DNV·GL

FINAL REPORT

Harmonised Risk Acceptance Criteria for Transport of Dangerous Goods

European Commission DG-MOVE

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Task and objective:
This study aims to analyse the feasibility of defining and using harmonised risk acceptance criteria in decision-making for the justification of safety measures in the inland transport of dangerous goods in the European Union.

This document presents the final report on the study. It reviews risk acceptance criteria that are in use at present, and proposes a harmonised approach that maximises their strengths and minimises their limitations. It then considers the practical and legislative implications of the harmonised risk acceptance criteria, and concludes on the overall feasibility of the harmonised approach.

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Reference to part of this report which may lead to misinterpretation is not permissible.

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0	2014-01-29	Draft report	John Spouge	Jonathan Ellis	Dr. Edward Smith
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0 SUMMARY

0.1 Background

The transport of dangerous goods (TDG) throughout the inland regions of the European Union (EU) is governed by Directive 2008/68/EC and the ADR, RID and ADN regulations for road, rail and inland waterways respectively[1]. In principle, these uniform regulations should permit free movement of dangerous goods (DG) at an acceptable level of safety. In practice, because Member States (MS) are also able to apply additional safety requirements where they are considered appropriate, this objective is not completely fulfilled. The additional requirements appear sensible in their intended area of application, but may produce inconsistencies and adverse impacts elsewhere, resulting in increases in cost for industries and unequal protection against risk for the public. One fundamental cause of these inconsistent and sub-optimal impacts may be the lack of explicit harmonised risk acceptance criteria (RAC) for TDG.

The European Commission Directorate-General for Mobility and Transport (DG-MOVE) has therefore commissioned Det Norske Veritas Ltd (DNV)[2] to perform a feasibility study on harmonising RAC for TDG in the EU.

0.2 Objective

The objective of the study is to analyse the feasibility of defining and using harmonised risk acceptance criteria in decision-making for justification of safety measures in the inland transport of dangerous goods in the European Union.

0.3 Approach

Task 1 of the study surveyed the various approaches to RAC of TDG that are in use in the EU, Norway and Switzerland. Task 2 evaluated possible approaches to developing harmonised RAC, and drew conclusions on their technical feasibility. Task 3 considered the practical and legislative implications of the harmonised RAC and assessed the overall feasibility of the harmonised approach. In Task 4, DNV and DG-MOVE held a public workshop with representatives of Member States, and received feedback on the proposed approach. The present report combines the results of all tasks of the study.

0.4 Application

The intended scope of application of the harmonised RAC is as follows:

- Risks of accidents causing fatalities. The RAC are also intended to take account of other impacts, including injuries, damage to property and infrastructure, and environmental impacts.
- Transport by road, rail and inland waterways. The study also considers whether the RAC can also be applied to pipelines.

[1] ADR: the European Agreement concerning the International Carriage of Dangerous Goods by Road, concluded at Geneva on 30 September 1957;
RID: the Regulations concerning International Carriage of Dangerous Goods by Rail, appearing as Appendix C to the Convention concerning International Carriage by Rail (COTIF) concluded at Vilnius on 3 June 1999;
ADN: the European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways, concluded at Geneva on 26 May 2000.

[2] Following a merger with the GL Group in 2013, DNV is now part of DNV GL.

- Transport of dangerous goods under the scope of Directive 2008/68/EC and ADR/RID/ADN.
- Transport within Europe. This includes the 28 EU MS, plus Norway and Switzerland. There is no technical reason why the harmonised RAC could not also apply world-wide.
- Transport between fixed installations or ports, including temporary stop areas (lorry parking, marshalling yards etc). The RAC are intended to harmonise with existing approaches for fixed installations.
- Transport at any scale, including individual DG shipments, whether existing or proposed, cumulative DG transport past a point or along a route, national totals and overall EU DG transport.

The harmonised RAC are intended to be used primarily for evaluation of decisions on additional restrictions under ADR/RID/ADN Chapter 1.9. They could also be used to evaluate other safety decisions such as approval of new DG transport or land-use developments near existing DG transport routes.

0.5 Definition of RAC

"Risk criteria" are defined by ISO as "terms of reference against which the significance of a risk is evaluated". "Risk acceptance criteria" is a slightly more specific term, indicating the standard for evaluating risk that is adopted by a decision-maker. In this report, terms such as "risk criteria", "tolerability limit" and "safety target" are all treated as broadly equivalent to RAC.

The study includes RAC of the following forms:

- Risk matrix RAC.
- Individual risk RAC.
- Societal risk RAC, including fatality rates and FN curves.
- Cost-benefit criteria, which are not strictly RAC but are closely connected to them.
- Consequence RAC.
- Qualitative RAC, defining the conditions under which a risk is accepted in any qualitative way.

RAC are small but critical elements within a larger methodology that defines how risks are assessed and managed. The metric chosen for the RAC may determine the methodology that is required in the assessment – for example, qualitative RAC or cost-benefit criteria require corresponding qualitative or cost-benefit approaches to the risk assessment. Therefore, in this report, the "approach" refers to the metric for the RAC and the implied approach to the risk assessment. For brevity, the report focusses on harmonising the RAC. In due course, it will be necessary to harmonise the other elements of the risk assessment process once the RAC have been chosen.

0.6 The Need for Harmonised RAC

Under Chapter 1.9 of ADR/RID/ADN, national authorities may make decisions about restrictions beyond those specified in ADR/RID/ADN, as well as other safety measures for TDG.

At present, these decisions use a variety of implicit and explicit RAC. This non-harmonised system causes several problems and inconsistencies.

One key problem is that different RAC can lead to different restrictions on TDG for similar situations in different MS, causing unequal protection against hazards or competitive disadvantage for some transport operators. An operator wishing to transport DGs across Europe may be subject to various restrictions on the time of day, weather conditions, routes that may be taken, maximum permissible speeds and permissible locations to stop. These restrictions respond to local concerns, and vary widely between MS. They increase transport costs but do not necessarily manage safety in an effective way. A harmonised approach is required to eliminate these inconsistencies.

Another type of problem is that RAC applied for good reasons in one location can result in unexpected changes to TDG, as operators change routes, transport modes or supply patterns. These changes can alter the risk pattern, and in some cases may increase the overall risk. An approach that is harmonised across the whole transport and production operation has the potential to eliminate these unintended effects.

Most of the additional restrictions that have been adopted under Chapter 1.9 of ADR/RID/ADN prohibit TDG of certain types, in certain locations, weather conditions or times of day. These all impose costs on operators in an attempt to protect local populations or infrastructures. Few MS have attempted to manage their infrastructure to achieve an optimum balance between risk and investment in safety measures. RAC provide a possible way of achieving this, and harmonised RAC provide a way of achieving a consistent approach at the EU level.

Some of the issues described above can be managed by national authorities, following the principle of subsidiarity. However, DG production and distribution is an international operation, and restrictions within one country often affect others. Some important restrictions affect TDG at international borders (e.g. through tunnels or over bridges), where they inevitably affect at least two countries. Some countries, located on transport routes between DG producers and consumers, may be subjected to the risks of TDG without receiving any of the benefits. Despite the international nature of the problem, no international standard RAC have yet emerged. For these reasons, EU-wide harmonisation is required.

0.7 Survey of Approaches

To understand the approaches to RAC of TDG that are in use in the EU, a survey of practice was carried out. A response was received from 86% of the countries contacted, covering all but one MS with significant movement of dangerous goods. It is evident from the responses that TDG is not managed in a consistent way either within MS or between them.

Seven MS reported no use of RAC and no additional restrictions beyond those in ADR, ADN and RID. Another seven MS reported some restrictions on TDG, but no specific RAC. They are considered to use implicit qualitative RAC, comprising local judgement-based decision making, to determine if a restriction is required. Eleven countries (9 MS plus Norway and Switzerland) and the Channel Tunnel Safety Authority reported using explicit RAC, although the forms of these varied widely.

Most published restrictions on TDG have no risk-based justification associated with them and vary widely between MS for the same hazards. For those MS using RAC it is not obvious how the restriction contributes to the achievement of the RAC. This suggests that even those MS that make use of RAC do not do so transparently or consistently.

0.8 Literature Review

A literature review was conducted to give further information on the possible approaches that could be used for harmonised RAC, including:

- More specific information on the RAC that were reported in the survey.
- Historical information on the development of RAC in MS.
- RAC used in major hazard installations and non-DG road and rail transport.
- RAC used in other industries, including aviation and maritime transport.
- RAC used in other countries world-wide.

0.9 Evaluation of Approaches

Based on the survey and the literature review, DNV identified a set of 10 different approaches to RAC that were considered candidates for use in a harmonised approach. These were evaluated in the following ways:

- Are they aligned with fundamental principles that have been identified for developing RAC?
- How far are they already in use for TDG in the EU?
- Do their current users consider they are suitable for a harmonised approach?
- Would they reduce the inconsistencies that exist in the current non-harmonised approach?
- What are their overall strengths and limitations with respect to other challenges in setting harmonised RAC?

It was concluded that each approach is beneficial in some respects, but no one approach has overwhelming strengths or limitations. Therefore, a harmonised approach is proposed, combining elements from all of the candidate approaches, and addressing all the fundamental principles.

0.10 Proposed Harmonised RAC

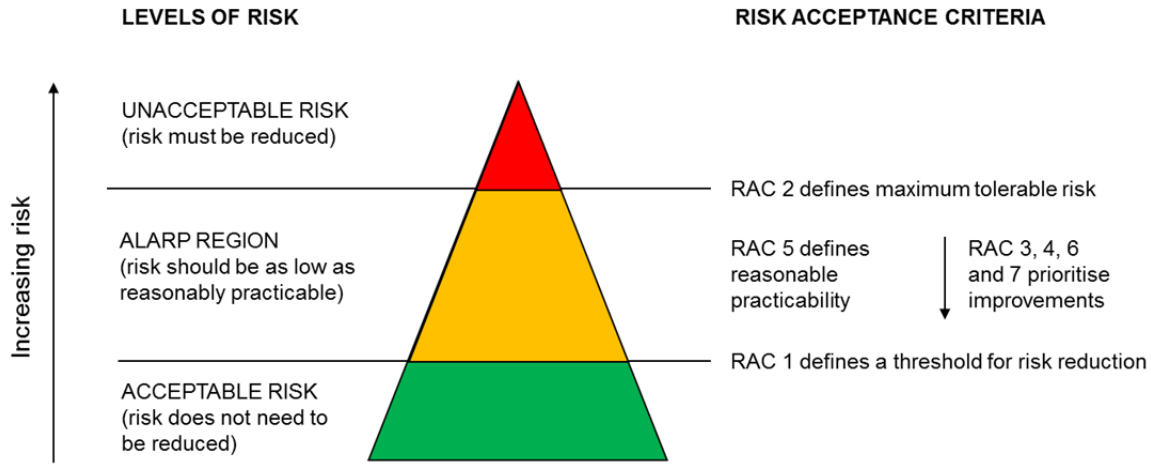
DNV's proposed harmonised approach to RAC includes seven distinct elements:

1. Threshold criteria, expressed as an expectation value of fatalities per year. Below this, detailed risk assessment and further risk reduction would not be required.
2. Individual risk (IR) criteria, expressed as maximum tolerable risks of death per year for the most exposed individuals. Above this, the risk would not be acceptable. This aims to protect individual workers or members of the public from unfairly high risks.
3. Societal risk (SR) criteria, expressed as FN curves for the most exposed communities. Above this, measures to reduce catastrophe risk should be investigated.
4. Scrutiny level, expressed as an expectation value of fatalities per tonne of DG transported over a route. Above this, justification of the transport would be needed, and additional restrictions or safety measures should be investigated. The scrutiny level aims to ensure that the risks of TDG are justified by its benefits.

5. ALARP criteria (i.e. defining what is as low as reasonably practicable), consisting of either qualitative or cost-benefit criteria for evaluation of additional restrictions or safety measures. This aims to ensure that safety measures are optimised, taking account of the costs and benefits of risk reduction.
6. Improvement target for TDG, expressed as an expectation value of fatalities per year from all modes of TDG. This would be used to monitor performance and propose additional safety measures.
7. Improvement target for DG, expressed as an expectation value of fatalities per year from all production and transport of DG. This would be a possible way of monitoring and improving consistency with requirements for fixed installations.

Only two of these elements (RAC 2 and 5) would determine the need for additional restrictions or safety measures. The other RAC are aimed at minimising analysis effort (RAC 1) and focussing improvement efforts (RAC 3, 4, 6 and 7). The relationships are summarised in Figure 1.

Figure 1 Summary of Harmonised RAC



In most TDG cases the core of the evaluation would be the ALARP criteria (RAC 5). In simple terms, provided risks have been considered on a broad scale, and are not exceptionally high by any of the other RAC, a restriction on TDG can only be justified if it is necessary to make the risks ALARP, i.e. if the costs of the restriction are outweighed by its benefits in terms of risk reduction, or if it is judged to comprise part of good operating practice.

