree of precision).

It was agreed that, within this project, the cost benefit analysis would focus on failures of airbag and ABS systems. The analysis could be extended to other vehicle systems later.

Table 1 shows, for each database, the estimated number of airbag faults and the number of airbag faults per billion vehicle-kilometres (BVK). The estimated UK total number of faults is also given. This is calculated assuming that the data from each sample is representative of the UK fleet as a whole.

Table 1. Airbag system faults found in the UK

Data	Total no. of Faults	Faults/BVK
Roadside call-out	723	7
Leasing fleet	1,627	220
Estimated UK total	79,601	220

Similarly Table 2 shows the estimated number of faults for ABS.

Table 2. ABS faults found in the UK

Data	Total no. of Faults	Faults/BVK
Roadside call-out	3,348	31
Leasing fleet	2,043	277
Estimated UK total	99,955	277

In order to estimate the likely number of failures across a sample of European Countries, the figures for the UK have been factored by the appropriate level of traffic in each country. For this analysis, it has been assumed that the levels of fitment of each system and the predicted traffic growth are the same across each of the countries. Based upon the failure rates stated above, figures for the year 2000 have been predicted assuming that traffic growth is 1.65% per annum, derived from UK government statistics. Table 3 shows the total number of failures for airbag and ABS accordingly.

Table 3. Estimated total number airbag and ABS failures for a sample of EC countries – year 2000

Country	Airbags	ABS
UK	85,098	107,146
Belgium	21,728	27,358
France	85,496	107,647
Germany	121,266	152,685
Sweden	13,078	16,466
Spain	34,525	43,470

3. COST BENEFIT ANALYSIS

The fundamental question in any cost benefit analysis concerns the relative magnitude of the costs and benefits associated with the proposed change; whether the benefits would more than balance the costs. In this case, the issue is whether the costs of introducing and carrying out annual testing of certain vehicle electronic systems would be balanced by larger benefits through removing some of the costs of breakdowns/repairs and accidents which directly result from electronic system failures.

There are two basic approaches to preparing a cost benefit analysis:

(1) Where both costs and benefits are known or can be estimated, the two figures may be presented and compared. A comparison of this type needs to be accompanied by a clear statement of the assumptions made in deriving the cost and benefit figures. Where costs and benefits are both known (or can be estimated), it is possible to conclude that the proposed action is (or is not) 'worthwhile' from a CBA standpoint. It should be borne in mind that there may be very good reasons for implementing the change even in cases where the CBA balance is 'negative' (ie costs are greater than benefits). In cases in which ranges of possible values may be derived for one or both quantities, a definite result ('worthwhile economically' or 'not worthwhile economically') may still be achievable; alternatively, a conditional result may be obtainable.

(2) In cases in which one of the quantities is unknown (for example, the benefits may be estimated but the costs are currently unknown), it will be possible to conclude that the proposed action is worthwhile as long as the costs do not exceed an annual figure which can be quoted. In the present case, as the numbers of vehicles which would need testing could be estimated, it should be possible to provide a maximum cost per vehicle in order to achieve a positive CBA).

4. COSTS

The specification for annual testing of airbag and ABS components has not been set out in any detail but it is envisaged that such annual testing would form part of the current annual test prescribed by Directive 96/96/EC (popularly known as the MOT test in the UK, controle technique in French speaking countries and the TUV test in Germany). The Directive requires testing of cars after 4 years and then every two years but member states frequently test more often if they wish. The MOT for the UK currently applies to vehicles that are three or more years old with subsequent testing each year. In Germany cars are tested after 3 years, then

two years and then every year. In the Netherlands cars are tested after 3 years and then every two years. It is open to debate whether airbag and ABS tests would be required on newer vehicles.

In this analysis, the cost of annual testing has not been formulated but it is believed that there would be a significant set-up and maintenance cost to provide testing equipment for a sufficient number of garages to make testing practical. Instead, the potential benefits have been analysed from which an estimate of the potential increase in testing costs can be derived that would balance an appropriate level of benefit, in terms of fault reduction.

5. BENEFITS

The benefits which would result from the introduction of testing are:

(1) The avoidance (or reduction) of accident related costs which includes potential reduction in injury severity.

(2) The removal (or reduction) of breakdown/repair related costs.

