Transport Research Laboratory

Evaluating the impact of possible new measures concerning category L vehicles

Final report

by T L Robinson, M McCarthy, M Pitcher, T Gibson and C Visvikis

CPR383

ENTR/05/17.01

CLIENT PROJECT REPORT

Transport Research Laboratory

CLIENT PROJECT REPORT CPR383

Evaluating the impact of possible new measures concerning category L vehicles

Final report

by T L Robinson, M McCarthy, M Pitcher, T Gibson and C Visvikis (TRL)

Prepared for: Project Record:	**ENTR/05/17.01**
	Evaluation of the impact (extended impact assessment) on possible new measures concerning motorcycle safety
Client:	**European Commission, DG Enterprise and Industry**
	Mr Giacomo Mattino / Mr Guido Gielen

This Client Report has been prepared for European Commission.

The views expressed are those of the author(s) and not necessarily those of European Commission.

	Name	Date Approved
Project Manager	Mike McCarthy	08/05/2009
Technical Referee	Iain Knight	26/05/2009

When purchased in hard copy, this publication is printed on paper that is FSC (Forestry Stewardship Council) and TCF (Totally Chlorine Free) registered.

Contents Amendment Record

This report has been issued and amended as follows

Version	Date	Description	Editor	Technical Referee
1	09/02/09	Draft final report	Mike McCarthy	Iain Knight
2	09/04/09	Draft final report	Mike McCarthy	Iain Knight
3	13/05/09	Final report	Mike McCarthy	Iain Knight
4	26/05/09	Amended formatting	Iain Knight	Iain Knight

Contents

List of Figures

List of Tables

Executive summary

Type approval requirements for mopeds, motorcycles, tricycles and quadricycles (vehicle category L) are currently contained in EC Directive 2002/24/EC and its daughter directives. This framework became mandatory for all category L vehicles sold in the European Union from 9th May 2003. Following the recommendations of regulatory simplification from the CARS21 initiative, the European Commission has proposed simplifying the legislation relating to category L vehicles by repealing the present framework directive and 14 associated Directives. It is intended that these be replaced by two regulations; one covering the main political aspects, adopted in co-decision; and one with all the detailed technical requirements, adopted by comitology.

While this regulatory simplification process has been considered, a number of changes to the technical requirements have also been proposed aimed at improving the level of safety for motorcycles in Europe. In 2006, motorcycles accounted for 2% of distance travelled, but accounted for 16% of road deaths in the EU-25 (ETSC, 2007). Indeed, the fatality rate per million kilometres travelled is, on average, 18 times greater than passenger cars (ETSC, 2007). Furthermore, while other vehicle modes have shown significant decreases in fatalities and serious injuries over time, those for motorcycles have exhibited much lower decreases or remained static. This report describes the potential economic, social and environmental impacts that would be expected if a range of different policy options were to be implemented. The technical changes to be considered in addition to the simplification of the regulatory framework are related to:

- Advanced braking systems (e.g. ABS/Combined Braking Systems) for motorcycles;
- Anti-tampering for mopeds, motorcycles, tricycles and quadricycles;
- 74kW power limit for motorcycles;
- Quadricycles (L6 and L7);
- Off-road quads; and
- Safety of hydrogen-powered category L vehicles.

This assessment of the proposal for regulatory simplification only considered impacts to individual Member States and to industry. Additional costs and benefits to the Commission relating to the implementation of the proposed changes, as well as the cost to make regular amendments to existing Directives have not been included here; it was anticipated that these costs would be addressed by the European Commission as part of the final impact assessment. It was concluded that by 2020 (i.e. 10 years after 2011, the earliest likely implementation date), there is likely to be a net benefit to society of between €77,811 and €371,657 if the option to replace the current type approval framework with "split level approach" legislation was introduced. The benefits would be greater if more than an average of two amendments were made annually. It is estimated that it would take between one and five years to achieve a benefit to cost ratio of one (i.e. break even) and by 2020, it is estimated that a benefit to cost ratio of between 1.24 and 2.53 could be achieved, with an average benefit to cost ratio of 1.44. Simplification was judged to provide a clearer regulatory process which would be a benefit to all, but which might benefit new entrants to the market and small and medium-sized enterprises (SMEs) to a greater extent. This analysis concluded that Option B (regulatory simplification) is the recommended option because it has significant economic benefits as well as societal and environmental benefits.

Effectiveness estimates for Anti-lock Braking (ABS) and Combined Braking Systems (CBS) were reviewed from a range of published studies; ranges for system effectiveness were selected, along with a best estimate. These estimates were based on predictive studies because no statistical retrospective studies were located which more robustly quantified in-service effectiveness.

Cost estimates for ABS and CBS were taken from published studies and information supplied by industry. These costs used the following ranges for Option A: ABS €150 - €822 (with a best estimate of €536), CBS €75 - €400 (best estimate €150). For options B and C, the costs used in the study were: ABS €100 - €200 (best estimate of €150), CBS €75 - €200 (best estimate €150). Benefit cost ratios were calculated using the "best estimate" system cost.

The benefit estimate for advanced braking systems was quantified in monetary terms using casualty valuations for fatal, serious and slight casualties used by Baum et al (2007). Member States use values which vary significantly, depending both on cost assumptions and whether or not the estimate includes "willingness to pay" components. The values used for this study were as follows: fatal €1,000.000, serious €100.000 and slight €15,000, with these being broadly consistent with a European average. It is acknowledged that the costs for individual accidents within each accident severity group may exhibit wide variation. However, the values used represent average values for the severity group. The benefits were estimated for full accident avoidance (i.e. influenced casualties reduced to non-injury) and for mitigation (fatalities reduced to serious casualties and serious casualties reduced to slight casualties). For the mitigation scenario, the effects on slight casualties were not assessed because these were considered difficult to mitigate without avoiding the accident.

It is estimated that mandating ABS on all motorcycles (Option B) would reduce the numbers of European fatalities compared to Option A, the "do nothing" option, by 471 (over period 2011-2013), 1,564 (2011-2016) and 4,562 (2011-2021). These estimates are based on the "best estimate" for fatality reduction for each option. Mandating ABS on motorcycles over 125cc and CBS on motorcycles less than or equal to 125cc (Option C) is estimated to reduce the numbers of European fatalities, compared to the "do nothing" option by 390 (over period 2011-2013), 1,324 (2011-2016) and 3,895 (2011-2021). These estimates are based on the "best estimate" for fatality reduction for each option.

Benefit to cost ratios for mandating ABS on all motorcycles (Option B) and mandating ABS on motorcycles with engine capacities over 125cc and CBS on those equal to or under 125cc (Option C), were compared to the "do nothing" baseline (Option A). These ratios were calculated for accident avoidance and casualty mitigation; the estimated benefit to cost ratio (BCRs) were compared with Option A (Do nothing). The best estimate BCRs, along with the estimated range in brackets are presented below:

	Option B (Mandatory ABS on all motorcycles)		Option C (CBS on motorcycles 50cc to 125cc; ABS on larger capacity machines)	
	Avoidance	Mitigation	Avoidance	Mitigation
Short term (2011 – 2014)	1.1 – 1.5 (0.6 – 2.9)	1.0 – 1.3 (0.5 – 2.4)	0.9 – 1.3 (0.5 – 2.7)	0.8 – 1.0 (0.4 – 2.2)
Medium term (2011 – 2016)	2.8 – 3.8 (1.0 – 5.3)	2.4 – 3.2 (0.9 - 4.5)	1.7 – 2.3 (0.9 – 4.9)	1.5 – 1.9 (0.8 – 4.1)
Long term (2011 – 2021)	4.2 – 5.6 (2.0 – 10.9)	3.6 – 4.6 (1.8 – 9.1)	3.5 – 4.8 (1.9 – 10.1)	3.0 – 4.0 (1.6 – 8.4)

The effects on noise, fuel consumption and emissions are predicted to be negligible provided riders do not change their driving style on motorcycles fitted with advanced braking systems. The addition of ABS systems on motorcycles will add a small amount of mass; information obtained from Industry suggested that by 2010 the additional mass will be less than the current average of 1.4 kg, although no data was collected from the consultation regarding the increase with CBS fitment. Potential fuel consumption and emissions increases were not assessed with respect to this factor.

Overall the mandatory fitment of advanced braking systems is predicted to have significant long term benefits in terms of casualty reduction, and to have a positive benefit to cost ratio over the short to medium term. Over the long term, the best estimate is for returns of between 3.5 and 5.6 times investment. With the data and assumptions used, Option B is predicted to have a greater casualty reduction effect with slightly more favourable benefit to cost ratios than Option C.

For the regulatory options relating to anti-tampering, the "do nothing" option is considered to have a neutral economic and societal impact, although there is potentially a negative environmental impact since some of these vehicles may continue to be modified in such a way that increases noise and perhaps also emissions. In addition, as vehicles become more electronically controlled, existing regulatory controls on anti-tampering may become less effective, although the effectiveness of existing measures are currently unclear. Repealing Chapter 7, taking away the requirements for anti-tampering, is considered a "backward step", with potential negative effects on safety, as well as negative economic and environmental impacts, although the magnitudes of these impacts are unknown and are difficult to quantify with the available information. Implementing new measures for anti-tampering has the potential to deliver positive impacts in all three categories. However the economic impact (not including quantified societal and environmental costs) could be negative, depending on the specific measures selected and the stakeholders affected; the overall net economic effect (including quantified environmental and societal benefits) has the potential to be positive.

Considering the proposed options for the limitation of motorcycle maximum power, the analysis found that the relationship between maximum power and accident risk could not be clearly established. A number of studies have shown that there other factors, such as rider attitude and experience, which have a greater influence on accident risk. Thus, no judgement could be made regarding societal impacts, and the effect on casualties of all options was considered neutral. The "do nothing" option was considered to have small positive impacts both economically and environmentally, although the magnitude of these impacts is uncertain. Repealing the option for a 74kW limit is expected to have a positive economic impact because manufacturers will not need to design vehicles specifically for the Member States which enforce the limit, but the environmental impacts are uncertain. Both harmonising the 74kW limit and using alterative limitation criteria are likely to have a negative economic impact, with the former having a significant cost not likely to be recouped by benefits. Using an alternative limitation method has potential for a positive environmental impact; however, the magnitude of the environmental impacts is currently uncertain until the method of limitation is more defined.

Accident data concerning L6 and L7 quadricycles and off-road quadricycles was very limited, although available data indicated that the fatality risk per 100,000 vehicle kilometres was between 10 and 14 times that of passenger cars, and lay between the risk for M1 vehicles and mopeds. The data was not disaggregated by quadricycle type, making the safety risk of different types of quadricycle difficult to determine. Furthermore it was not possible to establish the proportion of these accidents which would be influenced by the proposed regulatory changes. This made the assessment of societal benefits (likely to be a significant element of the benefit for any proposed measure) difficult to estimate. Further data is required to enable more accurate assessment of the influence on casualties, and it is considered important that accident data relating to specific quadricycle types is collected if future proposals, and subsequent monitoring of these measures, is considered necessary.

Excluding quadricycles from the framework directive was estimated to result in significant potential cost increases to Industry relating to increased approval costs. The benefits for this option were considered to be lower than the investment required.

Stakeholders indicated that reverting to national approvals has the potential to negatively influence the industry, because approving at a national level (potentially to different country specific requirements) may inhibit the market and would ultimately increase the costs to manufactures and consumers. Reducing quadricycle size and unladen mass limits has the potential to improve safety, although most current quadricycles exceed the proposed limits and therefore this may result in significant manufacturer development cost to meet new requirements. Industry was in favour of this option in principle, since it differentiates quadricycles for other vehicles, although the criteria suggested by industry were larger than the limits proposed by the EC and more consistent with current quadricycle dimensions.

Aligning the quadricycle requirements with M1 vehicles was estimated to result in significant cost increases to meet front and side crashworthiness requirements. Manufacturer cost would be significantly increased in materials, design, development, and testing; airbag development was estimated to cost in the region of €700,000. Significant societal and environmental benefits may result from this investment, but the effects and magnitude of these were uncertain. Reducing quadricycle size and mass was estimated to require lower investment, but with smaller resulting benefits. The environmental impacts were assessed as low negative for all options, apart from improving the requirements towards that of M1 vehicles, where low positive benefits for noise and emissions might be possible.

For assessment of the options for off-road quadricycles, similar problems were encountered relating to the limited data on current and modified approval costs and the potential safety benefits; no accident data was available to estimate the societal effect of the proposed options. Industry supported the creation of a new category for off-road quadricycles with specific requirements. The economic implications for this option are unclear, although more targeted requirements could reduce ongoing costs (after any one-off costs) which have the potential for societal and environmental benefits. It is important for the identification and monitoring of future measures that differentiation of off-road quadricycles in the accident data is implemented.

Hydrogen-powered vehicles have environmental potential (i.e. zero emissions from the vehicle), providing the hydrogen used is produced using clean energy and the significant infrastructure necessary can be implemented. Maintaining the current situation with respect to Hydrogen powered L category vehicles was considered to have minor negative environmental impacts, in that any environmental benefits of these vehicles may be delayed by inhibiting the market. Including these vehicles in the European type approval directive is likely to increase costs in the approval process. Stakeholders offered conflicting views that this option would create a uniform set of requirements, thereby improving investment, or that this would inhibit development due to increased approval costs and may also stifle innovation. As such, the overall effects are unclear, although inclusion of the these vehicles in the directive is considered by TRL to be more likely to provide economic benefits and mean that future changes could be easily implemented across the whole of the European market. This measure is also likely to result in significant environmental benefit (assuming "clean" hydrogen supply) although the magnitude was uncertain. The costs for national approval could not be quantified, but differing national requirements may mean that the full environmental effects may not be attained efficiently. Finally, it should be noted that the environmental benefits of adopting Hydrogen as a fuel is considered to be long-term, because significant infrastructure investment is required for the creation, storage and distribution to consumers. Furthermore, the "well to wheel" impacts must be considered since a clean energy supply is a prerequisite to deliver the full environmental benefit; without this, environmental harm is simply being transferred from energy use (emissions) to energy generation. Although providing a technology with low emissions, the necessity for a clean energy supply means that further research is required regarding the benefits of electric and hybrid vehicles in direct relation to Hydrogen vehicles.

1 Introduction

Type approval requirements for mopeds, motorcycles, tricycles and quadricycles (vehicle category L) are currently contained in Directive 2002/24/EC and its daughter directives. This framework became mandatory for all category L vehicles sold in the European Union from 9th May 2003.

Following the recommendations from the CARS21 initiative, the European Commission has proposed simplifying the legislation relating to category L vehicles by repealing the present framework directive and 14 associated Directives. It is proposed that these be replaced by two Regulations; one covering the main political aspects, adopted in co-decision; and one with all the detailed technical requirements, adopted by comitology.

While the Commission is considering these revisions to the legislative framework requirements, a number of changes to technical requirements have been proposed aimed at improving the level of safety for motorcycles in Europe. In 2006, motorcycles accounted for 2% of distance travelled, but accounted for 16% of road deaths in the EU-25 (ETSC, 2007). Indeed, the fatality rate per million kilometres travelled is, on average, 18 times greater than passenger cars (ETSC, 2007). Furthermore, while other vehicle modes have shown significant decreases in fatalities and serious injuries over time, those for motorcycles have exhibited much lower decreases or remained static.

The Commission is required to carry out an impact assessment when proposing significant changes to legislation and this report describes the findings of a cost benefit analysis intended to inform the Commission's Impact Assessment by identifying the likely economic, social and environmental effects that would be expected if a range of different policy options were to be implemented. The effects of a series of potential regulatory actions (as well as regulatory simplification) were considered on the topics of:

- ABS/coupling braking devices for motorcycles;
- Anti-tampering for mopeds, motorcycles, tricycles and quadricycles;
- 74kW power limit for motorcycles;
- Quadricycles (L6 and L7);
- Off-road quads; and
- Safety of hydrogen-powered L category vehicles.

This analysis only considered costs and benefits to individual Member States and to industry. Additional costs to the Commission relating to the implementation of the proposed changes, as well as the cost to make regular amendments to existing Directives have not been included here; it was anticipated that these costs would be addressed by the European Commission as part of the final impact assessment.

2 Simplification of the legislation

2.1 Problem definition

Type approval requirements for mopeds, motorcycles, tricycles and quadricycles (vehicle category L) are currently contained in Directive 2002/24/EC and its daughter directives. The framework Directive 2002/24/EC became mandatory for all category L vehicles sold in the European Union from 9th May 2003. The Directive applies to all two or three-wheel motor vehicles with a maximum design speed exceeding 6km/h intended to travel on the road and to the components or separate technical units of such vehicles. The Directive also applies to quadricycles (motor vehicles with four wheels whose unladen mass is not more than 400kg and maximum net engine power does not exceed 15kW). Quadricycles designed for carrying goods can have an unladen mass of 550kg and a trailer mass of up to 2.2 tonnes. Table 1 shows the current technical requirements from Annex 1 of Directive 2002/24/EC.

In 2005, the CARS 21 initiative was set up to carry out an automotive-related regulatory and policy review in order to advise the Commission on future policy options. One of the reasons for setting up CARS 21 was the concern expressed by industry that the cumulative cost of regulation had a negative effect on competitiveness and made vehicles unnecessarily expensive. A dedicated sub-group was set up to scrutinise the regulatory framework and to identify possibilities for withdrawing or simplifying the legislation in force.

The CARS 21 High Level Final Report (CARS21, 2005) describes how the CARS 21 sub-group concluded that most of the legislation in force should be maintained for the protection of health, safety, consumers and the environment. The group also recommended that 38 directives could be replaced by UNECE Regulations without any loss in the level of safety and environmental protection. The group identified one directive which could be repealed and 25 directives and UNECE Regulations in which self –testing and virtual testing could be introduced so as to reduce regulatory compliance costs for industry by making administrative procedures less costly and time-consuming.

Following the Cars 21 initiative the Commission would now like to simplify the legislation on category L vehicles by repealing the 14 present directives and the framework directive. These would be replaced by just two regulations, one adopted in co-decision and covering the main political aspects and the other adopted by comitology with all the detailed technical requirements. Furthermore, wherever possible, references to UNECE regulations will be made instead of duplicating the same requirements in EU regulation.

Table 1. Technical requirements for category L vehicles.

Subject	Directive number
Maximum torque and maximum net power of engine	95/1/EC
Anti-tampering measures	97/24/EC Chapter 7
Fuel tank	97/24/EC Chapter 6
Maximum design speed	95/1/EC
Masses and dimensions	93/93/EEC
Coupling devices and their attachment	97/24/EC Chapter 10
Anti-air pollution measures	97/24/EC Chapter 5
Tyres	97/24/EC Chapter 1
Braking systems	93/14/EEC
Installation of lighting and light-signalling devices on the vehicle	93/92/EEC
Lighting and light-signalling devices on the vehicle the mandatory or optional presence of which is laid down in the installation requirements	97/27/EC Chapter 2
Audible warning device	93/30/EEC
Position for the mounting of rear registration plate	93/94/EEC
Electromagnetic compatibility	97/24//EC Chapter 8
Sound level and exhaust system	97/24//EC Chapter 9
Rear-view mirror(s)	97/24//EC Chapter 4
External projections	97/24//EC Chapter 3
Stand (except in case of vehicles having three or more wheels)	93/31/EEC
Devices to prevent unauthorised use of the vehicle	93/33/EEC
Windows; windscreen wipers; windscreen washers; devices for de-icing and de-misting for three-wheel mopeds, motor tricycles and quadricycles with bodywork	97/24//EC Chapter 12
Passenger hand-hold for two-wheel vehicles	93/32/EEC
Anchorage points for safety belts and safety belts for three-wheel mopeds, motor tricycles and quadricycles with bodywork	97/24//EC Chapter 11
Speedometer	2000/7/EC
Identification of controls, tell-tales and indicators	93/29/EEC
Statutory inscriptions (content, location and method of affixing)	93/34/EEC

Note: Technical requirements only. Base directives have been listed here (not later amendments)

2.2 Objectives

The objectives of the EC proposal to simplify the legislation are:

- To contribute to the competitiveness of the European motor industry by simplifying the type-approval legislation to improve transparency and reduce administrative burden.
- To contribute to towards casualty reduction and environmental targets, by reducing administrative burden, resulting in more timely implementation of new safety and environmental measures.

2.3 Policy options

The options identified are as follows:

a. **No change**. The legislation remains as it is today with the Framework Directive and its daughter Directives;

b. **Repeal current directives and replace with two regulations**. The current type approval Directive and its daughter Directives will be repealed and replaced by one Regulation covering political aspects and a second Regulation covering the technical requirements. The new Regulations will make use of the existing technical requirements outlined in UNECE Regulations (or equivalent) where appropriate.

2.4 Analysis of impacts

The impacts associated with this proposal are mainly economic. However, the proposal could also lead to some social or environmental impacts. The impacts in each of these three areas in terms of both costs and benefits are discussed in the following sections.

2.4.1 Economic impacts

2.4.1.1 Option A: No change

For the "no change" option, Directive 2002/24/EC would remain unchanged, with all Member States retaining reference to the existing 14 implementing Directives.

As part of the research for the EC project "Evaluation of the impact of possible new measures concerning the type approval of agricultural vehicles", consultation was carried out to determine the procedure for European member states when one of the implementing Directives is amended. Dodd (2009) reported that each respondent provided an estimate of the staff time required to make the necessary changes as well as an estimated labour rate for the staff involved in the process. Based on this information, the cost for an individual Member State to make the necessary changes to their National Legal Framework was estimated to be between €270 and €18,040 per amended directive, with an average (mean) cost of €5,353 per change. This cost estimate encompasses a large range based on the small number of diverse responses obtained from six Member States: Finland, Greece, Latvia, UK, Hungary, and Slovenia. It is considered that the estimates reported by Dodd (2009) are directly applicable, since they report estimated effort required by Member states to action changes in implementing Directives. It is considered that the administrative effort involved in amending the type approval legislation in each member state is likely to be comparable for regulations relating to motorcycles as for those relating to agricultural vehicles.

The European Commission's website provides a chronological list of Directive and Regulations[1]. This list was used as a source to estimate that, over the ten year period

[1] http://ec.europa.eu/enterprise/automotive/directives/motos/index.htm

1996-2006, there were on average approximately two amendments or adjustments to EC Directives relevant to category L vehicles per annum.

Using this estimate of the frequency of changes per year, combined with the estimates of the administrative cost per amendment, provides an estimate of the cost of the current system (the "do nothing" option). This data suggests that, based on the person hours required to make the necessary changes and estimated staff costs, the annual cost estimate ranges from €540 and €36,080 per Member State, with an average of €10,706. Multiplying up these estimates to represent the whole of Europe provides a total estimated cost to EU-27, as shown in Table 2.

Table 2. Summary of estimated costs associated with current system (the "do nothing" option).

	Lower cost limit	Average (Mean)	Upper cost limit
Cost per change for individual Member State	€ 270	€ 5,353	€ 18,040
N° of amendments per year	2	2	2
Annual cost per Member State	€ 540	€ 10,706	€ 36,080
N° of Member States	27	27	27
Annual cost for EU-27	**€ 14,580**	**€ 289,062**	**€ 974,160**

Table 2 shows a substantial difference between the highest and lowest cost estimates for the current system. This difference is a result of the variation in the manpower estimates provided by the Member states that responded to the survey. Dodd (2009) reported that this variation might be because of differences in the way each respondent estimated the costs and effort required (i.e. the actual costs are the same in each Member State but the respondents did not have the necessary data to provide an accurate figure, and provided variable estimates). If this is the case, then the most appropriate method of estimating the cost across the EU-27 is to multiply the lowest and highest values by 27 to produce a range of results. However, it is perhaps equally possible that the costs stated by the respondents are accurate, but there is a genuine difference between the costs in each Member State. If this is the case, then the most appropriate method of estimating the cost to the EU-27 would be to take the average value for the cost and multiply this by 27.

Dodd (2009) reported that respondents to the agricultural vehicles consultation suggested that there may be genuine differences in the levels of effort (and therefore cost) required to implement changes to Directives in each Member State. Therefore, the true cost is likely to be closer to the average value quoted in Table 2 than either the maximum or minimum estimates. However, it should be noted that this is based on the responses from only six Member States and how representative this value is of the entire EU-27 is unknown.

Table 3. Option A - The Annual and cumulative cost in making no changes to the type approval framework.

	Annual Cost*			Cumulative Cost*		
Year	**Lower cost limit**	**Average (Mean)**	**Upper cost limit**	**Lower cost limit**	**Average (Mean)**	**Upper cost limit**
2009	€ 14,580	€ 289,062	€ 974,160	€ 14,580	€ 289,062	€ 974,160
2010	€ 14,300	€ 283,503	€ 955,426	€ 28,880	€ 572,565	€ 1,929,586
2011	€ 14,025	€ 278,051	€ 937,053	€ 42,905	€ 850,616	€ 2,866,639
2012	€ 13,755	€ 272,704	€ 919,032	€ 56,660	€ 1,123,320	€ 3,785,671
2013	€ 13,490	€ 267,460	€ 901,359	€ 70,150	€ 1,390,780	€ 4,687,030
2014	€ 13,231	€ 262,316	€ 884,025	€ 83,381	€ 1,653,096	€ 5,571,055
2015	€ 12,977	€ 257,272	€ 867,024	€ 96,358	€ 1,910,368	€ 6,438,079
2016	€ 12,727	€ 252,324	€ 850,351	€ 109,085	€ 2,162,692	€ 7,288,430
2017	€ 12,482	€ 247,472	€ 833,998	€ 121,567	€ 2,410,164	€ 8,122,428
2018	€ 12,242	€ 242,713	€ 817,959	€ 133,809	€ 2,652,877	€ 8,940,387
2019	€ 12,007	€ 238,045	€ 802,229	€ 145,816	€ 2,890,922	€ 9,742,616
2020	€ 11,776	€ 233,467	€ 786,802	€ 157,592	€ 3,124,389	€ 10,529,418

*: Costs include an inflationary increase of 2% per annum and a discount rate of 4%

Table 3 above shows the annual and cumulative costs in making no change to the EC framework. The values are derived from the data in Table 2 and assume that the source data are current (2009) valuations. The future costs incorporate an annual 2% inflationary increase and are discounted at 4% as recommended by SEC (2005) 791.

2.4.2 Translations

For the current regulatory system, when an amendment is made to a Directive, the document will be translated from English to the languages of individual Member States. Based on an estimated translation cost (per 1,000 words) and an estimate as to the average length of a new Directive or an amendment, the cost per translation has been estimated to be between €500 and €600.

If an amendment is a co-decision regulation, then the document must be translated into 23 different languages. For other proposals there is an exemption for Irish, meaning that just 22 languages are required. Therefore it has been assumed that each change in Directive could be translated into 22 to 23 languages, with two amended Directives per year. On this basis the annual cost for translations has been estimated to be between €22,000 and €27,600, as shown in Table 4.

Table 4. Option B - Estimated annual cost for translations.

	Lower cost limit	Average (Mean)	Upper cost limit
Cost per translation	€ 500	550	€ 600
Number of languages	22	22.5	23
Number of translations/yr	2	2	2
Annual cost of translation	**€22,000**	**€24,750**	**€27,600**

2.4.2.1 *Option B: Repeal current directives and replace with two regulations*

Research examining the potential benefits of simplifying legislation has largely been carried out as part of the CARS 21 initiative. The CARS21 research (CARS21, 2005) indicates that the replacement of 38 directives for cars and commercial vehicles with UNECE regulations could have a positive economic effect. The research refers to potential benefits due to reducing regulatory costs for manufacturers which could allow for the increased standardisation of vehicles and components. The research also indicated that as the major future increase in demand for vehicles would be from outside Europe, that global technical requirements will be a factor in creating a "level playing field" in the major automotive markets.

In the case of regulatory simplification, the current type approval Directive and its daughter Directives would be repealed and replaced by one Regulation covering political aspects and a second Regulation covering the technical requirements. The new Regulations would make use of the existing technical requirements outlined in UNECE Regulations (or equivalent) where appropriate.

If this option was selected there would be an initial administrative investment by Member States to replace the current type approval framework with the two regulations discussed, followed by a regular annual cost to adapt the new regulations to technical progress.