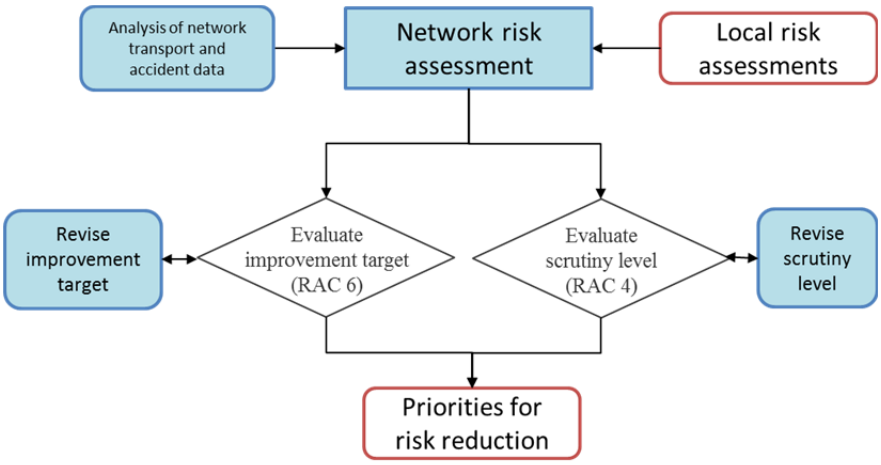
0.11 Implementation

The proposed implementation scheme is within a risk assessment that takes place at two levels:

- A network risk assessment, evaluating the whole TDG network (Figure 2). This would show whether the network was meeting its targets for continual improvement (RAC 6); and whether the risks from international trades were justified by their benefits (RAC 4). It would determine if further risk reduction were necessary at a network level, and if so propose priorities for it. This would give direction to local risk assessments, but would not normally conclude on the need for specific risk reduction measures. In some cases

it may also consider other RAC that are relevant at network level (RAC 2, 3 and 5), and ultimately could also address risks from fixed installations (RAC 7).

Figure 2 Network Risk Assessment



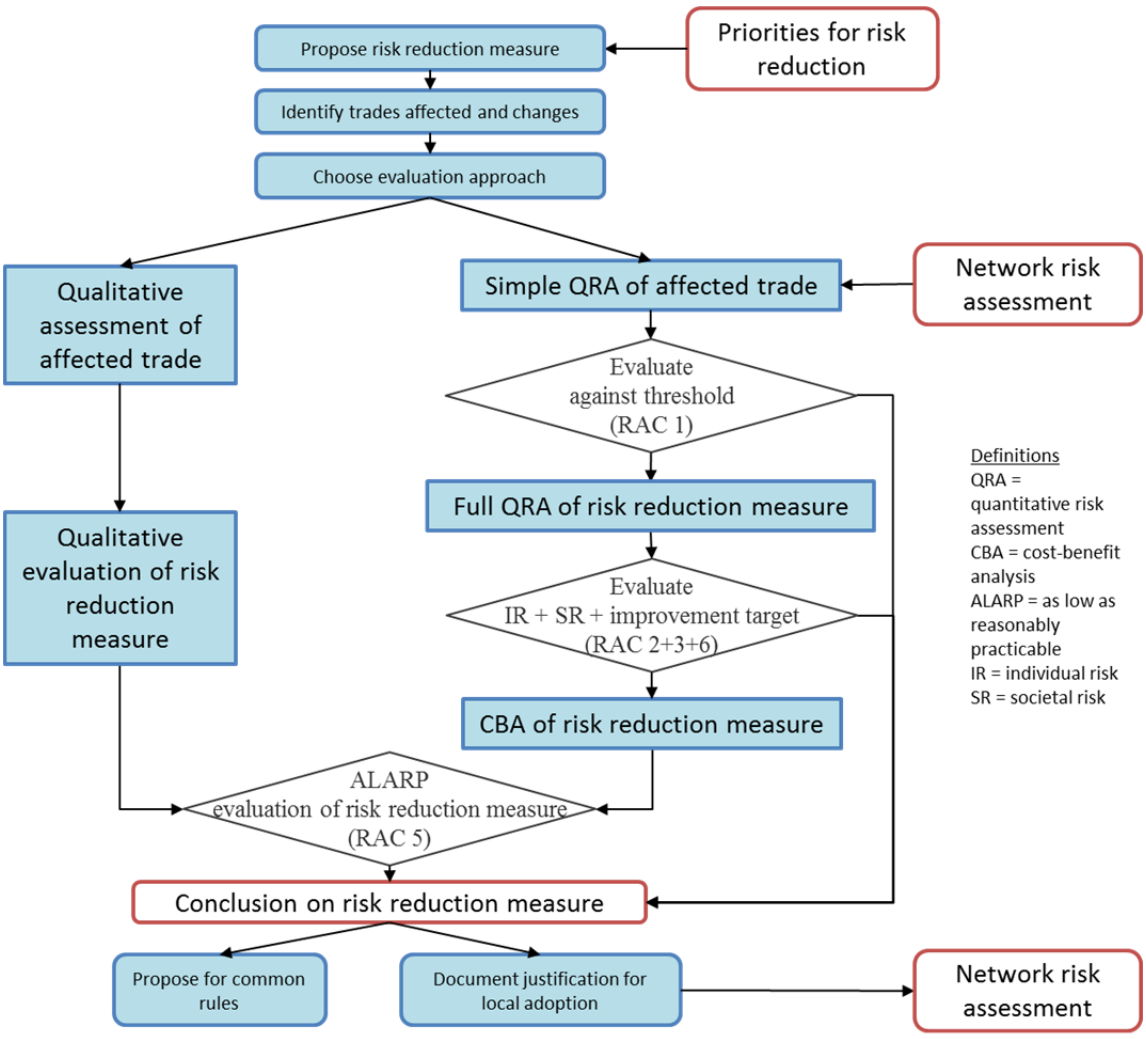
- Local risk assessments, evaluating specific risk reduction measures on individual TDG trades or at specific locations (Figure 3). This would show whether the risks exceeded the threshold requiring detailed evaluation (RAC 1); whether individual and societal risks arising from the specific TDG trade were acceptable (RAC 2 and 3) and improving at the required rate (RAC 6); and whether all reasonably practicable risk reductions had been adopted (RAC 5). Either qualitative or quantitative assessment would be possible. It would conclude on the need for additional restrictions or other risk reduction measures for the specific trade or location.

0.12 Legislative Implications

Based on a brief review of the legislative options and preliminary discussion with DG-MOVE, DNV recommends the following changes to EU policies and legislation:

- A new directive on DG safety in all transport modes. This would include road, rail and inland waterways. It would state the harmonised RAC and explain how they are intended to improve safety. Where MS intend to apply restrictions on TDG, it would require them to make a risk assessment coving the complete scope of changes in TDG that may result, and supply the results to the Commission for use in the EU level network risk assessment. It would also specify a common methodology for the risk assessment, and principles for collecting the necessary data
- Adjustment of the Commission's existing policy on road safety to include TDG risks explicitly.
- Adjustment of the common safety targets (CSTs) for rail safety to include TDG risks explicitly.

Figure 3 Local Risk Assessment



In addition, DNV recommends the Commission should take the following organisational steps:

- Analyse the data on TDG activity and incidents that has been collected under existing legislation, in order to produce accident frequencies suitable for the network and local risk assessments.
- Develop a suitable methodology for the network and local risk assessments.
- Conduct an initial network risk assessment as a research study, using voluntary assistance from MS.
- Develop a process for setting the specific values of the harmonised RAC.
- Communicate with MS the priorities for risk reduction that are selected in the network risk assessment, and review the results of local risk assessments of TDG restrictions.
- Review periodically the harmonised RAC, in the light of practical changes to TDG restrictions that they support, and adjust the RAC if necessary.

A new directive is most appropriate for the medium to long term, because it would require time and considerable resources to develop the methodology and necessary data, and to implement the required legislation. Therefore, to ensure that progress is made in the short-term, the first three organisational steps are recommended for immediate implementation. This would have the advantage of increasing understanding of how harmonised RAC would work in practice, and clarifying the challenges that the new directive would ultimately aim to overcome.

0.13 Impact Assessment

The impacts of the harmonised RAC, if implemented through the preferred legislative options, are assessed as follows:

- Public safety - harmonised RAC are considered to be a contribution to maintaining the current levels of risk in TDG, and helping to ensure that they do not increase in the future, but are not expected to achieve any major reduction in risk.
- Internal market - a positive impact, which is considered to be one of the main benefits of harmonised RAC.
- Business costs - the net effect is expected to be large and positive in the long-term, although in the short-term there will be costs before any benefits occur.
- Public authorities – if restrictions are proposed, there will be a significant cost of performing risk assessments, but this is already required to justify restrictions under ADR and RID, so it is not strictly an additional burden.
- Specific transport modes - no major unwanted impacts on individual transport modes are anticipated.
- Transport infrastructure - any impacts are expected to be small.
- Climate change - impacts are expected to be beneficial, and any adverse effects will be fully justified.
- The environment - any impacts are expected to be small.

Overall, there will be costs to public authorities and (in the short-term) to TDG operators. In the long-term, beneficial impacts on the internal market are expected to dominate.

0.14 Limitations

The study acknowledges some major limitations in the proposed approach, which limit the degree of harmonisation that can be achieved in practice:

- The very diverse approaches adopted by MS in their current use of RAC mean that it would be difficult for all MS to switch to a single harmonised approach. Therefore the proposed approach is relatively flexible, aiming to facilitate adoption by MS. An inevitable consequence of this is that it limits the degree of harmonisation that would be achieved in practice. This is considered to be an acceptable compromise in an attempt to gain acceptance from a majority of MS.
- There are substantial differences in the approach of different countries to regulation of risks, and direct application of harmonised RAC in these different contexts would not produce the intended harmonisation of risks. The present study has focussed on the feasibility of a harmonised approach to RAC, while leaving the specific values of the

RAC to future discussion. However, it may never be appropriate to harmonise specific values of the RAC to be used in local risk assessments. Provided the adopted restrictions are identical, or different for justifiable reasons, this is considered to be acceptable.

- Lack of data on TDG activity and incidents is seen as a critical obstacle to implementing harmonised RAC. Therefore the present study makes recommendations to improve data collection and analysis in addition to harmonising RAC.
- The cost burden of the proposed implementation method falls mainly on government authorities in each MS, and to a lesser extent on TDG operators. This burden should be compensated in the long-term by improvements in the internal market, but it is possible that this benefit will not be sufficient motivation for the MS to conduct the local risk assessments of TDG restrictions that are a key part of the practical implementation. This is considered a major risk for the successful implementation of the harmonised RAC.

0.15 Conclusions

The study concludes that it is feasible to define and use harmonised RAC for justification of restrictions on TDG, provided these are interpreted as guidelines rather than rigid rules. Implementation through the preferred legislative options appears to be practical, and to deliver a beneficial combination of impacts.

1 INTRODUCTION

1.1 Background

The transport of dangerous goods (TDG) throughout the inland regions of the European Union (EU) is governed by Directive 2008/68/EC and the ADR, RID and ADN regulations for road, rail and inland waterways respectively[3]. In principle, these uniform regulations should permit free movement of dangerous goods at an acceptable level of safety. In practice, because Member States are also able to apply additional safety requirements where they are considered appropriate, this objective is not completely fulfilled. The additional requirements appear sensible in their intended area of application, but may produce inconsistencies and adverse impacts elsewhere, resulting in increases in cost for industries and unequal protection against risk for the public. One fundamental cause of these inconsistent and sub-optimal impacts may be the lack of explicit harmonised risk acceptance criteria (RAC) for dangerous goods transport.

RAC have been used to manage the safety of major hazard installations for many years, and in some countries have become well established and consistent. Application of RAC to TDG has proved more challenging, because transport exposes a constantly changing population to the hazard over long and complex transport routes. In these circumstances it is difficult to calculate the risks, and even more difficult to develop RAC that produce appropriate restrictions on TDG, taking account of the value of the transport activity to industry and the society as a whole, and the alternatives that may result. Without this, RAC may produce inconsistent and sub-optimal results that would be little better than the current arrangements.

The European Commission Directorate-General for Mobility and Transport (DG-MOVE) has therefore commissioned Det Norske Veritas Ltd (DNV)[4] to perform a feasibility study on harmonising RAC for TDG in the EU.

1.2 Objectives

The objective of the study is to analyse the feasibility of defining and using harmonised risk acceptance criteria in decision-making for justification of restrictions on the inland transport of dangerous goods in the European Union.