The types of cost can be broken down into 3 categories as follows:

1. Repair related:

   - Breakdown
   - Labour
   - Parts
   - Loss of earnings

2. Casualty related:

   - Lost output
   - Human
   - Medical

3. Accident related:

   - Damage to property
   - Insurance administration
   - Police

The total breakdown costs has been calculated by using the following:

- The known number of breakdowns relating to airbags and ABS from the survey.
- An average value of airbag repair costs including parts and labour.
- An average value of ABS repair costs.
- An estimate of the loss of earnings.
- An estimate of the tow-in charge for recovering the vehicle.

The costs of repairs was obtained from three main vehicle dealers for typical mid-range family saloons from Renault, Ford and BMW and averaged together. The actual values, costs in Euros, are given below:

Number of breakdowns for ABS	3,348
Number of breakdowns for airbags	723
Ave. loss of earnings due to breakdown	160
Ave. ABS repair cost	763
Ave. airbag repair cost	841

A detailed analysis of accident costs has been reported by TRL, (Hopkin and Simpson, 1995). This report provides detailed costs for a wide range of accident and injury costs. The values have been brought up to date by adding inflation of 3% per year. Table 4 shows the costs per accident for different accident severities.

Table 4. Accident costs (Euros) for different levels of severity

Type of injury	Cost Euros
Fatal	1,522,000
Serious	180,000
Slight	17,700
Damage only	1,750

The cost benefit from reducing the accident severity level as shown in Table 5 has also been estimated.

Table 5. Potential cost saving of reduction in accident severity.

Fatal to serious	970,000
Serious to slight	120,000
Slight to damage only	11,500

6. COST BENEFIT ANALYSIS

6.1 ANALYSIS PROCEDURE

This section provides an analysis of the potential cost benefits relating to the reliability of UK failures for Airbags and ABS system. There are two key unknown factors that are difficult to determine. These are:

- The potential reduced number of accidents and breakdowns as a result of introducing a test.
- The probability of reducing the level of severity of an accident as a result of introducing a test.

The number of faults per year for each system has been estimated from the reliability database. A key assumption has been made that the introduction of the new testing regime (whatever the detailed arrangements) *would not affect the numbers of system failures* only their consequences.

It has been assumed that the numbers of failures whose consequences can be changed is X (for repairs (Xr) and for accidents (Xa)).

The probability that the severity of an accident being reduced as a result of an annual test is Pr (Pr1 for a reduction from fatal to serious; Pr2 for reduction from serious to slight). Pr values will be different for airbag and ABS related faults due to the different failure modes and their consequences.

The following assumptions have been made for these unknown variables:

0.1<(Xr=Xa)<0.9

0.0001<Pr1abs<0.0005

0.0003<Pr1bag<0.003

Pr2=0

It has been assumed that the number of failures whose consequences can be changed is the same for repairs and accidents, Xr=Xa. There is no evidence to justify a particular relationship for Xr and Xa and this is simply an arbitrary assumption for the purpose of this analysis. However, it is not unreasonable to assume that Xr and Xa lie within the range 0.1 to 0.9 on the basis that the test is only worth implementing if it can reduce the consequences of failure but is unlikely to reduce the consequences of failures completely.

Values for Pr1 and Pr2 are also difficult to determine and papers referenced in the bibliography, as well as some unpublished work has been examined to try to obtain some measure of this value. This has included detailed discussions with the TRL “on the spot” accident investigation team which is collecting detailed data on road accidents in the UK. As a result it has been concluded that the value of Pr1abs lies between 0.0001 and 0.0005 whilst Pr1bag lies between 0.0003 and 0.003. Similarly Pr2 has been estimated as being zero.

Having made these assumptions, the sum of the benefits can be calculated as follows:

Benefit due to repair:

Br = Xr(sum of repair costs)

Benefit due to accidents:

Ba = Xa(sum of accident costs)Pr

The different values for Pr are summed within the calculation.

