

Apollo Vehicle Safety

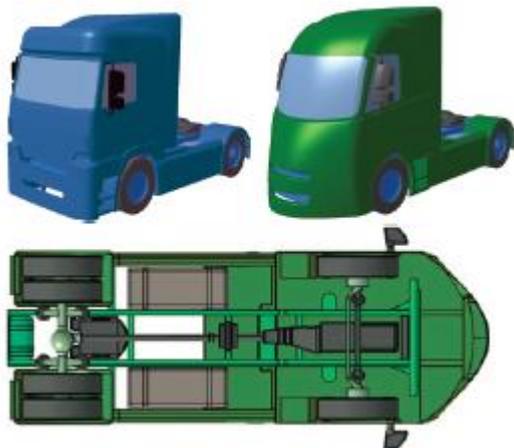
Automotive Research and Consultancy



PROJECT REPORT RR2014_002

Investigating the extent to which UNECE Regulation 93 constrains the ability of Europe to permit longer trucks to improve environmental and safety benefits

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Executive Summary

Transport & Environment are contributing to a European Commission expert group considering the appropriate technical requirements if the maximum length of goods vehicles were to be increased to permit safer and more aerodynamic designs. Previous work (Knight, 2014) indicated that UNECE Regulation 93 on front underrun protection had the potential to constrain the maximum length increase that would be possible, depending on the exact stiffness of FUP devices in service.

This report was commissioned by Transport & Environment in order to assess in more detail the extent to which R93 constrains the maximum length of cabs, what the implications would be if it needed amendment and whether alternative regulatory approaches could allow a length increase without amending R93 or compromising safety.

The previous analysis (Knight, 2014) was based on the assumption that a FUP fitted to an extended length vehicle would deflect under test loads by the maximum 400mm permitted by the current rules. This more detailed examination has identified that most of a small sample of production FUPs for which data was available were considerably stiffer than the minimum required. Using a FUP of this stiffness would allow an extension in length of 800mm without amending the current rules. However, because those rules were developed for flat fronted truck designs, some sub-optimal conditions remain:

- In the region of one third of devices may need to be made stiffer in order to comply with the requirements but this has been shown to be achievable at a mass of 60kg, likely to represent only a very small increase in mass;
- Curved designs that follow the profile of the front would be more difficult to test in accordance with the requirements but suitable interpretations should still allow it;
- Straight designs would be permissible and simpler to implement but would be set back from the foremost point of the vehicle by 350mm, introducing some risks of poor structural interaction if any other stiff structures are placed ahead of that point.

These small problems could be overcome by an appropriate amendment to the applicable Regulations. Several options exist, for example:

1. Introduce a simple permissive amendment, changing the definition of the position of the FUP relative to the front of the vehicle in a way that suits curved profiles, possibly taking as little as 15 months
 - a. Within Regulation 661/2009 for "extended length" vehicles only
 - b. Within UNECE R93
2. Mandate more stringent levels of performance and/or improved test methods, likely to take as much as 4 or more years
 - a. Within Regulation 661/2009, or a new implementing measure, for "extended length" vehicles only
 - b. Within UNECE R93

Whichever options is selected, European Whole Vehicle Type Approval Legislation allows the possibility that "new technologies or concepts" could gain an appropriate, temporary, exemption to manufacturers seeking an approval in advance of the amendment of the Regulations, though this would carry some financial risk for manufacturers.

1 Introduction

The maximum weights and dimensions of goods vehicles circulating within the European Community are laid down by Council Directive 96/53/EC of 25 July 1996. This prescribes a maximum length for articulated goods vehicles of 16.5m and for drawbar combinations of 18.75m. The highly competitive nature of the freight industry has meant that vehicles have traditionally been designed to maximise the commercial load space available within the permitted dimensions. Thus, almost all European Heavy Goods Vehicles (HGVs) are designed such that the front of the vehicle is a flat vertical plane, where the driver sits directly above the engine, and the load space extends at full height to the very rearmost point of the vehicle.

In recent years, it has become crucial to reduce greenhouse gas emissions and the consumption of petroleum products in the field of transport, and even more crucial for road transport, which accounts for 82% of the energy consumption of the transport sector. The European Commission's White Paper on Transport Policy, published in 2011 set a goal of reducing greenhouse gas emissions by 60% by 2050 in comparison with 1990 levels. In this context, the White Paper announced the revision of the Directive on the maximum dimensions and weight for road transport vehicles, with the aim of allowing more energy efficient, aerodynamic vehicles to be put on the market. The proposal aims to permit energy efficiency improvements without the dis-incentive of a reduced commercial load capacity.

Such a revision of the Directive could also offer an opportunity to improve road safety by improving the streamlining of the cab, allowing a reduction of the driver's blind spots, adding an energy absorbing structure in case of collisions, as well as increasing the driver's safety and comfort.

The European Commission has created an expert group to consider the detailed technical requirements of such a proposal. Transport & Environment are participating in that expert group and previously commissioned Apollo Vehicle Safety to undertake an expert review of the evidence available regarding the potential for the proposal to improve collision safety by using additional length to introduce improved crash compatibility and energy management characteristics at the front of trucks. That review found that UNECE Regulation 93 had the potential to constrain the maximum distance by which the front of the cab could be extended, depending on the exact stiffness of FUP devices used.