1.3 Approach

In Task 1 of the study, DNV surveyed the various approaches to RAC of TDG that are in use in the EU, Norway and Switzerland. In Task 2, DNV reviewed the various possible approaches to developing harmonised risk acceptance criteria, and drew conclusions on their technical feasibility. In Task 3, DNV considered the practical and legislative implications of the harmonised RAC and assessed the overall feasibility of the harmonised approach. In Task 4, DNV and DG-MOVE held a public workshop with representatives of Member States, and received feedback on the proposed approach. The present report combines the results of all tasks of the study.

[3] ADR: the European Agreement concerning the International Carriage of Dangerous Goods by Road, concluded at Geneva on 30 September 1957;
RID: the Regulations concerning International Carriage of Dangerous Goods by Rail, appearing as Appendix C to the Convention concerning International Carriage by Rail (COTIF) concluded at Vilnius on 3 June 1999;
ADN: the European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways, concluded at Geneva on 26 May 2000.

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1.4 Report Structure

Section 2 of the report provides a brief explanation of the purpose of RAC and the need for them in the field of TDG. It defines the term "risk acceptance criteria", and compares with other similar terms.

Section 3 reviews the fundamental principles that have been proposed as the basis for RAC in various industries, together with some practical methods of choosing specific values for them. This is intended to help understand the various RAC that are used in practice.

Section 4 summarises the results of a survey carried out by DNV into the various approaches to RAC for TDG that are in use by national authorities in the EU. This section also reviews other approaches to RAC that are described in the academic literature. It then draws the various possible approaches into a set of candidates that might be suitable for harmonised RAC for TDG in Europe. Appendix I explains the survey in more detail, and includes the full responses that were received.

Section 5 evaluates the candidate approaches for harmonised RAC. It first questions whether they are aligned with the fundamental principles for RAC. It then identifies their strengths and weaknesses, in respect of the inconsistencies in the current non-harmonised approach and other technical challenges that might affect their performance as harmonised RAC for TDG. Appendix II explains this evaluation in more detail.

Section 6 then proposes a harmonised approach to RAC for TDG that maximises their strengths and minimises their limitations. It explains how this could be implemented in practice as a harmonised RAC for TDG.

Section 7 considers what legislative changes would be needed to implement the harmonised RAC, and identifies several possible policy options.

Section 8 predicts the impacts of the harmonised RAC if implemented through the preferred legislative options. It considers the likely responses of Member States, and the expected benefits in the areas of safety, economics and the environment.

Section 9 concludes on the overall feasibility and desirability of the proposed harmonised RAC.

1.5 Scope Boundaries

The intended scope of application of the harmonised RAC is as follows:

- Risks of accidents causing fatalities. The RAC are also intended to take account of other impacts, including injuries, damage to property and infrastructure, and environmental impacts.
- Transport by road, rail and inland waterways. The study also considers whether the RAC can also be applied to pipelines.
- Transport of dangerous goods under the scope of Directive 2008/68/EC and ADR/RID/ADN.
- Transport within Europe. This includes the 28 Member States (MS) of the EU, plus Norway and Switzerland. There is no technical reason why the harmonised RAC could not also apply world-wide.

- Transport between fixed installations or ports, including temporary stop areas (lorry parking, marshalling yards etc). The RAC are intended to harmonise with existing approaches for fixed installations.
- Transport at any scale, including individual DG shipments, whether existing or proposed, cumulative DG transport past a point or along a route, national totals and overall EU DG transport.

The harmonised RAC are intended to be used primarily for evaluation of decisions on additional restrictions under ADR/RID/ADN Chapter 1.9. They could also be used to evaluate other safety measures such as approval of new DG transport or land-use developments near existing DG transport routes.

2 PURPOSE AND DEFINITIONS

2.1 The Purpose of Risk Acceptance Criteria

The transport of dangerous goods, like many other industrial activities, involves *hazards*, i.e. situations with a potential for causing harm. The *risk* from these activities is the chance of this harm occurring. This report focuses on the risk from *accidents*, i.e. sudden occurrences of harm, although similar concepts may also be applied to chronic harm to health or the environment.

In most activities, risks can be reduced at progressively greater cost, by adding further safety measures or achieving a higher standard of safety-awareness in operation. It is rarely possible to eliminate risks altogether without discontinuing the activity itself.

When planning a new transport activity or reviewing an existing one, decisions sometimes have to be made about questions such as:

- Should the transport be permitted at all?
- Are restrictions or other safety measures necessary to reduce its risks?
- How much risk reduction is required?
- What route, transport mode, design or risk management options should be chosen?
- What other land uses (such as housing, schools, shopping centres, etc.) should be permitted near to the transport route?

To answer questions such as these, the decision-maker must decide when the activity is *safe enough*, i.e. when the risks are so low that further safety measures are not necessary. Risk acceptance criteria (RAC) are intended to guide this decision-making process.

In a quantitative risk assessment, RAC can be used to translate numerical risk estimates (e.g. 10^{-7} per year) into value judgements (e.g. "negligible risk") which can be set against other value judgements (e.g. "beneficial transport of goods") in a decision-making process, and presented to the public to justify a decision.

RAC are also useful where risks are to be compared or ranked. Such comparisons are sometimes complicated by the multi-dimensional nature of risk, e.g. rare high-consequence accidents may be exchanged for more likely low-consequence ones. RAC can help the ranking of such options.

Risk assessment is often a qualitative process, based on expert judgement. In this case, RAC may be qualitative standards that help decide whether further action is needed.

2.2 Legislative Requirements for Risk Acceptance Criteria

The safety of most TDG activities world-wide is not managed through an explicit process of risk assessment. Instead, the incremental development of the ADR/RID/ADN regulations does this implicitly. The experts involved in developing these regulations subjectively assess the acceptability of risks and the necessity for risk reduction measures, without using explicit RAC. The intent is that, provided the requirements are fulfilled, the risks of TDG will then be acceptable everywhere. There is no formal use of RAC in developing these regulations, which makes it difficult to understand why particular regulations were adopted.

Chapter 1.9 of ADR/RID/ADN allows contracting states to apply additional provisions such as safety requirements or restrictions on particular structures, such as bridges, tunnels, transhipment installations and terminals, particular DGs or other operational restrictions. In the case of rail, RID requires the competent authority to provide evidence of the need for the measures. In the case of road (except for tunnels), ADR simply requires the competent authority to notify UNECE about the additional provisions without necessarily justifying them. To encourage a more uniform approach to risk assessment of TDG, there are generic guidelines on how to calculate risk[5,6], but these leave Member States free to define "target safety levels" (i.e. RAC) according to their national safety policy.

In the case of road tunnels, ADR requires the competent authority to assign the tunnel to one of 5 categories (A to E) with specified restrictions on the DGs to be accepted. European Directive 2004/54/EC[7] requires tunnels in the trans-European road network with special characteristics in certain respects to have a risk analysis to establish whether additional safety measures are needed. To assist these analyses, there is an established methodology for risk assessment[8]. This does not specify RAC, but several countries have developed their own[9].

In the case of railways in the EU, the Common Safety Method (CSM)[10], describes several methods of demonstrating risk acceptability for significant changes to the railway system, and Common Safety Targets (i.e. RAC) have been defined[11]. These do not specifically refer to TDG, but it is expected that they would help harmonise RAC for TDG.

The cumulative effect of these requirements is that national authorities are currently making decisions about various restrictions and other safety requirements for TDG, using a variety of implicit and explicit RAC.

2.3 The Need for Harmonised Risk Acceptance Criteria

The current system of diverse approaches to restrictions on TDG, resulting from an absence of harmonised RAC, causes several problems and inconsistencies. These inconsistencies create the motivation for the present study. They are explained in more detail in Section 5.5.

One key problem is that different RAC can lead to different restrictions on TDG for similar situations in different MS, causing unequal protection against hazards or competitive disadvantage for some transport operators. An operator wishing to transport DGs across Europe may be subject to various restrictions on the time of day, weather conditions, routes that may be taken, maximum permissible speeds and permissible locations to stop. These restrictions respond to local concerns, and vary widely between MS. They increase transport costs but do not necessarily manage safety in an effective way. A harmonised approach is required to eliminate these inconsistencies.

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[5] OTIF "Generic Guideline for the Calculation of Risk inherent in the Carriage of Dangerous Goods by Rail" approved by the RID Committee of Experts on 24 November 2005.

[6] UNECE, "General Guideline for the Calculation of Risks in the Transport of Dangerous Goods by Road. An introduction to the basic principles of risk assessment for chapter 1.9 ADR", 2008. http://www.unece.org/fileadmin/DAM/trans/danger/publi/adr/Calculation%20of%20risks_e.pdf

[7] Directive 2004/54/EC of the European Parliament and of the Council of 29 April 2004 on minimum safety requirements for tunnels in the trans-European road network

[8] OECD/PIARC DG-QRAM http://www.piarc.org/en/knowledge-base/road-tunnels/qram_software/

[9] PIARC "Current Practice for Risk Evaluation for Road Tunnels", 2010.

[10] EC Regulation 402/2013 of 30 April 2013 on the common safety method for risk evaluation and assessment and repealing Regulation (EC) No 352/2009.

[11] ERA "Recommendation on the 1st set of Common Safety targets as referred to in Article 7 of Directive 2004/49/EC, September 2009.

Another type of problem is that RAC applied for good reasons in one location can result in unexpected changes to TDG, as operators change routes, transport modes or supply patterns. These changes can alter the risk pattern, and in some cases may increase the overall risk. An approach that is harmonised across the whole transport and production operation has the potential to eliminate these unintended effects.

Managing safety through incremental development of regulations such as ADR/RID/ADN has a drawback that the regulations tend to grow more complex while the motivation for each regulation tends to become obscure. This is a particular problem when many different hazards are addressed, as in the case of TDG. The risk assessment approach can in these cases provide a more efficient management process, provided that harmonised RAC are available.

Most of the additional restrictions that have been adopted under Chapter 1.9 of ADR/RID/ADN prohibit TDG of certain types, in certain locations, weather conditions or times of day. These all impose costs on operators in an attempt to protect local populations or infrastructures. Few MS have attempted to manage their infrastructure to achieve an optimum balance between risk and investment in safety measures. RAC provide a possible way of achieving this, and harmonised RAC provide a way of achieving a consistent approach at the EU level.

Some of the issues described above can be managed by national authorities, following the principle of subsidiarity. However, the production and distribution of dangerous goods is an international operation, and restrictions within one country often affect others. Some important restrictions affect TDG at international borders (e.g. through tunnels or over bridges), where they inevitably affect at least two countries. Some countries, located on transport routes between DG producers and consumers, may be subjected to the risks of TDG without receiving any of the benefits. Despite the international nature of the problem, no international standard RAC have yet emerged. For these reasons, EU-wide harmonisation is required.

2.4 Definition of Risk Acceptance Criteria

"Risk criteria" are defined by ISO[12] as "terms of reference against which the significance of a risk is evaluated". The guideline on risk calculation under ADR[13] defines them as "reference parameters by which the significance of risk is assessed". In simple terms, they help answer questions such as "How safe is safe enough?", or "Which of several different risks is lowest?".

"Risk acceptance criteria" is a slightly more specific term, indicating the standard for evaluating risk that is adopted by a decision-maker. The CSM[14] defines RAC as "'the terms of reference by which the acceptability of a specific risk is assessed". It then explains that "these criteria are used to determine that the level of a risk is sufficiently low that it is not necessary to take any immediate action to reduce it further".

2.5 Alternative Terminology for Criteria

The term "risk acceptance criteria" is not universally accepted. It is not used in ISO documents on risk management[15]. It is disliked by regulators in the UK and USA because it

[12] ISO "Risk Management – Vocabulary", Guide 73:2009.
[13] UNECE op cit
[14] EC 402/2013 op cit
[15] ISO, "Risk management – Principles and guidelines", ISO 31000:2009.

implies that the person exposed has consented to receive the risks, and even regards them with favour. The American Institute of Chemical Engineers expressed the view as follows[16]:

> "*The concept of **risk tolerance** or **risk tolerability** is increasingly preferred to **risk acceptance**. The terminology has changed because organizations do not want to imply or create a public perception that risks attributable to their activities or operations are viewed as being acceptable. Rather, recognizing that eliminating all risks is impossible, some organizations prefer to speak of carefully managed residual risks being tolerable*."

Several alternatives exist:

- "Risk criteria" is widely used as a more general version. One definition of risk criteria[17] was "standards which represent a view, usually that of a regulator, of how much risk is acceptable/tolerable". This is in effect the same definition as given for RAC above, and makes the terms synonymous.
- "Tolerability limit" acknowledges the arguments above, but is in fact not widely used. The concept of "tolerability" was introduced in the UK to express the public's reluctant acceptance of risks in order to secure certain benefits[18].
- "Risk acceptability criteria" appears to be a minor variant of "risk acceptance criteria", but is less satisfactory. The "acceptance" of risks acknowledges that the decision-maker cannot call them "acceptable" (for the reasons expressed above); it merely describes conditions under which they are "accepted".
- "Bright lines" are used in discussion of the subject in the USA[19], although this is mainly in the context of recommending that they should not be established by regulatory agencies.
- "Safety target" is used in road transport and "Target level of safety" (TLS) in aviation transport. The term "target" implies an optimistic aim for the future, which may not be fulfilled, whereas "criteria" implies a less ambitious but mandatory standard. In practice, this distinction is not maintained consistently.