Finally the total benefit is given by:

Btotal = Br + Ba

6.2 ANALYSIS OF THE RESULTS

The potential benefits for reducing the breakdown costs have been calculated and are shown in the figure below:

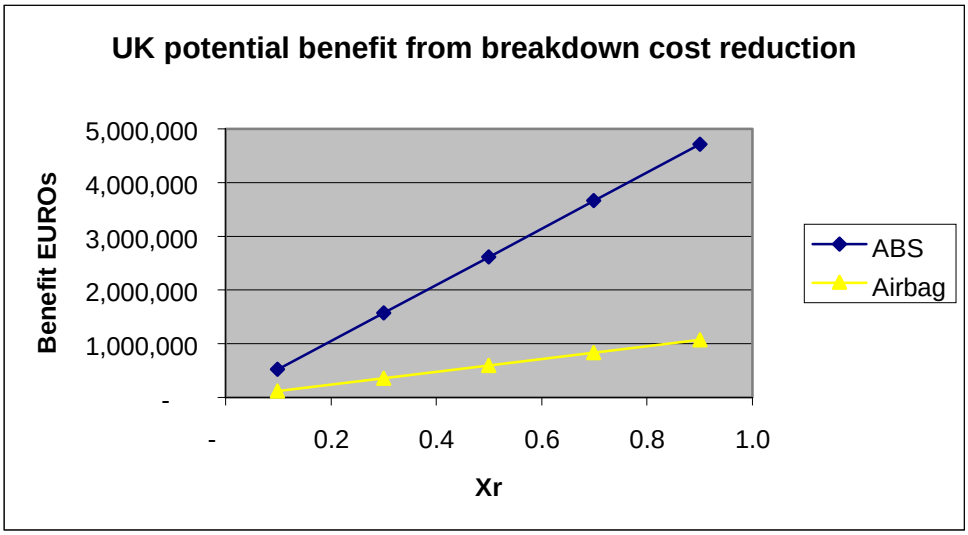

Figure 1. Breakdown cost reduction benefits

The large difference between the curves for airbag and ABS is simply due to the different number of failures recorded at roadside breakdowns. If it were assumed that the introduction of a test for airbags and ABS would reduce the number of consequences of failure by 50 per cent, Xr = 0.5, then the potential cost reduction for airbag related failures would be about 600,000 Euros whilst that for ABS would be about 2,600,000 Euros.

In the second analysis, the potential benefits for reducing repair costs have been calculated. The results are given in the figure below.

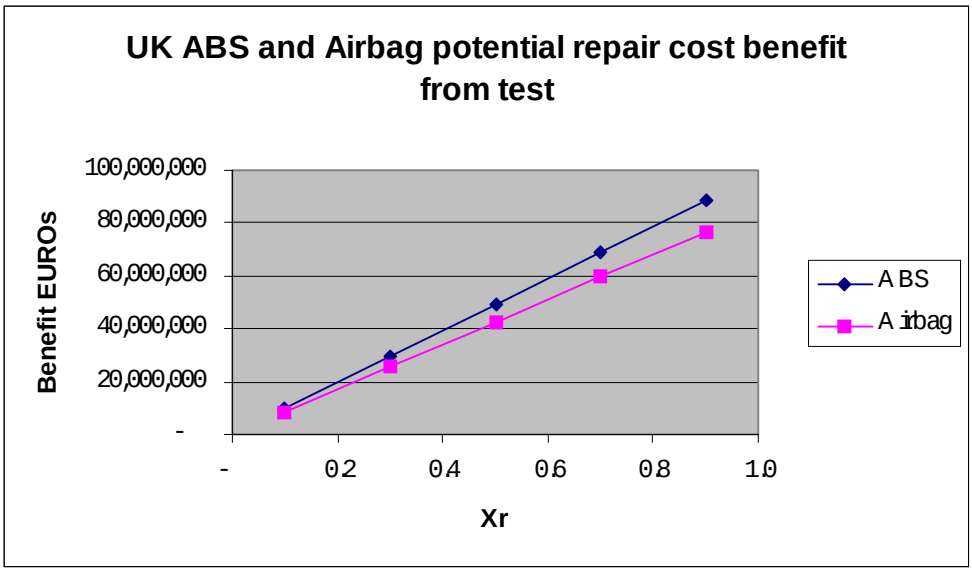

Figure 2. Repair cost benefit

In the third analysis, the potential injury benefits resulting from reduced accident costs and lowering the severity of injuries have been calculated. The results for introducing an airbag test are shown in the figure 3.