Dodd (2009) reported that stakeholder responses suggested that the costs of the initial investment of administrative effort could range from €675 to €135,000 per Member State. This represents substantial variation, which incorporates differing labour rates among Member States and the amount of effort each Member State reported necessary to complete the change. The majority of respondents reported that they would not need to introduce any new legislation but one Member State reported that they would have to adopt a new national legislation system.

Multiplying the above range by the 27 Member States gives an estimated initial investment cost ranging from €18,225 to €3,653,100 with an average of €909,225. Dodd (2009) commented that the true cost for the EU-27 is likely to closer to the average value, bearing in mind the large range of reported cost and the relatively small sample size (5 European member states). Furthermore, ongoing annual costs would be required in addition to the initial cost of altering the regulatory system. Values obtained by Dodd (2009) are directly applicable to this case and indicate that each ongoing regulatory change would cost between €70 and €9,020, with an average cost of €2,635.

Based on the estimate of two amendments per annum, the annual cost per Member State has been estimated to be between €140 and €18,040, with an average cost of €5,270. Multiplying this range by 27 Member States provides an estimated annual cost of between €3,780 and €487,080 with an average cost of €142,290, as shown in Table 5.

Table 5. Summary of costs to replace the EC Framework with two regulations.

	Lower cost limit	Average (Mean)	Upper cost limit
Investment cost per Member State	€ 675	€ 33,675	€ 135,300
N° of Member States	27	27	27
Investment cost for EU-27	**€ 18,225**	**€ 909,225**	**€ 3,653,100**

Cost per Member State to amend new Regulation	€ 70	€ 2,635	€ 9,020
N° of amendments per year	2	2	2
Annual cost per Member State	€ 140	€ 5,270	€ 18,040
N° of Member States	27	27	27
Annual cost for EU-27	**€ 3,780**	**€ 142,290**	**€ 487,080**

Therefore, by combining the estimated initial cost to amend the framework and the cost estimates for amendments for the first year of implementation, an estimated cost can be derived. These estimates for EU-27 cost are a minimum of €22,005, a maximum €4,140.180, and an average estimate of €1,051.515.

Table 6. Option B - Annual and cumulative cost in replacing with two regulations.

	Annual Cost*			Cumulative Cost*		
Year	**Lower cost limit**	**Average (Mean)**	**Upper cost limit**	**Lower cost limit**	**Average (Mean)**	**Upper cost limit**
2009	€ 3,780	€ 142,290	€ 487,080	€ 3,780	€ 142,290	€ 487,080
2010	€ 3,707	€ 139,554	€ 477,713	€ 7,487	€ 281,844	€ 964,793
2011	€ 21,167	€ 1,011,461	€ 3,982,473	€ 28,654	€ 1,293,305	€ 4,947,266
2012	€ 3,566	€ 134,238	€ 459,516	€ 32,220	€ 1,427,543	€ 5,406,782
2013	€ 3,498	€ 131,656	€ 450,679	€ 35,718	€ 1,559,199	€ 5,857,461
2014	€ 3,430	€ 129,124	€ 442,012	€ 39,148	€ 1,688,323	€ 6,299,473
2015	€ 3,364	€ 126,641	€ 433,512	€ 42,512	€ 1,814,964	€ 6,732,985
2016	€ 3,300	€ 124,206	€ 425,175	€ 45,812	€ 1,939,170	€ 7,158,160
2017	€ 3,236	€ 121,817	€ 416,999	€ 49,048	€ 2,060,987	€ 7,575,159
2018	€ 3,174	€ 119,475	€ 408,980	€ 52,222	€ 2,180,462	€ 7,984,139
2019	€ 3,113	€ 117,177	€ 401,115	€ 55,335	€ 2,297,639	€ 8,385,254
2020	€ 3,053	€ 114,924	€ 393,401	€ 58,388	€ 2,412,563	€ 8,778,655

*: Costs include an inflationary increase of 2% per annum and a discount rate of 4%

Table 6 shows estimated costs relating to replacing the existing framework with two regulations. For the first year of this option the initial investment cost and the estimated annual cost are combined. This data has been derived from Table 5 and assume the source data is current (2009) valuations. The implementation of the change has been assumed to occur in 2011 with the cost relating to changing the system being incurred in this year. As with the previous table, all future costs incorporate an annual 2% inflationary increase and are discounted at 4% as described by SEC (2005) 791. By subtracting the cumulative costs associated with replacing the existing framework with two regulations (Table 6) from the cumulative costs associated with maintaining the current framework (Table 3) it is possible to estimate the net cost effect of simplifying the regulatory framework by replacing the 14 directives with one Regulation covering political aspects and a second Regulation covering the technical requirements (Table 7).

Table 7. Option B - Estimated annual and cumulative benefit of simplifying the regulatory framework.

	Estimated Annual Benefit*			Estimated Cumulative Benefit*		
Year	**Lower cost limit**	**Average (Mean)**	**Upper cost limit**	**Lower cost limit**	**Average (Mean)**	**Upper cost limit**
2011	-€ 7,142	-€ 733,410	-€ 3,045,420	-€ 7,142	-€ 733,410	-€ 3,045,420
2012	€ 10,189	€ 138,466	€ 459,516	€ 3,047	-€ 594,944	-€ 2,585,904
2013	€ 9,992	€ 135,804	€ 450,680	€ 13,039	-€ 459,140	-€ 2,135,224
2014	€ 9,801	€ 133,192	€ 442,013	€ 22,840	-€ 325,948	-€ 1,693,211
2015	€ 9,613	€ 130,631	€ 433,512	€ 32,453	-€ 195,317	-€ 1,259,699
2016	€ 9,427	€ 128,118	€ 425,176	€ 41,880	-€ 67,199	-€ 834,523
2017	€ 9,246	€ 125,655	€ 416,999	€ 51,126	€ 58,456	-€ 417,524
2018	€ 9,068	€ 123,238	€ 408,979	€ 60,194	€ 181,694	-€ 8,545
2019	€ 8,894	€ 120,868	€ 401,114	€ 69,088	€ 302,562	€ 392,569
2020	€ 8,723	€ 118,543	€ 393,401	€ 77,811	€ 421,105	€ 785,970

*: Costs used to calculate cost savings (benefit) include an uplift of 2% per annum and a discount rate of 4%. The negative values are negative benefits (i.e. costs).

Table 7 provides estimates for the annual and cumulative benefits of Option B (i.e. to repeal the current Directive and its 14 "daughter" directives with one Regulation covering political aspects and a second Regulation covering the technical requirements). It has been assumed that simplified system is implemented in 2011, with all costs adjusted and discounted from the current (2009) estimate ranges. The negative values in the table should be interpreted as costs (negative benefits).

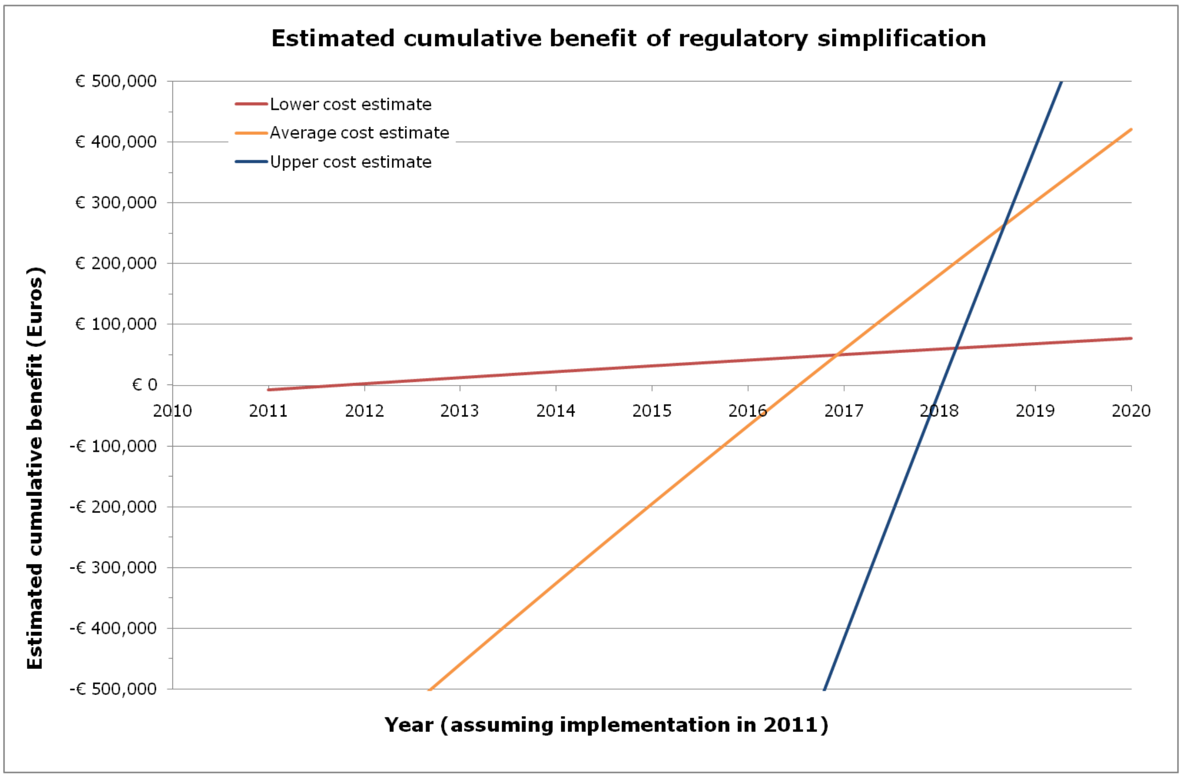


Figure 1. Option B: Estimated cumulative benefit of simplifying the regulatory framework.

It can be noted that after the initial investment in administrative effort within the member states, the simplification provides annual cost savings of between €10,189 and €459,516 in the first year following implementation.

It is estimated that it would take between one and eight years to achieve a benefit to cost ratio of one (i.e. break even) and ten years after the scheme is implemented (2020) it is estimated that a benefit to cost ratio of between 1.10 and 2.53 could be achieved, with an average benefit to cost ratio of 1.20.

However, it should be noted that future benefits will be accrued at a greater rate under the simplified regulatory system should there be an average of more than two amendments required per year. Conversely, the costs assessed relate to the cost incurred by the member states of the EU-27; no cost estimates have been included for costs incurred by the European Commission under the current regulatory system or the option for regulatory simplification.

2.4.3 Type approval costs

No specific information was collected regarding the current type approval costs, although stakeholders indicated that simplification of the regulation was considered unlikely to change to the number and annual cost of type approvals. This is consistent with information gathered from other recent consultations regarding this issue for other vehicle types. Thus, it is considered unlikely that there will be any significant increase in cost to the consumer as a result of simplifying the regulatory system.

2.4.4 Attend meetings

In addition to the cost of gaining type approval, there is also a cost for Member States and industry representatives to attend regular standard group meetings. No specific information was forthcoming from the stakeholder consultation regarding the current costs associated with meeting attendance, or the effect on the level of effort which might be brought about by regulatory simplification. Previous consultations, albeit on a different vehicle type, on this issue have produced conflicting evidence. For example, Dodd (2009) reported that responses ranged from a potential reduction in effort to a possible increase in required effort, with other responses indicating no expected increase. In light of the lack of appropriate data, and conflicting information from other consultations, this potential cost saving has not been quantified.

2.4.5 Other factors related to regulatory simplification

Within the option of regulatory simplification, there is the option for either a full reference to a technical standard (where a translation into the language of each Member State is required) or a direct reference (where no translation is required). If a direct reference was made to an equivalent standard then there would no requirement to translate the document into the 22-23 different languages. Therefore, in this case, there would be an estimated cost saving (benefit) of between €22,000 and €27,600 per annum. If a full reference to the relevant technical standard was necessary then translations would still be required and no cost savings would be anticipated.

Although the simplification of the regulatory framework is not expected to alter the cost of type approval, some non-monetary impacts can be identified. These relate to the clearer and less complex regulatory system. This step may have proportionately greater benefits for SMEs or new entrants to the market, since changes in regulatory requirements will be more transparent and easier to follow.

2.5 Societal impacts

The main benefits in terms of societal impacts for simplifying the regulatory framework result from the quicker implementation of changes to technical requirements. Therefore, changes which bring about safety or environmental benefits can be implemented more quickly and these benefits can be realised more rapidly. However, the magnitude of these benefits is difficult to quantify because they are dependent on the specific change to the technical requirements and the resulting effect on safety or environmental performance.

Other advantages of a simplified system are a clearer set of regulatory requirements; this may confer a proportionately larger benefit for SMEs or new entrants to the market, although the magnitude of any benefit is uncertain.

2.6 Environmental impacts

Option B (Repeal current directives and replace with two regulations) may have environmental benefits resulting from reduced travel to technical standards meetings. A reduction in travel would have carbon emission benefits, although the size of any saving is largely dependent on whether or not the proposed change results in the need for fewer technical meetings and may be negligible compared to other factors. The information reported by Dodd (2009) contains conflicting opinions. It is recommended that this issue should be monitored to allow future emission benefits to be more accurately estimated.

2.7 Comparing the options

The following table provides a summary of the identified impacts for the two options on the subject of regulatory simplification.

Table 8. Summary of impacts for regulatory simplification options.

Option	Impact type	Qualitative impacts	Quantified value: Low	Quantified value: Mean	Quantified value: High
A	Economic	This is the "do nothing" scenario and therefore there will be a minimal impact on the EU-27 and Industry	14,580	289,062	974,160
			These costs are currently incurred so no net change in cost		
B	Economic	After initial investment, reduced annual costs of regulatory system	Ongoing annual cost		
			3,780	142,290	487,080
			Net benefit 2011-2020 (Benefit to cost ratio in brackets)		
			77,811	421,105	785,970
			(1.10)	(1.20)	(2.53)
B	Economic	Translation cost eliminated if direct reference to technical standard	€22,000 to €27,600 per annum (average €24,750)		
B	Economic	Technical standards meeting effort reduced for Industry/EU-27	Not quantified; magnitude of change uncertain		
B	Economic	Standardisation of component and vehicle design leading to economies of scale	Not quantified; will only lead to savings for OEMs if standard design can be sold in more countries		
B	Societal	Time taken for implementation of regulatory change deceased so benefits can be accrued more rapidly	Not quantified; potential large safety/environmental benefit depending on the performance of proposed change and how much quicker it can be implemented compared with current situation		
B	Societal	More transparent regulatory system. Intangible benefits to all stakeholders; All Industry; potentially larger benefits for SMEs and new entrants	Not quantified; benefits difficult to quantify		
B	Environmental	Emissions resulting from travel to/from technical standards meetings reduced for Industry/EU-27	Not quantified; benefits uncertain		

Table 9 compares the economic, societal and environmental impacts for the options related to regulatory simplification. In the table, arrows are used to represent the estimated magnitude of each impact, with the direction of the arrow denoting whether the impact is positive or negative. Where the impact is considered to be neutral, there are no arrows. The "dotted" arrows are used where the magnitude of the impact is uncertain due to insufficient information or where the magnitude is dependent on other factors.

This analysis shows that Option B is the recommended option since this option has significant economic benefits as well as societal and environmental benefits.

Table 9. Comparison of impacts for the options relating to regulatory simplification.

			Impact	
	Option	**Negative**	**Neutral**	**Positive**
Economic	A		●	
	B		●———→	
Societal	A		●	
	B		●→·········→	
Environmental	A		←···●	
	B		●···→	

2.8 Monitoring and evaluation

The following issues should be monitored to ensure the effectiveness of the proposed change prior to the earliest implementation date (2011):

- Monitor the key cost parameters used as a basis for the analysis;
    - Number of amendments required to relevant Directives per annum
    - Ongoing costs to member states of implementing current system
    - Monitor numbers of type approvals per annum
    - Time taken for implementation of regulatory changes
    - Monitoring and standardisation of vehicle design
    - Number of technical standard group meetings, travel mode, distance and number of attendees

Evaluation of the proposed change should also monitor key costs to allow the accuracy of the cost saving (benefit) estimate of Option B to be assessed.

3 Advanced braking systems

3.1 Problem definition

For the purposes of this study, advanced braking systems are defined as Anti-lock Braking Systems (ABS) or Combined Braking Systems (CBS). Anti-lock braking systems (ABS) monitor the speed at which the wheels are rotating and rapidly modulate the brake pressure when imminent wheel lock is detected in order to increase effective braking and prevent the deceleration being dictated by the sliding friction between tyre and road. ABS is the only technical solution which directly monitors and prevents wheel locking and has been shown in test conditions to result in generally higher braking decelerations by maintaining the wheel slip such that friction is above the level provided by locked wheels. Preventing wheel lock under emergency braking provides the rider with increased confidence to apply higher brake forces.

Combined braking systems (CBS) are used to ensure that the correct braking distribution is applied regardless of which brake is activated; currently the rider must use two separate mechanisms to operate the front and rear brakes. The use of CBS allows one mechanism to operate both brakes (in a similar way to that of a passenger car). The primary aim of this system is to appropriately distribute the braking effort between the front and rear wheels. Compared with rider-controlled distribution of braking between the front and the rear, CBS reduces the chances of wheel lock and instability occurring at less than the maximum level of deceleration. For example, if a rider applied the rear brake very hard, without using the front brake, the rear wheel could lock and cause instability at a level of deceleration considerably less than half the maximum achievable. CBS can prevent such a situation but cannot prevent wheel lock when the rider applies the single brake control harder than required to produce maximum deceleration.

Field studies have shown that average Powered Two Wheeler (PTW) riders are able to achieve emergency braking decelerations of 0.6g to 0.7g, with experienced riders able to achieve higher braking decelerations. With ABS equipped motorcycles, tests have shown that both inexperienced and experienced riders are able to improve stopping performance, with inexperienced riders being able to achieve decelerations closer to that of experienced riders. ABS systems have been widely shown to assist all riders to use the braking capacity more effectively and achieve a higher level of deceleration. As well as improving decelerations in the emergency braking event, overall performance may be improved by providing the rider with increased confidence in applying the brakes.

European legislation states the motorcycle braking systems must meet minimum requirements in terms of deceleration, stopping distance, brake fade and performance when wet. No advanced braking systems are currently mandatory under current European legislation; however legislation denoting minimum braking performance must be met if systems are fitted.

PTWs fitted with ABS must also meet the minimum performance requirements for ABS specified in the directive. These ensure that vehicles fitted with ABS are able to make use of the adhesion available when on low and high friction surfaces. Brief periods of wheel locking or extreme wheel slip are allowed, provided that this does not affect the stability of the vehicle. Below speeds of 10 km/h wheel locking is permitted.

3.2 Objectives

The objective of this proposal is to contribute to the European casualty reduction targets by the introduction of advanced braking systems for motorcycles. In 2006, motorcycles on European roads accounted for 2% of distance travelled, but accounted for 16% of road deaths in the EU-25 (ETSC, 2007). Indeed, the fatality rate per million kilometres travelled is, on average, 18 times greater than passenger cars (ETSC, 2007). Furthermore, while other vehicle modes have shown significant decreases in fatalities and serious injuries over time, those for motorcycles have exhibited much lower decreases or remained static.

3.3 Policy options

The following three options have been identified for advanced braking systems:

a) **No change**. The situation stays as it is today. The fitting of ABS or any other form of advanced braking system is not made mandatory in EU legislation. Fitment of advanced braking systems are at the discretion of the vehicle manufacturer

b) **ABS on all motorcycles**. From 2011, all motorcycles (PTWs with engine capacity >50cc) would have to be fitted with ABS in order to be sold in Europe.

c) **ABS on motorcycles with cylinder capacity >125cc and advanced braking systems on motorcycles with cylinder capacity >50cc and ≤ 125cc**. This is the compromise solution. ABS would only be mandatory for larger motorcycles (cylinder capacity >125cc). For smaller motorcycles (cylinder capacity >50cc and ≤ 125cc), only an advanced braking system (e.g. coupled brakes) would be required.

3.4 Review of literature

There has been substantial research undertaken into the potential benefit of advanced braking systems. This includes various studies of accident data, field trials and large scale cost/benefit analyses.

A study conducted by the Austrian Road Safety Board (Vavryn and Winkelbauer, 2004) aimed to qualify and quantify how ABS improves brake handling of the average motorcycle rider in an emergency braking manoeuvre. The participants of the study included both new license holders and experienced riders taken to be representative of the Austrian riding population. The study found that, for motorcycles not equipped with ABS, experienced motorcycle riders achieved an average braking deceleration of about 6.6 ms^{-2}, while novices, after six hours of training, achieved an average of 5.7ms^{-2}. After an introduction to ABS and a few minutes practice, experienced riders were able to achieve an average deceleration of 7.8ms^{-2} and novices an average of 7.7ms^{-2} when using a motorcycle equipped with ABS. The report also stated that riders of motorcycles fitted with ABS are able to improve their brake performance immediately after receiving instructions on correct ABS brake handling. The report recommended that ABS should be mandatory equipment for every powered two-wheeler.

Sporner and Kramlich (2000) used in-depth investigation of 610 accidents which showed that in 65% of all accidents between motorcycles and cars, the motorcycle rider was able to brake before the collision. In 19% of these cases the rider fell off before the collision. On average, they concluded that about 55% of the 610 motorcycle accidents could be positively influenced by ABS.

A European Transport Safety Council (2001) paper also quotes the Sporner and Kramlich (2000) report, stating that ABS could reduce the number of accident victims by at least 10%. As a result the ETSC recommended that ABS should be mandatory for motorcycles and this measure was placed third on their list of priorities for legislation.

Gwehenberger *et al* (2004) studied 200 serious accidents to investigate the effectiveness of ABS. They found that ABS stabilises the braking process, shortens the braking distance and prevents the front wheel from over-braking, thus preventing dangerous falls whilst braking. They found that ABS ensures less effort intensive braking for the motorcycle rider, particularly during limit and emergency braking scenarios. Overall they predicted that ABS could avoid between 8% and 17% of all serious motorcycle accidents.

The authors also stated that rider training is required order to achieve the maximum advantages of ABS.

Two studies by McCarthy and Chinn (1998 and 1999) investigated ABS and its effect on BMW motorcycle accidents. The first study provided inconclusive results due to data limitations; primarily a very small sample size of ABS related accidents, with only 37 fatal and serious cases. The later report, with a larger sample size, found that the proportion of casualties from ABS-equipped machines that were fatal or serious were, on average, about 3% lower than from non-ABS equipped machines. The proportion of impacts that were to the front of the motorcycle was, on average, 8% lower for ABS-equipped machines when compared to non-ABS machines. The study also found that casualties from ABS-equipped machines were about 5% higher than that of non-ABS machines in poor road conditions (e.g. wet, snow, ice or flood). It was reasoned that this result was likely to have been influenced by factors such as rider behaviour and characteristics of the motorcycles in the sample, rather than a reflection of poor ABS performance in these road conditions. The proportion of casualties on ABS-equipped machines at or near road junctions was about 2% lower than for those on non-ABS equipped machines.

Furthermore, two large scale cost benefit studies have been undertaken. One was on behalf of the International Motorcycle Manufacturers Association (IMMA) and conducted by Dynamic Research Inc. (Kebschull and Zeller, 2007 & 2008), the other was completed by the University of Cologne (Baum *et al*, 2007).

Kebschull and Zellner (2007 & 2008) used data collected from European accidents using the MAIDS[2] accident study (data collected between 2000 and 2004) and for the USA using the research by Hurt *et al* (1981). This study included mopeds as well as motorcycles; TRL consider that the benefit of advanced braking systems are lower for mopeds due to the types of accidents they are involved in and the lower average travel speeds. The in-depth data from each of these sources was used to create computer simulations of each accident. A total of 921 European accidents and 900 American accidents were simulated, each one with and without ABS fitted to the motorcycle. Three ABS configurations were examined; front ABS only, rear ABS only and independent front and rear ABS. The study found that all types of ABS had a 'low effectiveness', and had costs much higher than for other 'low effectiveness' vehicle safety measures. This led to the report determining that ABS is not a cost effective safety measure.

In contrast, Baum *et al* (2007) assumed that ABS is effective in 85% of all accidents that involve a downfall, and that a rider is twice as likely to be fatally injured in a downfall[3] rather than a non-downfall accident. Benefit-cost ratios for two effectiveness levels were calculated; low and high. Low effectiveness only assessed the potential for injury mitigation for fatally injured riders in downfall accidents. The low effectiveness assessment assumed that ABS is 85% effective at preventing downfall accidents, with the casualty injury level being reduced from a fatal to a serious. The high effectiveness scenario considered the avoidance of accidents. It was assumed that fatalities, severe injuries and slight injuries were reduced to non-injured in the relevant group of accidents (those with downfall). The authors stated that both of these scenarios underestimate the effectiveness of ABS because it is not possible to assess the implications of the reduction in impact speed that ABS could provide. The high effectiveness scenario was stated to be the more realistic because it considered a wider range of casualty severities than the low effectiveness scenario. The benefit to cost ratio for the high effectiveness system was estimated to be between 4.6 and 4.9, while the benefit to cost ratio for the low effectiveness system was estimated to be between 1.7 and 1.8.

These two papers are fundamentally different in the way they approached the issue of ABS effectiveness; Kebschull and Zellner (2007 & 2008) used an arguably more robust case by case approach to assess the effect of ABS, while Baum *et al* (2007) applied a

[2] Motorcycle Accident In-Depth Study
[3] Downfall accidents are defined as accidents in which the motorcycle fell to the ground prior to impact

single effectiveness value to groups of accidents considered to be influenced by ABS. Kebschull and Zellner (2007 & 2008) considered accidents from USA and Europe, but the former group of data was very old (27 years). The European data was taken from the more recent MAIDS study (although this data was also over 5 years old) which collected in-depth samples from five countries: Spain, Italy, Germany, France and Holland. This data was not representative of the national accident situation for each of these countries. Each accident was reconstructed using a numerical model to determine whether ABS would influence the accident outcome. Kebschull and Zellner (2007) considered the effectiveness across all types of motorcycle accident. However, they did not consider that ABS could provide a benefit in accidents where the limit of braking had not been evidentially achieved. It is not clear how Kebschull and Zellner (2007 & 2008) determined the start of the braking event for input into the model, since the rider may have applied the brakes in advance of wheel lock and physical evidence being left at an accident scene. Research shows that riders may be able to brake more efficiently with ABS, and this may allow then to apply a greater brake force earlier in the braking event. For example, practical research comparing the braking of riders with and without ABS carried out by Winkelbauer (2005) showed that both experienced and novice riders were able to reduce their stopping distance when riding a motorcycle fitted with ABS compared to a standard motorcycle.

Kebschull and Zellner (2008) stated that a full ABS system is estimated to costs €539 .Information was obtained from the internet which shows retail costs of €350 for a Yamaha (2008) ABS system, and between €635 and €822 for BMW motorcycles (2008). Baum *et al* (2007) estimated the effectiveness of ABS based upon a literature review which resulted in effectiveness for ABS of 85% for its target population (downfall accidents). Similarly to Kebschull and Zellner (2007), Baum *et al* (2007) did not take into account, the reduction in stopping distance that a rider is able to achieve when riding a motorcycle fitted with ABS and only considered that ABS would be effective if the rider fell off the motorcycle during braking prior to the accident The study used much lower manufacturer costs of €150 instead of end user costs in its reportsAs the literature review has shown, there have been two recent cost/benefit analyses conducted. However, there appears to be a large variation in the assumptions made during the analyses, particularly in relation to the ‘target population’ of accidents in which ABS is likely to have an influence, the effectiveness of the braking system in these accidents, and the cost of the advanced braking system, be it ABS or a combined braking system with ABS.

Bayly *et al* (2006) investigated Intelligent Transport Systems and Motorcycle Safety and outlined the expected behaviour in comparison to accident types found in Australia. However, this report did not make any estimates of the actual effectiveness of ABS. The report is limited to defining the target population only.

McCarthy *et al* (2008) compared the potential influence of a wide range of active safety systems for PTWs. Preventing wheel lock using ABS was ranked number 6 from a list of 43 wide-ranging functional requirements which were not assessed for technical feasibility. The analysis was based on case reviews of 60 accidents recorded either in the UK OTS database or the COST327 database. The sample consisted of accidents of all severities, but was relatively small and was not representative of national statistics, by type or severity of accident.