In most cases these alternatives are synonymous with RAC, and in this report they are all are treated as types of RAC.

2.6 Terminology for Risk Regions

It is generally considered impractical to divide risks simply into "acceptable" and "unacceptable". In reality, there is a spectrum of risks, in which higher risks need more stringent control. RAC therefore typically divide the risk spectrum into regions, each calling for different types of response and usually give qualitative terms to each. Unfortunately, different decision-makers often use different terminology.

In most cases, RAC are seen as dividing "unacceptable" risks from "acceptable" ones, often with an intermediate region where risk reduction is desirable (e.g. see Figure 2.1). However, the

[16] CCPS, "Guidelines for Developing Quantitative Safety Risk Criteria", Center for Chemical Process Safety, American Institute of Chemical Engineers, 2009 p40.

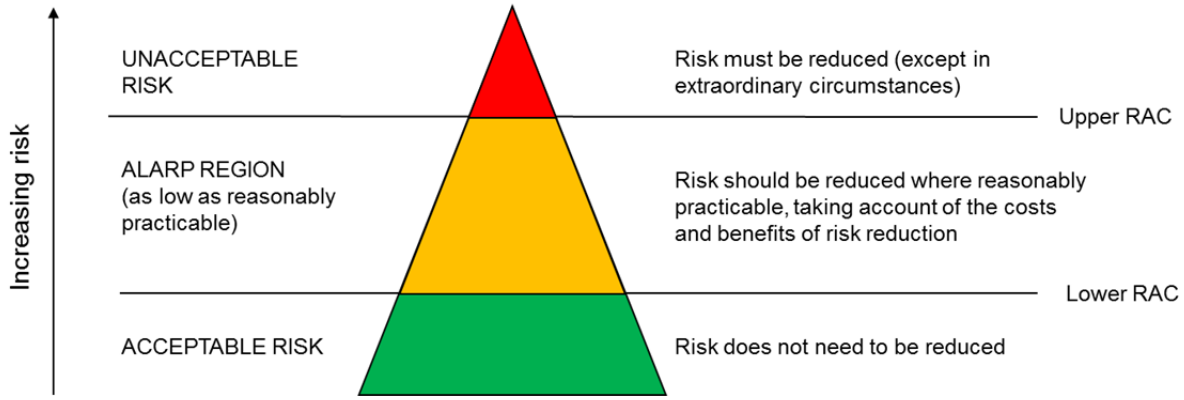
[17] HSE, "Generic Terms and Concepts in the Assessment and Regulation of Industrial Risks", Discussion Document DDE2, HSE Books, 1995

[18] HSE "The Tolerability of Risk from Nuclear Power Stations", Health and Safety Executive, HMSO, 1992.

[19] The Presidential/Congressional Commission on Risk Assessment and Risk Management, "Risk Assessment and Risk Management in Regulatory Decision-Making", 1997

terms "tolerable", "justifiable" and "negligible" are also used, sometimes to refer to different levels of risk and sometimes interchangeably.

Figure 2.1 Three Region RAC Framework



Where three regions (i.e. two RAC) are used, the intermediate region has been given different names, including "tolerable", "risk reduction desirable", "ALARP" (as low as reasonably practicable), "ALARA" (as low as reasonably achievable). In this report, all these terms are treated as broadly equivalent.

In the USA, the phrases "acceptable", "tolerable" and "negligible" are not used for legal reasons. US criteria use the phrases:

- De manifestis, meaning "obvious" or "significant" risk.
- De minimis, meaning "small enough to be ignored". The term is derived from de minimis non curat lex - "the law does not concern itself with trifles".

Overall, the terms can be sorted into the following groups:

Unacceptable/Intolerable/*De manifestis*	Highest risk
Tolerable/Risk reduction desirable/ALARP/ALARA	↑
Acceptable/Negligible/*De minimis*	Lowest risk

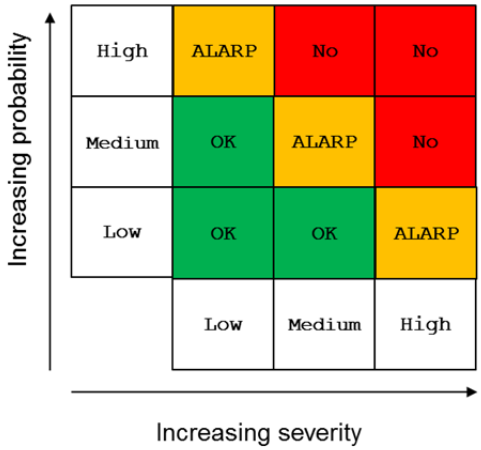
In this report, the terms within each group are treated as interchangeable.

2.7 Types of RAC

The definitions in Section 2.4 are very general, and allow RAC to vary widely in form. In fact, for every metric that can be used to describe a risk, there is a corresponding type of RAC. For clarity in this report the following types of RAC are distinguished:

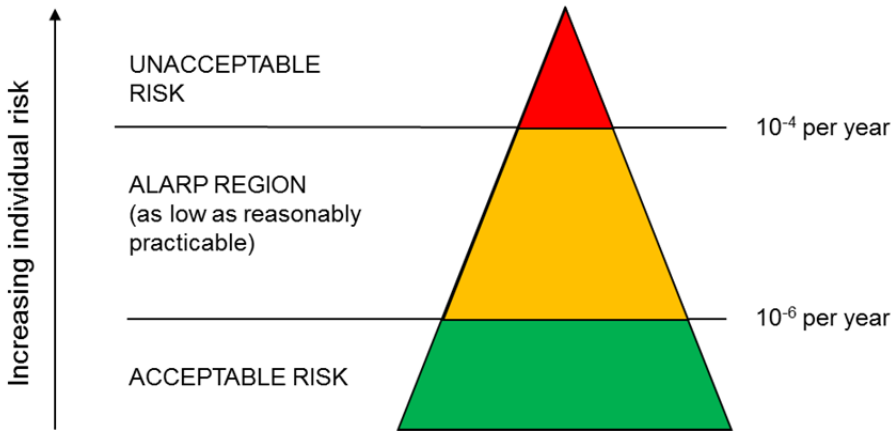
- Risk matrix RAC – showing the acceptable regions on a matrix of accident frequency (or probability) and consequence (or severity) – e.g. Figure 2.2.

Figure 2.2 Risk Matrix Form of Risk Acceptance Criteria



- Individual risk RAC – defining the acceptable level of risk of death to an individual – e.g. Figure 2.3. These can apply to:
    - Location-specific risks, i.e. annual risks at a particular location (often expressed as iso-risk contours)
    - Individual-specific risks, i.e. annual risks in a particular occupation or activity pattern.
    - Journey-specific risks, i.e. risks per journey or per kilometre of travel on a specific route.

Figure 2.3 Individual Risk Form of Risk Acceptance Criteria



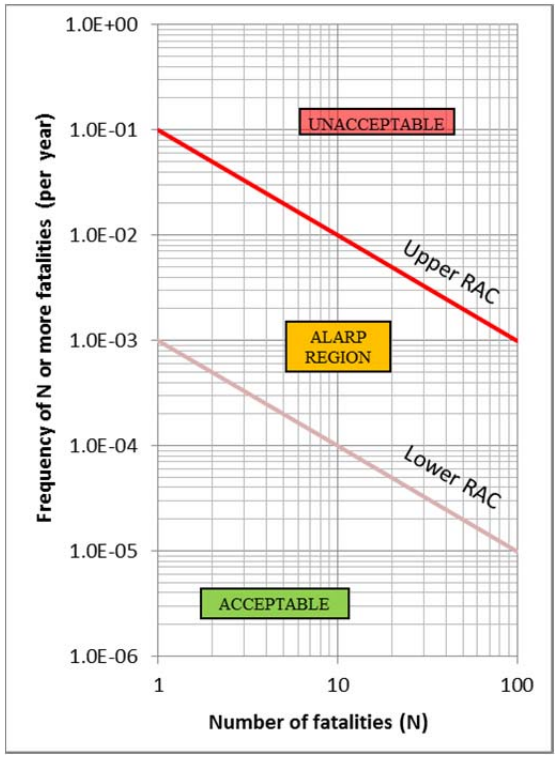
- Societal risk RAC - defining the acceptable level of risk of death to the whole exposed population. These can apply to:
    - Fatalities, i.e. annual number of fatalities in the activity. Where fatalities are rare, this is the mean or expectation value of the probability distribution.

- Fatality rates, i.e. numbers of fatalities divided by suitable measures of exposure such as train-km. These metrics are very similar to the journey-specific individual risks above.

- FN curves, i.e. complementary cumulative distributions of the annual frequency (F) of events causing N or more fatalities – e.g. Figure 2.4.

There are other comparable measures of non-fatality risks such as property damage, financial costs and environmental impacts.

Figure 2.4 FN Form of Risk Acceptance Criteria



- Cost-benefit criteria - defining the acceptable cost of risk reduction measures in a cost-benefit analysis (CBA). Although these do not evaluate the significance of risks directly, and hence are not strictly RAC at all, they do evaluate the need for risk reduction, and are closely connected to RAC; hence they are included in the present study. They can be expressed as:

    - Value of preventing a fatality (VPF) - the monetary valuation allocated to the reduction of one statistical fatality. This is really an input to the CBA, but is often so critical to the evaluation that it is treated here as a type of RAC.

    - Implied cost of averting a fatality (ICAF) - the cost of a measure divided by the expected number of fatalities averted. This is similar to the VPF, but allows the decision-maker to set a RAC for the output of the CBA.

    - Net present value (NPV) - the difference between the discounted benefits and the discounted costs of a measure. A measure is normally recommended if its

NPV is positive. The NPV is considered fundamental in a CBA, although it tends to emphasise large measures.

- Benefit/cost ratio (BCR) - the discounted benefits of a measure divided by the discounted costs. A measure is normally recommended if its BCR is greater than 1. The BCR is useful for ranking measures, although it may be sensitive to effects that are arbitrarily labelled costs or benefit reductions.

- Internal rate of return (IRR) - the discount rate that makes the discounted benefits of a measure equal to the discounted costs, and hence would make its NPV equal to zero. A measure is recommended if its IRR is greater than the usual discount rate. The IRR gives the same ranking as BCR but assumes that costs occur first and benefits later.

- Consequence RAC – defining the acceptable damage effects (e.g. thermal radiation levels, overpressure and toxic concentrations) that a hazard may impose on potentially affected objects, such as houses or commercial premises.
- Qualitative RAC – defining the conditions under which a risk is accepted in any qualitative way. These may include following codes and standards such as ADR/RID/ADN; safety management controls that are required in certain circumstances; procedures for obtaining permission to operate; monitoring of the compliance with requirements; conditions under which risk reduction measures are required, etc.

The category of qualitative RAC is quite broad and in principle might include quality criteria concerning the risk assessment itself, if this is a requirement for a risk to be accepted. Such criteria might include requirements to follow certain approaches to risk assessment, or for the work to be independently verified. These quality requirements are important but are considered outside the scope of the present study.

2.8 RAC and the Risk Assessment Approach

In general, RAC are small but critical elements within a larger methodology that defines how risks are assessed and managed. The metric chosen for the RAC may determine the methodology that is required in the assessment – for example, qualitative RAC or cost-benefit criteria require corresponding qualitative or CBA approaches to the risk assessment. Therefore, in this report, the "approach" refers to the metric for the RAC and the implied approach to the risk assessment. For brevity, the report focusses on harmonising the RAC. In due course, it will be necessary to harmonise the other elements of the risk assessment process once the RAC have been chosen.

3 FUNDAMENTAL PRINCIPLES

3.1 Introduction

Most RAC have developed through a process of expert judgement and political compromise, and consist of elements that may seem arbitrary or inconsistent with other approaches. Before continuing this pragmatic development of existing criteria, it is useful to consider the fundamental principles that could be applied to developing RAC, as this may provide a systematic foundation that helps justify the approach taken.

Section 3.2 therefore considers various sets of principles that have been used in the past for developing RAC, drawing on the relatively few sets of RAC that explicitly declare their underlying principles. From these, a set of principles is selected that would be appropriate to the current application of TDG.

Section 3.3 describes some practical methods of choosing specific values for RAC. Any of these could be used in setting RAC for TDG. These are included because practical methods are sometimes more important than principles in developing RAC.

3.2 Sets of Principles

3.2.1 ICRP Principles

One of the earliest general sets of principles for risk criteria was recommended by the International Commission on Radiological Protection (ICRP)[20]. The basic principles of their safety policy for occupational exposure to ionising radiation in the nuclear industry are:

- Justification of practice - no practice shall be adopted unless it has a positive net benefit.
- Optimisation of protection - all exposures shall be kept as low as reasonably achievable (ALARA), taking economic and social factors into account.
- Equity - individual radiation doses shall not exceed specific criteria.