This report was commissioned by Transport & Environment in order to assess in more detail the extent to which R93 constrains the maximum length of cabs, what the implications would be if it needed amendment and whether alternative regulatory approaches could allow a length increase without amending R93 or compromising safety.

2 Possibilities within Existing Regulatory Constraints

An earlier review (Knight, 2014) found that, in the normal course of Type Approval, the requirements of UNECE Regulation 93 had the potential to combine with the requirements for turning circles, to constrain the amount by which the front of vehicles could be extended, though the amount was dependent on the stiffness of FUP devices used.

The specific parts that constrain this is the requirement in Regulation 1230/2012 that the vehicle be able to drive for a full 360 degrees between two concentric circles of radius 12.5m and 5.3m, without any of the vehicle's outermost points protruding beyond the outer circle or intruding within the inner circle. For tractor semi-trailer vehicles without steered rear axles, 16.5m is the maximum length that can achieve this without the front corner of the vehicle protruding past the outer circle. Increased length can be achieved if the width is decreased as illustrated below.

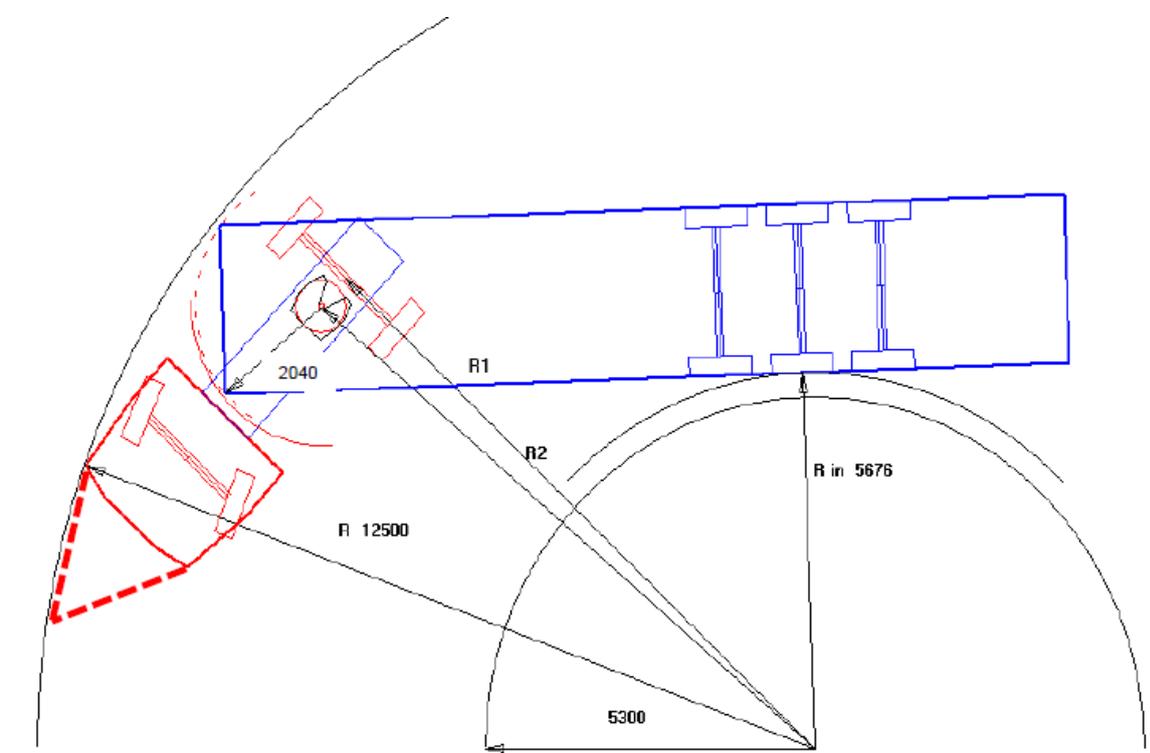


Figure 1: Illustration of the constraints on cab length applied by Regulation 1230/2012 and Directive 96/53/EC, source ACEA presentation

It should be noted that, as presented, this diagram implies any increase in length would require tapering of width. However, it can be seen that the trailer wheels are tracking 376mm within the inner boundary circle. For this particular vehicle geometry a tighter turn would be achievable (i.e. increased angle between tractor and trailer) which would allow room for a small length increase at full width. It is also worth noting that these constraints may not be so significant for rigid vehicles and drawbar combinations. Rigid vehicles can be up to 12m in length under the Regulations but are frequently constructed at shorter lengths than this because either:

- they carry more dense loads that reach the maximum mass limits before the maximum space limits; or
- they are intended for use as the prime mover in a drawbar trailer combination that is permitted to be up to 18.75m in length. These are usually configured to fit

with standardised loading units such that the loading length is equally divided between rigid HGV and trailer at 7.825m each, resulting in a prime mover of a little more than 10m.

Analysis (OECD, 2011) has shown that an 18.75m rigid drawbar combination has a slightly narrower swept path than the 16.5m artic, which suggests that more scope for a full width increase in length might be possible for rigid vehicles. However, further analysis would be required to explore the maximum changes achievable.

UNECE Regulation 93 requires that:

- 1) The FUP device covers the full width of the vehicle, to within 100mm of the outer edges of the tyres;
- 2) The test load point P1 is 200mm in-board of the outer edge of the tyre;
- 3) The FUP is positioned and deforms such that after the test loads have been applied, the loaded points shall not be more than 400mm behind "the foremost part of the vehicle", excluding parts of the vehicle more than 2m from the ground.