Smith *et al* (2009) reviewed literature to identify effectiveness values for ABS and CBS advanced braking systems. This included the research described above, as well as additional studies. Table 10 summarises the information that was identified in relation to the effectiveness of ABS.

Table 10. Effectiveness of ABS identified from the literature (Smith *et al 2009*).

Effectiveness	Source	Region	Study type	Sample size
85% of all downfall accidents with downfall before initial impact	Baum *et al* (2007) based on a predictive study.	Germany	Predictive	
Approximately 10% of motorbike accidents involving injury can be avoided or positively influenced	Sporner *et al* (2000,2002,2004) cited in Gwehenberger (2006) describe the dangers of braking with conventional braking systems and the avoidance potential of ABS in several studies based on the GDV accident database.	Germany	Predictive	
Avoids 8%-17% of serious motorbike accidents	Gwehenberger *et al* (2006). Results of analysis of 200 serious accidents by Allianz Center of Technology. Extrapolated to Germany would result in around 100 deaths and more than 1,000 serious injuries avoided a year	Germany	Predictive – case by case subjective	200 accidents
Net injury benefit 1%-3% of all casualties	Kebschull and Zellner (2007 &2008) conducted a series of computer simulations based on data collected in the MAIDS (2004) and Hurt *et al* (1981) studies. Several configurations of ABS were simulated.	USA and Europe	Predictive case by case computer modelling	1800 accidents
55% of Austrian motorcycle accidents could be avoided or positively influenced by ABS.	Vavryn and Winkelbauer (2004)	Austria and Germany	Predictive	
Increase in braking performance observed of novice and experienced test riders from 5.7ms^{-2} to 7.7ms^{-2} for novice riders and 6.6ms^{-2} to 7.8ms^{-2} for experienced riders	Vavryn and Winkelbauer (2004)	Austria	Human factors study	47 novice riders and 134 experienced riders
ABS reduces risk of riders being thrown from the bike. May lead to a reduction in forward collision and off-road crashes.	Bayly *et al* (2006)	Australia	N/A	N/A

Effectiveness	Source	Region	Study type	Sample size
3% reduction in fatal and serious casualties	McCarthy and Chinn (1999)	UK	Retrospective	
ABS was ranked 6th from a list of 43 functional requirements (not adjusted for technical feasibility)	McCarthy *et al* (2008), review of GB OTS/COST327 cases for PISa project	UK and Europe	Subjective case-by-case Predictive	60

3.5 Analysis of impacts

When estimating the impact of introducing a new vehicle safety system, it is necessary to estimate how the market for the vehicle to which the system is to be fitted will change in the future. In 2006, the EU-27 motorcycle fleet was 20,231,279 vehicles (ACEM, 2008). It has been predicted that this would rise to 21,537,922 by 2011 and 23,556,755 by 2021, using the rate of fleet increase of 0.9% per annum reported by COWI (2006). The size of the future EU-27 motorcycle fleet has been predicted as shown in Figure 2.

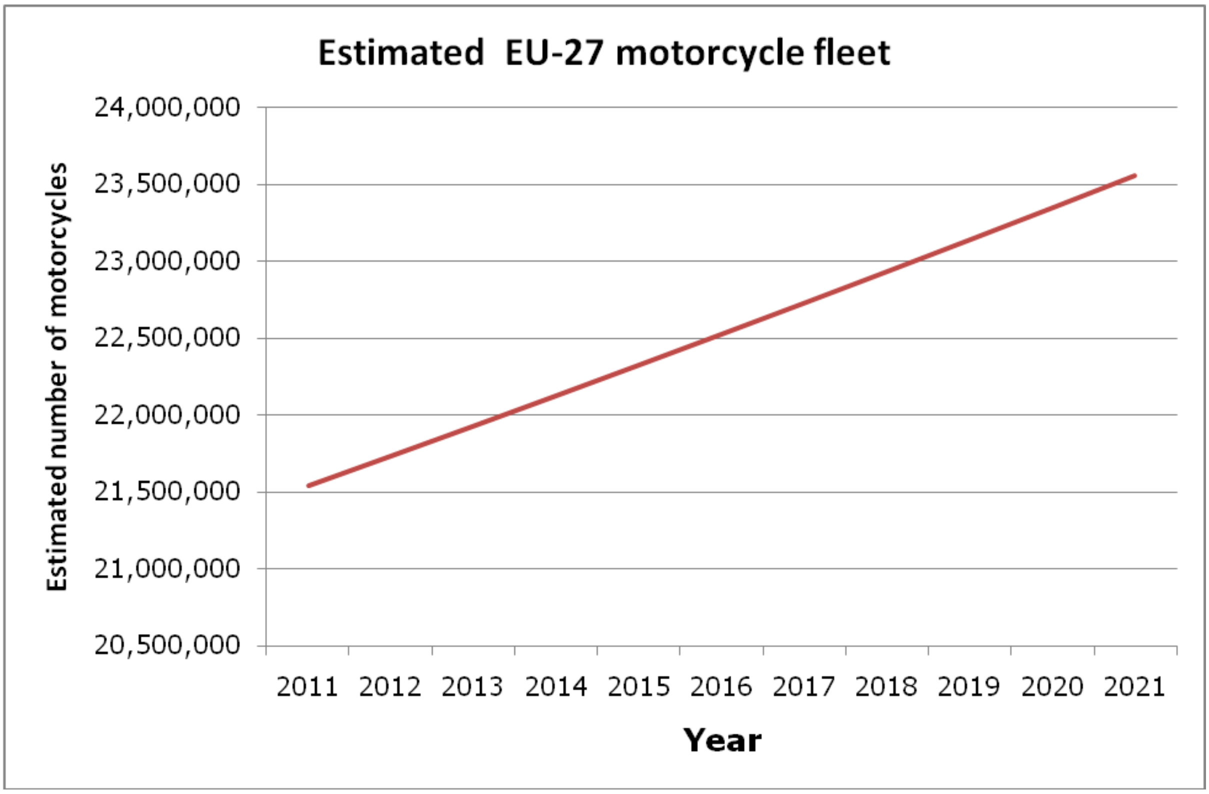


Figure 2. Estimated future motorcycle fleet.

In 2006, there were 1,855,761 new registrations in the EU-27 (ACEM, 2008); this number was slightly lower in 2005 at 1,657,955. It is difficult to accurately predict the numbers of new registrations in future years since there are many factors that could influence the situation. This includes the current economic climate, which could increase the number of motorcyclists, as people switch to more economical transport modes, or decrease the number as people decide to just have one vehicle per household (which is likely to be a passenger car). For the purposes of this study, it was assumed that there would be 1,800,000 new registrations per year, with this remaining constant throughout the timeframe considered (2011-2021).

Data on the breakdown of new registrations by engine capacity was not located by the consultation. For the purposes of this study, it has been assumed that 30% of the new registrations relate to motorcycles between 50cc and 125cc and 70% relate to motorcycles with an engine capacity greater than 125cc. This is consistent with European fleet data, which indicates that in 2007, approximately 30% of the European motorcycle fleet had engine capacities between 50cc and 125cc (ACEM, 2008).

Inflation and an economic discount rate have been applied to all monetary values. Inflation was applied at a rate of 2% per annum, with 2009 as the base year, and the economic discount was applied at a rate of -4% per annum, with 2009 as the base year. This allows the monetary impacts to be assessed by reflecting the current value of future costs and benefits.

3.5.1 Economic Impacts

3.5.1.1 Option A: No change

The most apparent economic impact of this proposal is related to the cost of the advanced braking systems, both for the manufacturer and for the consumer.

For option A, the costs of each advanced braking system are shown in Table 11. These costs are ‘end-user’ costs, that is, what the purchaser of a new motorcycle would have to pay. The best estimate value for ABS systems has been taken from the estimate made by Kebschull and Zellner (2008) for the end user cost of a dual ABS (ABS on each wheel) system. This estimate was considered to be the best estimate since it is a recent industry estimate and was broadly consistent with the median market cost obtained for optional ABS for Yamaha and BMW motorcycles. The minimum cost was taken from the difference between four models of Yamaha motorcycles currently for sale as ABS and non-ABS versions, or the costs of ABS as an option. These models were: Yamaha FZ1 Fazer, FZ6 Fazer, XJ Diversion and XJ6. The maximum cost of €822 was taken from information on the highest price for ABS as an optional extra on BMW motorcycles (from data obtained on ten current BMW models). The costs for CBS were estimated from Industry opinion, although objective evidence for these estimates was not found in the consultation.

Table 11. Option A: Advanced braking system costs, point of sale.

Cost	ABS	CBS
Maximum	€822	€400
Best estimate	€539	€150
Minimum	€150	€75

An increasing number of manufacturers are offering advanced braking systems such as ABS or combined braking systems on their motorcycles. ACEM have committed to offering 75% of street models with an advanced braking system as an option by 2015. The cost of this increasing fitment is voluntary for both the end-user and the manufacturer and can, therefore, be considered to be part of normal business practice. That is, the manufacturers take a business decision to invest in offering the advanced system as an option with the aim that a sufficient number of customers will purchase the option at a price which allows the generation of additional profit for the manufacturer. Thus, the consumer is spending additional money, but only on an item that they see as an additional benefit worth the price. It is possible that this could become a genuine cost to industry if an insufficient number of consumers purchase the option, such that the investment costs are not recovered but, again, this is a common business risk. For this reason, the economic impact of this option can be considered neutral. However, in order to provide a reference baseline for comparison with the other options, the nominal costs of the voluntary increase in fitment of advanced braking have been quantified as described below.

For Option A, the number of new registrations fitted with an advanced braking system for each year was estimated as shown in Table 12. The number of vehicles required to replace vehicles already fitted with an advanced braking system, because of accidents or reliability problems, was not taken into account. This may lead to an overestimate of the number of vehicles in the fleet fitted with advanced braking systems. The costs were calculated by multiplying the number of equipped vehicles introduced to the fleet each year by the cost of each system and subsequently adjusting the annual totals for 2% inflation and discounting the costs at a rate of 4%. For Option A, it was assumed that 30% of the new registrations equipped with an advanced braking system (equivalent to all those with an engine capacity of less than 126cc) in each year were fitted with a CBS system and 70% fitted with an ABS system (those with an engine capacity over 125cc).

Table 12. Percentage of the Motorcycle fleet fitted with an advanced braking system for Option A.

Year	Percentage of new registrations offered with ABS/CBS as an option	Percentage of ABS/CBS options "taken up" by consumer	Estimated number of new registrations with ABS/CBS	Estimated Percentage of fleet fitted with ABS/CBS
2011	50%	20%	180,000	8.84%
2012	55%	20%	198,000	9.67%
2013	60%	20%	216,000	10.57%
2014	65%	20%	234,000	11.53%
2015	75%	21%	283,500	12.70%
2016	75%	24%	324,000	14.02%
2017	75%	27%	364,500	15.50%
2018	75%	30%	405,000	17.13%
2019	75%	33%	445,500	18.90%
2020	75%	37%	499,500	20.87%
2021	75%	41%	553,500	23.04%

Table 12 shows the estimated number of motorcycles voluntarily fitted with an advanced braking system per year. The industry commitment is to 'advanced braking systems' in general, and the type of system likely to be fitted to different types of motorcycle has not been specified. For the purposes of this analysis it has been assumed that CBS will be offered as an option on motorcycles of an engine capacity of 51-125cc, with ABS offered on motorcycles of an engine capacity of greater than 125cc.

Costs for ABS were calculated by multiplying the numbers motorcycles (70% of new registrations with an advanced braking system; see Table 12) by the best estimate cost for an ABS system provided in Table 11. It was assumed that the proportion of vehicles offered with an advanced braking system was the same for smaller and larger capacity machines. Costs for CBS were calculated by multiplying the number of new registrations

(30% of the new registrations with an advanced braking system; see Table 12) by the best estimate cost for a CBS system provided in Table 11.

Table 13 details the total cost for the timescales considered; short, medium and long term. This shows the total cost involved for all motorcycles based upon the assumptions outlined, resulting in a minimum and maximum range and a best estimate for the cost of advanced braking system fitment.

Table 13 Range of costs for advanced braking systems fitted to motorcycles Option A (€million).

Term	Minimum	Maximum	Best estimate
Short term (2011-2013)	€ 71.4	€ 389.3	€ 236.4
Medium term (2011-2016)	€ 166.7	€ 909.1	€ 552.1
Long term (2011-2021)	€ 403.9	€ 2,203.1	€ 1,337.9

Costs include 2% annual inflation and 4% discount

3.5.1.2 Option B: ABS on all motorcycles

This option would, if implemented, mandate fitment of ABS to all motorcycles from 2011. The main economic impact will be the cost required to ensure that the system is fitted to all new motorcycles sold within the EU. However, as described above, some motorcycles would be voluntarily fitted with advanced braking systems under a business as usual scenario where some consumers are voluntarily prepared to pay the price for the system. The true economic impact of Option B is therefore related only to fitting the system to vehicles where the consumer was not prepared to pay for the system. In these cases either the manufacturer or consumer (or shared between both) have to accept an increase in costs. The economic impact associated with the mandatory fitment of ABS to all motorcycles was estimated using a similar process to that for Option A. In order to find the net economic assessment compared with Option A, the economic impacts for Option A should be subtracted from the results for Option B.

The costs for Option B were calculated by assuming that all new registrations (1,800,000 motorcycles per year) would be fitted with ABS. The number of new registrations was multiplied by the estimated ABS system costs; the best estimate cost used for both ABS and CBS was €150.

The reason that the system cost for option B is lower than estimated for option A is that information from Industry indicated that in the case of mandatory fitment of advanced braking systems (ABS and CBS), increased demand would lead to reduction in price, both to the manufacturer and to the consumer. Using this information from Industry and the estimated industry costs used by Baum *et al* (2007) in their cost benefit analysis, estimates for the end user costs were estimated for the year 2011. These were estimated, for ABS, at €100 (lowest estimate), €150 (best estimate) and €200 (highest estimate). For CBS, little information was available to determine how the cost would be influenced by economies of scale. Consequently, the cost ranges were assumed to be comparable with ABS, except for the lower estimate (€75) which was already lower than the lower estimate for ABS; it was retained at €75 since no cost information was forthcoming and it was considered that the cost may have a minimum threshold. If further information becomes available on CBS costs, this could be updated.

Table 14 Option B: Advanced braking system costs, point of sale.

Cost	ABS	CBS
Maximum	€200	€200
Best estimate	€150	€150
Minimum	€100	€75

Table 15 Range of costs for advanced braking systems fitted to motorcycles Option B (€million).

Term	Minimum	Maximum	Best estimate
Short term (2011-2013)	€ 509.5	€ 1,019.0	€ 764.3
Medium term (2011-2016)	€ 990.2	€ 1,980.4	€ 1,485.3
Long term (2011-2021)	€ 1,731.6	€ 3,463.2	€ 2,597.4

Costs include 2% annual inflation and 4% discount

3.5.1.3 Option C: ABS on motorcycles with cylinder capacity >125cc and advanced braking systems on motorcycles with cylinder capacity >50cc and ≤125cc

Option C requires the mandatory fitment of ABS to all motorcycles with an engine capacity of greater than 125cc and fitment of advanced braking systems to all motorcycles with an engine capacity of 51cc-125cc. For the purposes of this analysis, the advanced braking system has been assumed to be a combined braking system. The associated costs for this option have been calculated using the assumptions outlined earlier in Option B, but with all registrations (1,800,000 per annum) being equipped instead of just a proportion.

Table 16 shows the range of costs and the best estimate associated with the implementation of Option C over the short, medium and long term.

Table 16 Range of costs for advanced braking systems fitted to motorcycles Option C (€million).

Term	Minimum	Maximum	Best estimate
Short term (2011-2013)	€ 471.3	€ 1,019.0	€ 764.3
Medium term (2011-2016)	€ 915.9	€ 1,980.4	€ 1,485.3
Long term (2011-2021)	€ 1,601.7	€ 3,463.2	€ 2,597.4

Costs include 2% annual inflation and 4% discount

3.5.1.4 Other economic considerations

Information received from Industry indicates that current ABS systems require little or no maintenance, suggesting that, once fitted, ongoing costs are negligible and not significantly different to those which would apply to 'standard' braking systems. No information regarding the reliability of CBS systems was obtained from the consultation. However CBS is well proven on cars and no significant costs would be anticipated.

During the research and consultation, no evidence was found regarding the size of the market for aftermarket ABS fitment. All the information received suggested that if ABS or CBS was fitted, this was usually fitted by the manufacturer. Therefore, no evidence was found of a significant impact on existing aftermarket businesses.

3.5.2 Societal impacts

The latest data for road traffic fatalities in Europe (both for EU-27 and EU-20) are shown in Table 17. The motorcycle fatalities are shown alongside the total number of fatalities for all road users; differentiation of fatalities by vehicle type was only available for 20 Member States. This data shows that motorcyclist fatalities account for approximately 13.3% of all road user fatalities for the 20 Member States considered.

Table 17. European road traffic fatalities (Eurostat, 2008).

Year	Total number of fatalities (EU-27)	Total number of fatalities (EU-20[4])	Number of motorcycle fatalities (EU-20[5])
2005	45,131	33,965	4,420 (13.0%)
2006	42,952	32,671	4,158 (12.7%)
2007	42,854	32,558	4,449 (13.7%)
3 Yr Ave	43,646	33,202	4,402 (13.3%)

COWI (2006) predicted that the total number of EU-27 road fatalities will reduce at rate of 1.5% per annum until 2010, and then at a rate of 0.9% from 2011 to 2020. These reduction rates were used to obtain an estimate for the number of EU-27 road fatalities for the year 2011. It was then assumed that 13.3% of these fatalities will be motorcycle fatalities (see Table 18), with this number of annual motorcycle casualties remaining at this level until 2021 (i.e. throughout the period considered by this study). The division between motorcycles with engine capacity between 51-125cc and above 125cc was obtained from MAIDS data which indicated that 80% of accidents involve motorcycles with an engine capacity over 125cc (MAIDS, 2004). This data was used as the baseline for the following analysis of the impact of advanced braking systems on road casualties.

[4] Data from Bulgaria, Cyprus, Germany, Lithuania, Romania, Slovakia and Slovenia was not available by vehicle type to allow the motorcyclist fatalities to be identified.
[5] Data from Bulgaria, Cyprus, Germany, Lithuania, Romania, Slovakia and Slovenia was not available by vehicle type to allow the motorcyclist fatalities to be identified.

Table 18. Predicted annual EU-27 fatalities.

Total road fatalities	All Motorcycles
41,624	5,518

Smith *et al* (2009) estimated the effectiveness of advanced braking systems based on a critical review of literature. The estimated values of effectiveness that were used in analysis of the casualty benefits of advanced braking systems are shown in Table 19.

Table 19. Estimated effectiveness of advanced braking systems for fatalities (Smith *et al*, 2009).

Technology	Minimum	Maximum	Best Estimate
ABS	9%	36%	18%
CBS	6%	26%	8%

In order to calculate the benefits of the options in terms of fatality reduction, a prediction of the size of the vehicle fleet is required, along with the proportion of motorcycles fitted with advanced braking systems. The values for the current European motorcycle fleet are reported annually by ACEM. The 2008 Yearbook (ACEM, 2008) presented data for the motorcycle fleet for three years, from 2004 to 2006 and have been detailed in section 3.5. The fitment of advanced braking technologies to motorcycles has been estimated at 6% in 2006 and increasing by 0.5% per annum until 2010 (COWI, 2006). This information has been used to define estimates for the baseline conditions estimated for 2011,

COWI (2006) stated that for passenger cars there is a relationship between the implementation rate of a new system in a mandatory enforcement scenario and vehicle kilometres travelled, with newer vehicles in the fleet travelling a greater proportion of the fleet distance. For example if the fleet penetration is 50% then it might be expected that the 50% of the vehicle fleet fitted with the system would travel 75% of the total vehicle kilometres. COWI (2006), therefore assumes that newer vehicles will present a greater accident risk because of this greater exposure. The distance travelled by vehicles is generally a good overall indicator of the exposure to risk of an accident but in reality exposure to risk is more complex than simply the distance travelled by a class of vehicle. For example, while there is evidence that new cars travel longer distances than older cars, there is also evidence that they travel on the safest roads (e.g. motorways, autobahns etc) for a greater proportion of the time and are driven by older drivers with a lower accident risk.

No reliable evidence was found to accurately quantify these complex relationships for motorcycles was identified. Therefore, this study has used estimated penetration rates of equipped vehicles into the fleet, with the assumption that average distance travelled and exposure to accident risk is equal for motorcycles of all ages..

The figures obtained for the fatality reductions of the three options, were assigned a monetary value by multiplying the estimated number of fatalities affected for each option by the estimated fatality prevention value. The national values used for casualty valuations vary throughout the Member States depending on the methodology and assumptions used to calculate them. This study has used casualty valuations used by Baum *et al* (2007). These values are: fatal €1,000,000, serious €100,000 and slight, €15,000. It should also be noted that the casualty valuations used for fatal, serious and slight casualties are significantly lower than for some Member States and are also relatively old. Using higher casualty valuations would lead to larger predicted monetary benefits and more favourable benefit to cost ratios. For example, the 2006 GB valuations for fatal, serious and slight casualties were €1,936,285, €217,568 and €16,770 respectively (based on exchange rate of €1.3 per GB pound) (DfT, 2007).

The valuation of fatality prevention has been applied to the estimated number of fatalities influenced for each option to estimate the fatality prevention value associated with the introduction of the various options over the short, medium and long term. This estimate could be considered as being an overestimate because it would not realistically be expected that every fatality would be fully avoided. If the fatality is mitigated, and the rider or passenger receives serious injuries, the financial benefit attained is 90% of the value for avoidance. This is because the cost of a serious injury is €100,000, so reducing a fatality to a serious injury, accrues 90% of the fatality prevention value (€1,000,000). To estimate the societal impact in terms of fatality benefits for each system, the reductions have been estimated for each option in turn.

3.5.2.1 Option A: No change

For this option it was necessary to identify the proportion of the vehicle fleet and the proportion of motorcycle casualties that occurred for motorcycles with engine capacities less than 125cc or greater than 126cc. This was so that the benefits of CBS fitted to small motorcycles could be separated from the benefits of ABS fitted to larger motorcycles, since it was assumed that in the baseline case that CBS would be fitted to smaller machines and ABS to larger machines. A breakdown of the new registrations by engine capacity could not be located for the EU as a whole. It was therefore assumed that the proportion across Europe was comparable to the distribution of the European motorcycle fleet: 70% of new registrations were assumed to be over 125cc (ACEM, 2008). The fleet penetration rate is provided in Table 20. Note that values in the table are rounded to one decimal place.

Table 20. Estimated fleet penetration rate for Option A.

Year	Estimated motorcycle fleet	Estimated number with advanced braking	%Fleet with advanced braking	Estimated %Fleet with ABS	Estimated %Fleet with CBS
2011	21,537,922	1,903,034	8.8%	6.2%	2.7%
2012	21,731,763	2,101,034	9.7%	6.8%	2.9%
2013	21,927,349	2,317,034	10.6%	7.4%	3.2%
2014	22,124,695	2,551,034	11.5%	8.1%	3.5%
2015	22,323,818	2,834,534	12.7%	8.9%	3.8%
2016	22,524,732	3,158,534	14.0%	9.8%	4.2%
2017	22,727,455	3,523,034	15.5%	10.9%	4.7%
2018	22,932,002	3,928,034	17.1%	12.0%	5.1%
2019	23,138,390	4,373,534	18.9%	13.2%	5.7%
2020	23,346,635	4,873,034	20.9%	14.6%	6.3%
2021	23,556,755	5,426,534	23.0%	16.1%	6.9%

The estimated percentage of fatalities influenced by advanced braking systems was then calculated. The percentage of fatalities influenced is provided in Table 21. These values were calculated by adjusting the estimated fleet fitment percentages to reflect the fact that MAIDS data indicated that larger motorcycles were involved in approximately 80%

of accidents (MAIDS, 2004). The percentages in the table above were multiplied by 1.14 (80/70) since these machines were over-represented in the accident group relative to their fleet penetration. Similarly, the percentage of motorcycles with an engine capacity of less than 125cc was multiplied by 0.67 (0.2/0.3) to account for the under-representation of these motorcycles in the accident group.

Table 21. Estimated percentage of fatalities involving vehicles with advanced braking systems.

Year	Number of fatalities	Estimated %fatalities involving vehicle fitted with ABS	Estimated %fatalities involving vehicle fitted with CBS
2011	5,518	7.1%	1.8%
2012	5,518	7.7%	1.9%
2013	5,518	8.5%	2.1%
2014	5,518	9.2%	2.3%
2015	5,518	10.2%	2.5%
2016	5,518	11.2%	2.8%
2017	5,518	12.4%	3.1%
2018	5,518	13.7%	3.4%
2019	5,518	15.1%	3.8%
2020	5,518	16.7%	4.2%
2021	5,518	18.4%	4.6%

To calculate the number of fatalities which the advanced braking systems would influence, the estimated number of EU-27 motorcycle fatalities (5,518) was multiplied by the estimated percentage of fatalities which could be influenced and by the effectiveness values. This assumes that the effectiveness values apply uniformly across all motorcycle engine capacity categories; these assumptions were necessary as data limitations prevented more detailed analysis. The estimates for the number of fatalities avoided or mitigated for Option A are presented in Table 22.

Table 22. Estimated number of fatalities avoided/mitigated for Option A.

Year	Fatalities avoided / mitigated (>50 - 125cc)			Fatalities avoided/mitigated (>125cc+)			Fatalities avoided / mitigated (All cc)		
	Min	Max	Best Estimate	Min	Max	Best Estimate	Min	Max	Best Estimate
2011	6	25	8	35	140	70	41	166	78
2012	6	28	9	38	154	77	45	181	85
2013	7	30	9	42	168	84	49	198	93
2014	8	33	10	46	183	92	53	216	102
2015	8	36	11	50	202	101	59	238	112
2016	9	40	12	56	223	111	65	263	124
2017	10	44	14	62	246	123	72	291	137
2018	11	49	15	68	272	136	79	321	151
2019	13	54	17	75	300	150	88	355	167
2020	14	60	18	83	332	166	97	392	184
2021	15	66	20	92	366	183	107	432	203

Note: numbers in table are rounded to nearest whole number

Table 23 shows the estimated reduction in the number of fatalities over future years based on the voluntarily increasing fitment expected under policy Option A. This includes estimates for the short term (2011 to 2013), the medium term (2011 to 2016) and the long term (2011 to 2021). The casualty savings estimated have been calculated assuming the accident is avoided (i.e. fatalities become non-injury) and for casualty mitigation. In the latter case, it has been assumed that fatalities are reduced to serious casualties. Therefore, the casualty saving benefit is 90% of that for avoidance (i.e. €1,000,000 - €100,000). The estimates for avoidance and mitigation are two separate assessments, depending on whether the effectiveness of the system is effective at avoiding or simply influencing the injury outcome. Thus, the avoidance and mitigation assessments are not additive.

Table 23. Estimated number of fatalities avoided or mitigated and associated fatality saving estimates for Option A

Estimation principle	Term	Number of fatal casualties influenced	Estimated fatality saving (€million)
Fatality avoidance	Short term (2011-2013)	257	€ 241.9
	Medium term (2011-2016)	594	€ 542.1
	Long term (2011-2021)	1,437	€ 1,233.6
Fatality mitigation	Short term (2011-2013)	257	€ 217.7
	Medium term (2011-2016)	594	€ 487.9
	Long term (2011-2021)	1,437	€ 1,110.3

Benefits include 2% annual inflation and 4% discount

3.5.2.2 Option B: ABS on all motorcycles

For Option B, all newly registered motorcycles (assumed to be 1.8 million per annum) would be fitted with ABS. Therefore, the percentage of motorcycles will increase more rapidly than in Option A.

Table 24 shows the estimated percentage of the motorcycle fleet fitted with ABS.