In this approach, the RAC specify an upper limit on individual risk, qualitative or cost-benefit criteria defining when exposures are ALARA, and a positive NPV for all practices.

3.2.2 Royal Society Principles

A development of the ICRP principles to apply to other industries was proposed by the Royal Society[21], consisting of:

- An upper limit of risk which should not be exceeded for any individual. This implements the ICRP principle of "equity", which ensures that no-one is exposed to undue risk.
- Further control so far as is reasonably practicable, making allowance if possible for aversions to the higher levels of risk detriment. This corresponds to the ICRP principle of "optimisation of protection".
- A cut-off in the deployment of resources below some level of exposure or detriment judged to be trivial. This introduces a new principle of an assessment threshold.

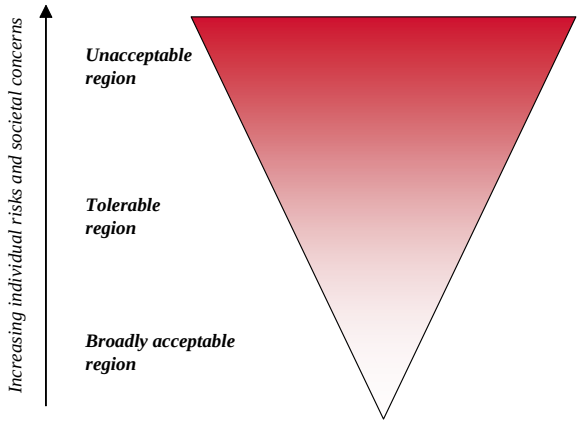
[20] ICRP "Recommendations of the ICRP", International Commission on Radiological Protection, Publication 26, Oxford, Pergamon Press, 1977.
[21] Royal Society "Risk Assessment", Report of a Royal Society Study Group, The Royal Society, London, 1983.

In this approach, the RAC specify upper and negligible limits on individual risk, in between which protection would be optimised.

3.2.3 HSE Tolerability of Risk Framework

The UK Health and Safety Executive (HSE) uses a framework for the tolerability of risk based on the Royal Society's principles (Figure 3.1). This was originally published in 1987 for nuclear power stations[22], but now applies to all health and safety risks for people at work[23].

Figure 3.1 HSE Tolerability of Risk Framework



The framework divides risks into three regions:

- Unacceptable risks – only permitted in exceptional circumstances.
- Tolerable risks – to be kept as low as reasonably practicable (ALARP), taking costs and benefits into account.
- Broadly acceptable risks – not normally requiring further reduction.

In this approach, the RAC specify upper and negligible limits on individual risk, in between which cost-benefit balancing would occur, which could be formal CBA or judgemental reasoning. ALARP thus corresponds to the ICRP principle of "optimisation of protection". This approach has been widely used, although the terminology varies (see Section 2.6).

3.2.4 ACDS Framework

The Advisory Committee on Dangerous Substances (ACDS) of the UK Health & Safety Commission developed a framework for applying the tolerability of risk framework to the transport of dangerous substances[24]. This combined RAC for individual and societal risk, acknowledging the importance of societal risk in transport applications. The societal risk RAC were expressed as FN curves, encapsulating a principle of "aversion to catastrophes".

The framework divided risks into four bands (illustrated for societal risks in Figure 3.2):

- Intolerable risks – above the maximum tolerable risk criteria for individuals or local communities (i.e. equity for individuals and communities).

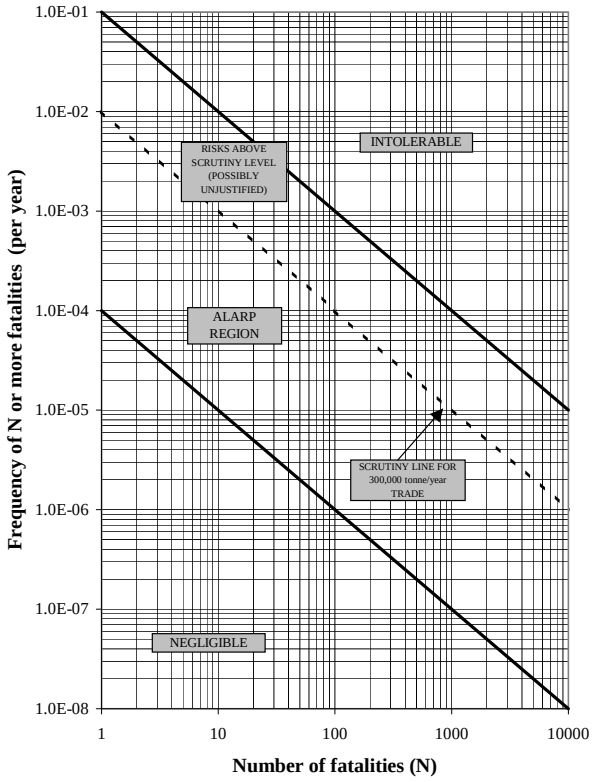
[22] HSE "The Tolerability of Risk from Nuclear Power Stations", Health and Safety Executive, HMSO, 1987.

[23] HSE, "Reducing Risks, Protecting People. HSE's Decision-Making Process", Health & Safety Executive, 2001.

[24] ACDS "Major Hazard Aspects of the Transport of Dangerous Substances", Health and Safety Commission, Advisory Committee on Dangerous Substances, HMSO, 1991.

- Possibly unjustifiable risks – above a scrutiny level, which in principle should reflect the value added by the transport activity, although in practice this was approximated by the tonnage of DGs transported. In this region, further examination of the overall risks and benefits of the activity would be required (i.e. justification of practice).
- ALARP region – risks considered tolerable provided they were as low as reasonably practicable (ALARP). In this region, only the marginal costs and benefits of remedial measures would be examined (i.e. optimisation of protection).
- Negligible risks – not justifying further analysis (i.e. an assessment threshold).

Figure 3.2 ACDS Tolerability of Transport Risk Framework



3.2.5 Basisnet Framework

Since 1984 the Netherlands Ministry of Housing, Physical Planning and the Environment (VROM) has used RAC for evaluation of external safety risks. They cover two types of risk, each reflecting different underlying principles:

- Individual risk RAC protect individuals against hazards (i.e. equity requirements).
- FN RAC protect society against the occurrence of major accidents (i.e. aversion to catastrophes).

The Netherlands Ministry of Infrastructure and Environment is currently implementing legislation on a base transport network (Basisnet) for transport of dangerous goods. The purpose of this is stated to be[25]:

[25] OTIF "New Legislation in the Netherlands: Basisnet (Base transport network)", INF.3, 51st Session of the Committee of Experts on the Transport of Dangerous Goods, Berne, 2012

- Guarantee the accessibility of the main industrial sites in the Netherlands and abroad (i.e. protection of transport).
- Ensure important spatial developments (i.e. protection of development).
- Provide a basic level of safety for local residents (i.e. protection of safety through the individual and societal risk criteria above).

Further details on the RAC themselves are given in Section 4.3.5 below.

3.2.6 GAME Safety Principle

The Government of France adopted the GAME (Globalement au moins équivalent) principle, expressed as follows[26]:

> *"Any change to an existing system, and the design and manufacture of a new system, must be carried out in such a way that the resulting global level of safety is at least equivalent to the existing level, or as existing systems which provide comparable services or perform comparable functions."*

This could be described as a principle of "equivalence". However, the implicit aim is to encourage improvement in safety by prohibiting any regression. By referencing a global level of safety, the GAME principle allows flexibility in how the improvement is achieved. The underlying principle is therefore considered to be "continuous improvement". However, it does not guarantee that this is achieved, as it depends on which systems are chosen for the comparison.

3.2.7 European Railway Safety Framework

The European Railway Safety Directive[27] adopted the following objective:

> "*Member States shall ensure that railway safety is generally maintained and, where reasonably practicable, continuously improved.*"

This principle of "continuous improvement" includes the principle of optimisation of protection, implied by the reasonable practicability test. Its interpretation (see Section 4.5 below) uses accident rate measures that keep the individual risk constant (or reducing where cost-effective) while allowing societal risk to increase if traffic is growing.

3.2.8 EUROCONTROL Safety Strategy

The European Organisation for the Safety of Air Navigation (EUROCONTROL) adopted a safety objective for air traffic management (ATM) as follows[28]:

> *"To improve safety levels by ensuring that the numbers of ATM induced accidents and serious or risk bearing incidents do not increase and, where possible, decrease."*

This is a principle of "continuous improvement". Its interpretation is interesting, because aviation is a field where traffic is increasing. It judges that the current of number of accidents in effect defines the maximum tolerable level of societal risk, and hence no increase can be tolerated whatever the increase in traffic. Therefore, as the number of flights increases, the accident risk per flight must *reduce* in proportion to the traffic increase. This ensures that individual risk reduces while societal risk remains constant. This is a very demanding target

[26] Decree No 2000-286 of 30 March 2000 concerning safety of the national rail network.
[27] EC Directive 2004/49/EC on safety on the Community's railways.
[28] EUROCONTROL, "Air Traffic Management Strategy for the Years 2000+", 2003.

for a growing industry, especially since collisions tend to grow in proportion to the square of the traffic.

3.2.9 Principles Selected for TDG

The following proposes a set of principles to underpin the RAC for TDG, combining the approaches described above. They are intended to be valid for any activity that involves risks of accidents:

1. Justification of activity – the risks of the activity should be justified by its benefits (in terms of goods transported, value added, jobs etc) for the society as a whole. This is particularly important for countries who are exposed to transport risks without benefitting from the production or consumption of DGs.
2. Optimisation of protection – the risks should be minimised by appropriate safety measures, taking account of their benefits (in terms of risk reduction) and costs, and also of established good practice.
3. Equity – the risks should not be unduly concentrated on particular individuals or communities.
4. Aversion to catastrophes – the risks of major accidents (including multiple-fatality, high cost or widespread impacts) should be a small proportion of the total.
5. Assessment threshold – negligible risks should be exempted from detailed assessment.
6. Continuous improvement – overall risks should not increase, and preferably should reduce.

It is recognised that, when resources are limited, the principles may be in conflict with each other. For example, reducing catastrophe risks may introduce greater risks from low-consequence accidents[29]. Resolution of such conflicts would require political rather than technical judgement.

The implementation of these principles through specific RAC is considered in Section 5.2 below. The following section considers the practical ways in which RAC could be set.

3.3 Practical Development of RAC

3.3.1 Based on Historical Risks

One of the simplest approaches to setting quantitative RAC is to base them on the risk levels that have been achieved by the activity in the past, as revealed by statistical analysis of previous accidents. It is particularly appropriate when accidents are frequent and the risk estimates themselves are based largely on modifications of historical accident statistics.

A possible form of criterion using this approach would be as follows:

The predicted risk for an activity should be at least a factor of 2 lower than the historical average.

The factor of 2 in the example above is illustrative of an approach intended to ensure that new activities achieve greater safety than existing ones.

[29] Evans, A.W. & Verlander, N.Q., "What is Wrong with Criterion FN-Lines for Judging the Tolerability of Risk?", *Risk Analysis*, vol17 no2 1997.

The advantages of basing RAC on historical accident experience are:

- The criteria are clearly based on performance already achieved, and hence are readily comprehensible to workers, managers and the public.
- The approach implements the "continuous improvement" principle from Section 3.2.
- The approach has been used successfully in rail, road and aviation transport (see Sections 4.5, 4.6 and 4.7.3).
- The approach can be extended to apply to individual TDG trades, routes or equipment types. For example, an operator could specify a failure rate for a new chlorine tanker in terms of a specific improvement over the performance achieved by existing units.

The disadvantages of this approach are:

- Clearly, it can only be used where accident experience has already been accumulated. This gives it one of the disadvantages of a reactive approach to safety management.
- The approach is most appropriate for accidents that occur relatively frequently. For example, the historical data on catastrophic accidents is very sparse, and is difficult to use to establish criteria.
- The approach is difficult to use in cases where the risk metric is increasing due to greater activity. Possible approaches are considered in Appendix II.6.2.
- Historical risks are uncertain. The statistics tend to fluctuate as accidents occur, and hence the values may be sensitive to the time period over which they are averaged. They may also be affected by incomplete reporting, or differences in environmental conditions or operating standards.
- The reduction factor between the historical risk and the acceptable risk is entirely judgemental. However, such arbitrary judgements are invariably required in RAC.
- The idea that an acceptable risk can be based on an average historical risk is open to question. A risk may be accepted due to lack of awareness, but once attention is called to it, it may then be seen as unacceptable. This is one reason for applying a reduction factor to the historical risks.

Overall, this approach works best where high quality data has been collected from the activity in question.