It is these requirements, in combination with the constraints applied by the turning circles, that limit the maximum length achievable, though the absolute limit depends on the extent to which the FUP deflects under the prescribed test loads.

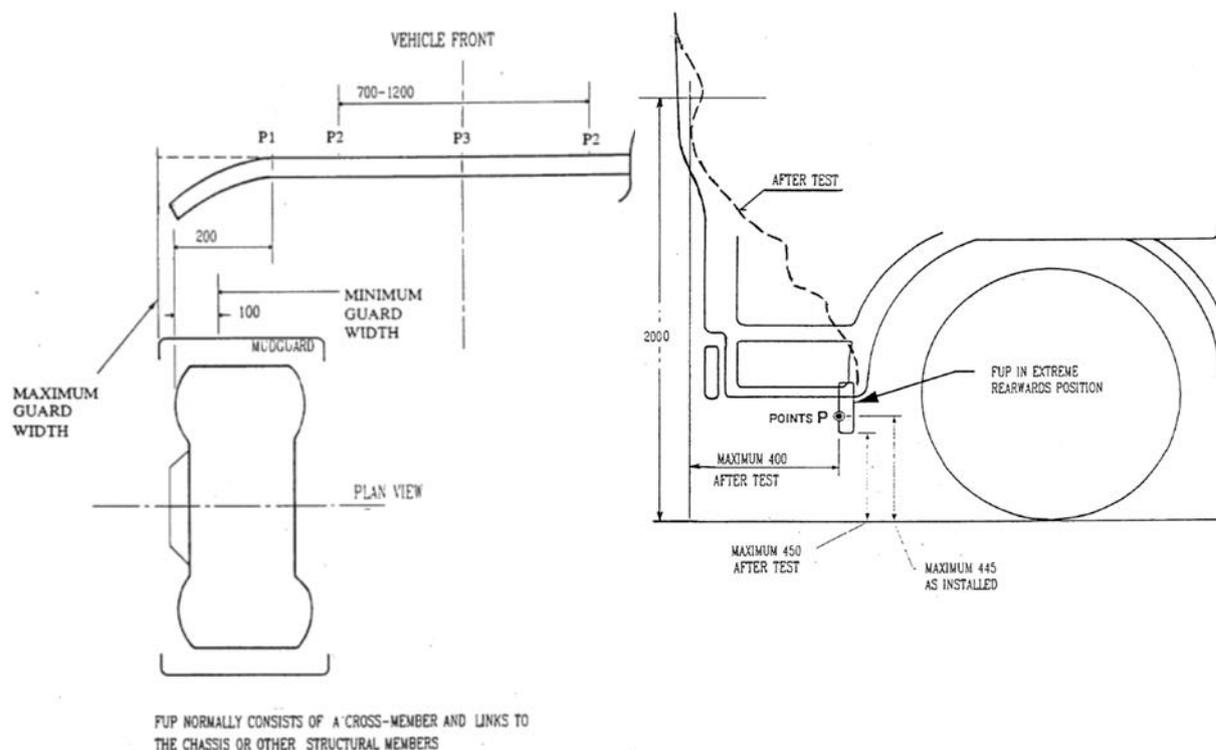


Figure 2: Constraints on width and forward position of the FUP in UNECE Regulation 93. Source (UNECE, 1994)

The sketches below illustrate the problem.