Table 24 Percentage of the Motorcycle fleet fitted with an advanced braking system

Year	Estimated motorcycle fleet	Estimated number with ABS	%Fleet with ABS
2011	21,537,922	3,523,034	16.4%
2012	21,731,763	5,323,034	24.5%
2013	21,927,349	7,123,034	32.5%
2014	22,124,695	8,923,034	40.3%
2015	22,323,818	10,723,034	48.0%
2016	22,524,732	12,523,034	55.6%
2017	22,727,455	14,323,034	63.0%
2018	22,932,002	16,123,034	70.3%
2019	23,138,390	17,923,034	77.5%
2020	23,346,635	19,723,034	84.5%
2021	23,556,755	21,523,034	91.4%

Table 25 presents the estimated number of fatalities which may be influenced for the Option B scenario.

Table 25. Estimated number of fatalities avoided/mitigated for Option B.

Year	Number of fatalities per year	Fatalities avoided/mitigated (<126cc)			Fatalities avoided/mitigated (126cc+)			Fatalities avoided/mitigated (All cc)		
		Min	Max	Best Estimate	Min	Max	Best Estimate	Min	Max	Best Estimate
2011	5,518	16	65	32	65	260	130	81	325	162
2012	5,518	24	97	49	97	389	195	122	487	243
2013	5,518	32	129	65	129	516	258	161	645	323
2014	5,518	40	160	80	160	641	320	200	801	401
2015	5,518	48	191	95	191	763	382	239	954	477
2016	5,518	55	221	110	221	884	442	276	1104	552
2017	5,518	63	250	125	250	1002	501	313	1252	626
2018	5,518	70	279	140	279	1117	559	349	1397	698
2019	5,518	77	308	154	308	1231	615	385	1539	769
2020	5,518	84	336	168	336	1343	671	420	1678	839
2021	5,518	91	363	181	363	1452	726	454	1815	907

Note: numbers in table are rounded to nearest whole number

Table 26. Estimated number of fatalities avoided or mitigated and associated fatality saving estimates for Option B

Estimation principle	Term	Number of fatal casualties influenced	Estimated fatality savings (€million)
Fatality avoidance	Short term (2011-2013)	728	€ 684.3
	Medium term (2011-2016)	2,158	€ 1,954.5
	Long term (2011-2021)	5,999	€ 5,106.9
Fatality mitigation	Short term (2011-2013)	728	€ 615.9
	Medium term (2011-2016)	2,158	€ 1,759.1
	Long term (2011-2021)	5,999	€ 4,596.2

Benefits include 2% annual inflation and 4% discount

3.5.2.3 Option C: ABS on motorcycles with cylinder capacity >125cc and advanced braking systems on motorcycles with cylinder capacity >50cc and ≤125cc

This option requires the same method for splitting the vehicle fleet as discussed in 3.5.2.1 for Option A, where the vehicle fleet comprised 30% of vehicles with an engine capacity of less than 126cc and 70% greater than 126cc. The vehicle fleet implementation rate has been calculated using the same methodology described for Option A. The estimated fleet penetration is presented in Table 27.

Table 27. Percentage of the Motorcycle fleet fitted with an advanced braking system for Option C

Year	Estimated motorcycle fleet	Estimated number with advanced braking	%Fleet with advanced braking	Estimated %Fleet with ABS	Estimated %Fleet with CBS
2011	21,537,922	3,523,034	16.36%	11.45%	4.9%
2012	21731763	5,323,034	24.49%	17.15%	7.4%
2013	21927349	7,123,034	32.48%	22.74%	9.8%
2014	22124695	8,923,034	40.33%	28.23%	12.1%
2015	22323818	10,723,034	48.03%	33.62%	14.4%
2016	22524732	12,523,034	55.60%	38.92%	16.7%
2017	22727455	14,323,034	63.02%	44.11%	18.9%
2018	22932002	16,123,034	70.31%	49.22%	21.1%
2019	23138390	17,923,034	77.46%	54.22%	23.2%
2020	23346635	19,723,034	84.48%	59.14%	25.3%
2021	23556755	21,523,034	91.37%	63.96%	27.4%

Table 28. Estimated percentage of fatalities influenced by advanced braking systems for Option C.

Year	Fatals	Estimated %Fatalities influenced by ABS	Estimated %fatalities influenced by CBS
2011	5,518	13.1%	3.3%
2012	5,518	19.6%	4.9%
2013	5,518	26.0%	6.5%
2014	5,518	32.3%	8.0%
2015	5,518	38.4%	9.6%
2016	5,518	44.5%	11.1%
2017	5,518	50.4%	12.6%
2018	5,518	56.3%	14.1%
2019	5,518	62.0%	15.5%
2020	5,518	67.6%	16.9%
2021	5,518	73.1%	18.3%

The numbers of fatalities which are estimated to be influenced in the Option C scenario have been calculated using the data in Table 28 and the effectiveness estimates for the systems. This results in estimates of fatality mitigation/avoidance as presented in the following table.

Table 29. Estimated number of fatalities avoided/mitigated for Option C

Year	Number of fatalities per year	Fatalities avoided/mitigated (<126cc)			Fatalities avoided/mitigated (126cc+)			Fatalities avoided/mitigated (All cc)		
		Min	Max	Best Estimate	Min	Max	Best Estimate	Min	Max	Best Estimate
2011	5,518	11	47	14	65	260	130	76	307	144
2012	5,518	16	70	22	97	389	195	114	460	216
2013	5,518	22	93	29	129	516	258	151	609	287
2014	5,518	27	116	36	160	641	320	187	757	356
2015	5,518	32	138	42	191	763	382	223	901	424
2016	5,518	37	160	49	221	884	442	258	1043	491
2017	5,518	42	181	56	250	1002	501	292	1182	556
2018	5,518	47	202	62	279	1117	559	326	1319	621
2019	5,518	51	222	68	308	1231	615	359	1453	684
2020	5,518	56	242	75	336	1343	671	392	1585	746
2021	5,518	60	262	81	363	1452	726	423	1714	807

Note: numbers in table are rounded to nearest whole number

Table 30. Estimated number of fatalities avoided or mitigated and associated fatality saving estimates for Option C

Estimation principle	Term	Number of fatal casualties influenced	Estimated fatality savings (€million)
Fatality avoidance	Short term (2011-2013)	647	€ 608.3
	Medium term (2011-2016)	1,918	€ 1,737.3
	Long term (2011-2021)	5,332	€ 4,539.5
Fatality mitigation	Short term (2011-2013)	647	€ 547.5
	Medium term (2011-2016)	1,918	€ 1,563.6
	Long term (2011-2021)	5,332	€ 4,085.5

Benefits include 2% annual inflation and 4% discount

Table 30 shows the estimated reduction in fatalities and associated fatality savings for both accident avoidance and fatality mitigation for Option C.

3.5.3 Serious and slight casualties

3.5.3.1 Introduction

So far in this analysis, the estimated casualty benefits have focussed solely on the prevention of fatalities, largely because the most reliable European accident data is for this group. However, literature on the effectiveness of advanced braking systems suggests that benefits due to improved braking performance are likely to also be conferred to serious and slight motorcycle casualties. However, the number of European serious and slight casualties is very seldom reported because of the variations in the severity definitions between different Member States. There are also greater issues in relation to the underreporting of accidents as the severity decreases. Therefore, the estimation of any benefit for serious and slight casualties is problematical, but despite this, it was considered important to estimate the benefit accrued for serious and slight European motorcycle casualties. The following section describes how the benefit for non-fatal motorcyclist casualties was estimated.

3.5.3.2 Estimating the benefit of ABS for serious and slight casualties

Smith *et al* (2009) generated estimates for the effectiveness of ABS in serious and slight accidents. These estimates were ranges based on published literature; the ranges used are presented in Table 31.

Table 31. Estimated benefit of fitting ABS for all motorcycle casualties (Smith *et al* 2009).

Severity	Effectiveness (%)		
	Min	Max	Best estimate
Fatal	9	36	18
Serious	3	17	10*
Slight	0	7	4
Total	1	10	6

*This is the mid-point of the range and not a best estimate.

For serious casualties, the effectiveness used was based upon the estimates outlined in Gwehenberger *et al* (2006) and McCarthy and Chinn (1999). Although Gwehenberger *et al* (2006) included accidents of all severities, the sample is most representative in relation to serious casualties and states an effectiveness range of between 8% and 17%. McCarthy and Chinn (1999) state an effectiveness value for fatal and serious casualties, however the effectiveness value presented is likely to be dominated by the effectiveness for serious casualties, and therefore 3% was selected as a lower boundary for the effectiveness for serious casualties.

Sporner (2000, cited in Gwehenberger *et al*, 2006) stated that ABS is effective in 10% of PTW accidents of all severity levels. However, Kebschull and Zellner (2007) carried out a comprehensive study resulting in an overall effectiveness of between 1% and 3%. Both of the studies have limitations as described earlier and therefore the average from these two studies has been used for the best estimate. Based on the mid range value from Kebschell and Zellner of 2%, the best estimate is 6%. The extreme values from the two studies have been used to generate the overall range of effectiveness.

It was not possible to identify the effectiveness for slight casualties; therefore it had to be estimated using the data that had been identified. The weighted average of effectiveness values for each severity should be equivalent to the effectiveness for all casualties. Working backwards, using the 6% value for all accidents and the best estimates of 18% for fatalities and 10% for serious casualties, a best estimate effectiveness of 4.2% was calculated for slight casualties using equation 1. The upper and lower effectiveness values are calculated using the same method.

$$E_L = \frac{E_T N_T - (E_F N_F + E_S N_S)}{N_L} \quad (1)$$

where E = effectiveness

N = number of casualties

T = total

F = fatal

S = serious

L = slight

In order to estimate the benefit to serious and slight casualties, the number of European serious and slight motorcycle casualties was estimated. This was achieved by deriving a "scaling factor" for the numbers of serious and slight casualties from data from four European countries. Table 32 shows the data used.

Table 32. Numbers of motorcycle casualties in four European countries.

Country	Fatal	Serious	Slight
Spain (2002)	401	2,239	8,052
Netherlands (2002)	93	821	1,178
Germany (2002)	913	11,854	25,488
Great Britain (2007)	562	5,218	13,543

For each of the four countries, the number of serious and slight casualties was divided by the number of fatal casualties. This resulted in the "scaling factors" presented in Table 33.

Table 33. Serious and slight motorcycle casualties relative to number of fatal casualties in four European countries.

Country	Ratio of serious casualties in relation to number of fatals	Ratio of slight casualties in relation to number of fatals
Spain (2002)	5.58	20.08
Netherlands (2002)	8.83	12.67
Germany (2002)	12.98	27.92
Great Britain (2007)	9.28	24.098

Therefore, based on the available data for four European countries, this indicates that the target population for serious European motorcycle casualties is between 5.58 and 12.98 times greater than that of fatals. Similarly, the European target population for slight motorcycle casualties is between 12.67 and 27.92 times greater than that of fatals.

The effectiveness estimates for ABS (see Table 31) were converted into estimates of the effectiveness for serious and slight casualties *in relation to the effectiveness for fatal casualties;* these are presented in Table 30.

Table 34. Proportion of target population influenced as a proportion of effectiveness for fatals.

Severity	Effectiveness (%) best estimate	Effectiveness in relation to fatals
Fatal	18	1
Serious	10	0.55
Slight	4	0.22

The valuations used for fatal, serious and slight casualties are presented in Table 35, below. The relative valuations for serious and slight casualties with respect to fatalities are also shown.

Table 35. Valuations for fatal, serious and slight casualties and proportion of value compared with fatals.

Severity	Casualty valuation (€)	Casualty valuation value in relation to fatals
Fatal	€1,000,000	1
Serious	€100,000	0.1
Slight	€15,000	0.015

Table 36 shows the information used to calculate the benefit for serious and slight casualties as a proportion of the fatality benefit estimate and is a summary of the key values derived from the preceding tables.

Table 36. Summary of values used to calculate serious and slight benefit in relation to fatality data assuming casualty avoidance.

Severity	Change in target population relative to fatals	Casualty valuation value in relation to fatals	Effectiveness in relation to fatals
Serious	5.58 - 12.98	0.1	0.55
Slight	12.67 - 27.92	0.015	0.22

The estimated casualty benefit for serious and slight motorcycle casualties (expressed as a proportion of the benefit for motorcycle fatalities) was calculated by multiplying the values in Table 36 together, using the upper and lower estimate for the number of serious and slight casualties to obtain the values presented in Table 37.

Table 37. Estimated casualty benefit for serious and slight motorcycle casualties expressed as a proportion of fatality benefit estimate assuming casualty avoidance.

Severity	Proportion of fatal benefit accrued
Serious	0.31 - 0.72
Slight	0.04 - 0.09
Total range	**0.35 - 0.81**

The values presented in Table 37 assume that the effectiveness used relates to casualty avoidance (i.e. the casualties are reduced from serious and slight to non-injury). If the effectiveness value used in this analysis is considered to relate to mitigation of injuries, then the potential benefits will change. Each casualty will have the severity of their injuries reduced by one severity level (i.e. fatal becomes serious injuries and serious injuries become slight injuries etc.). The proportion of fatal benefit accrued for serious and slight motorcycle casualties will therefore be as shown in Table 38. For injury mitigation, the casualty valuation value becomes 0.094, calculated by taking the difference in valuation between serious and slight (€100,000 - €15,000) and dividing by €900,000; the valuation for fatalities mitigated to serious casualties (€1,000,000 - €100,000).

Table 38. Summary of values used to calculate serious and slight benefit in relation to fatality data assuming casualty mitigation.

Severity	Change in target population relative to fatals	Casualty valuation value in relation to fatals	Effectiveness in relation to fatals
Serious	5.58-12.98	0.094	0.55

For the mitigation scenario, no reduction was made for slight casualties because these casualties are predicted to be very difficult to mitigate if the accident is not avoided.
Table 39 shows how the data has been combined to estimate the injury mitigation benefits for non-fatal motorcyclist casualties relative to the benefits for fatalities.

Table 39. Estimated casualty benefit for serious motorcycle casualties assuming mitigation, expressed as a proportion of fatality benefit estimate.

Severity	Proportion of fatal benefit accrued
Serious	0.29-0.68
Total range	**0.29-0.68**

For CBS, insufficient literature exists to define ranges for the effectiveness in serious and slight accidents. In the absence of any data, if the effectiveness in serious and slight accidents was comparable to that estimated for ABS, then the additional benefit for serious and slight accidents would be as presented in Table 37 and Table 39.

It should be noted that this analysis assumes that the proportion of casualties from the two motorcycle groups (less than 126cc and 126cc and over) are represented in the same proportions in serious and slight casualties as they are for fatal casualties. This assumption cannot be tested because insufficient accident data exists to verify or refute this; this issue could be investigated should relevant data become available.

3.5.4 Environmental impacts

3.5.4.1 Option A: No change

This option will have little or no impact on the noise, emissions or fuel consumption associated with the motorcycle. The voluntary fitment of ABS/CBS systems on motorcycles will add a small amount of mass. Information received from Industry indicated that the weight of ABS systems has decreased substantially over time, to an average of 1.4 kg. Industry opinion indicated that by 2010 the additional mass of an ABS system may be lower than the current 1.4 kg average, perhaps lower than 1kg (some systems are currently 0.8kg). However, no data was obtained from the consultation to quantify the effects of this on emissions or fuel consumption.

3.5.4.2 Option B: ABS on all motorcycles

This option will have little or no impact on the noise generated by the motorcycle. The effects on fuel consumption and emissions are predicted to be negligible provided riders do not change their driving style on motorcycles fitted with advanced braking systems. The addition of ABS systems on motorcycles will add a small amount of mass (likely to be less than 1.4 kg by 2011), although no data was obtained from the consultation to quantify this.

3.5.4.3 Option C: ABS on motorcycles with cylinder capacity >125cc and advanced braking systems on motorcycles with cylinder capacity >50cc and ≤125cc

This option will have little or no impact on the noise generated by the motorcycle. It must be noted that the noise generated by decelerating motorcycles is not generally measured as part of the type approval process; therefore, little or no data is available to substantiate any effect. The impact on emissions and fuel consumption is estimated to be similar to that described for Option B.

3.6 Comparing the options

3.6.1 Numbers of motorcycle fatalities influenced

Table 40 shows the cumulative number of fatalities estimated to be influenced by each option over the short, medium and long term, with the range for the estimate in brackets. The range for the estimate is given, along with the best estimate of the number of casualties addressed. Option A is predicted to influence approximately 25% of the fatalities that Options B and C would address over the long term.

Table 40. Comparison of options in terms of fatality reduction.

Duration	Option A			Option B			Option C		
	Min	Max	Best est.	Min	Max	Best est.	Min	Max	Best est.
Short term (2011-2013)	135	545	257	364	1,457	728	340	1,376	647
Medium term (2011-2016)	312	1,263	594	1,079	4,317	2,158	1,007	4,077	1,918
Long term (2011-2021)	754	3,054	1,437	2,999	11,997	5,999	2,799	11,331	5,332

Estimated economic costs associated with each option

Table 41 provides a summary of the estimated cost for each option, using the "best estimate" for the costs of each option. Note that these costs are for each option in isolation.

Table 41. "Best estimate" costs associated with each option (€million)

Duration	Option A	Option B	Option C
Short term (2011-2013)	€ 236.4	€ 764.3	€ 764.3
Medium term (2011-2016)	€ 552.1	€ 1,485.3	€ 1,485.3
Long term (2011-2021)	€ 1,337.9	€ 2,597.4	€ 2,597.4

Costs include 2% annual inflation and 4% discount

3.6.2 Benefit cost ratios assuming accident avoidance

The benefits include the estimated casualty savings resulting from accident avoidance. These benefits have been estimated by assuming that a proportion of fatal and serious casualties (based on the system effectiveness) have been reduced to non-injury.

This information has been presented for the options in isolation and using the "best estimate" for system cost from

Table 41. It should be noted that the benefit for fatality reduction is based on actual data for the numbers of European fatalities, whereas the numbers of serious and slight casualties have been estimated based on the ratio of fatal to serious motorcycle casualties in four European countries (see Section 3.5.3).

Table 42. Comparison of the options over short, medium and long term assuming accident avoidance for Option A.

Duration	Benefit €million (fatal)	Benefit €million (serious)	Benefit €million (slight)	BCR
Short term (2011-2013)	€242 (€127 - €514)	€75 - €174 (€39- €370)	€10 - €22 (€5 - €46)	1.4 – 1.9 (0.7 – 3.9)
Medium term (2011-2016)	€542 (€285 - €1,152)	€168 - €390 (€88 - €829)	€22 - €49 (€11 - €104)	1.3 – 1.8 (0.7 – 3.8)
Long term (2011-2021)	€1,234 (€648 - €2,621)	€382 - €888 (€201 - €1,887)	€49 - €111 (€26 - €236)	1.2 – 1.7 (0.7 – 3.5)

Benefits and costs include 2% annual inflation and 4% discount. BCR = Benefit to Cost Ratio.

Table 43. Comparison of the options over short, medium and long term assuming accident avoidance for Option B.

Duration	Benefit €million (fatal)	Benefit €million (serious)	Benefit €million (slight)	BCR
Short term (2011-2013)	€684 (€342 - €1,369)	€212 - €493 (€106 - €985)	€27 - €62 (€14 – €123)	1.2 – 1.6 (0.6 – 3.2)
Medium term (2011-2016)	€2,490 (€977 - €3,909)	€772 - €1,793 (€303 – €2,815)	€100 - €224 (€39 – €352)	2.3 – 3.0 (0.9 – 4.8)
Long term (2011-2021)	€5,107 (€2,553 - €10,214)	€1,583 - €3,677 (€792 – 7,354)	€204 - €460 (€102 - €919)	2.7 – 3.6 (1.3 – 7.1)

Benefits and costs include 2% annual inflation and 4% discount. BCR = Benefit to Cost Ratio.

Table 44. Comparison of the options over short, medium and long term assuming accident avoidance for Option C.

Duration	Benefit €million (fatal)	Benefit €million (serious)	Benefit €million (slight)	BCR
Short term (2011-2013	€608 (€319 - €1,293)	€189 - €438 (€99 - €931)	€24 - €55 (€13 - €116)	1.1 – 1.4 (0.6 – 3.1)
Medium term (2011-2016)	€1,737 (€912 - €3,692)	€539 - €1,251 (€283 -€2,658	€70 - €156 (€37 - €332)	1.6 – 2.1 (0.8 – 4.5)
Long term (2011-2021)	€4,539 (€2,383- €9,646)	€1,407 - €3,268 (€739 - €6,945)	€182 - €409 (€95 - €868)	2.4 – 3.2 (1.2 – 6.7)

Benefits and costs include 2% annual inflation and 4% discount. BCR = Benefit to Cost Ratio.

3.6.3 Benefit cost values assuming casualty mitigation

The benefits in the following tables show the estimated casualty savings resulting from casualty mitigation. It has been assumed that a proportion of fatal and serious casualties (based on the system effectiveness) are influenced, but those fatalities influenced have been reduced to serious, rather than avoided altogether. Similarly, serious casualties have been assumed to be reduced to slight injury. No benefit has been assumed for slight casualties for the mitigation scenario since it is considered difficult to mitigate these without avoiding the accident entirely. This information has been presented for the options in isolation.

It should be noted that the benefit for fatality reduction is based on actual data for the numbers of European fatalities whereas the numbers of serious and slight casualties have been estimated based on extrapolation based on the ratio of fatal to serious motorcycle casualties in four European countries (see Section 3.5.3).

Table 45. Comparison of the options over short, medium and long term assuming casualty mitigation for Option A.

Duration	Benefit €million (fatal)	Benefit €million (serious)	Benefit €million (slight)	BCR
Short term (2011-2013	€218 (€114- €463)	€63 - €148 (€33 - €315)	-	1.2 – 1.5 (0.6 – 3.3)
Medium term (2011-2016)	€488 (€256 - €1,037)	€142 - €332 (€74 - €705)	-	1.1 – 1.5 (0.6 – 3.2)
Long term (2011-2021)	€1,110 (€583 - €2,359)	€322 - €755 (€169 - €1,604)	-	1.1 – 1.4 (0.6 – 3.0)

Benefits and costs include 2% annual inflation and 4% discount. BCR = Benefit to Cost Ratio.

Table 46. Comparison of the options over short, medium and long term assuming casualty mitigation for Option B.

Duration	Benefit €million (fatal)	Benefit €million (serious)	Benefit €million (slight)	BCR
Short term (2011-2013	€616 (€308- €1.232)	€179 - €419 (€89 – €838)	-	1.0 – 1.4 (0.5 – 2.7)
Medium term (2011-2016)	€2,241 (€880- €3,518)	€650 - €1,524 (€255 - €2,392)	-	1.9 – 2.5 (0.8 – 4.0)
Long term (2011-2021)	€4,596 (€2,298 - €9,192)	€1,333 - €3,125 (€666 - €6,251)	-	2.3 – 3.0 (1.1 – 5.9)

Benefits and costs include 2% annual inflation and 4% discount. BCR = Benefit to Cost Ratio.

Table 47. Comparison of the options over short, medium and long term assuming casualty mitigation for Option C.

Duration	Benefit €million (fatal)	Benefit €million (serious)	Benefit €million (slight)	BCR
Short term (2011-2013	€547 (€287 - €1,163)	€159 - €372 (€83 -€791)	-	0.9 – 1.2 (0.5 – 2.6)
Medium term (2011-2016)	€1,564 (€821 - €3,323)	€454 - €1,064 (€238 - €2,260)	-	1.4 – 1.8 (0.7 – 3.8)
Long term (2011-2021)	€4,086 (€2,145- €8,682)	€1,185 - €2,778 (€622 - €5,904)	-	2.0 – 2.6 (1.1 – 5.6)

Benefits and costs include 2% annual inflation and 4% discount. BCR = Benefit to Cost Ratio.

3.6.4 Benefit cost ratios for the options assuming Option A as baseline

Benefit to cost ratios (BCRs) have been calculated for the options B and C using the "do nothing" option (Option A) as a baseline. These benefit to cost ratios, for both accident avoidance and casualty mitigation, are presented in the following tables:

Table 48. Benefit to cost ratios of the options over short, medium and long term assuming accident avoidance.

Duration	*Option B (using Option A as baseline)*	*Option C (using Option A as baseline)*
Short term (2011-2013	1.1 – 1.5 (0.6 – 2.9)	0.9 – 1.3 (0.5 – 2.7)
Medium term (2011-2016)	2.8 – 3.8 (1.0 – 5.3)	1.7 – 2.3 (0.9 – 4.9)
Long term (2011-2021)	4.2 – 5.6 (2.0 – 10.9)	3.5 – 4.8 (1.9 – 10.1)

Table 49. Benefit to cost ratios of the options over short, medium and long term assuming casualty mitigation.

Duration	*Option B (using Option A as baseline)*	*Option C (using Option A as baseline)*
Short term (2011-2013	1.0 – 1.3 (0.5 – 2.4)	0.8 – 1.0 (0.4 – 2.2)
Medium term (2011-2016)	2.4 – 3.2 (0.9 - 4.5)	1.5 – 1.9 (0.8 – 4.1)
Long term (2011-2021)	3.6 – 4.6 (1.8 – 9.1)	3.0 – 4.0 (1.6 – 8.4)

3.7 Monitoring and evaluation

In order to monitor the effect of any change in legislation, the number of motorcycle casualties should be monitored, preferably in relation to the engine capacity of the motorcycle, and the equipment fitted. The quality of this impact assessment was influenced by a lack of reliable non-fatal casualty data, requiring some broad assumptions to be made. Collection/reporting of reliable non-fatal data would enable these assumptions to be verified and would a more accurate evaluation of the effect of any changes.

There was minimal information available regarding the costs and effectiveness of combined braking systems. Data from research studies similar to those identified for ABS would enable a higher confidence in the estimated societal impact for casualty prevention. Minimal information was also available regarding future ABS costs and the effect of large scale fitment of systems on the market price. In particular, information on CBS costs was lacking and these were estimated. More detailed information will be very important to verify the assumptions made and to review the effects of any changes to legislation regarding advanced braking systems.

4 Anti-tampering for mopeds, motorcycles, tricycles and quadricycles

4.1 Problem definition

Small motorcycles (<125cc) and mopeds have to comply with the requirements of Chapter 7 of Directive 97/24/EC relating to anti-tampering. There are currently no measures in place for larger motorcycles, tricycles or quadricycles.

At the request of Directive 97/24/EC, a study was granted to TÜV Nord (Dittmar *et al*, 2003) in order to assess the effectiveness of this legislation. Due to the lack of vehicles type-approved according to Directive 97/24/EEC at the time the study was carried out, it was not possible to conclusively assess the effectiveness of the legislation. However, the study proposed a range of new measures concerning anti-tampering.

The study by Dittmar *et al*, 2003 identified the main aims of typical consumers considered likely to perform unauthorised manipulations of their machines:

- Higher engine power output
- Higher engine torque
- Alteration of torque/power characteristic
- Increasing top speed
- Alteration of the sound signature

The reasons for unauthorised manipulations were:

- By-passing driver licensing restrictions
- Saving on road tax
- Saving on insurance premium
- By-passing recurring technical inspections for special categories of vehicle
- General interest in customising and modification

However, these reasons differ between Member States because of differing legislation.

Alternative measures were discussed in the special motorcycle working group of the Commission on 12 July 2005 where some other possible amendments were proposed by France (MCWG, 2005).

4.2 Objectives

The objectives of the Commission’s proposal are:

- To contribute to the casualty reduction targets by ensuring that the in-use vehicle performance remains as specified by the manufacturer for specific vehicle and licensing requirements.
- To contribute to environmental targets by preventing vehicle modifications that can result in increased noise and emissions.

4.3 Policy options

The Commission has identified the following three options for anti-tampering:

a. **No change**. Legislation concerning measures for anti-tampering is already in place. The suitability and effectiveness of the current measures are reviewed.

b. **Repeal Chapter 7 of Directive 97/24/EEC**. This assessment of this option relates to the effectiveness of the existing legislation in relation to the objectives and what the effect of repealing this legislation will be.

c. **New measures on anti-tampering**. The research by Dittmar *et al* (2003) identified some alternative measures for anti-tampering and a draft proposal for an amendment to Chapter 7 of Directive 97/24/EC was presented to the Motorcycle Working Group in July 2005 by the representative from France (MCWG, 2005). This option considers the potential alternative measures that could be implemented.