3.3.2 Based on Background Risks

A common approach to setting quantitative RAC is to base them on risks experienced in other industries or in daily life. This is particularly useful in searching for generally agreed standards across all industries. These are known as comparative or equity-based risk criteria.

A possible form of criterion using this approach would be as follows:

> The individual risk of death for members of the public from an activity should be no more than 5% of the total risk of death for the lowest risk age group in the society.

The choice of 5% in the example above is purely arbitrary. Values such as 50% or 0.5% could equally well have been used.

The advantages of basing criteria on risks experienced in other industries or in daily life are:

- The approach can be used to achieve consistency between industries and countries.
- It has been used successfully by regulators in the UK and the Netherlands (see Section 4.3). It is also the basis of the MEM (minimum endogenous mortality) principle.
- The approach implements the "equity" principle from Section 3.2.
- It is pro-active, because it does not require accidents to occur before risk criteria can be set.

The disadvantages of this approach are:

- Background risk data may not be appropriate for industrial risks.
- The choice of appropriate data on which to base the criteria is invariably arbitrary.
- The reduction factor between the background risk and the acceptable risk is entirely judgemental.
- Background risks are different in different countries, but it is open to question whether the same should apply to multi-national industries.

As a result of these problems, RAC are usually set by a series of political judgements, rather than from the background data. Nevertheless, this may be used to ensure that the criteria are reasonable. This approach suits types of risk that are common to hazardous industries and daily life, such as individual risks of death.

3.3.3 Based on Reference Cases

Where activities are already accepted, and other similar ones are to be evaluated, it is possible to use the accepted ones as reference standards, and ensure the others do not exceed their risks. This approach is commonly used for technical systems.

A possible form of criterion using this approach, which is embedded in the GAME principle (Section 3.2.6), is as follows:

The predicted risk for a new system should be no higher than the risk for an existing comparable system.

The advantages of basing criteria on reference cases are:

- This approach is suitable for industries creating many similar situations, such as TDG.
- It has been used successfully for road tunnels (see Section 4.4) and railway systems.
- The acceptability of the first case can be decided through detailed analysis and political negotiation. Subsequent cases can be evaluated in a much simpler process of comparison.
- The approach is pro-active, because it does not require accidents to occur before risk criteria can be set.

The disadvantages of this approach are:

- The approach is only possible when the acceptability of a reference case has already been evaluated through some other approach.

- The idea that an acceptable risk can be based on an existing risk is open to question. A risk may be accepted due to lack of awareness, but once attention is called to it, it may then be seen as unacceptable.
- The evaluation may be sensitive to the choice of the reference case, as different comparable systems may have different risks. This opens the approach to bias (whether deliberate or perceived) if a high-risk reference case is chosen.
- The case being evaluated may not correspond precisely with the reference case, so that the evaluation may be inappropriate.
- Simple comparison of risks is not necessarily possible, e.g. when two FN curves intersect.

3.3.4 Based on Economic Analysis

Cost-benefit criteria are usually developed through standard economic techniques used in CBA.

Criteria such as NPV, BCR and IRR all depend on the discount rate, which can be set as a matter of government policy.

The value of preventing a fatality (VPF) or the ICAF criterion can be set through techniques such as:

- Human capital approaches. These estimate the VPF in terms of the future economic output that is lost when a person is killed. This may be in terms of gross output (in effect, the lifetime salary) or net output (in effect, the lifetime tax payments). This narrow economic approach is now largely discredited, since it is recognised that people value life for its own sake rather than for its capacity to maintain economic output.
- Willingness-to-pay (WTP) approaches. These estimate the amount that people in society would be prepared to pay to avoid a statistical fatality. There are two main types:
    - The "revealed preference" approach uses observed behaviour, such as wage differentials for riskier jobs.
    - The "contingent valuation" or "stated preference" approach uses expressed opinions on hypothetical situations in questionnaires. This approach is widely used, and a recent meta-analysis[30] evaluated 900 studies with a median VPF of $2.8m (2005 prices).
- Life quality approaches. These are based on social indicators of quality of life that reflect life expectancy and GDP. By relating the costs of a measure to the GDP and the risk benefits to life expectancy, it is possible to identify the point at which further safety measures have a negative overall impact on the quality of life. This negative impact can arise because safety measures divert expenditure from other uses, which include health care and other expenditure which extend life expectancy by indirect routes. The optimum VPF ensures that safety measures are only recommended when

[30] OECD, "Valuing lives saved from environmental, transport and health policies: a meta-analysis of stated preference studies", ENV/EPOC/WPNEP(2008)10/FINAL, Organisation for Economic Co-operation and Development, 2010.

their direct benefit exceeds the lost indirect benefit of the expenditure that they require. This is approximately $2 to 4m among OECD countries[31].

Although VPFs could be based on original research of these types, they are more commonly chosen from the ranges indicates by previous research. Since VPFs are widely used in CBA of road and rail transport, a VPF for TDG may be developed simply by choosing the appropriate existing value.

3.3.5 Based on Expert Judgements

Qualitative RAC can only be set through expert judgement. They are usually the result of negotiation between stakeholder groups.

Most quantitative RAC that are used in practice have evolved through an iterative process, which may have started from one of the approaches above, but is usually dominated by negotiation between stakeholder groups. This typically results in RAC that seem arbitrary from a technical point of view, but are in fact carefully chosen to achieve risk evaluations that conform to stakeholder expectations. In this case, quantitative RAC can be seen as standards that align QRA results to qualitative expert judgements about the risk. The absence of a rigorous technical justification is not a particular weakness, because all the formal approaches above involve arbitrary factors and choices too.

[31] Skjong, R. & Ronold, K.O., "So Much for Safety", Offshore Mechanics and Arctic Engineering (OMAE), Oslo, Norway, 23 - 28 June, 2002

4 EXISTING APPROACHES

4.1 Survey of Practice

4.1.1 Methodology

To understand the existing approaches to RAC for TDG that are in use in the EU, a survey of current practice was carried out. DNV contacted 232 experts, representatives of the EU Member States (MS) plus Norway and Switzerland, and representatives of the transport and dangerous goods industries. The survey was designed to be concise and easy to complete. It was intended to capture what RAC were employed and to then provide a means of exploring this further should it be warranted. A full description of the survey methodology is provided in Appendix I.

4.1.2 Response

A response was received from 86% of the countries contacted. The responses covered all countries with significant movement of dangerous goods, with the exception of Poland. It is concluded that the survey responses give comprehensive coverage of the use of RAC in deciding on restrictions to the TDG in the EU, Norway and Switzerland. The full survey results are included in Appendix I.

4.1.3 Analysis

The first observation that is evident from the responses is that the transport of dangerous goods is not managed in a consistent way either within MS or between them. Some countries (such as Belgium) provided separate responses to the survey by transport mode in which differing departments are separately responsible, whilst others (such as Ireland) indicated that the management of dangerous goods varies by the classification of the goods. Transport of dangerous goods by rail was particularly well represented in the survey responses partly because each MS has, under EU law, a dedicated safety authority for rail, but there is no equivalent in road and inland waterways. Indeed for road the responses came not only from road authorities but also civil emergency planning authorities and general transport ministries.

Whilst this distribution of responsibility undoubtedly represents that country's view of how dangerous goods risk should best be managed, it does indicate a wide and diverse set of opinions. Often each transport mode is treated separately and the issue may be viewed as one of general transport, land use planning, civil emergency or economics. Additionally it appears that little link is made to the requirements of the Seveso Directive (see Section 4.3.1 below) and that the transport of dangerous goods is not considered on an end-to-end or transport corridor basis.

The central questions in the survey relate to whether the country uses RAC in deciding to impose additional restrictions on TDG beyond those in ADR, ADN and RID. Table 4.1 presents DNV's summary of the responses, which is necessarily highly simplified. The responses are gathered into three broad groups, as explained below.

Table 4.1 – DNV's Interpretation and Simplified Summary of the Survey Results

RAC	Count	Country	Comment
No Restrictions, No RAC	7	Bulgaria, Czech Republic, Estonia, Greece, Hungary, Latvia, and Slovakia	In effect RAC is harmonised between all seven Member States as all rely solely on the provisions in ADR, AND and RID and do not make use of chapter 1.9.
Some Restrictions, Implicit RAC	6	Finland, Ireland, Lithuania, Romania, Spain, and Sweden	Expert judgement is applied at a local level.
	1	Belgium	Expert judgement is applied at a local level. The Flemish region of Belgium is currently engaged in a project to develop a quantitative approach and associated RAC.
Some Restrictions, Explicit RAC	2	Denmark and Italy	RAC are applied to specific projects.
	1	United Kingdom	Impact analysis reflecting the prevailing government policy is employed.
	1	Channel Tunnel Safety Authority	Qualitative approach comparing DG with non-DG traffic on the same route.
	1	France	A risk matrix exists but no RAC are defined in law. Comparison is made to other routes to determine the need for restrictions.
	1	Norway	Risk methodologies are used but no formal RAC exist. Comparison is made to other routes.
	1	Germany	A risk methodology is employed for road tunnels and RAC are provided in guidance/research report, but not in law.
	1	Portugal	Simple risk threshold.
	2	Austria and Slovenia	Quantitative RAC for road tunnels based upon individual risk. RAC and risk methodology fully harmonised between the two countries.
	2	Netherlands and Switzerland	Quantitative RAC based upon societal and individual risk.

Seven MS reported no use of RAC and no additional restrictions beyond those in ADR, ADN and RID.

Another seven MS reported some restrictions on TDG, but no specific RAC. They are considered to use implicit RAC, comprising local judgement based decision making, to determine if a restriction is required. Among this group, the Flemish region of Belgium is developing a systematic quantitative risk assessment methodology but has not yet selected any RAC.

Eleven countries (9 MS plus Norway and Switzerland) and the Channel Tunnel Safety Authority reported using explicit RAC, although the forms of these varied widely. The Netherlands and Switzerland both use quantitative RAC for transport, as do Austria and Slovenia for road tunnels. Portugal reports the use of a simple risk threshold but no further details are available at present. France, Norway and Germany employ risk assessment but currently this is used to inform a decision only and no RAC are legally mandated. Denmark, Italy and the Channel Tunnel Safety Authority have compared TDG risk to that of the same transport corridor without dangerous goods on it or to an already existing corridor that is deemed acceptable, but the RAC are chosen for each study individually. In the UK an impact analysis is used to evaluate specific restrictions in line with the prevailing government policy. In the terminology of Section 2.7, this is a type of cost-benefit criterion.

4.1.4 Validation

In order to validate the survey responses, DNV surveyed the transport restrictions on the transport of dangerous goods that are published across Europe. These restrictions all concern road or rail transport, as no additional restrictions have been notified for the transport for dangerous goods by inland waterway. A full description of the survey of restrictions is included in Appendix I.

In nearly all cases, the published restrictions were consistent with the responses to the corresponding survey question, indicating that this question at least had been correctly understood. For one MS, DNV's interpretation of the survey response has been amended to take account of the published restrictions.

In general the published restrictions have no risk-based justification associated with them and vary widely between MS for the same hazards. For those MS using RAC it is not obvious how the restriction contributes to the achievement of the RAC. This suggests that even those MS that make use of RAC do not do so transparently or consistently.

4.2 Literature Review

A literature review was conducted to give further information on the possible approaches that could be used for harmonised RAC, including:

- More specific information on the RAC that were reported in the survey in Section 4.1.
- Historical information on the development of RAC in MS.
- RAC used in major hazard installations and non-DG road and rail transport.
- RAC used in other industries, including aviation and maritime transport.
- RAC used in other countries world-wide.

The results of this review are presented in the following sections, defining the specific RAC that have been used.

In the absence of a harmonised approach, the existing approaches have developed in different ways in different fields. The review follows this structure, and distinguishes:

- Major hazard RAC covering fixed installations and TDG (Section 4.3)
- Tunnel RAC (Section 4.4)
- Rail transport RAC (Section 4.5)
- Road transport RAC (Section 4.6)

- Other transport RAC (Section 4.7)

These approaches are considered in turn below. Based on this review, Section 4.8 selects a set of candidate approaches for more detailed evaluation in Section 5.

4.3 Major Hazard RAC

4.3.1 EU Seveso Directive

The Seveso Directive[32] is the main European legislation governing the safety of industrial activities involving DGs. It only applies to fixed installations, which exceed threshold quantities of various substances. It explicitly excludes TDG, defined as follows:

> "*The transport of dangerous substances and intermediate temporary storage by road, rail inland waterways, sea or air, outside the establishments covered by this Directive, including loading and unloading and transport to and from another means of transport at docks, wharves or marshalling yards*".

The Directive requires a Safety Report, which describes the probabilities and consequences of major accident scenarios, but does not need explicit risk measures or RAC. It requires measures to limit the consequences of major accidents, and requires MS to adopt land-use planning to maintain appropriate safety distances around establishments. Different MS have adopted different methods of setting distance requirements[33]:

- Risk-orientated quantitative approach, with individual or societal risk RAC for various land-use categories.
- Semi-quantitative approach, with risk matrix RAC representing the compatibility of frequency and consequence combinations with land-use categories.
- Consequence-oriented approach, with damage effect RAC defining the required separation from land-use categories.