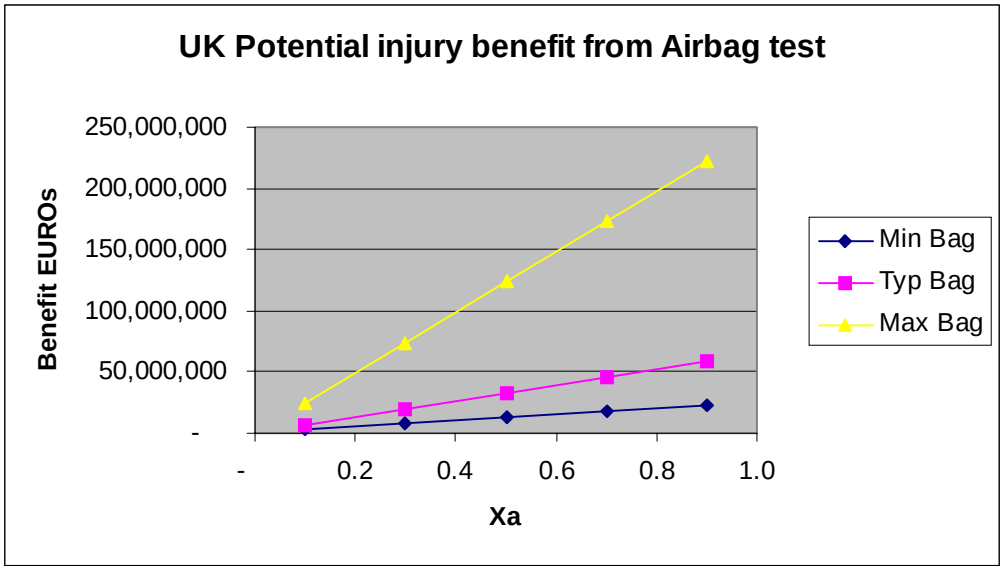

Figure 3. Potential injury benefit from airbag test

In this case the analysis includes the probability of reducing the severity of the accident from fatal to serious, Pr1bag. Three curves representing the minimum, maximum and typical benefits calculated in the estimate have been plotted.. As in the previous analysis, if wean assumption was made that the value of Xa was 0.5, then the typical, or middle value, benefit would be about 33,000,000 Euros for airbags.

Similarly the same analysis for ABS has been applied as shown in the figure 4 below:

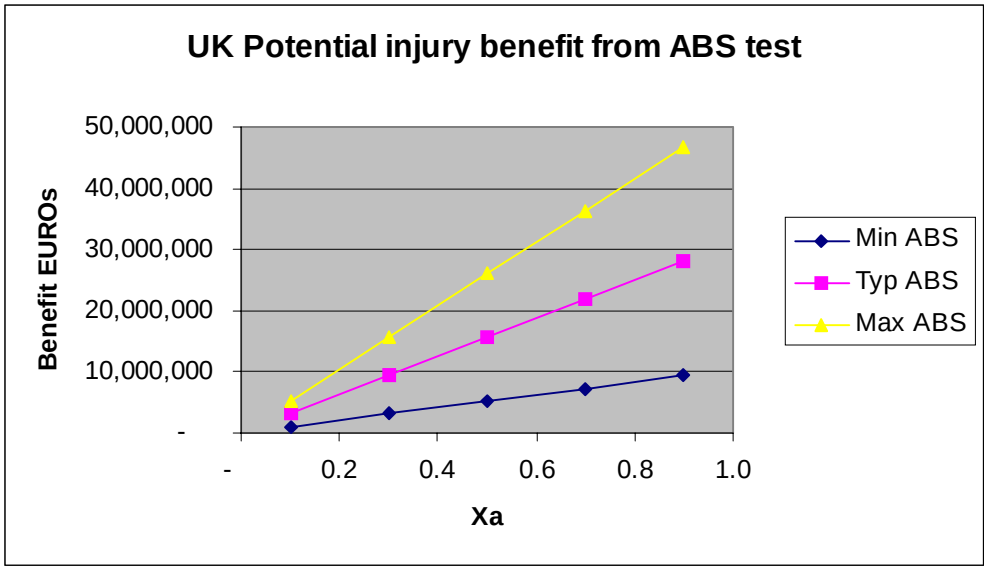

Figure 4. Potential injury benefit from ABS test

In this example, if it were assumed that Xa = 0.5, then the typical benefit from ABS would be about 15,500,000 Euros.