4.4 Analysis of impacts

The impacts associated with this proposal are mainly societal, with respect to safety and environmental issues. There are also likely to be some economic impacts, as a direct result of the proposal or as a secondary outcome from the safety or environmental impacts. The impacts outlined above are discussed in the following section in relation to the costs and benefits for the wide range of stakeholders affected.

4.4.1 Economic impacts

There are potential economic impacts associated with this proposal. These are likely to have a direct impact on the vehicle manufacturers. There are also likely to be secondary impacts affecting the general population. Examples of such secondary impacts are improved task efficiency, which may be caused by a reduction in the amount of congestion.

4.4.1.1 Option A: No change

For the “no change” option, the existing anti-tampering measures will remain in place. Therefore, the economic impact on all stakeholders is neutral. Manufacturers could extend the measures if considered appropriate.

4.4.1.2 Option B: Repeal chapter 7

Repealing the existing requirements for anti-tampering has the potential to reduce the economic burden on vehicle manufacturers. However, information supplied by the Association des Constructeurs Européens de Motocycles (ACEM) indicates that current moped anti-tampering provisions are integrated by design in the engine components and do not add any cost. However, there are a few items that have marginal construction costs, such as the information sticker or frangible bolts, however, these costs were not quantified by ACEM. Therefore, the economic impact in relation to the vehicle manufacturers of repealing the anti-tampering measures will be proportional to the costs of the additional components that are currently used and are likely to be negative. There is also a positive economic impact for the OEM, because there is one less approval that must be obtained for each vehicle type.

There will also be an adverse economic impact on the suppliers of the parts which are no longer required (information stickers, frangible bolts etc.). No information was provided as to these suppliers, but some may be SMEs.

There is currently a larger after-market industry that supplies equipment/services for the modification of vehicles. Some of these modifications can be used to by-pass the existing anti-tampering measures, therefore repealing these measures could have an economic impact on this market, which is likely to contain a number of SMEs. However, it is not possible to quantify this impact with the information available. The impact of repealing the legislation could have a negative economic impact if there becomes reduced demand, however, if it becomes easier to modify vehicles there could be increased demand and hence a positive economic impact.

Dittmar *et al* (2003) identified some of the reasons why unauthorised manipulations are carried out. These were:

- By-passing driver licensing restrictions;
- Saving on road tax;
- Saving on insurance premiums; and
- By-passing recurring technical inspections.

It can be implied from this, that vehicles that are subject to anti-tampering measures are desirable because of their low running/maintenance costs when compared to higher performance vehicles. Repealing the anti-tampering measures could make these vehicles more desirable because the owners could improve the performance more easily whilst still retaining the benefits of owning a vehicle that incurs lower running costs. Making these vehicles easier to modify could increase demand for aftermarket supplies, with a possible positive economic impact.

4.4.1.3 Option C: New measures

The economic impact associated with introducing new measures will be dependent on the types of measure that are introduced and the vehicles to which they are applied. If the new measures can be designed into the vehicles in a similar way to the current measures, then there will be a minimal economic burden on the manufacturers of vehicles that currently require anti-tampering measures. If the new measures cannot be integrated into the designs, there is a potential increase in costs for the manufacturers. However, this cannot be quantified with the information that is currently available.

Changes to the anti-tampering measures are likely to require the design/development of new parts that are not currently used for the existing measures. This could have a negative economic impact on companies (possibly SMEs) that supply the existing parts to the OEM, but in turn could have a positive impact on other suppliers (which could also be SMEs). The magnitude of this impact cannot be quantified at this time and will be very dependent on the form of the new measures.

This option is likely to have an economic impact on the after-market vehicle modifications sector. It is possible that demand for some existing products and/or services might decrease, but there may also be new products and/or services that are developed. This impact cannot be quantified with the information currently available.

4.4.2 Societal impact

It is anticipated that the options presented will have societal effects in terms of safety.

4.4.2.1 Option A: No change

This option will retain the existing measures. It is expected that this will result in a neutral effect on safety in the short term. However, as the methods used to improve the performance of restricted vehicles move more towards electronic manipulation, there is likely to be a negative safety impact as the existing anti-tampering measures become less effective. It is not possible to quantify this impact with data that is currently available because the incidence of tampering within the current vehicle fleet and the relationship between tampering and accident risk is not fully quantified in the literature/data available.

If tampering were to have no influence on accident risk, the proportion of accident involved PTWs that had been tampered with would be expected to be the same as the proportion of PTWs in the vehicle fleet that had been tampered with. The analysis of MAIDS (ACEM, 2004) indicates that mopeds that have been tampered with are over-involved in accidents, i.e. the proportion of vehicles that have been tampered with in the accident sample is greater than that in the exposure sample. ACEM (2004) suggests that 17.8% of the L1 vehicles involved in accidents had been tampered with compared with only 12.3% of the exposure sample. This suggests that vehicles that have been tampered with are more likely to become involved in an accident. However, this apparent over-involvement is subject to a number of caveats:

- The conclusion has not been tested for statistical significance;
- The data pre-date the implementation of the chapter 7 anti-tampering measures;
- If it was unknown whether a vehicle had been tampered with or not it was classified as a non-tampered vehicle. If, in fact some of those unknowns had been tampered with, it could affect the conclusions.

L1 vehicles are restricted to a maximum speed of 45km/h. Analysis of fatal accidents in the MAIDS database (ACEM, 2004) showed that up to 40% of fatal accidents involved L1 vehicles travelling at speeds greater than 50km/h, implying that:

- a much higher proportion of vehicles are tampered with than the accident investigators were able to identify during their visual inspection of their machine; or
- tampered vehicles are much more severely over-involved in fatal accidents; or
- a combination of both.

However, this does not necessarily suggest that preventing tampering could prevent up to 40% of fatalities because the vehicle speed would only have contributed to the cause of the accident or injury in a proportion of the cases identified. Other factors that would have contributed to the cause of the accidents or injuries, for example rider behaviour/experience or the actions of the other road users involved, were not identified in the analysis.

4.4.2.2 Option B: Repeal chapter 7

This option will result in there being no anti-tampering measures in place. The proportion of vehicles that were manipulated prior to introduction of Chapter 7 – the exposure data from MAIDS (ACEM, 2004) indicates that for the period 1999-2000 12.3% of mopeds had some form of engine or driveline tampering. The Directive came into force in 1999, therefore, this data is likely to represent the proportion of mopeds before the legislation. The study by TÜV (Dittmar *et al*, 2003) estimated that 2.5% of motorcycles were manipulated based on annual inspection data for 2001 and 2002. There is no indication of the age of the vehicles, therefore this data is also more likely to indicate the occurrence of manipulation on vehicles not approved to Chapter 7.

The effectiveness of the existing legislation and the proportion of vehicles that are currently manipulated is unknown. Therefore, it is not possible to determine the effect of this option, although it is considered likely to have a negative effect on safety and would represent a backwards step from the current situation. The potential negative impact is expected to reduce with time, because the existing anti-tampering measures will not be compatible with future developments of the vehicles, e.g. electronic manipulations.

4.4.2.3 Option C: New measures

This option is intended to introduce new measures that are considered more relevant to the current and future vehicle fleet. It is anticipated that this option will be at least as effective as the current measures were initially. Unlike Option A, the effectiveness of this measure would be expected to be maintained further into the future and so would have a positive societal impact. However to quantify the benefits, the effectiveness of the existing measures have to be known.

A draft proposal for an amendment to Chapter 7 of Directive 97/24/EC was presented to the Motorcycle Working Group in July 2005 by the representative from France (MCWG, 2005). This document proposes additional requirements compared with those in the existing document and also provides separate provisions for category A and category B vehicles. The main differences are in relation to:

- Definition of vehicle sub-categories for mopeds:
    - A1 – low performance mopeds;
    - A2 - mopeds other than those in category A1;
- Engine control units for vehicles in category A1, A2 and B;
- Specifications for category A1 and A2 vehicles relating to the construction of the transmission (including continuous variable transmissions).
- Requirements for conformity of production.

Modifications to this proposal, particularly in relation to the measures relating to ECUs and the marketing of interchangeable components have been proposed by ACEM.

Research by TÜV (Dittmar *et al*, 2003) concluded that the Directive requires modifications to:

- Allow for modern vehicle technology (e.g. electrical components);
- Improve marking of vehicle components; and
- Control vehicles by spot checks.

The TÜV research recommended that these modifications should also be accompanied by re-structuring Chapter 7 of the Directive. This study also made recommendations to improve the political acceptance of the proposals, which were:

- Spot checks of two and three wheeled vehicles registered before and after 17th June 1999;
- EU-wide accident research including the state of the vehicles involved;
- Where carried out, inclusion of unauthorised manipulations in periodical technical inspections;
- Observe the market of electronic tuning devices; and
- Practical research into the effect of electronic tuning on emissions, noise and top speed.

4.4.3 Environmental impact

4.4.3.1 Option A: No change

When considering the impact on emissions, it should be recognised that the exhaust system on vehicle subject to anti-tampering measures is often replaced by a 'sporty' exhaust system. The original exhaust is likely to include a catalytic converter, so replacing the exhaust will remove the catalyst, thus significantly increasing the emissions from the vehicle. The impact on fuel consumption would be less significant.

The current in-service testing regime across member states, for example the UK, only includes a cursory check on the noise level (generally, at the testers' discretion as to whether the noise is louder than the standard system). There is no in-service emissions test at present for 2-wheelers. Therefore the removal of the catalyst is not recorded within the in-service testing. In some cases, the ECU may also be modified (re-mapped) when changing the exhaust. There are "power commanders" available for this, e.g.: http://www.dynojet.co.uk/powercommander/index.htm. However, the impact of these changes on emissions and fuel consumption, whilst increasing the maximum power, remains uncertain.

There are anecdotal concerns that some of these types of vehicles are being modified with after-market components that do not increase power or maximum speed but do increase the noise levels substantially. Therefore, this option could have a medium negative impact on noise if the rate of this type of tampering increases in future. It is known that some modified exhausts which increase exhaust flow may actually have a neutral or low positive effect on emissions, but be significantly noisier. However, limited research has been done on the individual effects of manipulations, and therefore it is not possible to quantify this impact at the present time.

4.4.3.2 Option B: Repeal chapter 7

This option has the potential to have a high negative impact on the issue of environmental noise. However, this cannot currently be quantified because the effectiveness of the legislation is unclear. This option would also be likely to increase emissions and fuel consumption. However it has also not been possible to quantify these impacts.

4.4.3.3 Option C: New measures

This option has the potential to have a medium to high positive effect on noise and emissions (and fuel consumption) if additional effective controls were put in place. However, there would be a need to ensure that vehicles were monitored periodically to enforce compliance and to ensure that these benefits would be realised in-service.

4.5 Comparing the options

Table 50 compares the economic, societal and environmental impacts for the three options related to anti-tampering measures. In the table, arrows are used to represent the estimated magnitude of each impact, with the direction of the arrow denoting whether the impact is positive or negative. Where the impact is considered to be neutral, there are no arrows. The “dotted” arrows are used where the magnitude of the impact is dependent on external factors or unknown at this time.

Table 50. Comparison of impacts for options relating to anti-tampering measures.

			Impact	
	Option	**Negative**	**Neutral**	**Positive**
Economic	A			
	B			
	C			
Societal	A			
	B			
	C			
Environmental	A			
	B			
	C			

Option A is considered to have a neutral economic and societal impact, although there is potentially a negative environmental impact. Option B is likely to have a negative societal impact, as well as negative economic and environmental impacts, although the magnitudes of the economic and environmental impacts are unknown. Option C has the potential to deliver positive impacts in all three categories. However the economic impact could be negative, depending on the measure selected and the stakeholders affected.

4.6 Monitoring and evaluation

In order to monitor the effect of the selected option it is recommended that the following actions be taken:

- Identify baseline data, especially relating to the current levels of tampering, and the magnitude of the effect that the tampering has on noise, tailpipe emissions and the involvement of relevant vehicle types in accidents.
- Monitor the in-use condition of vehicles, undertaking a survey at a representative sample of periodic/roadside inspections.

TRL recommend that to provide more definitive guidance on the effect of future policy options, the impact of tampering on safety and the environment should be reviewed in order that the effects can be quantified. If effects are identified which cause concern, then a survey should be conducted to monitor the current rates and types of tampering present in the current fleet. This could be carried out at periodic inspections, or by roadside checks, as used by previous studies.

5 74kW power limit for motorcycles

5.1 Problem definition

Directive 95/1/EC on maximum design speed, maximum torque and maximum net engine power[6] harmonized the national requirements in this field. However, it still allows Member States to use national legislation to refuse the initial registration and any subsequent registration within their territory of vehicles with a maximum net power of more than 74 kW. This creates a situation where a motorcycle above 74 kW type-approved in one country can be refused approval in another one. This type of situation jeopardizes the creation of the internal market.

It is understood that currently only one Member State, France, applies the 74kW power restriction. Therefore, motorcycles that are intended to be registered in France must be specifically designed for that market, or only specific models are sold there.

As requested by Directive 95/1/EC, a study was granted in 1997 to TNO in order to assess the possible link between engine power and the occurrence of accidents. The study concluded that such a link was difficult to establish, in particular because of the lack of accident data.

5.2 Objectives

The objectives of this proposal are:

- To remove barriers to ensure the free movement of goods within the internal market; without
- Jeopardizing the continuing efforts to reduce the number of road traffic casualties; and

  To contribute to environmental objectives by reducing environmental noise and emissions.

5.3 Policy options

The Commission has identified the following four policy options in relation to power restrictions:

a. **No change**. The present legislation applies. Member Sates' option to limit the maximum power of motorcycles to 74kW is maintained;

b. **Repeal the option given to Member States to limit the power to 74kW**. With this scenario no power limit would be set out;

c. **Set a harmonized limit of 74kW**. This scenario would result in all motorcycles sold in Europe having the power limited to 74kW. In that case, the impact of extending the requirement to tricycles will also be assessed;

d. **Use an alternative limitation**. In this scenario, another criterion, such as power-to-mass ratio or acceleration potential, will be considered. Such measures would be used to limit the accident occurrence of motorcycles.

[6] OJ L 52, 8.3.1995, p. 1

5.4 Analysis of impacts

5.4.1 Economic impacts

5.4.1.1 Option A: no change

For this "do nothing" scenario, there is no change to the current situation, and therefore there will be a minimal economic impact on all stakeholders if the Member States that currently apply the 74Kw limit continue to do so.

Although this option reflects no change in the EU legislation, there is potential that, in the future, the number of Member States that apply the 74kW power limit through national legislation could increase. However, the technical measures that need to be applied already exist for some (if not all) of the manufacturers that sell motorcycles in Europe. It has not been possible to quantify this impact and it is unclear if the impact will be positive or negative. There are a number of factors that could influence the magnitude of this impact including:

- There may be a minimal cost to the manufacturers to produce the restricted motorcycles. It may reduce the cost in some cases, depending on the balance between restricted and non-restricted markets.
- How will applying the power restriction affect sales within the markets that are currently not restricted, will there be an increase or decrease in sales?
- There is no clear evidence to suggest that limiting the power of a motorcycle to 74kW has a positive impact on the number of road accidents involving motorcycles, therefore the potential economic impact of road accidents is unclear.

Conversely, those Member States that currently apply the 74kW power limit (currently thought to be only France) may rescind the National Legislation. This is likely to have a moderate positive economic impact, although it is not currently possible to quantify this with the information available.

5.4.1.2 Option B: repeal the option to limit power to 74kW

This option will result in no Member State being able to refuse the registration of a motorcycle with a maximum power exceeding 74kW. Therefore, any motorcycle that has a European approval can be registered in any Member State.

If this option is adopted, then the OEMs will not be required to add specific measures to vehicles for specific markets therefore this should result in a positive economic impact for the OEMs with respect to reduced technical and administrative costs. However, because the option to restrict maximum power to 74kW has only been adopted in one Member State, the impact of this option is likely to be relatively small.

The effect of restricting the maximum power of motorcycles to 74kW is unclear. Therefore the economic impact from accidents associated with repealing this limit is not possible to quantify.

5.4.1.3 Option C: set harmonised 74kW power limit

This option would result in all motorcycles type approved in Europe being restricted to a maximum power of 74kW. This is likely to result in some of the new model replacements for vehicles that are currently approved to have reduced power. This has the potential to have a large negative impact on some specialist manufacturers that concentrate on the production of high powered motorcycles, where maximum power is essential for their brand.

5.4.1.4 Option D: use an alternative method of limitation

The economic impact of this option will be dependent on the method of limitation that is selected. Regardless of the method of limitation, the following aspects of costs to the OEMs are likely with respect to the approval process:

- Development of motorcycles that meet the new criteria
- Approval to an additional technical requirement

Additionally, there may be an impact on the sales of new motorcycles if the new method of limitation is inconsistent with the requirements of the target market.

5.4.2 Societal impacts

5.4.2.1 Option A: no change, Option B: repeal the option to limit power to 74kW and Option C: set harmonised 74kW power limit

Road safety is one of the main areas that could be influenced by this proposal, with subsequent impacts on society.

A European Commission funded study was published in 1997 (Ruijs and Berkhout, 1997). The study aimed to examine whether there is a relationship between motorcycle accident occurrence and motorcycle engine power exceeding 74kW. The first phase consisted of a literature review, the main findings of which are summarised below:

- Many factors determine the accident risk, particularly age, experience and annual mileage;
- Drivers' attitude and the choice of a specific motorcycle and engine power are correlated, but hard or impossible to discriminate in a survey;
- Restriction of engine power to 74kW does not reduce the accident risk significantly, lightweight motorcycles have great potential for acceleration.

Additionally, it was concluded that a new study into the relationship between motorcycle accidents and motorcycle power exceeding 74kW would have very limited (theoretical) chance of finding a scientific and objective relationship/correlation between engine size or power and motorcycle accidents. Phase B of the project considered:

- Detailed arguments as to why a new study would not produce any statistically reliable relationship between engine power and accident occurrence;
- Descriptions of accidents where engine power has or may have played a role, with respect to the actions of the rider and the perception of speed by other road users;
- A comparison of power-to-weight ratio and acceleration potential of motorcycles with those of fast passenger cars and sports cars

Data for motorcycle accident studies reviewed in the literature study by Ruijs and Berkhout (1997) identified numerous factors that influence the accident rate of motorcyclists. These factors are related to the motorcyclist, the accident circumstances and exposure data (experience, annual mileage, age, road type, time of accident) rather than vehicle related factors such as the engine size, power or power-to-weight ratio. The conclusion of the literature study was that there is no scientific evidence that engine size is a major factor in motorcycle accidents and that accident risk per distance travelled is not influenced by engine size, engine power or power-to-weight ratio. Ruijs and Berkhout (1997) commented further that an extensive study which identified all influential factors and their relationship to motorcycle accidents, would not necessarily guarantee that the relationship between engine power and power related factors could be discerned from effects like the attitude of the rider.

Sexton *et al* (2004) report the findings from a study for the UK Department for Transport, the objective of which was to explore and quantify the interacting influences which determine motorcyclist accident (and casualty) liabilities in Great Britain. Based on analysis of 11,306 respondents to the survey, the influence of engine size and type of bike on non-fatal accidents was considered. The report describes the complex relationship between engine size and power (also acknowledged by Ruijs and Berkhout, 1997). Generally up to 600cc, the engine power increases with engine size. However, for engines over 600cc, the power is related more to the type of bike than the capacity, a 600cc sports bike will develop more power than a 1200cc touring bike. For all severities of accident considered, riders of bikes with less than 125cc had a higher accident involvement than those with larger bikes. However this over-involvement for bikes up to 125cc decreases as the severity of the accident increases, and for serious accidents, there is no clear relationship between engine size and accident involvement. The report also states that any relationship in the data does not imply a causal link between engine size and accident involvement, because other factors, such as exposure, type of use an experience, are associated with the type of bike ridden.

To help identify factors that influence motorcycle accident risk, Sexton *et al* (2004) carried out further analysis of the survey data, using multivariate analysis. The effect of bike size was analysed using the generalised linear modelling method. The analysis grouped the motorcycles into those with an engine capacity up to 125cc and those with an engine capacity of 125cc or greater. The results from the analysis suggest that once age, experience, annual mileage and "rider dedication" have been accounted for, riders of larger bikes (125cc+) had an accident liability of 0.85 times that of the riders of smaller bikes, i.e. 15% lower.

Broughton (1988) analysed injury accidents in STATS19 (National Road Accident Database for Great Britain) alongside other data. He found that engine capacity was related to the rate of injury accidents per million kilometres. In particular, motorcycles with engine capacity greater than 125cc had a much lower risk than those up to 125cc. However the fatality rate for motorcycles over 250cc was twice the average fatality rate and for those over 500cc the fatality rate was about 40% higher than average. However this study was unable to account for rider experience and age. The use of a linear accident rate, rather than one based on a power function of mileage was cited as one limitation of the study, which would lead to an overestimate of the risk to smaller motorcycles compared to larger ones. Analysis of fatality rates included pillion passengers, which are more likely to be carried on larger capacity bikes. There was also an increase in the proportion of accidents that involved overtaking or travelling round bends, accidents at night and multi vehicle accidents as the engine size increased.

Norwegian studies of accidents in 1995, 1997 and 1999 (MC Rådet, 1995, 1997 and 1999) were referenced by the stakeholders that were consulted (reports only available in Norwegian). The 1999 study concluded that models with a "fierce image" were more often involved in accidents than other models with a "kinder image". However, in several cases the motorcycles with a "kinder image" had significantly more power. An example of this is provided based on the Kawasaki ZX-7R and ZZ-R 1100. The ZX-7R is 750cc with a horsepower of 122 and an accident rate of 46.7 per 1000, whereas the 1100cc 147 horsepower ZZ-R 1100 has an accident rate of 4.5 per 1000. For a number of manufactures, the lower powered "street-racer" bikes had higher accident rates than the higher powered "touring" bikes.

A Swedish literature review and meta-analysis (available in Swedish, Ulleberg, 2003) was also cited by one of the stakeholders consulted. The report summarised that the evidence suggests that the driver and driver behaviour is the main cause of accidents, not the engine size of the motorcycle.

Analysis of MAIDS data showed that when comparing the accident involvement of PTWs by engine capacity with the exposure data there was no significant difference between the samples, except for those over 1001cc, which were shown to be under-represented (ACEM, 2008).

Feedback from stakeholders indicated that France is the only Member State that imposes the 74kW power limit. The stakeholders made reference to a report by the General Council for Roads and Bridges in France (Guyot, 2008) which indicated that there was no positive effect on the French accident statistics since the introduction of the power limit.

Although TRL has not independently reviewed all foreign language material, the English summaries of these documents confirm that the relationship between maximum power and accident risk cannot be proven and that there is a higher likelihood that other factors such as rider attitude and experience have a greater influence on accident risk. Therefore the impact of maintaining the existing requirements, repealing or harmonizing the maximum power of motorcycles (options a, b and c) are therefore likely to be minimal with respect to road safety.

5.4.2.2 Option D: use an alternative method of limitation

With regard to the option relating to an alternative method of restriction, analysis of MAIDS was provided by ACEM. The analysis showed that 56 of the 523 accident involved L3 motorcycles were recorded as "moving in a straight line, accelerating" just prior to the precipitating event. Just over one third (N=20) of those were sport/replica motorcycles, which are considered to have the highest power-to-mass ratio, accounting for 3.8% of all the accident involved motorcycles. The accidents identified in the analysis include vehicles at all travel speeds (35% less than 50km/h) and all engine capacities. This analysis suggests that the conclusions from Ruijs and Berkhout (1997) remain valid and that there is minimal evidence to link accident risk with power related measures. Therefore this option is likely to also have a minimal impact on the number of road accidents.

5.4.3 Environmental impacts

The overall noise generated by motorcycles is a combination of a number of factors: power-to-mass ratio, engine speed, acceleration rate, maximum power, when the maximum power is achieved, engine type and exhaust type and configuration. There is insufficient data available to be able to make reliable comparisons as to the effect of just changing engine power.

Data is available from the type approval process where static and drive-by measurements are recorded. Brief examination of this data shows there is a weak correlation of noise as power increases, (0.44) however there is a lot of scatter in the range of values for lower powered machines (<50kW) when compared to the higher powered machines (>50kW) with the maximum values remaining similar. This trend is seen for both the static and drive-by measurements.

Levels of vehicle emissions and fuel consumption can also be impacted by this proposal although insufficient data exits to quantify these parameters.

5.4.3.1 Option A: no change

If the current situation remains with respect to the number of Member States implementing the 74kW power limit. This option is predicted to have a neutral effect on the noise generation, emissions and fuel consumption.

An increase in the number of Member States applying the power restrictions has the potential to affect the noise, emissions and fuel consumption, most likely in a positive manner, although the effect is uncertain since data shows that lower power machines may create noise levels similar to higher power machines, and the magnitude of effects on fuel consumption and emissions are difficult to quantify without further research.

5.4.3.2 Option B: repeal the option to limit power to 74kW

This option is likely to have a neutral impact on noise, with the possibility of either a very low positive or negative impact. However, the impact on emissions and fuel consumption is likely to be negative, and of greater magnitude.

However, whatever changes there are will only be applied to vehicles registered in France, 7% of the EU-27 vehicle fleet.

5.4.3.3 Option C: set harmonised 74kW power limit

This option is likely to have a neutral or a low positive effect on noise and emissions. This is because a greater proportion of lower power machines may have higher noise levels and this may offset any benefit due to reduced emissions; the magnitude of the positive and negative effects is unclear from the information available and can be influenced by the design of the exhaust system.

5.4.3.4 Option D: use an alternative method of limitation

This option has the potential to lead to a greater impact on noise than the other options presented, depending on the criteria/limitation that is used. Investigations into the relationships of these potential parameters would need to be completed before the impacts of noise could be assessed.

There is potential for this option to have a positive impact on emissions and fuel consumption, although the availability of supporting data is currently weak. This impact would also be dependent on the criteria/limitation that is used.

5.5 Comparing the options

Table 51 compares the economic, societal and environmental impacts for the four options related to the 74kW power limit. In the table, arrows are used to represent the estimated magnitude of each impact, with the direction of the arrow denoting whether the impact is positive or negative. Where the impact is considered to be neutral, there are no arrows. The "dotted" arrows are used where the magnitude of the impact is dependent on external factors such as how the existing legislation is applied in future for Option A or the measure that is selected for Option D.

Table 51. Comparison of impacts for the four options under consideration with respect to the 74kW power limit.

		Impact		
	Option	**Negative**	**Neutral**	**Positive**
Economic	A		◄···●·······►	
	B		●──►	
	C	◄──────────	●	
	D		◄──●	
Societal	A		●	
	B		●	
	C		●	
	D		●	
Environmental	A		●···►	
	B		◄···●►	
	C		●···►	
	D		●···········	►

This summary shows that the anticipated societal impact of all the options is neutral. Option A is likely to have a positive impact both economically and environmentally, although the magnitude of these impacts is uncertain. Option B is expected to have a positive economic impact, but the environmental impact could be negative or positive. Both options C and D are likely to have a negative economic impact, but Option D has potential for a larger positive environmental impact. However, the magnitude of the environmental impacts is currently uncertain.

5.6 Monitoring and evaluation

To allow the progress towards the objectives to be monitored, the following recommendations are made:

- Determine baseline data, including:
    - Sales data with respect to engine power/acceleration potential or whatever measure is used as the limitation.
    - Accident rates with respect to engine power/acceleration potential or whatever measure is used as the limitation.
    - Emissions/noise data with respect to engine power/acceleration potential or whatever measure is used as the limitation.
- Monitor these data in relation to any other changes that could influence the number of accidents, emissions or noise, for example anti-tampering measures, approval of hydrogen powered vehicles etc.

These actions should allow the effect of the proposal to be identified after implementation, or before if the implementation is delayed to quantify the possible impacts further.

6 Quadricycles (Category L6 and L7)

6.1 Problem definition

L6 and L7 Quadricycles, sometimes referred to as micro-cars or mini-cars, are defined as four-wheel vehicles with limited performance and mass. This section addresses proposals relating to "car-like" quadricycles, with the Section 7 of this report dealing with off-road quadricycles. For pictures of typical quadricycles in these categories, the reader is referred to page 23 of Geivanidis *et al.* (2008). Quadricycles were included in the scope of Directive 2002/24/EC because they were considered comparable to a moped with bodywork (light quadricycle) or to a small motorcycle (< 125cc) with bodywork (heavy quadricycle).