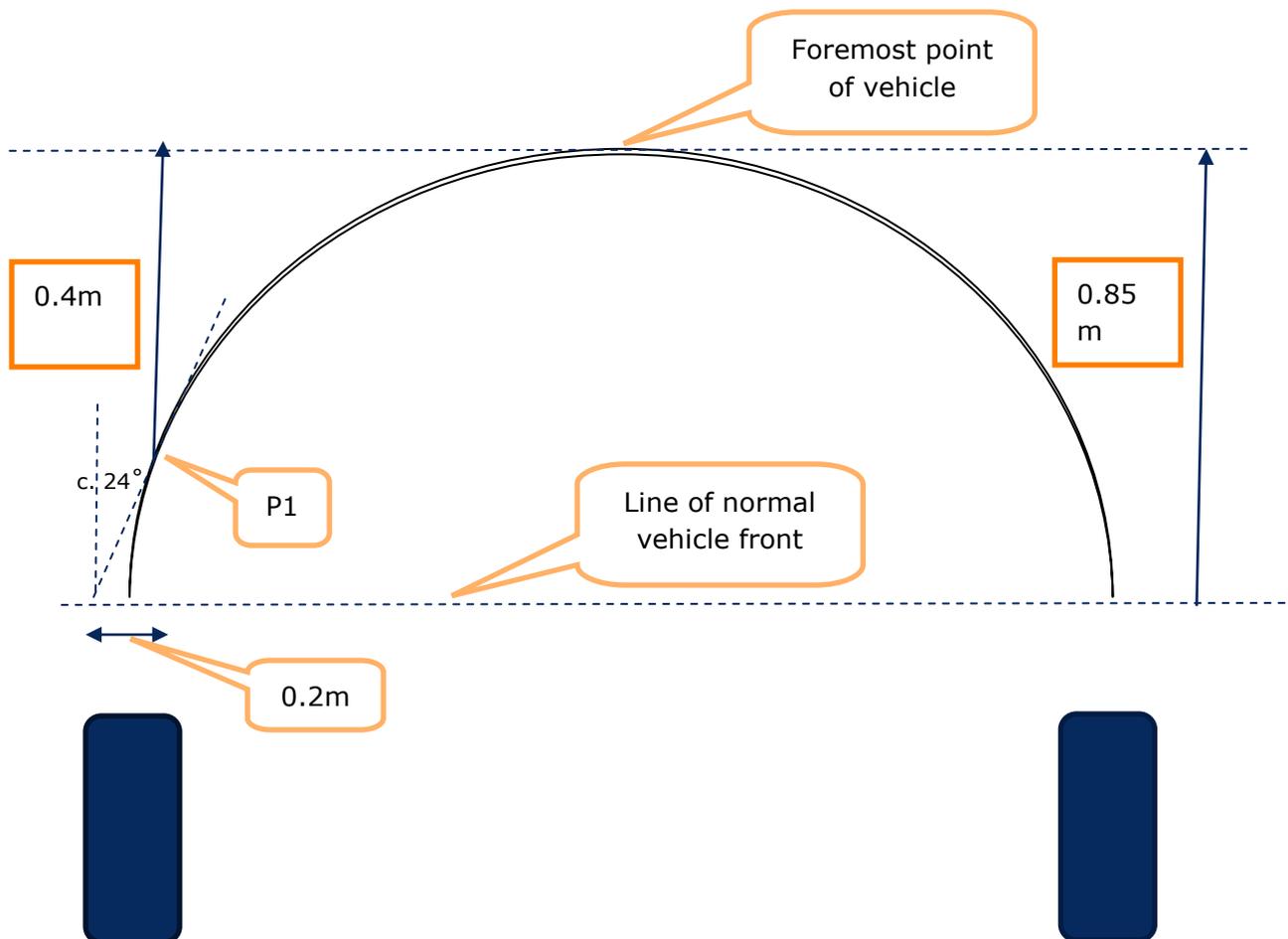


Figure 3: Illustration (plan view) of constraints if the FUP exactly followed the profile of the front of the vehicle, with an extension of 800mm¹

In the example above, the point P1 would be approximately 400mm behind the foremost part of the vehicle **before** the application of the test loads. It would therefore have to be perfectly rigid under test loads to meet the requirement, which would present additional engineering challenges. There is no explicit requirement prohibiting curved FUPs and the same problem would apply in a traditionally designed vehicle – if the FUP was curved in its initial condition, it would have to be considerably stiffer at its end than in the middle, in order to meet the requirement not to be positioned more than 400mm rearward of the foremost point of the vehicle after application of the test loads.

A curved profile FUP would also create practical difficulties during the current quasi-static test because it would generate a lateral reaction force on the ram, which would require either a re-configuration of the test equipment (e.g. clamp a perpendicular loading plate to each test point on the curved device) and/or re-configuration of the magnitude and direction of the applied forces (i.e. resolve the force into two separate components, one applied perpendicular to the beam and one applied along the length of the beam via some form of clamp). In this situation, where a device that was not envisioned by the

¹ It should be noted that a circular profile has been drawn for ease of presentation. Any profile would be permissible within the constraints formed by any overall length limit and the envelope required by the limits on turning circles and illustrated in Figure 1

original drafting of the regulations but complied with the requirements was not easy to test, it would be expected that the approval authorities would be able to apply appropriate interpretation of the test process as long as ultimately the test remained just as demanding.

Using a straight FUP incurs the same problem, if you move it toward the front of the vehicle, the outer edge will protrude beyond the edge of the vehicle. Thus, if perfectly rigid, the extension in length could be as above, around 850mm. If deflecting under test load by the full permitted 400mm, then the maximum extension in length could be approximately 0.45m. Extending length by between 0.45 and 0.85m would be possible but would imply an increased stiffness of FUP.