In the final analysis, the results for breakdowns and accidents have been combined to provide an overall estimate. The results for airbags are shown in the figure 5.

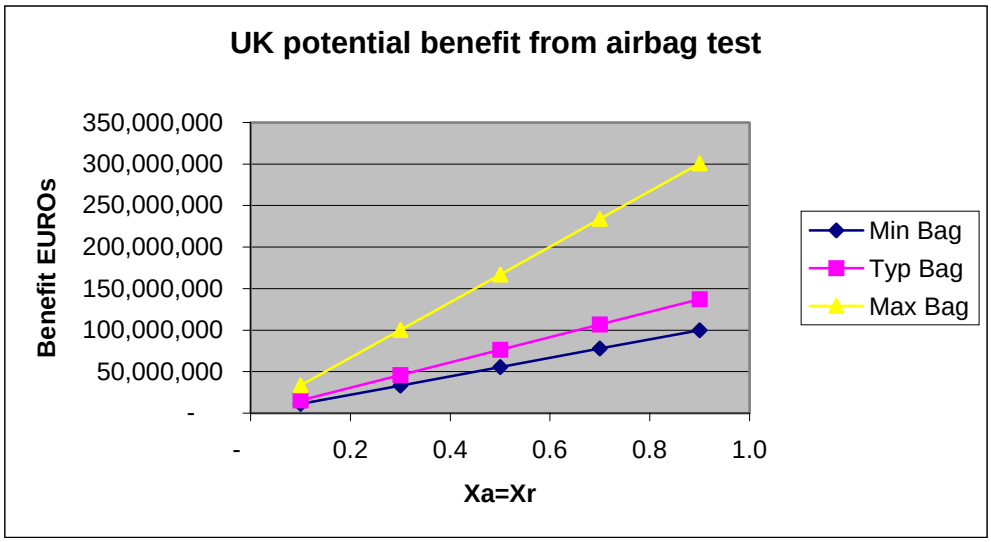

Figure 5. Overall benefit from airbag test

As before, the typical benefit, assuming Xa = Xr = 0.5, would provide a benefit of about 75,600,000 Euros for airbags.

The similar results for ABS are shown in figure 6 below:

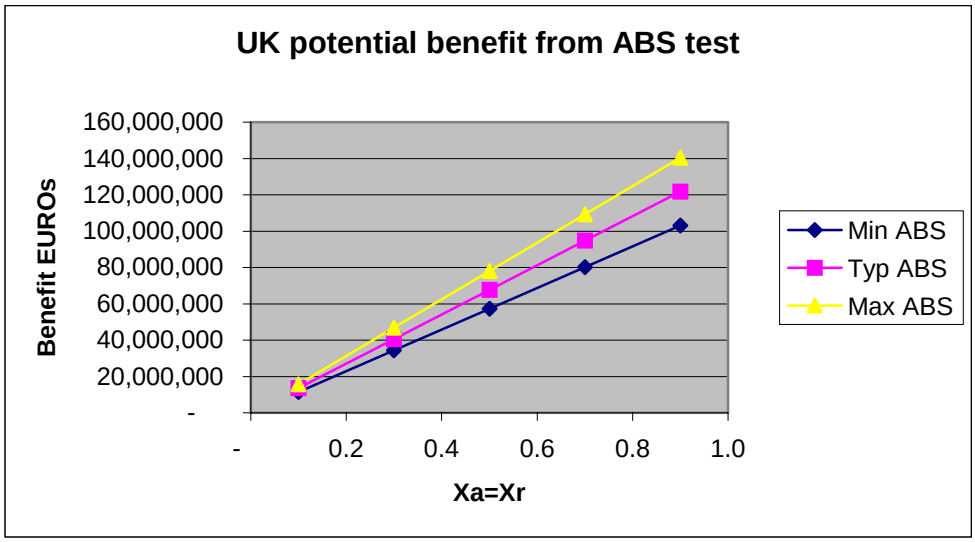

Figure 6. Overall benefit from ABS test

Similarly, the typical benefit for ABS would be about 65,000,000 Euros.