The quadricycle market in Europe is small and is mainly localised to France, Italy and Spain. In most European countries quadricycles can be driven with only a moped licence and even without a driving licence in some countries such as Italy. Light quadricycles are typically used in rural areas by older people who have never passed their car driving licence, and typically in urban areas by younger drivers starting to learn to drive. There are also heavy quadricycle utility vehicles which are usually used as delivery vehicles in city centres. In recent years, electric quadricycles have started to become more popular with inner city drivers, due to their economy and exemption from emissions and congestion charges.

Quadricycles are expected to become more popular with the increasing public concern associated with environmental issues such as emissions and climate change and with economic drivers such as increasing fuel prices. This is likely to lead a greater number of car purchasers to select vehicles with good fuel economy and lower emissions; quadricycles would therefore be an attractive alternative. Also, the number of congestion/road charging schemes is likely to increase, and quadricycles, if they continued to be treated favourably, would again be an attractive option for consumers. The increasing popularity of these vehicles, together with the less regulated safety of these vehicles compared with cars, therefore gives cause for concern.

Quadricycles generally look like small cars but they can be longer than the smallest vehicles approved under passenger car regulations (M1), for example, a Daimler Smart car. The Commission regularly receives questions about the safety of quadricycles and the adaptation of the legislation in force. The Commission has therefore requested an analysis of various regulatory proposals relating to these vehicles.

Quadricycles are currently type-approved under the motorcycle Framework Directive 2002/24/EC and are classified as either:

1. Light quadricycle (L6) which is defined as:
    - Unladen mass less than 350kg
    - Maximum speed not more than 45km/h
    - Engine cylinder capacity less than 50cm^3 (petrol engines)
    - Maximum net power does not exceed 4kW (diesel engines)
    - Maximum continuous rated power does not exceed 4kW (electric vehicles)
    - Fulfil technical requirements of L2 (3-wheeled mopeds), unless specified differently in any separate Directives
2. Heavy quadricycle (L7) which is defined as:
    - Unladen mass less than 400kg (550kg for goods vehicles)
    - Maximum net power does not exceed 15kW

- Fulfil technical requirements of L5 (motor tricycles), unless specified differently in any separate Directives

The relevant EU Directives that apply to both L6 and L7 quadricycles are presented in the following table.

Table 52. EU Directives which apply to L6 and L7 quadricycles.

Technical requirement	Directive	Technical requirement	Directive
Power & Speed	95/1/EC	Braking system	93/14/EEC
Anti-tampering	97/24/EC (C7)	Lighting Installation	93/92/EEC
Fuel Tank	97/24/EC (C6)	Lighting Devices	97/24/EC (C2)
Masses & Dimensions	93/93/EEC	Audible Warning Devices	93/30/EEC
Coupling Devices	97/24/EC (C10)	Rear Registration Plate	93/94/EEC
Anti-air Pollution Measurers	97/24/EC (C5)	Electromagnetic	97/24/EC (C8)
Tyres	97/24/EC (C1)	Rear-view Mirror	97/24/EC (C4)
External Projections	97/24/EC (C3)	Stand	93/31/EEC
Windows	97/24/EC (C12)	Anchorage Points	97/24/EC (C11)
Passenger Hand-holds	93/32/EEC	Speedometer	2000/7/EC
ID of Controls	93/29/EEC	Statutory Inscriptions	93/34/EEC
Sound Level & Exhaust System	97/24/EC (C9)	Device to Prevent Unauthorised Use	93/33/EEC

6.2 Objectives

The objective of this study is to investigate the costs and benefits of introducing changes to the legislation affecting quadricycles, based upon the options outlined in the following section. The aims of these options include:

- clarifying the distinction between quadricycles, motorcycles and cars by improving the definition of quadricycles;
- to assess whether quadricycles are currently legislated for at the most appropriate level, and;
- to identify whether there is justification for improved safety requirements to be introduced.

6.3 Policy options

The EC has identified the following four policy options for quadricycles:

a. **No change**. The European legislation remains unchanged with quadricycles continuing to be defined as they are now and approved to EU Framework Directive 2002/24/EC.

b. **Exclude quadricycles from the Framework Directive**.

c. **Return to the original spirit of the legislation (i.e. mopeds and small motorcycles with four wheels).** Limit quadricycle length (2.7m) and width (1.5m) and limit the number of passengers for L6 quadricycles (including the driver) to two, creating a stricter definition for the unladen mass requirements.

d. **Improving the legislation by adding new requirements based on car requirements**. Align the safety requirements of quadricycles as much as possible with car requirements in order to improve the safety of such vehicles.

6.3.1 Consultation with stakeholders

Although a consultation period was conducted as part of the project the majority of information was only received from EQUAL (**E**uropean **QUA**dricycle **L**eague), which is the association of European manufacturers of quadricycles. The organisations that are focused on motorcycles had no comments on quadricycles.

6.4 Analysis of impacts

6.4.1 Economic impacts

6.4.1.1 Option A: No change

Option A would result in the current costs of gaining type approval remaining unchanged. EQUAL indicated that type approval to L6/L7 quadricycle requirements of Directive 2002/24/EC is approximately €10,000 per model.

6.4.1.2 Option B: Exclude quadricycles from the Framework Directive

There are around 320,000 quadricycles in Europe, with only around 35,000 new quadricycles sold each year. When this is compared to the 14 million new M1 vehicles and 1.5 million new motorbikes and 900,000 new mopeds, (2007 figures) the quadricycle population is relatively small. This therefore raises the question of whether these small numbers of vehicles require legislating at a European level.

Currently vehicles produced in volumes of less than 200 per type per year can be made exempt from the EU Framework Directive and legislated by National Small Series requirements. Despite the localised market and the fact there are not many different models of quadricycles the major manufacturers sell volumes in excess of 200 vehicles per type per year and therefore cannot be approved under Small Series requirements

Option B would result in the costs to the manufacturer increasing since approvals would be required to approve quadricycles in each of the member states in which it was marketed. Information from industry indicated that the approval cost of €10,000 per model would be applicable in every member state in which the model was marketed, creating a significant additional cost to industry; this is considered likely to also lead to increased consumer costs.

Furthermore, if quadricycles were legislated at a national level a variation in requirements could develop between countries requiring quadricycle manufacturer to design country specific quadricycle models, which would not be cost effective for the manufacturers. EQUAL is of the opinion that reverting to National type-approval would conflict with the European Union’s policy of lifting restrictions to the free movement of goods and services. They believe that this option would therefore inhibit the spread and development of quadricycles across Europe.

Should the number of quadricycles increase in popularity as a result of environmental or economic drivers, this is likely to result in quadricycles being sold in more European countries. Therefore, it seems highly unlikely that there will be a financial benefit in excluding them from the framework Directive, since each member state is likely to demand at least similar (or perhaps even more demanding) national requirements, In addition, should the market of quadricycles increase it would be desirable to have a uniform and easily updated set of safety requirements in place for the European market.

6.4.1.3 Option C: Return to the original spirit of the legislation (i.e. mopeds and small motorcycles with four wheels).

Option C involves investigating the impact and the feasibility of limiting quadricycles' length to 2.7m and their width to 1.5m and limiting the number of passengers for L6 (including the driver) to two and limiting unladen mass to 350kg (400kg for L7 vehicles). Currently, of the vehicles produced by the seven major quadricycle manufacturers, only two models are shorter than 2.7m (see Table 53). The majority of L7 quadricycles are between 2.8m-3.0m long in order to allow room to accommodate the rear passengers. By limiting the length of quadricycles it may result in reduced occupant space and crush space used for occupant protection in front impacts.

Table 53. Quadricycle dimensions.

Manufacturer	Model	Description	Length (mm)	Width (mm)
Axiam	Crossline	L7	2729	1508
Axiam	Scouty	L7	2729	1508
Axiam	A751	L7	2897	1474
Axiam	Multi Truck	Goods Vehicle	3328	1490
Axiam	Mega City	L7 (Electric)	2897	1474
Bellier	Docker	Goods Vehicle	2870	1350
Chatenet	Baroder	L7	2950	1560
JDM	Albizia	L6	2640	1450
Ligier	X-Too2	L6	2805	1440
Ligier	X-Too Max	L6	2985	1465
Microcar	MC1	L6	2955	1495
Microcar	MC2	L7	3130	1495
REVA	G-Wiz	L7 (Electric)	2600	1300

From the information in Table 53 it can be seen that most current quadricycles are outside the proposed dimensional restrictions. Therefore, the effect of this option might be to influence the sizes of quadricycle produced by the manufacturer. The effect of this would be to demand the manufacturer change the design of future vehicles to obtain European approval and therefore seek approval at national level. Stakeholder responses indicated that manufacturers would be likely to continue with current designs meaning that many quadricycles would not be approved at the European level. The economic impact would depend on how quadricycles exceeding the size requirements were dealt with by member states. Should they be considered as M1 vehicles then the costs to manufacturers would be significantly increased and the economic impacts would be comparable to Option D.

EQUAL provided information that Option C, returning to the original spirit of the legislation, would help differentiate quadricycles from category M1 and N1 automobiles as well as 'leisure' vehicles. However, the specification suggested by EQUAL was for larger vehicle sizes than proposed under this option (see Appendix A).

6.4.1.4 Option D: Improving the legislation by adding new requirements based on car requirements

Option D (improving the legislation by adding new requirements based on car requirements) is considered likely to have economic impacts to the manufacturer relating to additional testing, design, development, materials and approvals which would be required to improve the technical requirements to that of M1 vehicles. The costs involved in improving the requirements to those of M1 vehicles, particularly in relation to front and side impact protection, are likely to be very significant. These costs would impose a significantly higher financial burden on manufacturers than the current situation, both in relation to increased test costs and in designing vehicles to satisfy minimum performance requirements. EQUAL commented that this would not be economically viable since only 35,000 quadricycles are sold each year and that the highest volume model represents less than 10,000 units per year.

Quadricycle manufacturers consulted did not provide full costs for meeting the same safety requirements as an M1 vehicle, and responded that meeting M1 requirements was unfeasible. However EQUAL indicated that a €700,000, 18 month development period would be needed for the design of an airbag. The airbag would result in an additional cost to the consumer of approximately €1000. The quadricycle manufacturers maintain that the current EU requirements for quadricycles are sufficient and provide an adequate level of safety protection for the occupants. They support this claim with the evidence from the French accident data, despite this not being sufficient to determine any current safety issues.

6.4.2 Societal impacts

6.4.2.1 Introduction

To assess whether there is a current safety problem relating to quadricycle safety it is necessary to examine accident data to identify and quantify the magnitude of any issue. Due to the relative low volumes of quadricycles in European countries the accident statistics information for quadricycles is limited. However, it is important to consider the available data.

European sales of quadricycles number around 35,000 per year with the total European fleet at around 320,000. The majority of these vehicles are located in France, Italy and Spain. The European quadricycle manufacturers only sell a few hundred quadricycles each year in Holland, Portugal, Austria, Belgium, UK and Germany. In addition REVA the makers of the G-wiz claim to have sold around 900 in the London area. Nearly 50% of the 320,000 estimated quadricycles in Europe are found in France. Since mandatory registration in 1992, quadricycles have been included in the official accident statistics published by the French Ministry of Transport. Official figures issued by ONISR for 2007[7] (National interministerial observatory for road safety) state that KSI (killed or seriously injured) casualties per 100,000 vehicles in France are:

- 159 for passenger cars
- 1,264 for mopeds
- 1,494 for motorcycles
- 229 for quadricycles

[7] http://www2.securiteroutiere.gouv.fr/infos-ref/observatoire/accidentologie/categories-d-usagers.html

It can be seen that the KSI casualties per 100,000 vehicles are significantly lower than for motorcycles or mopeds, but are 44% higher than that for cars. If quadricycles are used to replace journeys currently made by M1 vehicles, rather than mopeds or motorcycles, this may create a safety problem.

The fatality rate per 100,000 vehicles in France is:

- 17.1 for quadricycles
- 66.5 for motorcycles
- 25.8 for mopeds
- 8.1 for passenger cars

This shows that although quadricycles have a low overall KSI casualty rate compare to other vehicle types, when an accident occurs, the KSI group contains a higher proportion of fatalities. The proportion of KSI casualties that are fatally injured can be calculated by dividing the fatality rate by the KSI casualty rate: for quadricycles (7%) compared to passenger cars (5%), motorcycles (4%) and mopeds (2%). This data therefore indicates that quadricycle accidents yield a disproportionate number of fatalities compared to other vehicle groups, although the small sample size should be acknowledged. Thus, the proportion of fatalities within the KSI group is greater for quadricycles than other vehicle types.

The number of registered vehicles is one of the most crude indicators of exposure to risk available because it takes no account of the distance travelled by different vehicles. The distance travelled by quadricycles in France is unknown but it is estimated by EQUAL to be similar to mopeds (2,020 km), which is only approximately 15% of that of passenger cars (13,029 km). From this data the fatality rate per 100,000 vehicle km can be estimated:

- 0.0084 fatalities per 100,000 vehicle km for quadricycles
- 0.0006 fatalities per 100,000 vehicle km for passenger cars
- 0.032 fatalities per 100,000 vehicle km for mopeds

Therefore, after taking into account vehicle exposure, the fatality rate per 100,000 vehicle km is 14 times that of passenger cars and nearly 4 times lower than mopeds.

An accident study in Austria, published by Nussbaumer and Nitsche (2008) also provided evidence supporting the observation of increased casualty risk for quadricycles. The study examined accident data in Austria from 2001-2005. 326 accidents involving injuries were identified; of these, there were 404 casualties and 22 fatalities. Figures for 2003-2004 show the fatality rate per 100,000 vehicles in Austria:

- 38 for quadricycles
- 15 for mopeds
- 12 for passenger cars

The study estimates that quadricycles only travel around 4,750 km per year compared to passenger cars which travel around 15,000 km per year. Thus, fatality rate per 100,000 vehicle km can be calculated as:

- 0.008 fatalities per 100,000 vehicle km for quadricycles
- 0.0008 fatalities per 100,000 vehicle km for passenger cars

Therefore, after taking into account vehicle exposure, the fatality rate per 100,000 vehicle km is 10 times that of passenger cars and indicates a similar picture to the French quadricycle data. However this accident study from Austria represents only around 5% of the total fleet of quadricycles in Europe and therefore may not be a fair representation of the entire European situation. This data indicates that it is currently unclear whether there is a significant safety issue relating to quadricycles, with the fatality rate appearing to be intermediate between mopeds and passenger cars. Since the magnitude of the current situation cannot be detailed, the societal (casualty reduction) benefits of the options proposed are difficult to quantify.

6.4.2.2 Option A and B: Do nothing and exclude quadricycles from the Framework Directive

It is considered that options A and B would not result in additional casualty savings. The "do nothing" option would maintain the status quo and Option B would result in quadricycles meeting the requirement of national approvals. It has been assumed that the requirements at a national level are similar to those which exist under the current situation. The advantage of keeping the legislation for quadricycles at a European level is that future improvements to requirements can be easily implemented across all European countries

6.4.2.3 Option C: Return to the original spirit of the legislation (i.e. mopeds and small motorcycles with four wheels)

The societal impacts of Option C are dependent on the response of the manufacturers to this change. If manufactures choose to meet the size requirements then this might have a negative effect on safety due to reduced occupant space and the available vehicle crush space, potentially exposing occupants to increased intrusion risk in an impact. If manufacturers continue to produce vehicles which exceed the size limits, these would require approval at the national level. No information has been obtained to compare the requirements of the national level with the current type approval requirements, although it is assumed that these would be equivalent. However, enforcing a stricter mass limit could have an affect on weight distribution, and therefore stability. Limiting L6 quadricycles to only two occupants would be beneficial as it would not require the manufacturer to try and accommodate rear seat passengers at the expense of front passenger space and vehicle impact protection.

EQUAL proposed to redefine quadricycles definitions (see Appendix A) for L6 (length 3m, width 1.5m and unladen mass 475kg) and for L7 (length 4m, width 2m and unladen mass 625). However the proposal dimensions of the L7 would make them very similar in size to existing small passenger cars. This could result in road users finding it even more difficult to distinguish between quadricycles and cars, which could result in problems due to their low top speed (proposed as 90 km/h). This may also lead purchases of quadricycles to believe that because the vehicle is a similar size and has a 'car-like' appearance it will offer the same occupant crash protection. Conversely increasing the weight limit and dimensions of quadricycles will reduce the manufacturers design constraints and could allow for improved safety measures to be incorporated.

The advantages and disadvantages of this option are also unclear. It could be argued that restricting the overall length of a quadricycle would reduce the safety of these vehicles as the occupant space and the available vehicle crush space would be reduced. However enforcing a stricter mass limit could have an affect on weight distribution, and therefore stability. Limiting L6 quadricycles to only two occupants would be beneficial as it would not require the manufacturer to try and accommodate rear seat passengers at the expense of front passenger space and vehicle impact protection.

6.4.2.4 Option D: Improving the legislation by adding new requirements based on car requirements

For Option D, the magnitude of the benefit which might be obtained by aligning the requirements as far as possible with M1 vehicles is dependant on the proportion of current quadricycle accidents which might have improved accident outcomes resulting from more stringent M1-type requirements. These benefits are difficult to quantify due to the lack of detailed accident data.

There are 51 EU Directives relating to the safety requirements for M1 vehicles (passenger cars). In comparison there are only 25 EU Directives that apply to motorcycles to which quadricycles are classified and approved to. Hardy *et al.* (2009) compared the requirements for motorcycles relating to safety to the requirements for cars and assesses the potential risk. The potential risk was estimated based on how difficult it would be for the quadricycle to meet the M1 technical requirement, if it did not already (No Risk). Table 54 shows a summary of the comparison.

Table 54 shows that the main difference in safety requirements is the lack of requirements for front and side impact protection. Meeting the requirements for front and side impact would be the most challenging to achieve but provide the greatest improvement in safety. Hardy et al (2009) describes that there have been some quadricycles tested to the front impact and side impact test requirements for M1 vehicles, with these not meeting the requirements. Some quadricycles manufacturers maintain that quadricycles do not need the same level of safety protection as an M1 vehicle because of their limited speed and use in low-speed environments. However crash tests are based on impacts with a vehicle of similar mass and due to the low mass of quadricycles, an impact with anything with sufficiently larger mass at low speed, would have the equivalent impact energy as a M1 vehicle in a high speed impact.

It is unclear how close to passing the EU Directive requirements the majority of quadricycles are. It is also difficult to estimate the required changes in design to achieve this. It could mean an increase in material size to gain the extra strength required from the chassis, however this would probably result in the vehicle exceeding the current category weight limit. The alternative is to replace existing materials with lighter stronger material; however this would result in larger material costs and therefore an increase in the manufacturing costs of the vehicle. Both options would ultimately result in an increase in the retail price for the consumer.

Table 54. Comparison of motorcycle requirements relating to safety compared to car requirements and the potential risk (Hardy *et al* 2009).

Directive	Difference between Motorcycle requirement and Car requirement	Risk Assessment
Fuel Tank	No internal pressure test only mechanical strength test	Medium Risk
Rear Registration Plate	Size, shape differences	No Risk
Audible Warning	Same requirements as cars	No Risk
Rear-view mirrors	Mirrors should not move during driving conditions	Low Risk
Braking	No significant differences	Low Risk
Electromagnetic	Same requirements as cars	No Risk
Speedometers	Accuracy of car's speedometer slightly higher	Low Risk
Seat Belt Anchorages	Higher strength requirements for cars	High Risk
Lighting Installation	Same requirements	No Risk
Reflectors, side, stop, daytime, indicators, headlamps, fog	Same requirements	No Risk
Seat belts	Same requirements	Low Risk
ID of controls	Extra symbols not found on M/C	Low Risk
Glazing, Defrost, Wash, Heating	Same requirements	Low Risk
Masses & Dimensions	Different requirements	Low Risk
Tyres	Can use car tyres	Low Risk
Trailer	Same requirements	Low Risk
Currently there is no provision for:		
Steering effort	Probably met	Low Risk
Door Latches & hinges	Probably met or not an issue	Low Risk
Interior fittings	Expected to be met	Low Risk
Protective steering	Should be possible but may require cost	High Risk
Seat Strength	Manufacturers may use existing seats that meet requirements	Medium Risk
Towing Hooks	Little effort if any	Low Risk
Parking Lamps	Assume met	Low Risk
Forward Vision	Probably met	Low Risk
Wheel Guards	Already met	Low Risk
Head Restraints	Probably met	Low Risk
Frontal Impact	Difficult to meet, substantial cost and weight penalties	High Risk
Side Impact	Difficult to meet, substantial cost and weight penalties	High Risk
Frontal Protection System	Unlikely to be fitted	Low Risk
Pedestrian protection	Good shape and crush space	Medium Risk

6.4.3 Environmental impacts

Options A, B and C are considered to have a low negative impact on noise and emissions, mainly due to the possibility of the growth of the market for these vehicles. These vehicles have higher 'type approval' noise limits than their M1 counterparts by 6db(A). However, a lack of data prevents the magnitude of the impact from further quantification.

Option D would have a low positive impact on noise, emissions and fuel consumption, these vehicles are very 'car like' and therefore should comply with the current directives for emissions from whole vehicles and emissions from tyres as M1 category vehicles have to currently.

6.5 Comparing the options

Option A would mean the current situation continuing and therefore would not create any change in costs or benefits.

Both Option B and Option D would increase manufacturing costs and retail cost for the consumer. Option B has the potential to inhibit the free sale and development of quadricycles and would ultimately increase the costs to manufactures and consumers because of the increase in the number of approvals and the potential requirement for greater model variants as a result of varied national requirements.

Option C is the option favoured by industry and also has the potential to improve the safety of quadricycles and clarify the categorisation of quadricycles to distinguish them from ATVs and other leisure vehicles. Whether the redefined definition for category L6 and L7 vehicles proposed by EQUAL will have a positive effect on safety is unknown. By reducing the mass and dimension restrictions currently on quadricycle designs allows manufacturers the potential to improve the safety of the vehicles. However designing them to look more 'car-like' may cause problems on the roads and with consumers expecting a vehicle with M1 safety.

Option D may have an effect on reducing casualties, especially fatalities. This data would suggest that the crash protection of quadricycles needs to be improved to reduce the proportion of fatalities in accidents resulting in injuries. However the published accident information made available does not identify the types of accident in which these vehicles are involved. This is a particularly important consideration when assessing the effect of new safety measures proposed in Option D. Although the increased costs benefit cannot be quantified exactly, basic estimates such as airbag development shows that in an industry of relatively low volumes of vehicles, meeting M1 safety requirements would impose significant costs to industry. This option would increase the costs for the manufacturers and the consumers.

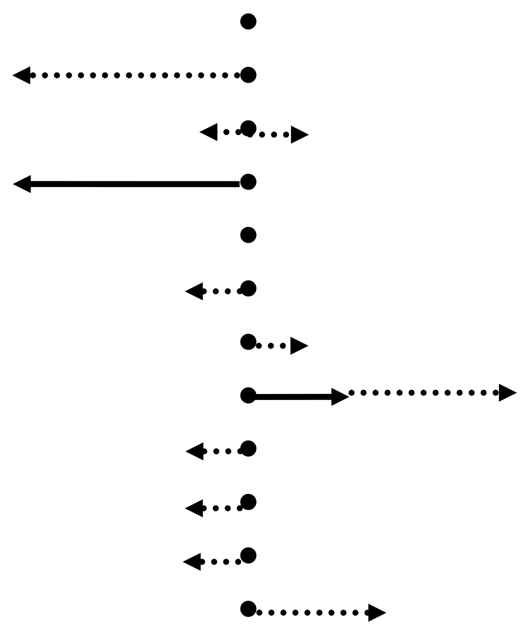
A summary of the estimated impacts for the proposed options is provided below:

Table 55. Summary of impacts for options relating to Quadricycles (L6 and L7 vehicles).

Option	Impact type	Qualitative impacts	Quantified value
A	Economic	Regulatory system costs unchanged	Not quantified; current costs unchanged
A	Economic	Technical standards meeting effort; current costs unchanged	Not quantified; no data
B	Economic	Exclude quadricycles from type approval directive	Not quantified; Significant cost increase if technical requirements vary between countries. Cost impact particularly high for SMEs
B	Economic	Technical standards meeting effort unchanged	Not quantified; current costs unchanged
C	Economic	Regulatory system costs; specify size and weight limits	Not quantified; impact uncertain
C	Economic	Technical standards meeting effort unchanged	Not quantified; current costs unchanged
D	Economic	Align requirements as far as possible with M1 requirements	Not quantified; increase in scope for testing to match M1 would impose very significant additional cost on Industry
D	Economic	Technical standards meeting effort unchanged	Not quantified; increase over current situation
B	Societal	Less transparent regulatory system	Not quantified; benefits difficult to quantify
C	Societal	More transparent regulatory system	Not quantified; benefits difficult to quantify but clearer definitions for quadricycles may result in improved safety
D	Societal	Technical requirements improved to M1 vehicle equivalent; improved safety	Not quantified; increase in safety and reduction in casualties but magnitude uncertain
A	Environmental	Noise, emissions and fuel consumption; low negative impact	Not quantified; no data
B	Environmental	Noise, emissions and fuel consumption	Not quantified; low negative impact
C	Environmental	Noise, emissions and fuel consumption; low negative impact	Not quantified; insufficient data
D	Environmental	Noise, emissions and fuel consumption	Not quantified; potential low positive impact but magnitude uncertain
D	Environmental	Emissions resulting from travel to/from technical standards meetings reduced	Not quantified; impact uncertain – potential increase in emissions

Table 56. Comparison of impacts for the four options under consideration with respect to Quadricycles.

	Option	Impact: Negative	Impact: Neutral	Impact: Positive
Economic	A			
	B			
	C			
	D			
Societal	A			
	B			
	C			
	D			
Environmental	A			
	B			
	C			
	D			



6.6 Monitoring and evaluation

Significant uncertainties remain regarding key costs in the approvals process and in the casualty and environmental impacts of the proposed options. These should be monitored and further data obtained to refine the assessments of potential impacts.

More detailed accident data is required to provide information on the safety of quadricycles and to allow the impact of any measures to be assessed. A more specific categorisation for quadricycles would allow the safety impact of future measures to be monitored.

7 Off-road quads

7.1 Problem definition

In recent years, off-road quads or ATVs (All Terrain Vehicles) have been EC type-approved as a quadricycle, even though the legislation was not intended for this vehicle type. For pictures of typical quadricycles of this type, the reader is referred to page 23 of Geivanidis *et al.* (2008). As their name suggests, these vehicles are mainly intended to be used off-road, however use on the road between trail routes is virtually unavoidable in Europe. Often a non-homologated version of the ATV, for use only off-road, is also sold in the same shop. Using ATVs on the road may have safety issues because of their high acceleration capability and their high centre of gravity, which can result in the vehicle rolling while corning.

An ATV is defined by industry as "any motorised vehicle designed to travel on four low pressure tires on unpaved surfaces, having a seat designed to be straddled by the operator and handlebars for steering control".

ATVs are subdivided into two types as designed by the manufacturer:

- **Type I** - A Type I ATV is intended for use by a single operator and no passenger; and
- **Type II** - A Type II ATV is intended for use by an operator and a passenger. It is equipped with a designated seating position behind the operator designed to be straddled by no more than one passenger.

ATVs are designed to cope with a wide variety of terrain types. ATVs are mainly used for leisure activities, but some are used for utility purposes such as in the agricultural and forestry sectors.

7.2 Objectives

Currently off-road quadricycles do not have separate legislation and therefore are type-approved in Europe as category L6 and L7 vehicles to EU Directive 2002/24/EC (Table 52). The majority are approved as category L7 vehicles due to the power requirements; even then, many are power restricted to enable them to be used on the road. Off-road quadricycles that do not require type-approval (because they are not used on the road) are approved as machinery to EU Directive 2006/42/EC. The purpose of this study is to evaluate as far as possible, several proposed policy options (Section 7.3) to legislate ATVs in Europe.