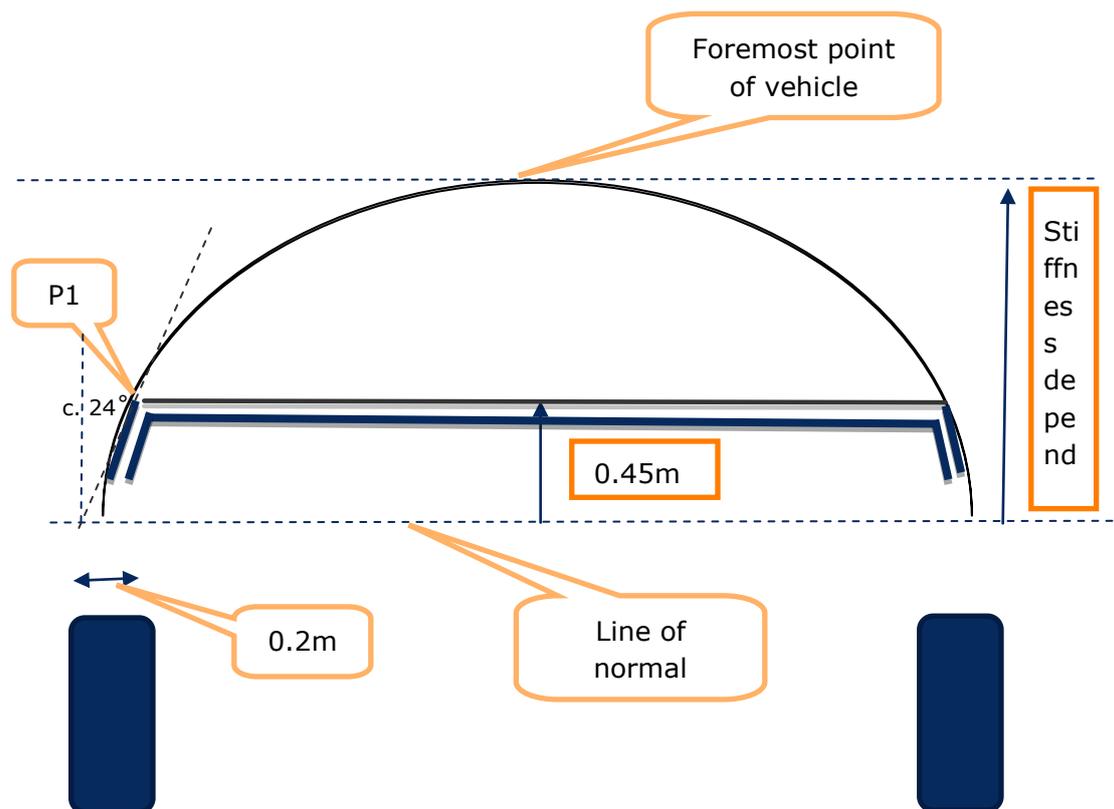


Figure 4: Illustration (plan view) of constraints associated with fitting a straight FUP, behind a curved front profile

So, a length extension of 800mm would be possible within the constraints of existing legislation but point P1 would need to be at least 350 mm behind the foremost point of the vehicle such that it would have to deflect by no more than around 50mm under test loads.

Although adopting a solution such as that above is technically feasible, it may not be optimal. In order for such an approach to offer at least an equivalent level of safety to a traditional design, the frontal structures ahead of the FUP must have no adverse effect on the crash performance of the incoming car. This would not be guaranteed unless suitable amendments were made to the existing Regulations.

It is clear that to permit extensions in excess of 450 mm without amending Regulations would require a FUP device that is stiffer than the minimum permitted by the current Regulations. However, the extent to which this is a constraint depends on the actual stiffness of devices currently in the market. That is, if existing devices are voluntarily

much stiffer than permitted, greater increases in length can be achieved without requiring an increase in stiffness. (Anderson, 2003) undertook an inventory of (then) current underrun devices and identified type approval data for several production front underrun devices. The data is summarised in Table 1, below.

Table 1: Summary of type approval test results for a selection of production front underrun devices available in 2003. Source (Anderson, 2003)

Vehicle	Maximum horizontal displacement (mm)		
	P1 (80kN)	P2 (160kN)	P3 (80kN)
Mercedes Actros	50	30	10
Mercedes Atego C	43	33	13
Mercedes Atego E	135	70	28
Daf CF (max at any point)	48		
Daf LF (P1 was max of any point)	42	Not reported	Not reported
Daf LF + (max at any point)	398.5		
Daf XF	48		
Scania	142		

From this data, the theoretical maximum extension to the front that could be achieved within the constraints of R93 can be calculated for each vehicle.

$$Ext_{Max} = 450 + (400 - peak\ displacement)$$

The results are shown in Table 2, below.

Table 2: Theoretical maximum length extension achievable within the constraints of R93, based on actual FUP performance of each vehicle

Vehicle	Maximum possible extension (mm)
Mercedes Actros	800
Mercedes Atego C	807
Mercedes Atego E	715
Daf CF	802
Daf LF	808
Daf LF	451.5
Daf XF	802
Scania	708

This analysis suggests that 5 of 8 production devices available in 2003 would have been sufficiently stiff to allow them to be mounted far enough behind the foremost point of the vehicle that an extension of 800mm could be achieved within the constraints of R93 without incurring significant mass or cost implications.

(Matheis & Welfers, 2011) studied a concept design for a crash management system capable of absorbing energy and improving crash performance compared to a standard device. However, this device was designed such that it operated on the basis of a trigger force, which meant that it acted in an essentially rigid fashion until a force of 160kN was reached and then it began to crush. The paper showed a time history of a simulated regulatory test that suggested no significant crush took place. Although it did not explicitly present a deflection measurement, it is likely that it would also pass the regulatory test with less than 50mm peak deflection and thus would allow an extension of 800mm without a change to Regulations and would be expected to improve performance not degrade it, provided the curved profile is not sufficient to cause horizontal alignment problems and no stiff structures were mounted ahead of the FUP. The mass of the device studied was 60kg, only 7kg heavier than comparable production devices.