The approaches in selected countries are described below.

4.3.2 Belgium

The Government of the Flemish Region of Belgium has established RAC for its implementation of the Seveso Directive[34]. It has also been developing a risk analysis system for TDG[35], which is intended to support decision-making, but it does not yet include explicit RAC.

Individual risk RAC have been established for land-use planning. Where the 10^{-5} risk contour passes outside the boundary of the establishment, a safety information plan is required to exchange information about risks with other establishments in the area. For risks in the range 10^{-7} to 10^{-5}, various land uses are permitted. Risks below 10^{-7} are in effect treated as negligible.

The maximum acceptable societal risk for installations is expressed on an FN diagram as $F<0.01/N^2$ for $10 \leq N \leq 10000$ fatalities. No societal risk RAC apply for $N<10$ fatalities. No

[32] Council Directive 96/82/EC of 9 December 1996 on the control of major-accident hazards involving dangerous substances.

[33] JRC, "Overview of Roadmaps for Land-use Planning in Selected Member States", Joint Research Centre, European Commission EUR 23519, 2008.

[34] Duijm, N.J., "Acceptance Criteria in Denmark and the EU", Danish Ministry of the Environment, project 1269, 2009.

[35] Bogaert, M., Imbrechts, K. & Grooten, L., "New Flemish Approach for Risk Analysis System for the Transport of Dangerous Goods", Chemical Engineering Transactions, vol 31, 2013.

accidents are permitted with N>1000 fatalities. This excludes people working at the establishment itself.

The Walloon Region of Belgium has also established RAC for its implementation of the Seveso Directive[36]. The 10^{-6} risk contour defines a consultation zone, within which certain types of buildings (e.g. schools, hospitals and nurseries) are not permitted. Houses are not permitted within the 10^{-5} risk contour. Societal risk is not taken into account.

4.3.3 France

France has adopted a semi-quantitative approach to managing the risk from hazardous installations. Although it is not used for transport directly is nevertheless applied to temporary stop areas such as marshalling yards.

The risk from each hazard is described by its probability of occurrence and the number of people exposed to lethal or irreversible effects. The RAC are expressed in a matrix where each combination of probability and consequence is characterised as acceptable or not. The matrix for fixed installations, shown in Figure 4.1[37], includes an ALARA region in which plants can be approved once all practicable safety measures are implemented. The corresponding matrix for temporary stop areas is to be divided into three similar zones representing the priority of risk reduction, but the precise boundaries (i.e. the RAC) are not specified[38].

Figure 4.1 Risk Matrix Criteria in France

Seriousness / *Frequency class*	*Moderate*	*Serious*	*Major*	*Very major*	*Disastrous*
A	ALARA	No	No	No	No
B	OK	ALARA	No	No	No
C	OK	ALARA	ALARA	No	No
D	OK	OK	ALARA	ALARA	No
E	OK	OK	ALARA	ALARA	No

4.3.4 Germany

Germany has adopted the consequence-oriented approach to managing hazardous installations[39]. The approach is based on consequence calculations in specific release scenarios, with damage effect RAC including thermal radiation of 1.6kW/m^2, overpressure of 0.1 bar, and toxic concentrations equal to the EPRG-2 value for the substance [40] . When detailed consequence calculations are not available, standard separation distances are specified for individual DGs.

[36] Delvosalle, C. et al, "Land Use Planning around Seveso sites in Walloon Region (Belgium)", CHISA, Praha, 2006, cited in Beaudoint, D. et al, "Analysis and modelling of risk associated with the transport of hazardous materials in Walloon Region (Belgium)", ESREL 2012.

[37] Duijm op cit

[38] MEDDE, "Circulaire du 19 novembre 2012 relative aux mesures de maîtrise des risques et au porter à connaissance à metre en œuvre dans le cadre des études de dangers remises en application de l'article L.551-2 du code de l'environment", Ministère de L'Écologie, du Développement Durable et de L' Énergie.

[39] Duijm, op cit.

[40] EPRG, "Emergency Response Planning Guidelines".

4.3.5 The Netherlands

In the Netherlands, two RAC are applied to regulate the external safety of an activity (i.e. the risks it imposes on people nearby who are not involved in the activity itself). These are individual risk and societal risk criteria. The criteria for fixed installations were implemented in a Statutory Decree[41]. Corresponding legislation for the base transport network (Basisnet) is under development at present[42]. RAC are published by the Ministry of Infrastructure and the Environment[43].

The maximum acceptable individual risk is 10^{-6} per year. This is a statutory limit for "vulnerable objects" (i.e. housing, hospitals, schools etc), and a target to be achieved as far as possible for "less vulnerable objects" (i.e. shops, offices, recreational facilities). This applies equally to risks from fixed installations and TDG. It is calculated for an unprotected person (i.e. outdoors) present all year at specific locations.

There is also a requirement for risks to be made as low as reasonably achievable (ALARA) in addition to meeting the individual risk RAC. This applies to fixed installations but does not apply to transport. It is recognised that in some cases a balancing of interests may lead to acceptance of a risk higher than 10^{-6} per year[44].

The maximum acceptable societal risk for fixed installations is expressed on an FN diagram as 10^{-5} per year for 10-fatalities, with $F=10^{-3}/N^2$ for higher fatalities. It does not apply for fewer than 10 fatalities. The calculation of societal risk takes account of occupancy patterns and protection through being indoors. It excludes people employed or visiting the risk source, but includes employees of neighbouring facilities, depending on their emergency response arrangements. It also excludes people on roadways, in train stations and public areas such as parks[45].

The corresponding societal risk RAC for transport is expressed on an FN diagram as 10^{-4} per year for 10-fatalities, with $F=0.01/N^2$ for higher fatalities. This includes all people involved in the accident (i.e. road/railway/waterway users and nearby residents and workers) but does not include the workers involved in the activity (i.e. vehicle/train/barge crew). It refers to a single kilometre of route, which implies that 100m of transport route is given the same RAC as a fixed installation. It is applied to all transport modes (road, rail, inland waterway and pipeline). In order to minimise risk calculations, it is applied only to the highest-risk kilometre of each route, which is identified in a simplified way using the consequence area and the surrounding population density.

The societal risk RAC is applied in a less strict way than the individual risk RAC. It is a guide intended to promote risk reduction, but the competent authority may decide to accept higher risks. The Basisnet approach identifies parts of routes where the individual risk may be restricted to 10^{-7} per year or 10^{-8} per year, to avoid unacceptable societal risks. Voluntary agreements are made with TDG operators to improve safety, and with land-use developers to mitigate any increases in societal risk.

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41 Decree on External Safety of Installations (Besluit externe veiligheid inrichtingen – BEVI), 2004.

42 OTIF "New Legislation in the Netherlands: Basisnet (Base transport network)", INF.3, 51st Session of the Committee of Experts on the Transport of Dangerous Goods, Berne, 2012.

43 http://www.rws.nl/zakelijk/veiligheid/rbmii/beleid/index.aspx

44 Bottelberghs, P.H., "External Safety Policy in the Netherlands", PAO course, 1996.

45 CCPS op cit p66

Other restrictions apply to TDG in the Netherlands which do not come directly from risk evaluation, but could be considered qualitative types of RAC:

- Safety zoning of about 30m is applied based on the dimensions of a pool fire.
- For chlorine transport by rail, operational requirements include speed limitation, train composition, supervision and notification.

4.3.6 Spain

In Spain the risks from TDG are managed by restricting DG to certain specified routes, or prohibiting them in certain time-frames (see Task 1 report). These are types of qualitative RAC. The following is an example RAC of this type[46]:

> "*Trains carrying dangerous goods must necessarily use, where available, the lines that circumambulate populations except when they have to make loading and unloading operations in these populations.*"

4.3.7 Switzerland

In Switzerland, the Ordinance on Major Accidents[47] requires assessment of risks to the public and the environment from fixed installations and DG transport, including railway installations, transit roads and the Rhine (when used to transport or trans-ship DGs). The Swiss Federal Office for the Environment[48] has published societal risk RAC:

- Upper RAC: $F=10^{-3}/N^2$ for $10 \leq N \leq 10{,}000$ fatalities
- Lower RAC: $F=10^{-5}/N^2$ for $10 \leq N \leq 1000$ fatalities

For risks between these RAC the ALARP principle is applied, with safety measures adopted where cost-effective. The same criteria are applied to fixed installations and to 100m sections of road tunnels.

4.3.8 United Kingdom

In the UK the Health and Safety Executive (HSE) has published tolerability limits[49] for use with the tolerability of risk framework (Figure 3.1). The RAC for individual risk are:

- Maximum tolerable risk for workers 10^{-3} per year
- Maximum tolerable risk for the public 10^{-4} per year
- Broadly acceptable risk 10^{-6} per year

They apply to any industrial activity. Their applicability to TDG was confirmed in a study by the Advisory Committee on Dangerous Substances (ACDS)[50].

These are considered to be guidelines, not rigid criteria to be complied with in all cases, and may be adapted to take account of societal concerns. The criterion for workers refers to "any substantial category of workers for any large part of a working life", and hence might be

[46] Royal Decree 412/2001 dated April 30.

[47] Swiss Federal Council, Ordinance on Protection Against Major Accidents, 1991.

[48] BAFU (Swiss Federal Office for the Environment), "Beurteilungskriterien zur Stöfallverordnung StFV", 2001, cited in PIARC, "Current Practice for Risk Evaluation for Road Tunnels", 2012.

[49] HSE, "Reducing Risks, Protecting People. HSE's Decision-Making Process", Health & Safety Executive, 2001.

[50] ACDS "Major Hazard Aspects of the Transport of Dangerous Substances", Health and Safety Commission, Advisory Committee on Dangerous Substances, HMSO, 1991.

exceeded by "fairly exceptional groups". The criterion for workers is based on the risk experienced by the highest risk groups of workers.

In the ALARP region between the maximum tolerable and negligible RAC, risks are kept as low as reasonably practicable (ALARP). Legal precedent established that, in order to make risks ALARP, risk reduction measures should be adopted unless their cost is "grossly disproportionate" to the benefit gained. This requires a transparent bias in favour of safety when computing costs and benefits. HSE has not specified how this should be done, but indicated that it uses the valuation of statistical fatalities from road transport as a benchmark but regards "higher values as being appropriate for risks for which people appear to have a high aversion"[51].

HSE suggested a societal risk criterion for major industrial installations, such as an existing chemical plant near to a housing estate, as a maximum tolerable frequency of 2×10^{-4} per year for accidents causing 50 fatalities or more. This applies to "a single major industrial activity from which risk is assessed as a whole, such as all chemical manufacturing and storage units within the control of one company in one location or within a site boundary, a cross-country pipeline, or a railway line along which dangerous goods are transported"[52]. This RAC does not appear to be used in practice, and subsequent efforts to develop societal risk criteria have not reached agreement.

ACDS developed societal risk criteria for communities affected by TDG, e.g. people living near a port.

- Maximum tolerable risk $F=0.1/N$
- Negligible risk $F=10^{-4}/N$

The upper RAC was based on the estimated risk levels at the Canvey Island oil and gas complex[53], which were considered just tolerable. The lower RAC was based on the cost of a committee considering the risk.

For port risks, ACDS used a "scrutiny level" to indicate the justifiable societal risk in small trades and also in the overall national traffic in bulk dangerous goods. This was scaled from the tolerable line at Canvey Island, according to the annual tonnage of dangerous goods shipped. The intercept of this line with N=1 was 3.2×10^{-8} per tonne/year, within the range 10^{-4} to 10^{-1} per year. This is illustrated in Figure 3.2 for an example port (or a single trade in a port) handling 300,000 tonnes per year of dangerous goods.

For ports that exceeded the scrutiny level, a fundamental assessment was required, to see whether the risks were justified by the benefits of the trade. Below it, in the ALARP region, only marginal costs and benefits of risk reduction measures were examined. A cost of £2m per fatality averted was used to indicate where risk reduction measures were "reasonably practicable". The ACDS approach was used to evaluate all major ports in Great Britain, but has not been used since.

[51] HSE "Reducing Risks, Protecting People" op cit, p36.

[52] ibid p47.

[53] HSE, "Canvey - A Second Report. A View of Potential Hazards from Operations in the Canvey Island/Thurrock Area 3 Years after Publication of the Canvey Report", Health and Safety Executive, HMSO, 1981.

4.4 Tunnel RAC

4.4.1 Austria

In Austria, the Federal Ministry for Transport, Innovation and Technology (BMVIT) has defined a complete procedure for risk assessment of DG in road tunnels using the program DG-QRAM[54].