7.3 Policy options

The following four options for off-road quadricycles were considered:

a. **No change**. The present legislation applies so that ATVs continue to be type-approved as L6 or L7 quadricycles.

b. **Exclude off-road quads from the Framework Directive**. These vehicles would be excluded from Directive 2002/24/EC. They could only be considered as machines or be approved at National level.

c. **Keep the existing category and add new requirements on safety for all quads**. The definition would remain the one used today (L6 & L7). But specific requirements would be added to improve the safety of such vehicles.

d. **Create a new category for off-road quadricycles with specific requirements**. This solution was suggested by the association of European off-road quadricycles manufacturers (ATVEA).

7.3.1 Stakeholder consultation

Although a consultation was conducted as part of the project, the majority of information was only received from ATVEA (**A**ll **T**errain **V**ehicle industry **E**uropean **A**ssociation) which represents ATV manufacturers (about 70% of the European ATV market). Feedback was also received direct from Bombardier an ATV manufacturer. The organisations that are focused on motorcycles had no comments on ATVs.

7.3.2 Background

ATVs are designed for multiple tasks ranging from pulling and pushing work equipment to travelling over different terrains for utility and recreational purposes. They have several unique characteristics:

- ATVs are 'Rider active' vehicles requiring the rider to shift their body weight to control direction;
- Handlebar steering with thumb-operated throttle control allows strong turning of the machine while allowing the rider to shift their body over the saddle;
- Low pressure tyres (about one tenth of normal tyre pressures), create a very large contact surface, absorb roughness of terrain and leave almost no imprint on the ground;
- Live rear axle (no differential) means that the rear wheels will always turn at the same speed, which is an advantage in loose earth terrain (but disadvantageous on paved road); with a differential, one rear wheel might start slipping and the vehicle loses traction; and
- ATVs require enough engine power to perform the work they are designed for and to travel over various terrains.

The number of European sales of ATVs is around 158,000 per year (2007) with an estimated total fleet of approximately 0.8 million. The major markets for ATVs are France, Spain, Germany and the UK. Several thousand ATVs are sold in 11 other EU countries each year and a few hundred in the remaining 12 countries.

It is estimated from information provided by ATVEA that 80-90% of ATVs sold in Europe are type-approved, allowing them to travel on public roads. Vehicles that are not type-approved are confined to private land and may never be used on public roads. All ATVs must comply with the safety requirements of the Machinery Directive. Out of the ATVs which are type-approved, 60-70% are type-approved as L6 or L7 category vehicles. The remaining 30-40% are type-approved at a National level (mainly in Spain, Portugal. Germany, UK and France).

Due to the insufficient categorisation at a European level, Spain and Portugal have defined their own category for ATV homologation. If other countries follow this example and introduce National legislation there is potential for a large variation in requirements between EU countries. Spain has introduced special vehicle requirements which apply to ATVs. There are additional requirements for emission limits, a different sound test method and limits, and a requirement for a maximum speed plate. Portugal applies Small Series requirements (200 units, per type, per year) to ATVs. There are additional requirements for sound limits, mass limits, lighting requirements, requirement for mirrors and limiting the maximum power to 15kW. No cost information was obtained relating to these more stringent requirements.

In Germany ATVs can have single vehicle approval as either a tractor or as a convertible car (less desirable due to higher insurance cost of a convertible). This single vehicle approval system is often used by importers for ATVs purchased directly from USA, Canada or Australia.

Approving imported ATVs through single vehicle approval, or sometimes National type-approval, can have the consequence that the Conformity of Production cannot be guaranteed. This is because the importers have no link to the production facilities of the official manufacturer of the ATVs. This can be an issue for the original ATV manufacturers, since the ATVs are equipped with a new VIN (Vehicle Identification Number), making them untraceable from the original manufacture in case of a safety recall.

In the UK, there is a system is that allows ATVs to be registered as agricultural equipment if they are equipped with the necessary parts for use on public roads (i.e. lights, mirrors etc.) The UK registration system also allows for special taxation for the vehicles.

7.4 Analysis of impacts

7.4.1 ***Economic impacts***

7.4.1.1 Option A: No change. The present legislation applies so that ATVs continue to be type-approved as L6 or L7 quadricycles.

Option A would result in the current costs of gaining approval remaining unchanged. ATVEA reported that the cost of type approval to Directive 2002/24/EC was approximately €10,000 per vehicle type. One manufacturer reported that type approval costs approximated to about €1,000 of the cost at the point of sale, but the number of vehicles produced/sold was not stated.

7.4.1.2 Option B: Exclude off-road quads from the Framework Directive. These vehicles would be excluded from Directive 2002/24/EC. They could only be considered as machines or be approved at National level.

In 2007, around 158,000 ATVs were sold in Europe. This shows that ATV sales are significantly larger than the annual quadricycle sales however they are still fairly minor when compared to car sales (14 million), motorbike sales (1.5 million) and moped sales (0.9 million). This raises the question of whether such small numbers of vehicles require legislation at a European level. Option B proposes that these vehicles are excluded from the Framework Directive and approved at the National level. Currently, vehicles produced in numbers of less than 200 per type, per year, can be made exempt from the EU Framework Directive and legislated by National Small Series requirements. However, the major ATV manufacturers sell volumes well in excess of 200 of each type of vehicle each year.

Option B is considered to result in increased costs to the manufacturer as additional costs may be required to approve quadricycles at the national level. Industry indicated that type approval costs were approximately €10,000 per vehicle type; if approval was performed at the national level, this cost might be required for approval in each member state (up to 27 times this cost for each vehicle).

Therefore switching ATV type-approval to a national level will inevitably increase the costs for both manufacturers and consumers. Although the effect on the final cost to consumer could not be quantified, ATVEA provided information highlighting the importance of the industry to Europe. From a study in 2003, it was estimated that the ATV industry in Europe generated €900 million of revenue. Although ATVs are not actually manufactured in the European Union, 72% of this revenue was generated in the European Union. This was made up of; distribution margin, fuel, rental, 2nd hand margins, VAT, import duty, insurance, accessories and transportation. ATVEA estimate that in 2008, based on the numbers of ATVs sold that this now means €1.5 billion of revenue is generated in the European Union.

A further advantage of keeping the legislation for ATVs at a European level is that future improvements to requirements can be easily implemented across all European Member

States. If ATVs were legislated at a National level a variation in requirements could develop between countries requiring ATV manufacturers to design country specific ATV models, which would not be cost effective for the manufacturers. Furthermore, if ATVs were only approved to the safety requirements of the Machinery Directive (2006/42/EC), this may not allow ATVs to be used on the road, which is essential for their use according to ATVEA.

7.4.1.3 Option C: Keep the existing category and add new requirements on safety for all quads. The definition would remain the one used today (L6 & L7). But specific requirements would be added to improve the safety of such vehicles.

It is believed that with the addition of new requirements, costs are most likely to increase, with costs to the manufacturer related to undertaking additional tests and in developing these assessments via technical working groups increasing. Additional costs would also be incurred by the Member States in implementing any additional regulation but these costs are likely to pass to the manufacturer. However, since the specific changes in the test have not been identified, these costs cannot be quantified.

7.4.1.4 Option D: Create a new category for off-road quadricycles with specific requirements. This solution was suggested by the association of European off-road quadricycles manufacturers (ATVEA).

ATVEA submitted a proposal to the European Commission in May 2007 for a New Type-Approval category for ATVs in Europe. In the proposal from ATVEA, it was highlighted that although ATVs have been type-approved as part of the quadricycle category for 5 to 6 years, this category was originally intended only for ‘micro-cars’. Despite the fact that ATVs are sometimes referred to as quadricycles, they have little in common with micro-cars. Micro–cars are only intended for use on public paved roads whereas ATVs are intended for use on a range of terrains including off-road use or for use on public non paved roads. They are also completely different in their basic construction characteristics, technical requirements and technologies. Therefore, both the micro-car and ATV industries believe that these two types of vehicles should be separated into different categories because this would be the best way to take their specific requirements into account.

The UNECE document ECE/TRANS/WP.29/2008/46 suggests a reclassification of the definition of a quadricycle:

Alternative quadricycle definition (L6 & L7)

(a) Have seats,

(b) Are horizontally confined by a body,

(c) Have a roof or other rollover protection,

(d) Are steered by a steering wheel, and

(e) Have foot-throttle control.

Based on these criteria for L6 and L7 vehicles, Industry-based stakeholders proposed the following ATV classifications (L8 & L9):

(a) Have saddles, but no seats,

(b) Have no body,

(c) Have no roof or other rollover protection,

(d) Are steered by a handlebar, and

(e) Have a hand-throttle control

(f) L8 classified as single rider vehicles

(g) L9 classified as designed to transport a passenger

Industry also indicated that ATVs can be distinguished from quadricycles by the fact that they have no differential and have low pressure tyres.

ATVEA suggested some specific technical requirements for an ATV specific category in their proposal to their European Commission. The additional safety requirements suggested by ATVEA for ATVs amend the following Directives:-

- Exhaust Emissions – Use non road mobile machine (97/68/EC) test cycle
- Sound testing – Use 74/151/EEC requirements
- Brakes – Separate front/rear operated service brake
- Tyres – Possibly use ISO/TC 31/SC 10 recommendations
- Passenger Handholds – Amend 9/32/EEC to include provision for handholds
- Foot Environment – New Directive, minimum space for feet requirement
- Lighting – Either EC Directives or SAE std for North America
- Speed Plate – Speed limitation plate for road use
- Warning Labels – New requirements added to 93/34/EC
- Trailer weight – Change in-line with HSE guidelines

Option D would result in similar cost implications to Option C, but no specific costs were identified which allowed these to be further quantified.

7.4.2 Societal impacts

There currently are no representative accident statistics specifically for ATVs in Europe because they are not separated from quadricycles; this makes it impossible to determine the proportion of casualties for this vehicle type and to assess the potential saving should improved safety requirements by implemented. Therefore the societal benefit of Options A, B, C and D cannot be quantified.

The only limited data is from the UK Health and Safety Executive (HSE) which estimates that on average there are 2 fatalities and 1,000+ serious injuries per year as a result of ATV accidents in the UK. This is roughly equivalent to a KSI (Killed or Seriously Injured) rate of 1,565 per 100,000 vehicles and a fatality rate of 3.1 per 100,000 vehicles. When compared to quadricycle data, the fatality rate is relatively low. However the KSI rate is high compared to the French quadricycle statistics. It should be noted that the UK accounts for only around 10% of ATVs in Europe and therefore its representation of the whole fleet is unclear; the accident data is insufficient to draw robust conclusions.

Option D would create a new category for off-road quadricycles with specific requirements. This would have the advantage of being able to target future safety improvements to these vehicles once these have been established, and prevent other vehicles from being inappropriately type-approved to this category. An imprecise definition can lead to type-approval of vehicles that do not really belong to the category or that normally should not be homologated. Information from ATVEA indicated that mini quadricycles, karts and tracked machines have all tried to obtain homologation in the past. A precise definition of an ATV would prevent these unwanted effects from taking place.

Option D is strongly supported by industry. However, the casualty benefit directly attributable to the implementation of Option D could not be evaluated since the baseline accident situation for ATVs is not available at the required level of detail. The advantages of this option will be that ATVs will have specific appropriate requirements, which can be targeted to improve safety and environmental impacts. However, with the information available it is unclear as to the scale of the benefits which might be realistically obtained by these measures.

This option has the potential to reduce costs because the number of requirements would be reduced only to those that are applicable to ATVs.

The question of where a new specific vehicle category for ATVs would fit in the regulatory framework was raised; should they be within the Agricultural tractors Framework or the Motorcycles Framework?. Responses were, that in principle, it would not make a difference which Framework Directive ATVs were contained in, but that the construction requirements for tractors are very different, and the Framework is a mix of type-approval requirements and health and safety requirements. ATVEA responded that it would be more appropriate and cost effective for the new ATV category to remain within the motorcycle Framework.

7.4.3 Environmental impacts

Option A is predicted to have a low impact on noise and emissions, due to the nature of the use of these vehicles. However, this category of vehicle can be open to abuse with modifications to the engine and exhaust system, increasing the noise and emissions generated by the vehicle. If used as a true off-road vehicle, disturbance to local residents is generally low as vehicles are generally singular working vehicles. If popularity increases, with the use of the vehicle changing from 'working to recreational' then vehicles may be used in more urban areas where disturbance is more likely. The magnitude of any effect could not be quantified due to insufficient data.

Option B is considered, depending on their use and locations, to have a low negative impact on noise and emissions. Options C and D are considered to have a low to medium positive impact on noise and emissions, although no quantative data was available. This is because the quadricycle complies improved emissions and sound levels.

Relevant to Option D, Directive 97/68/EC specifies an 8 mode steady-state test cycle. For ATVs, TRL would recommend that a transient cycle would be preferable. It may be feasible to use the lower speed parts of the motorcycle test. However, checks would need to be undertaken to ensure that the ATVs could follow/drive the test cycle.

The only additional environmental impact which could be identified relates to the potential increase in carbon emissions relating to increased technical working group meeting attendance. This cost is considered to relate to industry and member states and is applicable to Options C and D where new requirements for ATVs are implemented. However, no data was obtained to allow this effect to be quantified.

7.5 Comparing the options

There is currently very limited accident data in Europe to allow the casualty benefits of the proposed options to be evaluated. This is because few, if any, significant sources of accident data separately identify ATVs as a unique accident type. The only accident data estimates from the UK suggest that the fatality rate is low, but the KSI rate is higher than mopeds and motorcycles. However, this was based on small sample sizes.

A summary of the main impacts identified for each of the proposed option is presented below:

Table 57. Summary of impacts for options relating to off-road Quadricycles.

Option	Impact type	Qualitative impacts	Quantified value
A	Economic	Type approval costs unchanged	Current cost approximately €10,000 per vehicle
B	Economic	ATVs approved at national level	Increase in cost to manufacturers over current situation, potentially requiring €10,000 per vehicle for approval in each member state
B	Economic	Different national approval requirements	Not quantified; risk of divergent requirements leading to trade barriers
C	Economic	Add new requirements for all quadricycles	Not quantified; insufficient data but cost increase if additional tests added. Likely to also result in increased cost to consumers
D	Economic	Add new Quadricycle category and specific requirements	Not quantified; cost increase over current situation if additional to current requirements but reduction possible if specific requirements mean reduced cost
A	Societal	Casualty rates remain unchanged; current casualty rates appear high in relation to cars and PTWs	Not quantified; data insufficient to draw robust conclusions
B	Societal	Approved as machines or other alternative	Not quantified; effect on casualties not clear
C	Societal	Add new requirements for all quadricycles	Not quantified ; effect on casualties not clear
D	Societal	Add new Quadricycle category and specific requirements	Not quantified; effect on casualties not clear. Targeted measures may be more effective at reducing casualties than Option C.
C & D	Environmental	Emissions resulting from travel to/from technical standards meetings	Not quantified; potential increase

Table 58. Comparison of impacts for the four options under consideration with respect to off-road Quadricycles.

	Option	Impact		
		Negative	Neutral	Positive
Economic	A		●	
	B	◄··············	●	
	C	◄········	●	
	D	◄········	●	···►
Societal	A	◄···	●	
	B	◄···	●	
	C	◄···	●	
	D		●	·····►
Environmental	A		●	
	B		●	
	C		●	·····►
	D		●	·····►

7.6 Monitoring and evaluation

The data required to perform a full cost benefit analysis for these options was not obtained from the consultation process. Evaluation of the costs of the proposed options could be gathered by monitoring type approval costs prior to 2011 (the proposed earliest implementation of any change) and further investigation of costs for national approval. This would allow costs involved with the approval processes of all proposed options to be more accurately quantified.

For all options it is important that a means of collecting European accident data for quadricycles is implemented and that this accident data is disaggregated for different quadricycle types and accident locations (on-road and off-road). This would allow clearer assessment of the societal benefits of future safety improvement measures. Monitoring of accident data would allow future safety related changes to be identified and evaluated.

8 Safety of hydrogen powered L category vehicles

8.1 Problem definition

Hydrogen is an energy carrier: it moves energy in a usable form from one place to another. It has several attractive features in this respect. For example, it is stored easily and when used as a fuel, it burns readily with oxygen, without producing carbon emissions (such as carbon monoxide, carbon dioxide, unburned hydrocarbons or particulates). Although combustion in air produces nitrogen oxides, (due to nitrogen in the atmosphere) these can be reduced significantly through design. Another attractive feature is the abundance of hydrogen on Earth; however, it is found only in combination with other elements (for example, with oxygen in water). Significant quantities of energy from a primary source are therefore required to separate it from these other elements. Nevertheless, it is possible to produce hydrogen cleanly from renewable and nuclear energy, or from natural gas and coal with carbon dioxide capture and storage.

Although it is not used widely today, hydrogen is considered alongside bio-fuels and electric power as having the potential to contribute as an alternative fuel for the road transport sector. There are two possibilities for hydrogen-powered vehicles: hydrogen internal combustion engines and hydrogen fuel cells. A hydrogen internal combustion engine runs on hydrogen rather than petrol. While some of the components of current petrol engine designs would need to be adapted for hydrogen, the fundamental technology is very similar. Major technological innovation is not, therefore, required. Such engines can achieve an overall efficiency of 38 percent, which is 20-25 percent better than a petrol engine (Research Reports International, 2006). Although burning hydrogen in combustion engines produces nitrogen oxides, these can be up to 90 percent lower than petrol engines because the engine can operate in the so-called "lean-burn" mode with an excess of air (International Energy Agency, 2005). The use of hydrogen in a fuel cell vehicle results in fuel economy of two to three times that of a conventional petrol engine vehicle (Ahluwalia *et al.*, 2004). In addition, hydrogen fuel cells emit only water, thus maximising the environmental benefits. These efficiency and environmental benefits must, of course, be balanced with the method of generating hydrogen (when a non-renewable source is used).

The European Commission would like to assess if small vehicles, designated under EC type-approval legislation as category L vehicles, could be possible early adopters of hydrogen as a fuel. This is because introducing hydrogen for these vehicles could require less effort than for larger vehicles. As such, the technical challenge and level of investment may not be as great. At present, hydrogen-powered category L vehicles are not included in the European Commission type-approval Framework. Hence, if a vehicle obtains National or single type-approval in one Member State, it is not guaranteed that the vehicle will be authorised in other Member States. In fact, Member States may even establish different requirements, potentially resulting in a fragmented internal market, with costly and complicated approval procedures.

There are no specific provisions for hydrogen-powered vehicles in the European type-approval Framework for category L vehicles. A manufacturer who wishes to place such a vehicle on the market may face difficulties with the present situation. It is likely that the vehicle will be considered outside the scope of the Framework Directive 2002/24/EC. This is due to an exemption clause set out in Article 16.3. The exemption relates to vehicles that incorporate new technologies which cannot, due to their nature, comply with the separate Technical Directives. A hydrogen-powered category L vehicle might fit into this category. This is because the Directives were developed with either internal combustion engine vehicles or electric vehicles in mind and the use of hydrogen may result in additional risks, such as fire, which are not considered by 2002/24/EC.

Although a hydrogen-powered category L vehicle could be exempt (for the reasons described above), the Framework Directive does allow vehicles featuring new technologies to obtain type-approval. However, it is necessary to demonstrate to the relevant authority, a level of safety and environmental protection that is equivalent to that in the Technical Directives. This could prove very challenging technically both for the manufacturer and for the relevant authority.

With the current arrangement, the relevant authority in each Member State would have to derive the appropriate tests required to demonstrate an equivalent level of safety and/or address any additional risks in order to approve the vehicle in their territory. However, it is likely that their National legislation will also not provide for hydrogen-powered vehicles. Some Member States could choose to effectively ban the vehicle (in the absence of an appropriate testing regime), while others may approve it on an individual vehicle basis, if it was intended to be made in very low numbers. Such an approval would be unlikely to be valid in other Member States.

8.1.1 Background

A great deal of research has been carried out on the potential of hydrogen and fuel cells in the transport sector. However, it was not the intention to review this research here; instead, the focus was on the use of this technology in category L vehicles. For wider information, a study carried out for the Commission (by TRL) summarised the literature on the environmental and safety issues associated with hydrogen in vehicles. If the hydrogen system is designed and constructed to a sufficient standard, Treleven *et al.* (2007) found that:

- When hydrogen is leaked in a controlled way from a storage system it is considered to be no more dangerous than gasoline or natural gas. Hydrogen has much wider flammable and detonation ranges than the alternatives, but also has a lower energy density, a higher flammable limit and dissipates much faster.
- In experiments, it took as long for a properly designed hydrogen tank to vent in a vehicle fire as it took for the seals on a gasoline tank to fail.
- There was no evidence of the hydrogen tanks used in any of the reported experiments exploding. This was due to their design and the incorporation of pressure relief valves.
- Tests concluded that properly designed tanks are capable of withstanding the energy of regulation type vehicle impact. The integrity of hydrogen systems in high severity impacts has not been quantified by research. There is no requirement for conventional fuel systems to be designed to survive higher severity impacts, but the consequences of such impacts are well known. The effect of placing hydrogen systems in such high severity impacts is not known. It has been assumed that hydrogen systems follow the same relationship as conventional systems with regards to risk in higher severity impacts. Further research would be required to determine the accuracy of this assumption.

While Treleven *et al.* (2007) focussed on M and N Category vehicles; it seems likely that many of the key findings are applicable to category L vehicles also. Unfortunately, it was impossible to verify this from the literature. In fact, very few studies were found on the use of hydrogen as a fuel for category L vehicles.

The FRESCO project was partially funded by the Commission under its fifth Framework programme. The project aimed to demonstrate the technical viability of fuel cell propulsion for scooters, by developing a dedicated system and integrating it in a modern mass-production type scooter. Although the FRESCO project ended in July 2005, an additional effort was made by the project partners and the University of Pisa to enhance the vehicle's performance and effectiveness (Fuel Cells Bulletin, 2006). The scooter was capable of a top speed of 45 mile/h with a range of 75 miles. The on-board hydrogen supply comprised a 525 bar tank with a carbon-reinforced liner. The HYCHAIN MINI-TRANS project is a more recent Integrated Project of the sixth Framework programme.

The project is deploying several fleets of innovative fuel cell vehicles in four regions of Europe (in France, Spain, Germany and Italy). The vehicles include scooters, tricycles, small utility vehicles, minibuses and wheelchairs. The project comprises two phases: 2006 – 2007 was spent manufacturing the vehicles and developing the infrastructure and in 2008 – 2010, the vehicles will be tested under real world conditions. Although the need for further consultation was identified to gain more information about the costs associated with these vehicles, attempts to contact HYCHAIN MINI-TRANS and Intelligent Energy were unsuccessful.

Four further studies were found in the scientific literature (Lin 2000; Tso and Chang, 2003; Horng *et al.*, 2006; Mirzaei et al., 2007). These focussed on the technological aspects for hydrogen-powered two wheel vehicles such as motorcycles and scooters. All four studies were carried out in Asia, where these vehicles are particularly popular. While these studies reported interesting developments in the fundamental technology required for hydrogen-powered motorcycles and scooters, their value is limited for this study.

Other developments in hydrogen-powered category L vehicles include those by Intelligent Energy. The company has developed a motorcycle powered by a hydrogen fuel cell: the ENV. The vehicle has a top speed of 50 mile/h and a range of 100 miles on a tank of compressed hydrogen. The company web site states that they are currently working towards type-approval for the motorcycle (www.intelligent-energy.com). Intelligent Energy is also working with Suzuki Motor Corporation in Japan on another fuel cell motorcycle: the Crosscage. The vehicle was presented at the 40th Tokyo Motor Show in 2007. The cross-shaped frame is intended to protect the hydrogen tank, which is located below an air-cooled fuel cell developed by Intelligent Energy.

Finally, TRL understands that both Honda and Aprilia have developed hydrogen powered scooters; however, very limited information is available about the current status of these vehicles. Other organisations that are developing hydrogen technology for category L vehicles are: Masterflex AG, Derbi, VEM and H2 LogicObjectives. Currently there are no specific provisions for hydrogen-powered vehicles in the European type-approval Framework for category L vehicles. With this in mind policy options to legislate hydrogen-powered vehicles in the 2002/24/EC Framework have been evaluated.

8.2 Policy options

The following three options for the safety of hydrogen-powered category L vehicles have been considered:

a. **No change**. No new legislation is created to accommodate hydrogen-powered category L vehicles.

b. **Legislation at European Union level**. The type-approval legislation for category L vehicles is adapted to include provisions on the safety of hydrogen-powered vehicles.

c. **Legislation at National level**. Individual Member States are free to pass legislation on category L vehicles at a National level.

8.3 Analysis of impacts

8.3.1 Economic impact

8.3.1.1 Option A: No change

No costs were obtained from the consultation regarding the cost of approval for hydrogen-powered category L vehicles. For Option A, costs would remain unchanged. If a vehicle was able to gain approval for sale in a Member State, it would be likely to be on an individual vehicle basis. With this approach, there is very limited testing involved. Existing manufacturers would have a strong commercial incentive to produce safe hydrogen vehicles, even in such a market. However, new companies with the opportunity to produce hydrogen-powered vehicles may represent a greater risk due to the extensive technical experience required. This option may also create a barrier to the development of hydrogen technology in the European Union; it is possible that manufacturers would be more reluctant to invest in a fragmented market, although further consultation is required. No costs were obtained regarding the costs to the manufacturer of developing hydrogen systems or the costs involved in scrapping systems. Finally, this option could lead to very high costs for the approval of these vehicles; however, further consultation is also required to quantify this effect.

8.3.1.2 Option B: Legislation at the European Union level

For Option B, new legislation would be required to include provisions for hydrogen-powered vehicles. This option would result in an increase in costs relating to the implementation of technical requirements. The magnitude of the cost increase is unknown. This option would also potentially create an additional market for test houses. The effect on the approval costs are unclear and are considered to be dependent on the size of the intended market. For example, for an L category vehicle aimed at a localised market, the costs in industry might increase reflecting additional testing required. However, for a PTW aimed at a larger market, European regulation may reduce overall cost since the need for approvals in separate countries would be eliminated. This option would lead to uniform safety and environmental standards in the European Union and would open the markets of Member States that do not currently allow such vehicles. It may also increase the likelihood of investment in these vehicles, since it reduces uncertainty about the market. The vehicles will be approved for sale throughout the EU, reducing the need to obtain separate approvals for each Member State where the vehicle is to be sold.

The European Hydrogen Association, which currently represents 14 national hydrogen and fuel cell organisations and the main European companies active in the development of Hydrogen infrastructure considers that a regulatory Framework is needed for such vehicles. This was based on the observation that many of the organisations involved in the development of hydrogen-powered category L vehicles are small companies who may be unable to afford the necessary approvals, Member State by Member State, under special procedures that are subject to varying and unpredictable requirements and timeframes. However, other sectors of industry voiced the opinion that any regulatory activity could stifle innovation and delay the conversion of these vehicles to hydrogen.

The Fédération Internationale de Motocyclisme (an international motorcycling organisation comprising 98 national federations around the world) provided stakeholder response that any regulatory activity could stifle innovation and delay the conversion of these vehicles to hydrogen. This has the potential to delay any environmental benefits of hydrogen powered L category vehicles. The Fédération prefers ad-hoc authorisation at a National level on the basis that it is more flexible for fostering innovation. This is in contrast to the consultation responses received from the European Hydrogen Association who were in favour of European regulation. With the consultation responses obtained, it is unclear which of these views is more valid, although the logical rationale of the European Hydrogen Associated is considered by TRL to provide a clearer explanation of the mechanisms influencing this issue.

8.3.1.3 Option C: Legislation at national level

The costs for Option C are unknown since no data was identified for legislation at the national level. Costs to industry would be dependent on the number of countries for which approval is required and also on the divergence of the requirements between countries. This option would allow the introduction of hydrogen-powered category L vehicles, but would lead to a more fragmented market. While some vehicles might be intended for local markets only, this option would increase the costs of approval for vehicles intended to be sold across the European Union.

8.3.2 Societal impacts

No direct societal impacts (casualty savings) were identified from the options proposed. It is considered that the effects of these proposals are primarily economic and environmental.

8.3.3 Environmental impacts

Hydrogen vehicles offer potentially large, local environmental benefits (i.e. at the point fo use), depending on the availability of "cleanly produced" hydrogen and the methods used for its distribution. Option A has the potential to confer local environmental disbenefits, since the adoption of hydrogen as a fuel for L category vehicles may be inhibited.