3 The potential to adapt UNECE Regulation 93

A close study of the text of UNECE Regulation 93 does not reveal any clauses that would easily allow optimisation of the designs identified in Section 2. The closest possibility would involve substantial interpretation of the requirements outlined in paragraph 4.2.4 of the Regulation:

"For applications pursuant to Parts II or III of this Regulation" [installation of a FUP with a component approval or approval of whole vehicle in respect of its' FUP] "a vehicle not comprising all the components proper to the type may be accepted for test provided that they do not adversely affect the front underrun protection"

In theory, if the bodywork of the extended front were deemed not to adversely affect front underrun protection, then a vehicle without those panels could be tested. If the approval authorities also then accepted the "foremost point" of the extended front as being the foremost point of the completed vehicle, then a design like that shown in

Figure 4 would become feasible. However, this is a very significant "interpretation" of a clause not intended to permit what is proposed and there are a large number of stakeholders that would be required to accept such an interpretation before it could be uniformly applied across the EU. Initial contact with a very small number of those stakeholders suggests that interpretations are generally made where the requirements of the Regulation are unclear in terms of their application to a particular device or system. In this case, the requirements are very clear and, so, an interpretation may not be considered appropriate.

A proper solution to the problem would involve amending R93 to specifically permit the type of design required to deliver good structural interaction in collisions with cars. As found by (Knight, 2014), this would involve good vertical alignment, good horizontal alignment and good stiffness matching.

In order to achieve good vertical alignment, the FUP cannot be too far from the front axle because ground clearance would become a problem.

To achieve good horizontal alignment, the car must be loaded along its' designated load paths, principally its' two longitudinals. A highly curved or "pointy" design such as that illustrated earlier in Figure 3 would not be desirable because in a full overlap impact the first point of contact between FUP and car would be where the "point" of the front of the truck met the very rigid engine which could transfer load to the passenger compartment before the longitudinals had absorbed significant energy, increasing the risk of intrusion. For example, if a 0.8m extension was achieved with a circular profile from edge to edge of a 2.5m wide truck, then the radius of the circular profile would be derived from the formula:

$$r = \frac{c^2}{8M} + \frac{M}{2}$$

Where c is the length of the chord across the circle (2.5m) and M is the distance from the mid-point of the chord to the edge of the circle, measured perpendicular to the chord (0.8m). For the situation described above, the radius (r) is 1.38m. If a typical car of 1.8m width collides head on with zero offset (centre line meets centre line) and it is assumed that the main crash longitudinals are position 10cm from each edge of the vehicle then they would be 1.6m apart. Given a radius of curvature of the front of the truck of 1.38m then the distance that the centre of the truck will penetrate into the engine compartment of the car can be calculated by rearranging the equation above and solving the resulting quadratic equation. This analysis suggests that the foremost point of the truck will have penetrated the engine compartment of a flat fronted vehicle by almost 20cm before the longitudinals come into contact with the front of the truck.

A solution, similar to that illustrated in

Figure 4, where a substantial proportion of the width of the FUP is either straight or following a large radius curve would be preferable from a horizontal alignment point of view. However, this means that for an extension to the front of 800mm it is likely that at least part of the FUP would have to be placed some distance rearward of the foremost point of the vehicle. To guarantee good stiffness matching, additional requirements would be needed to ensure no stiff structures likely to adversely affect the safety performance of the car's structure or restraints were positioned ahead of the FUP. Of particular concern would be structures at a height just above the region that would interact directly with the bumper of a car in a collision and which could pass over the top of the bonnet and interact directly with the A-pillars or windscreen. Such structures would have to have very low stiffness in order not to risk injury to car occupants.

Currently, part II of R93 (installation of an approved FUP Device, paragraph 8.3 states that:

"The FUPD shall be so fitted to the vehicle that the horizontal distance measured in the rearward direction from the foremost part of the vehicle to the front of the FUPD does not exceed 400mm diminished by the recorded deformation...measured at any of the points where the test forces have been applied during the type approval of the FUPD in conformity with part I of this Regulation.."

Similarly, in part III of the Regulation (relating to a vehicle with a FUP not previously approved as a component), paragraph 10.5 states that

"The FUP shall have sufficient strength that the horizontal distance measured in the rearward direction from the foremost part of the vehicle after application of the test forces...and the test ram contact surface on the vehicle does not exceed 400mm"

One simple way of amending R93 to permit longer vehicles would be to replace the expression "foremost point of the vehicle" in each of the above paragraphs with an expression that made the reference point for the measurement the leading edge of any stiff structures. For example, possibilities include:

- *The FUPD shall be so fitted to the vehicle that the horizontal distance measured in the rearward direction from **a transverse plane passing through the leading edge of the foremost stiff structure** to the front of the FUPD does not exceed 400mm diminished by the recorded deformation...measured at any of the points where the test forces have been applied during the type approval of the FUPD in conformity with part I of this Regulation.* A footnote could further define "stiff structure" as, for example:
 - A structure that has the potential to affect the structural interaction between the vehicle presented for approval and a typical vehicle of category M₁ or N₁ that is in collision with it; or
 - A structure that will deform by less than [X]mm when a quasi-static load of [Y]N is applied horizontally in a direction parallel to the longitudinal axis of the vehicle

This type of amendment might maximise the chances of being accepted by signatories outside of the EU because it does not require or permit any change to any traditional cab-over engine or bonneted (cab behind engine) designs used elsewhere in the world. However, it would leave the vehicle manufacturer free to design the front as they saw fit with stiff structures all the way to the front of the vehicle and a strongly curved FUP, or with a straight FUP set a considerable distance back from the front of the vehicle but

with low structural stiffness ahead of it. Not all of the parameters related to safety would be explicitly controlled by such an amendment.