In figures 5 and 6, the significant differences are due to the different numbers of recorded failures and the effects of the probabilities of reducing the accident severity which are different for airbag and ABS related failures.

Table 6 shows the estimated range of benefits from introducing tests for airbags and ABS assuming that Xa = Xr = 0.5.

Table 6. Estimates of potential benefits from introducing tests for airbags and ABS

Level of benefit	Airbag benefit MEuros	ABS benefit MEuros	Total benefit MEuros	Cost per car Euros
Minimum	55.6	57.3	112.9	4
Typical	76.2	67.7	143.9	6
Maximum	167.0	78.0	245.0	10

The analyses described above have been based upon UK reliability data supported by accident data from Germany, the USA and the UK. Currently the UK has about 25 million passenger cars operating on public roads. If the total benefits are divided by the total number of passenger cars in the UK then a value representing the cost per car of implementing both tests for airbags and ABS can be calculated. The values are shown above in Table 6.

Whilst the analysis is based upon data for the UK, it is useful to extend the applicability to other EC countries. Table 3 shows the estimated number of failures for some EC countries based upon the level of traffic. This assumes that the fitment rate for airbags and ABS for each of the countries is the same. It also assumes that the reliability levels of the equipment are also the same. Information on fitment rates was not available and so we cannot estimate this effect precisely. However, it is known that the fitment rate of airbags and ABS is less than 100 per cent for the UK and the rate in Germany is likely to be higher than the UK rate. A higher rate will result in more failures and consequences and, therefore, a higher benefit and possibly higher inspection costs in the future.

The calculations are also based upon the assumption that every car is inspected annually. In reality, because of the different test intervals used by EC countries, the national applications of Directive 96/96/EC will result in only 40-70 per cent of the whole vehicle fleet being inspected every year. Therefore the potential benefit from additional testing will also be reduced but in a smaller proportion. As an example, for an inspection rate of 50 per cent and the benefit reduced to 65 per cent of that of a 100 per cent inspection rate, a typical inspection cost of about 8 Euros per vehicle would result.

Another factor that varies within individual EC countries is the number of fatal road accidents. This report relates to passenger cars so it is important to compare the passenger car fatal accident data and not the total number of fatal accidents. As examples, the total number of passenger car fatal accidents in 1999 in the UK was 1,778 compared to 5,455 in France, 4,640 in Germany and 3,522 in Italy. As part of the calculation of the potential benefits, the potential reduction in the level of injury severity and the effect this may have on the overall benefit has been estimated. Clearly, as the number of fatal passenger car accidents is significantly higher in France, Germany and Italy compared to the UK, then the potential benefits of introducing additional vehicle testing in these countries is likely to be higher.

In real terms, the additional cost of inspections to cover the testing of airbags and ABS could reach about 10 Euros per vehicle. In the future, tests will be needed for other safety related systems, for example electronic steering, which will lead to further benefits although the cost of testing will increase accordingly.

7. CONCLUSIONS

A cost benefit analysis has been completed to estimate the potential benefits of introducing annual testing for airbags and ABS fitted to passenger cars. The analysis included both roadside breakdown and accident costs.

In the UK, the typical potential reduction in the cost of breakdowns alone related to airbag faults was 600,000 Euros whilst for ABS this was 2,600,000 Euros. Similarly the cost benefits from reduced repair costs were 42,600,000 Euros for airbags and 49,500,000 Euros for ABS. Furthermore, the benefits from reducing the injury severity in road traffic accidents were 33,000,000 Euros for airbags and 15,500,000 Euros for ABS.

The total typical potential benefits for the UK were estimated to be 75,600,000 Euros for airbags and 65,000,000 Euros for ABS.

The analysis also considered the potential benefits across the European Union. However, the level of traffic, number of vehicles, fitment rate of equipment and the number of fatal accidents vary between the different EC countries. If these factors are considered to be similar to the UK, then it is estimated that the total benefits of testing airbags and ABS, assuming that 50 per cent of the consequences of failure were removed, would lie in the range 4 to 10 Euros per car. A typical value would be 6 Euros per car.

The benefits of additional testing can be applied to all the EC countries although it is difficult to predict accurate benefits due to the variations in traffic, accidents and fitment rate for equipment.

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