Option B has potential local environmental benefits since uniform requirements may mean that the technology (and any benefits) are realised more quickly as a result of more investment. However, it should be noted that significant infrastructure investment is required before hydrogen is widely used as a fuel. For example, significant investment is required in the production facilities and distribution facilities used to create, store and transport hydrogen to the point of use by the consumer. Developing these capabilities would take time and is likely to require extensive capital investment. Therefore, the environmental benefits are seen as long-term (perhaps 10-20 years) before they are widely attainable. At the same time, the need for cleaner fuel is a high priority and creating Europe-wide requirements may encourage the investment required to realise these future benefits; a time when they might be much more valuable.

In terms of emissions, the use of Hydrogen in a conventional engine will reduce overall exhaust emissions, when compared to conventional fuels. Use of Hydrogen in a fuel cell will further reduce emissions. However, little data are available to quantify the benefits. However, when comparing the benefits of Hydrogen, it is important to undertake a full energy system assessment, as the emissions associated with Hydrogen use may not be associated with the point of use, but with the point of production. This can often significantly reduce the benefits of these alternative fuel types. It is considered that ongoing emission benefits are possible, with the magnitude of these dependent at least in part on the energy source used for production. Clean energy production is a prerequisite to attaining the full environmental benefit. If this challenging aim can be achieved, it is recommended that the technical aspects and overall system benefits of Hydrogen vehicles are compared with those of electric and hybrid vehicles. All options are predicted by TRL to have a neutral impact on noise. However, it should be noted that comparisons of noise levels with this type of vehicle using conventional combustion fuels and hydrogen are not known at this time, and so some degree of uncertainty remains regarding these effects.

8.4 Comparing the options

It is anticipated the options presented will have the following effects:

Table 59. Summary of impacts for options relating to Hydrogen powered L category vehicles.

Option	Impact type	Qualitative impacts	Quantified value
A	Economic	This is the "do nothing" scenario. Approval costs remain unchanged. Potentially high costs for approval in multiple countries and this may be inhibiting investment in market	Not quantified; no available data
B	Economic	include Hydrogen L-category vehicles in Type Approval Directive; potential to reduce overall costs if vehicle aimed at European market	Not quantified; Costs unknown. Also conflicting stakeholder responses that would a) promote investment through a clearer market or b) inhibit innovation by more test and cost requirements
C	Economic	Approve Hydrogen L-category vehicles at national level	Not quantified; costs uncertain
A	Environmental	Current situation unchanged; if lack of clear European requirements is inhibiting investment then may be delaying attaining any environmental benefit	Not quantified; effect uncertain but potentially delay in attaining benefit
B	Environmental	include Hydrogen L-category vehicles in Type Approval Directive; reduced emissions	Not quantified; magnitude of benefit dependent on whole life cycle costs but potential overall local benefit
C	Environmental	Approve Hydrogen L-category vehicles at national level; if lack of clear European requirements is inhibiting investment then may be delaying attaining any environmental benefit. Potential for differing requirements across Europe	Not quantified; effect uncertain

Table 60. Comparison of impacts for the options under consideration relating to Hydrogen powered L category vehicles.

		Impact		
	Option	**Negative**	**Neutral**	**Positive**
Economic	A		◄····●	
	B	◄············	●	············►
	C		◄····●	
Societal	A		●	
	B		●	
	C		●	
Environmental	A		◄····●	
	B		●	·············►
	C		●	

Significant uncertainty remains regarding the quantification of these factors. For Option B the assessment has been made assuming local impacts only.

8.5 Monitoring and evaluation

Some hydrogen-powered category L vehicles are likely to be produced in very low numbers only. For these vehicles, it might be acceptable to pursue a policy that results in individual vehicle approval schemes at Member State level. However, other vehicles, such as scooters, have the potential for Europe wide mass production as early adopters of hydrogen as a fuel. However, although there are significant environmental benefits at a local level, the overall environmental benefits are dependent on a clean energy supply. This can be seen as a prerequisite to attaining the maximum environmental benefits and if in place, other technologies such as electric and hybrid vehicles shoud be considered

It has not been possible in this study to conduct a cost-benefit due insufficient information for the options for hydrogen-powered category L vehicles:

- The proportion of current environmental impacts from road transport that is due to each category of vehicle
- The rate at which hydrogen-powered category L vehicles will be introduced in EU27 countries
- The costs of hydrogen-powered category L vehicles (design, fitment etc.)
- The costs of type-approval
- Costs involved in scrapping vehicles
- Full energy cycle assessment information, including emissions created to form, supply and store hydrogen.

Possible uncertainties include: the proportion of road miles likely to be driven by each category of hydrogen-powered category L vehicles; the environmental effects of new petrol and diesel engines; the effects of any Government incentives. It should be noted that Honda have recently launched the first hydrogen-powered production passenger car. It therefore seems likely that the first hydrogen-powered motorcycle or moped will not be far behind. However it is recommended that before any legislation is implemented that further consultation is conducted. The aim of this would be to agree with industry, legislation that sets appropriate requirements for the safety and environmental effects of hydrogen-powered vehicles without creating design restriction.

9 Conclusions

This study has assessed a range of proposed technical requirements for L category vehicles as well as regulatory simplification in line with CARS21 recommendations. The main conclusions can be summarised as follows:

1. The option to simplify the current type approval framework was estimated to provide a benefit to society of €421,105 over the period 2011-2020 (range of estimate between €77,811 and €785,970), with the benefits being greater if more than an average of two annual amendments are made. It is estimated that it would take between one and five years to achieve a benefit to cost ratio of one (i.e. break even) and by 2020, it is estimated that a benefit to cost ratio of between 1.24 and 2.53 could be achieved, with an average benefit to cost ratio of 1.44. It should be noted that this assessment excludes any costs or benefits attributable to the Commission in the implementation of this option.
2. Regulatory simplification was judged to provide a clearer regulatory process which would be a benefit to all, but which might benefit SMEs and new entrants to the market to a greater extent. However, FEMA commented that SMEs may have problems interpreting links between EU and UNECE regulations, and this could make it less transparent to those without technical or legal knowledge.
3. The effectiveness estimates of ABS and CBS were reviewed from a range of published studies; ranges for system effectiveness were selected, along with a best estimate. These estimates were based on predictive studies as no statistical retrospective studies were located which more robustly quantified in-service effectiveness.
4. Cost estimates for ABS and CBS were taken from published studies and information supplied by industry. These costs used the following ranges for Option A: ABS €150 - €822 (with a best estimate of €536), CBS €75 - €400 (best estimate €150). For options B and C the costs used in the study were: ABS €100 - €200 (with a best estimate of €150), CBS €75 - €200 (best estimate €150). Benefit cost ratios were calculated using the "best estimate" system cost.
5. The benefit estimate for advanced braking systems was quantified for full accident avoidance (i.e. influenced casualties reduced to non-injury) and for mitigation (fatalities reduced to serious casualties and serious casualties reduced to slight casualties). For the mitigation scenario, the effects on slight casualties were not assessed as these were considered difficult to mitigate without avoiding the accident.
6. It is estimated that mandating ABS on all motorcycles (Option B) would reduce the numbers of European fatalities compared to the "do nothing" option by 472 (over period 2011-2013), 1,564 (2011-2016) and 4,562 (2011-2021). These estimates are based on the "best estimate" for fatality reduction for each option.
7. Mandating ABS on motorcycles over 125cc and CBS on motorcycles less than or equal to 125cc (Option C) is estimated to reduce the numbers of European fatalities, compared to the "do nothing" option by 391 (over period 2011-2013), 1,324 (2011-2016) and 3,895 (2011-2021). These estimates are based on the "best estimate" for fatality reduction for each option.
8. For analysis of the benefit to cost ratios, mandating ABS on all motorcycles (Option B) and mandating ABS on motorcycles with engine capacities over 125cc and CBS on those equal to or under 125cc (Option C), were compared to the "do nothing" baseline (Option A). These ratios were calculated for accident avoidance and casualty mitigation; a range for the best estimate is provided, with the total range in brackets. The benefit to cost ratios assuming accident avoidance were estimated as:

- Option B
    - 1.1 - 1.5 (0.6 – 2.9) in the short term (2011-2013);
    - 2.8 – 3.8 (1.0 – 5.3) in the medium term (2011-2016) and;
    - 4.2 – 5.6 (2.0 – 10.9) in the long term (2011-2021).
- Option C
    - 0.9 – 1.3 (0.5 – 2.7) in the short term (2011-2013);
    - 1.7 – 2.3 (0.9 – 4.9) in the medium term (2011-2016) and;
    - 3.5 – 4.8 (1.9 – 10.1) in the long term (2011-2021).

For casualty mitigation, these benefit cost ratios relative to Option A were estimated as:

- Option B
    - 1.0 – 1.3 (0.5 – 2.4) in the short term (2011-2013);
    - 2.4 – 3.2 (0.9 – 4.5) in the medium term (2011-2016) and;
    - 3.6 – 4.6 (1.8 - 9.1) in the long term (2011-2021).
- Option C
    - 0.8 – 1.0 (0.4 – 2.2) in the short term (2011-2013);
    - 1.5 – 1.9 (0.8 – 4.1) in the medium term (2011-2016) and;
    - 3.0 – 4.0 (1.6 – 8.4) in the long term (2011-2021).

9. The effects on noise, fuel consumption and emissions are predicted to be negligible provided riders do not change their driving style on motorcycles fitted with advanced braking systems. The addition of ABS systems on motorcycles will add a small amount of mass, although no data was collected from the consultation regarding the size of the increase with the fitment of ABS or CBS; potential fuel consumption and emissions increases were not assessed with respect to this factor.
10. Considering anti-tampering measures on L category vehicles, the available data for tampering rates related to pre-Chapter 7. Thus, it was not possible to assess the current situation (no data) or the relative effect of repealing Chapter 7, although the latter was considered likely to have negative safety and environmental impacts.
11. Implementing new measures for anti-tampering has the potential to deliver positive economic, societal and environmental impacts. However the economic impact also has the potential to be negative, depending on the measure selected and the stakeholders affected.
12. For power limits for motorcycles, the analysis carried out confirmed the findings of the previous TNO study that the relationship between maximum power and accident risk cannot be clearly established, and there are other factors, such as rider attitude and experience, which have a greater influence on accident risk.
13. Setting harmonised 74kW power limits was predicted to have a significant negative economic impact for all manufacturers, especially those specialising in high power machines.
14. Other effects of the proposals on the option to limit motorcycle power to 74kW were generally assessed to have small impacts; the "do nothing" option having potentially positive economic and environmental effects; repealing the option conferring positive economic but negative environmental impact, and Option D having negative economic effect.

15. Accident data concerning L6 and L7 quadricycles and off-road quadricycles was limited, although the accident risk per 100,000 vehicle km was estimated to be between 10-14 times greater that of cars based on data from France and Austria. It was not possible to establish the proportion of these accidents which would be influenced by the proposed regulatory changes.

16. More detailed quadricycle accident data is required to enable more accurate assessment of the influence on accidents and casualties. It is considered important that accident data relating to specific quadricycle types is collected if future proposals and subsequent monitoring of these measures are to be rigorously assessed in terms of their casualty effects.

17. Reverting to national approval was estimated to result in significant cost increases to Industry for both quadricycles and off road quadricycles. Current type approval cost was estimated as €10,000 per model, with similar costs estimated for approval in each member state. The benefits for this option were considered to be lower than the investment required.

18. Enforcing stricter size limits on quadricycles was predicted to have minor societal benefits and minor environmental disbenefits. Industry was in favour of limiting quadricycle dimensions, limiting the number of passengers for L6 quadricycles (including the driver) to two, and creating a stricter definition for the unladen mass requirements. However, industry proposed size and weight limits in excess of those proposed by the Commission and more in line with current quadricycle attributes.

19. Aligning quadricycle requirements with M1 vehicles was estimated to result in significant cost increases, mainly in meeting frontal and side impact requirements; significant societal and environmental benefits may result from this investment, but the effects and magnitude of these were uncertain. Option C was estimated to require lower investment, but with smaller resulting benefits.

20. Keeping the existing category and adding additional safety requirements for all quadricycles was considered to increase costs and the resulting benefits were uncertain.

21. New requirements for off-road quadricycles were strongly supported by Industry. This option is likely to result in increased costs, but also potential societal and environmental benefits. The magnitude of these effects is uncertain with the information available.

22. Maintaining the current situation with respect to Hydrogen powered L category vehicles was considered to have minor negative environmental impacts because any environmental benefits of these vehicles may be inhibited

23. Including hydrogen powered vehicles in the European type approval directive is likely to increase costs in the approval process. Stakeholders offered conflicting views that this option would create a uniform set of requirements, thereby improving investment, or that this would inhibit development due to increased approval costs. As such, the overall economic effects are unclear, although the former has a more convincing rationale.

24. Including hydrogen powered vehicles in the Framework Directive is considered likely to encourage adoption of hydrogen and also encourage the investment required to attain the predicted environmental benefit.

25. Attaining the environmental benefit is dependent on the production of “clean” hydrogen and, bearing in mind the significant infrastructure investment required, these benefits are unlikely to be attained in the short term.

26. The confidence in the estimates in this study could be improved if additional responses and data were available from stakeholders. The lack of data has meant

that some of the estimates made in this impact assessment could not be made quantitatively; these could be updated should more detailed information become available.

Acknowledgements

The work described in this report was carried out in the Safety, Security and Investigations department of the Transport Research Laboratory. The authors are grateful to Iain Knight who carried out the technical review and auditing of this report.

References

ACEM (2004). *MAIDS final report 1.2.* Available at http://ec.europa.eu/transport/roadsafety_library/publications/maids_report_1_2_september_2004.pdf accessed 23rd October 2008.

ACEM (2008). *Yearbook 2008*. Available at http://www.acem.eu/media/d_ACEM_yb_08_75492.pdf accessed on 15th January 2009.

Ahulwalia R. K., Wang X., Rousseau A. and Kumar R. (2004). Fuel economy of hydrogen fuel cell vehicles. *Journal of Power Sources* 130 (1), pp.192-201.

ATVEA (2007). *Proposal for a New Type Approval Category for ATVs in Europe.*

Baum H., Westerkamp U. and Geißler T. (2007). *Cost-benefit analysis for ABS of motorcycles. Institute for Transport Economics at the University of Cologne, Cologne.*

Bayly M., Regan M., and Hosking S. (2006). *Intelligent Transport Systems and Motorcycle Safety*. Monash University Accident Research Centre.

Broughton J. (1988). *The relationship between motorcycle size and accident risk.* Research Report RR169. Crowthorne, TRL, 1988.

CARS21 (2005). *CARS 21: a competitive automotive regulatory system for the 21st century final report.* Available at http://ec.europa.eu/enterprise/automotive/pagesbackground/competitiveness/cars21finalreport.pdf accessed 23rd October 2008.

COWI (2006). *Cost-benefit assessment and prioritisation of vehicle safety technologies.* Reference TREN-ECON2-002. ECORYS Nederland BV, The Netherlands.

DfT (2007). *Road Casualties Great Britain: 2006*. Department for Transport. London: The Stationery Office.

Dittmar K., Melz M., Baumeister K., Berg M., Braun T., Hartmann S., Leiber M. and Saforovic H. (2003). *Study on anti tampering devices relating to two or three wheeled motor vehicles.* Available at http://ec.europa.eu/enterprise/automotive/projects/report_anti_tampering_devices.pdf accessed 23rd October 2008.

Dodd M. (2009). *Evaluation of the impact of possible new measures concerning the type approval of agricultural vehicles*. Draft Project Report RPN492. TRL Limited, Crowthorne

ETSC (2007). News Release: Motorcycle deaths in Europe. http://www.etsc.eu/documents/News%20release%20Flash%207%20final.pdf

ETSC (2001). *Priorities for EU motor vehicle safety division. European Transport Safety Council, Brussels*

Eurostat. http://ec.europa.eu/dgs/energy_transport/figures/pocketbook/2007_en.htm.

Fuel Cells Bulletin (2006). European development of fuel cell scooter. In: *Fuel Cells Bulletin*, June 2006. Kiddlington, OX: Elsevier Ltd, pp7.

Geivanidis S., Ntziachristos L., Samaras Z., Xanthopoulos A., Steven H. and Bugsel B. (2008). Study on possible new measures concerning motorcycle emissions – Final report. Report No: 08.RE.0019.V2. Available at http://ec.europa.eu/enterprise/automotive/projects/report_measures_motorcycle_emissions.pdf

Guyot R. (2008). *Gisements de sécurité rouitière: les deux-roues motorise.* Available to purchase at http://www.ladocumentationfrancaise.fr/catalogue/9782110069795/ accessed 23rd October 2008.

Gwehenbereg J., Schwaben I., Sporner A. and Kubitzki J. (2006). *Serious accidents involving motorcycles- analysis of accident structures and effectiveness of ABS Allianz Centre for Technology, Munich.*

Horng, R-F., Chang, Y-P. and Wu, S-C. (2006). Investigation on the production of hydrogen rich gas in a plasma converter for motorcycle applications. *Energy Conversion and Management* 47, pp.2155-2166.

Hardy B. J., Carroll J. A. and Pitcher M. (2009). *Comparison of Safety Requirements in Quadricycles and Cars*. RPN 247. TRL Limited, Crowthorne

Hurt H.H. Jr., Ouellet J.V. and Thom D.R. (1981). *Motorcycle accident cause factors and identification of countermeasures: Volume 1: Technical report, Final Report.* US Department for Transport, Washington DC.

International Energy Agency (2005). *Prospects for hydrogen and fuel cells.* Paris: International Energy Agency.

Kebschull S. and Zellner J. (2007 & 2008). *Analysis of cost effectiveness of motorcycle antilock brake systems. Accomplished for International Motorcycle Manufacturers Association, Geneva. Dynamic Research Inc, California.*

Kühn M. (2007). *Results of the GDV research project: High-speed crash performance, conclusions.* Presented Brussels, 26 June 2007. Berlin, Germany: Gesamtverband der Deutchen Versicherungswirtschaft (GDV).

Lin, B. (2000). Conceptual design and modelling of a fuel cell scooter for urban Asia. *Journal of Power Sources* 86, pp.202-213.

MAIDS (2004). *MAIDS: In-depth investigation of accidents involving powered two wheelers, Final Report 1.3*. ACEM, Brussels, Belgium.

MC Rådet (1995). *SSB undersøkelse av motorsykkelulykkene i 1995.* Available at http://arkiv.nmcu.org/publ/ssb_1995/index.html accessed 23rd October 2008.

MC Rådet (1997). *SSB undersøkelse av motorsykkelulykkene i 1997.* Available at http://arkiv.nmcu.org/publ/ssb_1997/index.html accessed 23rd October 2008.

MC Rådet (1999). *SSB undersøkelse av motorsykkelulykkene i 1999.* Available at http://arkiv.nmcu.org/publ/ssb_1999/index.html accessed 23rd October 2008.

McCarthy M. and Chinn B.P. (1998) *ABS and its effect on BMW motorcycle accidents PR/SE/470/98 TRL Ltd, Crowthorne.*

McCarthy M. and Chinn B.P. (1999) *ABS and its effect on BMW motorcycle accidents: supplementary report PR/SE/470/98(supplemental) TRL Ltd, Crowthorne.*

McCarthy M., St.Clair V. and Halewood C. (2008). *Powered Two Wheeler Integrated Safety (PISa)- Annual report 2007*. Published Project Report PPR351. TRL Limited, Crowthorne, UK.

Mirzaei, M., Dehgham, A. A. and Asaei, B. (2007). Design and simulation of a fuel cell hybrid powered motorcycle and comparison with non-hybrid system. In: *Vehicle Power and Propulsion Conference*, 9-12 September 2007, Arlington, TX. Piscataway, NJ: Institute of Electrical and Electronic Engineers, pp.843-848.

Motorcycle Working Group (2005). *Proposal from French delegation concerning chapters 7 and 9 of Directive 97/24/EC on anti-tampering measures (MCWG-05-06).* Available at http://ec.europa.eu/enterprise/automotive/mcwg_meetings/12-07-2005/mcwg_05_06.pdf accessed 23rd October 2008.

ONISR (Observatoire National Interministériel de Sécurité Routière (National Interministerial Observatory for Road Safety)) reports analyses of French national accident data: www.securite-routiere.gouv.fr.

Research Reports International (2006). *Transportation fuel cells: challenges and opportunities.* Evergreen, CO: Research Reports International, Inc.

Ruijs P. A. J. and Berkhout M. J. (1997). *Motorcycle power 74kW study Phase B Report* prepared by TNO for European Commission DG 11, Industry. Report No. 97.OR.VD.056.1//PR.

SEC (2005). 791. *Impact Assessment Guidelines*. ec.europa.eu/governance/impact/docs/key_docs/sec_2005_0791_en.pdf.

Sexton B., Baughan C., Elliott M. and Maycock G. (2004). *The accident risk of motorcyclists.* TRL Report TRL607, Crowthorne, TRK, 2004 ISSN 0968-4107.

Smith T.L., Gibson T. and McCarthy M. (2009). Development of a methodology for the evaluation of safety systems for powered two-wheelers- final report. Published Project Report PPR381. TRL Ltd, Crowthorne, UK.

Treleven, C., Couper, G., Leben, J. and Knight I. (2007). *Evaluation of the impact (extended impact assessment) of the introduction of hydrogen as fuel to power motor-vehicles considering the safety and environmental aspects*. Crowthorne: Transport Research Laboratory.

Tso, C. and Chang, S-Y. (2003). A viable niche market - fuel cell scooters in Taiwan. *International Journal of Hydrogen Energy* 28, pp.757-762.

Ulleberg P. (2003). *Motorcykelsäkerhet – en litteraturstudie och meta-analys.* TØI rapport 681/2003 available at http://www.vv.se/filer/27656/2_motorcykelsakerhet_en_litteraturstudie_och_meta_analys.pdf accessed 23rd October 2008.

Vavryn K. and Winkelbauer M. (2005). *Braking performance of experienced and novice motorcycle riders- Results of a field study. Austrian Road Safety Board, Austria*

Appendix A Proposal from EQUAL relating to Option C for Quadricycles

EQUAL believe that Option C, returning to the original spirit of the legislation would help differentiate quadricycles from category M1 and N1 automobiles as well as 'leisure' vehicles. To achieve this, the classification of L6 and L7 quadricycles should be redefined:

1. Light quadricycle (L6) should be defined as:
    - Unladen mass in running order of the full bodied vehicle or chassis with cab, less than or equal to 475 kg. (Including; the basic mass of the driver at 75 kg, 90% of the nominal capacity of the fuel tank, all other liquids, tools, spare wheel and all equipment options. Not including the mass of the traction batteries in the case of an electric vehicle.)
    - Maximum mass that is technically permissible when the vehicle is loaded, as defined by the manufacturer must be less than or equal to 675 kg. (Not including the mass of the traction batteries in the case of electric vehicles)
    - Maximum towable mass: nil
    - Overall length less than or equal to 3 m
    - Overall width less than or equal to 1.5 m
    - Maximum speed not more than 45 km/h
    - Engine cylinder capacity does not exceed 50cm^3 (petrol engines)
    - Maximum net power does not exceed 6kW (diesel engines)
    - Maximum continuous rated power does not exceed 6kW (electric vehicles)
    - The vehicle can only carry one passenger in addition to the driver
    - Fulfil technical requirements of L2 (3-wheeled mopeds), unless specified differently in any separate Directives

2. Heavy quadricycle (L7) should be defined as:
    - Unladen mass in running order of the full bodied vehicle or chassis with cab, less than or equal to 625 kg. (Including; the basic mass of the driver at 75 kg, 90% of the nominal capacity of the fuel tank, all other liquids, tools, the spare wheel and all equipment options. Not including the mass of the traction batteries in the case of an electric vehicle.)
    - Maximum mass that is technically permissible when the vehicle is loaded, as defined by the manufacturer must be less than or equal to:
        - 850 kg for vehicles intended for carrying people (Not including the mass of the traction batteries in the case of electric vehicles.)
        - 1500 kg for vehicles intended for carrying goods (Not including the mass of the traction batteries in the case of electric vehicles.)
    - Maximum towable mass:
        - Unbraked trailer 300 kg maximum
        - Braked trailer 750 kg maximum
    - Overall length less than or equal to 4 m

- Overall width less than or equal to 2 m
- Maximum speed not more than 90 km/h
- Maximum net power does not exceed 15 kW
- Vehicles intended for carrying people can carry a maximum of 3 passengers, in addition to the driver

In both L6 & L7 definitions the body of the vehicle must also correspond to one of the following definitions:

- Saloon – Enclosed body with or without a central column for the side windows, with 2 or 4 side doors, can have an opening at the back (tailgate) as well as a solid fixed roof; however, part of the roof can be opened.
- Break – Enclosed body with or without a central column for the side windows, with 2 or 4 side doors and an opening at the back (tailgate), arranged so as to open up into a large interior area as well as a solid fixed roof; however, part of the roof can be opened.
- Cabriolet – Body which can be uncovered with or without a central column for the side windows, with or without side doors, can have an opening at the back (tailgate). The soft or solid roof has at least 2 positions: in one, it covers the body, in the other it disappears.
- Chassis-cab – Vehicle only intended for carrying goods, fitted with all regulatory technical entities, designed to hold the following in the back of the cab (space for the driver and passenger), a removable superstructure (platform, van, dumpster, tanker, stairs, support for billboard, etc.) or a machine as per the Directive 2006/42/CE.

The mass of these superstructures or machines is considered to be part of the useful load (difference between the maximum mass that is technically permissible when loaded and the unladen mass in running order with the driver).

The vehicle which is fitted with these superstructures or machines must comply with the maximum permissible loads when the vehicle is loaded, and the axles stipulated by the manufacturer, along with the dimensional limits imposed by the category L6 or L7.

EQUAL have reviewed the current applicable EU Directives for quadricycles and commented on their suitability as presented in Table 61. In addition to those changes shown in Table 61, EQUAL also suggested that provisions should be made for the use of quadricycles that are powered by natural gas (GNV) or liquid gas (GPL) in the category. Also to add a provision that would allow a hybrid quadricycle to obtain European type-approved. Finally to introduce the uniform safety provisions for electric vehicles such as the provisions of Regulation 100.

Table 61. EQUAL review of current quadricycle requirements

EU Directive	Type of regulation	Comments for L6 and L7 categories
95/1/CE	Maximum torque and maximum engine power	SD (Separate Directive) to be kept: R85 (automotive regulation) needs specific correction factors taking account of the efficiency of the transmission
97/24/CE(C6)	Fuel tank	Security standard fits to the vehicle, equivalent to automotive standard
95/1/CE	Maximum speed	Requirement for L6e category(45km/h) EQUAL supports an engineering limitation to 90km/h for L7e category
93/93/CEE	Masses and Dimensions	EQUAL supports a regulation to limit the number of passengers : L6e = 1 driver+ 1 passenger L7e (tourism model) = 1 driver + 3 passengers L7e (goods transport) = 1 driver + 1 passenger New mass & dimension requirements Notion of braked & unbraked trailers Introduce measurements of CO_2 & fuel consumption for electric vehicles
97/24/CE(C5)	Emissions, diesel smoke	Smoke may be replaced with R24
97/24/CE(C1)	Tyres	R30 is an alternative
93/14/CEE	Braking	Regulation fits to main characteristics of the vehicle (max speed and power)
93/92/CEE	Light installation	EQUAL supports : 3rd stop light, Day running lights, side flashers
93/30/CEE	Horn	R28 is an alternative
93/94/CEE	Rear registration plate space	Regulation equivalent to automotive sector
97/24/CE(C8)	EMC	R10 is an alternative
97/24/CE(C9)	Noise	Regulation fits to the vehicle
97/24/CE(C4)	Mirrors, rear field of vision	Regulation fits to the vehicle dimension and performance
97/24/CE(C3)	External projections	Introduce R26 requirements
93/33/CEE	Anti theft protection	SD to be kept; R116 too constricting not very accessible technically to our technology which does not include engine electronics
2000/7/EC	Speedometer	R39 is an alternative Introduce presence of reverse operation