A more comprehensive amendment could be made to introduce a performance test to replace the quasi static load method. This could stipulate criteria to control both acceleration and intrusion. However, such a test does not yet exist, would take time to develop and would be much more costly than the existing approval procedure. Thus, it is more likely to be controversial in regulatory meetings.

Consultation with individual Member States experts suggests that the minimum time required to gain an amendment to UNECE Regulation 93 is:

- The time required to develop a proposal for change.
- Presenting the proposal for change at the first available GRSG meeting
- Accepting the change at the subsequent GRSG meeting and forwarding on to WP29
- Review and acceptance of the change at WP29.

The next GRSG meeting is scheduled for the 30th September 2014, the subsequent one will be 6 months after that, approximately 30th April 2015. WP 29 meetings are scheduled in March, June and November. Thus, in theory at least, a proposal developed now could be approved by WP29 in June or perhaps November 2015.

However, if not all parties are in agreement about the proposal, the time spent by review in GRSG could be increased significantly. As an example, Germany has been proposing amendment to UNECE Regulation 58 to increase the stringency of requirements since 2011. This exercise has not yet concluded and an extract of the minutes of the last GRSG meeting in 2014 is presented below to indicate the status of discussions. Thus, the earliest this could now be adopted by WP29 is March 2015, a period of 4 years, and it is quite possible that debate could continue for considerably longer.

*Documentation: ECE/TRANS/WP.29/GRSG/2014/11
ECE/TRANS/WP.29/GRSG/2014/18*

Informal documents GRSG-106-11, GRSG-106-26, GRSG-106-32 and GRSG-106-40

28. Recalling the purpose of ECE/TRANS/WP.29/GRSG/2013/27, the expert from Germany presented ECE/TRANS/WP.29/GRSG/2014/18 and GRSG-106-26 introducing into UN Regulation No. 58 more stringent requirements for rear underrun protection devices. The expert from OICA proposed ECE/TRANS/WP.29/GRSG/2014/11 on alternative provisions. The expert from Germany presented GRSG-106-32 with a comparison of the proposed requirements listed in the documents. The expert from CLCCR presented some observations and recommendations of his organization (GRSG-106-11). The expert from Sweden raised concerns related to the test conditions for type-approval of rear underrun protection devices (GRSG-106-40). GRSG noted a number of comments.

29. Following the discussion, GRSG agreed to resume consideration at its next session in October 2014, on the basis of a revised official document to be prepared by the experts from Germany jointly with the experts from Sweden,

CLCCR and OICA. The secretariat was requested to keep GRSG-106-32 on the agenda.

Thus, the amount of time taken to amend a UNECE Regulation is not fixed and is likely to depend on the complexity and potential impact of the change on the stakeholders involved in the process. Thus, the time taken can be anywhere from around 15 months to 4 years or more.

In addition to the process delays, significant lead time can also be built in between publication of the final Regulation and the time that manufacturers must comply with the requirements. This is to allow the manufacturer's time to adapt the design of their vehicles to meet the final form of the Regulation. However, where the change in the Regulation does not mandate change and merely permits change at the discretion of the manufacturer, this lead time is not necessarily included.

4 The potential to adapt Regulation (EC) 661/2009 – The General Safety Regulation

Regulation (EC) 661/2009 is known as the general safety Regulation and sets high level safety requirements and specifies separate “implementing measures”. In relation to front underrun protection for trucks, Article 6(2) states that:

“Vehicles of categories N₂ and N₃ shall be constructed to ensure that, in the event of a front collision with another vehicle, the risk of injury to a vehicle occupant due to underrun is minimised”

The implementing measure for front underrun is a compulsory application of UNECE Regulation 93.

It is at least theoretically possible that the General Safety Regulation could be amended in order to regulate for the front underrun protection of extended length vehicles. If this route were to be followed, then it is likely that a legislative definition of the extended length vehicle would be required. This could be achieved by amending Directive 2007/46/EC to formally define a vehicle sub-category such that an N_{3x} is an N3 vehicle with an extended front. Text could then be inserted in the Regulation to specify that N2 and N3 vehicles must comply with UNECE Regulation 93 unless designated sub-category X. Separate provisions could then be inserted specifically for that sub-category and, in the same way as described for potential amendments to R93 (see section 3) these could be simple or complex. At the simple end there could be a statement that says, for example:

“for vehicles of sub-category x applying for an EU type approval using UNECE Regulation 93 in respect of it’s front underrun protection, the foremost point of the vehicle shall be considered to be the leading edge of the foremost stiff structure, likely to affect the structural interaction and opponent protection during a frontal collision with a car”

Alternatively, for more complex requirements such as the incorporation of a performance test or energy absorption capability, a new and separate implementing measure could be created specifically for sub-category [x]. It would be entirely appropriate for this to be an EU only Regulation, not globally harmonised, because this concept would be new and, to begin with at least, available only in the EU.

5 Alternative approaches permitted by Directive 2007/46/EC Type Approval Framework

Directive 2007/46 is the regulatory instrument providing the framework for EC Whole Vehicle Type Approval. This instrument defines the separate technical requirements that must be complied with for vehicles of each individual category to gain an approval. In respect of front underrun protection, it specifies that the requirements of Regulation (EC) 661/2009 and UNECE Regulation 93 must be complied with.

However, Article 20 of 2007/46 also provides a mechanism for dealing with new technologies or concepts incompatible with separate directives. In such a case, Member States may, on application by the manufacturer, grant an EC type-approval in respect of a type of system, component or separate technical unit that incorporates technologies or concepts which are incompatible with one or more of the separate regulatory acts defining the detailed technical requirements. Until this exemption is confirmed by the European Commission and their Technical Committee for Motor Vehicles (TCMV, comprising representatives of all Member States) then the approval is valid only in the territory of the Member State that issued it.

The Member State that seeks such an exemption must provide:

- the reasons why the technologies or concepts in question make the system, component or separate technical unit incompatible with the requirements;
- a description of the safety and environmental considerations concerned and the measures taken;
- a description of the tests, including their results, demonstrating that, by comparison with the requirements from which exemption is sought, at least an equivalent level of safety and environmental protection is ensured.

If the Commission accepts this as an EC approval then the validity of that approval shall be for at least 36 months. Once such an exemption is approved, Article 21 requires the Commission to take action to adapt the relevant Directives or Regulations such that the exemption would no longer be required. Where this relates to a UNECE Regulation, the Commission shall propose an amendment to the relevant UNECE Regulation in accordance with the procedure applicable under the Revised 1958 Agreement. If the necessary steps to adapt the regulatory acts have not been taken, the validity of an exemption may be extended, at the request of the Member State which granted the approval, by another decision adopted by the TCMV.

One example of this procedure being successfully used in the past is in relation to spray suppression equipment. The requirements for spray suppression defined two specific types of material by design. A test procedure tailored to those specific designs is used to prove compliance. A UK company had invented a method of using airflow to suppress spray which by virtue of its design could not pass the regulatory test. However, in full scale tests it was shown to work more effectively than the existing methods and was additionally found to provide small benefits to overall aerodynamics and fuel economy. Article 20 was used to grant component approval to these devices.

It is clear that the concept of permitting extra length for the benefit of safety and environment, not load space, could potentially be considered a "new concept" in relation to Article 20. Thus, this could potentially be used to approve such a vehicle without requiring immediate amendment of UNECE Regulation 93, although such an amendment would have to be sought. The advantage of this approach would be that it could act as a

temporary solution to allow the optimisation of vehicles with more than around 450mm extra length ahead of the front axle without having to wait for UNECE R93 to be amended. There are at least two potential disadvantages:

- Uncertainty for the vehicle manufacturer – Article 20 guarantees only a 36 month minimum approval period. It is possible that the UNECE committee could vote against amending Regulation 93, or could agree to amend it in a way that solved the problem in the future but did not permit the original design. Article 20 is not explicit about what would happen in these circumstances although it does allow for an ability to extend the exemption, with a second decision of the TCMV, if no action is taken to amend the relevant Regulations. If the investment required to optimise the integration of FUP in a longer cab design is significant, then this uncertainty could act as a dis-incentive to the manufacturers.
- Administrative burden – in the case of the spray suppression example, the approval was for a component. With one approval, the component manufacturer was able to sell the product to all vehicle and trailer manufacturer's. However, if applied to an exemption of a vehicle from Regulation 93, it is likely that an application would be required for every vehicle type seeking to exploit the additional length. This could mean a large volume of approvals to be processed through TCMV until such time that the appropriate Regulations were amended.

6 Conclusions

- 1) If vehicle length were extended using a FUP device that deformed in the regulatory test by the maximum 400mm, then the maximum extension of length possible would be around 450mm, as a result of the constraints of UNECE R93 and the European turning circle requirements.
- 2) However, many production FUPs (5 of a sample of 8) already deform by 50mm or less in the regulatory tests. Using a FUP of this level of stiffness would allow an extension in length of 800mm under the current rules.
- 3) The current rules were developed for flat fronted truck designs, and as a result, applying them to extended fronts with curved profiles allows the possibility of some sub-optimal conditions:
 - a) In the region of one third of devices may need to be made stiffer in order to comply with the requirements but this has been shown to be achievable at a mass of 60kg, likely to represent only a very small increase in mass;
 - b) Curved designs that follow the profile of the front will be more difficult to test in accordance with the requirements but suitable interpretations should still allow it;
 - c) Straight designs would be simpler to implement but would be set back from the foremost point of the vehicle by 350mm, introducing some risks of poor structural interaction if any other stiff structures get situated ahead of that point.
- 4) These problems could be overcome by an appropriate amendment to the applicable Regulations and the mass and cost savings combined with the advantages of increased space could provide a strong incentive to do so. Several options exist:
 - a) Introduce a simple permissive amendment, changing the definition of the position of the FUP relative to the front of the vehicle in a way that suits curved profiles
 - i) Within Regulation 661/2009 for "extended length" vehicles only
 - ii) Within UNECE R93
 - b) Mandate more stringent levels of performance and/or improved test methods
 - i) Within Regulation 661/2009, or a new implementing measure, for "extended length" vehicles only
 - ii) Within UNECE R93
- 5) The minimum amount of time taken for a simple, non-controversial, permissive amendment might be around 15 months. A more complex change requiring a higher standard of protection or a substantially different test procedure could easily take 4 or more years.
- 6) Article 20 of Directive 2007/46/EC covering "new technologies or concepts" could be used to grant an appropriate, temporary, exemption to manufacturers seeking an approval in advance of the amendment of the Regulations. However, this could represent a significant financial risk for Manufacturers and is a purely voluntary mechanism.

7 References

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