Stage 1 of the procedure is based on an expected value of 1 x 10^{-3} fatalities per year. This is used to populate a matrix that screens out tunnels requiring no further analysis. In effect, this is an assessment threshold.

Stage 2 compares the estimated FN curve of the tunnel to a societal risk RAC, defined as $F=0.1\ L^{0.5}/N^2$. This is only applied in the region N>10 fatalities. It takes account of the tunnel length (L in km), but is less than proportional to it. If any part of the FN curve exceeds this line, additional risk reducing measures are investigated. It is not clear on what basis these measures are selected, but it is presumed to be expert judgement.

Previous suggestions by the Austrian Commission for Tunnel Safety[55], consisting of two societal risk RAC, dividing risks into non-tolerable, ALARP and tolerable regions, and extending to N=1, have apparently been abandoned.

Stage 3 considers alternative routes for DG where the tunnel risks are considered intolerable. In general, an existing transport activity is allowed to follow the route with the lowest risk.

4.4.2 Czech Republic

In the Czech Republic the following RAC have been recommended for road tunnels[56], although there is no legal requirement:

- Upper RAC: $F=0.1/N$ for $1 \leq N \leq 1000$ fatalities
- Lower RAC: $F=10^{-4}/N$ for $1 \leq N \leq 1000$ fatalities

For risks between these RAC the ALARP principle is applied, with safety measures adopted where cost-effective. The criteria are for a 1km long tunnel, and in effect are proportional to tunnel length. They apply to the overall risk from all the traffic using it.

4.4.3 Denmark

RAC were used to help manage the risks on the Øresund link tunnel and bridge connecting Denmark and Sweden[57]. The risk policy required the average individual risks for users to be comparable to Danish/Swedish motorways/railways having similar length and traffic intensity. This covered all risks, not just TDG. The main RAC were for individual risk:

- For road: 33 fatalities per billion passages of the Link
- For rail: 4 fatalities per billion passages of the Link

In addition, FN criteria were applied with an ALARP region in-between:

[54] Diernhofer, F., Kohl,B. & Hörhan, R., "New Austrian Guideline for the Transport of Dangerous Goods through Road Tunnels", 5th International Conference on Tunnel Safety and Ventilation, Graz, 2010.

[55] Knoflacher, H. & Pfaffenbichler, P.C., "A Comparative Risk Analysis for Selected Austrian Tunnels", International Conference on Tunnel Safety and Ventilation, Graz, 2004.

[56] Holicky, M., "Kriteria rizik silnicnich tunelu", Ceska silnicni spolecnost (Czech Road Society), Silnicni obzor, vol 67, no 11, cited in PIARC, "Current Practice for Risk Evaluation for Road Tunnels", 2012

[57] PIARC, "Towards Development of a Risk Management Approach", 2010.

- Upper RAC: $F=0.4/N^2$
- Lower RAC: $F=0.004/N^2$

Since the Link opened in 2000 the risk profile has exceeded the upper FN RAC and the rail individual RAC. It appears the RAC were used to guide risk reduction effort rather than to determine acceptability.

4.4.4 France

In France, a 2-stage methodology is used for the evaluation of DG transport in road tunnels[58].

Stage 1 is based on an expected value of 1.0×10^{-3} fatalities per year, used to screen out tunnels for which no DG restrictions are required.

Stage 2 compares the risks for the tunnel with various safety measures and alternative routes, but no specific RAC are prescribed.

4.4.5 Germany

In Germany, a methodology for the evaluation of DG transport in road tunnels was developed in a research project by the Federal Highway Research Institute[59], but this is not legally binding.

Stage 1 of the procedure is based on an expected value of 6.2×10^{-3} fatalities per year per kilometre of tunnel. This is also split into different accident scenarios. It is used to screen out tunnels for which no DG restrictions are required.

Stage 2 compares the estimated FN curve of the tunnel to a societal risk RAC, defined as $F<0.01\ L\ /N^2$. This is only applied in the region $10<N<1000$ fatalities. It takes account of the tunnel length by normalising to a 1 km length. If any part of the FN curve exceeds this line, additional risk reducing measures are investigated. Otherwise no DG restrictions are required.

Stage 3 considers alternative routes and other safety measures, and evaluates them using cost-benefit analysis in order to determine appropriate measures.

4.4.6 Italy

In Italy, the government-owned motorway company ANAS uses an Italian Risk Analysis Method (IRAM) for road tunnel safety[60]. This includes societal risk RAC:

- Upper RAC: $F=0.1/N$ for $N\geq1$ fatality
- Lower RAC: $F=10^{-3}/N$ for $N\geq1$ fatality

For risks between these RAC the ALARP principle is applied, with safety measures adopted where cost-effective. For risks above the upper RAC, safety measures must be implemented regardless of cost.

4.4.7 The Netherlands

In the Netherlands, the Ministry of Infrastructure and the Environment uses the DG-QRAM program and has defined RAC for tunnel users based on an individual risk of 1×10^{-7} per

[58] PIARC, "Current Practice for Risk Evaluation for Road Tunnels", 2012.

[59] BMVBS/BAST (German Federal Ministry of Transport, Building and Urban Development/Federal Highway Research Institute), "Verfahren zur Kategorisierung von Straβentunnel gemäβ ADR 2007", cited in PIARC, "Current Practice for Risk Evaluation for Road Tunnels", 2012.

[60] ANAS (Azienda Nazionale Autonoma delle Strade), "Guidelines on Road Tunnel Safety Design", 2009, cited in PIARC, "Current Practice for Risk Evaluation for Road Tunnels", 2012.

person-kilometre and a societal risk of $0.1/N^2$ per year per kilometre[61]. This is only applied in the region N>10 fatalities. It is used as a target value, and may be exceeded if sufficient arguments are applied.

4.4.8 Norway

In Norway there is no formal threshold for acceptable risk for TDG in tunnels. Comparisons of risks are made with alternative routes avoiding the tunnels (see Appendix I).

4.4.9 Slovenia

In Slovenia, the Ministry of Infrastructure and Spatial Planning uses the DG-QRAM program and the same RAC as Austria for DG in road tunnels[62].

4.5 Rail Transport RAC

4.5.1 European Common Safety Targets

The European Commission, based on recommendations by the European Railway Agency, has adopted Common Safety Targets (CSTs) for use in the Common Safety Method (CSM) to evaluate changes to the railway system. CSTs are used in cases where codes of practice and comparison with similar reference systems do not give sufficient guidance. CSTs were first adopted in 2009, and revised in 2012[63].

The CSTs consist of National Reference Values (NRVs) for 25 Member States (MS), which are RAC for the following risk categories:

- Risk to passengers, measured in units of passenger fatalities and weighted serious injuries (FWSI) per passenger train-km, and passenger FWSI per passenger-km.
- Risk to employees, measured in units of employee FWSIs per train-km.
- Risk to level crossing users, measured in terms of level-crossing user FWSI per train-km (since data for more relevant metrics is not yet available).
- Risk to other people, measured in units of other FWSI per train-km.
- Risk to unauthorised persons on railway premises, measured in units of unauthorised person FWSI per train-km.
- Risk to the whole society, measured in units of FWSI per train-km.

The NRVs were calculated from accident experience in each MS (or in adjacent larger MS) during the period 2004-09, using an approach defined by the Commission[64].

The aim of the approach is to ensure that the current safety performance of the railway system is not reduced in any MS, and to harmonise safety levels, in terms of RAC.

The NRV indicates the maximum tolerable risk in each MS, but this is capped at a level of a CST, defined as the NRV that is highest amongst the MS, or a value equal to 10 times the European average value, if this is lower. At present, the spread of NRVs is such that the CSTs

[61] PIARC, "Current Practice for Risk Evaluation for Road Tunnels", 2012.
[62] Kohl, B. & Zibert, M., "Risk Analysis Study for Slovenian Motorway Tunnels", Portoroz, 2010.
[63] Decision 2012/226/EU of the European Commission of 23 April 2012 on the second set of common safety targets as regards the rail system.
[64] Decision 2009/460/EC of the European Commission of 5 June 2009 on the adoption of a common safety method for assessment of achievement of safety targets.

are equal to the highest of the NRVs amongst the MS. Hence at present the applicable RAC is always the NRV.

At present, the CSTs only refer to the whole of the railway system in each MS. In principle, the approach is applicable to specific parts of the system, which might include TDG, but this is not feasible at present due to the lack of harmonised and reliable data on safety performance.

Nevertheless, the CSM[65] does specify a RAC "for technical systems where a functional failure has credible direct potential for a catastrophic consequence; the associated risk does not have to be reduced further if the rate of that failure is less than or equal to 10^{-9} per operating hour." ERA has proposed[66] to develop this into a set of RAC covering a range of consequence severities, as shown in Table 4.2. This does not apply to DG, but it might indicate a possible form for such RAC.

Table 4.2 ERA Proposal for Revised RAC for Railway Technical Systems

Severity of the estimated consequences	Acceptable rate of occurrence (R) of the analysed unwanted direct consequence (e.g. of an accident with catastrophic consequences)
multiple fatalities	$R \leq 10^{-9}$/h
single fatality and/or multiple serious injuries	10^{-9}/h < R ≤ 10^{-8}/h
single serious injury and/or multiple light injuries	10^{-8}/h < R ≤ $3x10^{-7}$/h
single light injury	$3x10^{-7}$/h < R ≤ 10^{-5}/h
non safety related consequence	not applicable

4.5.2 Eurotunnel DG Policy

Eurotunnel, which operates the rail tunnel between France and the UK, under the oversight of the Channel Tunnel Safety Authority, has a policy for TDG that adopts additional restrictions beyond ADR/RID to reflect the unique nature of the tunnel. The underlying RAC are all based on judgement. A risk-based approach was applied to a change in this policy for a specific material, using a qualitative comparison with the risks of non-DG cargo[67].

4.6 Road Transport RAC

4.6.1 European Road Safety Target

The European Commission[68] has adopted a common target of "halving the overall number of road deaths in the EU by 2020 starting from 2010". This continues an earlier target set in 2003 for the period to 2010. Following the principle of subsidiarity, the Commission encourages MS "to contribute through their national road safety strategy to the achievement of the common objective, taking account of their specific starting points, needs and circumstances".

[65] EC Regulation 402/2013 op cit

[66] ERA, "Agency report on the experience with the existing regulation (EC) N° 352/2009 on a common safety method on risk evaluation and assessment and on the revision of that regulation", 2012.

[67] DNV/ESG, "Formulation of a risk-based approach to the Eurotunnel Policy on the Transport of Dangerous Goods", Confidential Report for Eurotunnel by Det Norske Veritas and Environmental Scientifics Group, 5 Jan 2012.

[68] EC COM(2010) 389 final "Towards a European road safety policy area: policy orientations on road safety 2011-2020"

4.6.2 Member State Road Safety Targets

Many countries have implemented road safety strategies around a framework of quantitative road safety targets[69]. Most EU countries aim to reduce the annual number of deaths by 40 to 50% within typically about 10 years. These include Austria, Denmark, Estonia, Finland, France, Great Britain, Greece, Ireland, Italy, the Netherlands, Poland and Sweden. Some EU countries are pursuing the long-term outcome of the elimination of deaths, with interim target reductions. Some (e.g. the Netherlands) have adopted regional targets aggregating to the national target. Some (e.g. Great Britain) have adopted targets for particular road users such as children. No specific targets for DG transport are known.

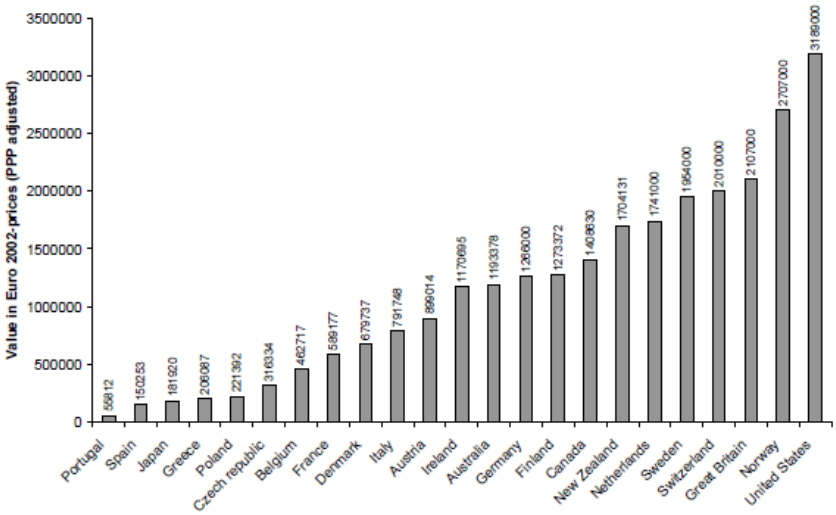
Some countries also use intermediate outcome targets, e.g. reductions in average speed or increases in seat belt use. Some set output targets for their institutional service delivery, e.g. numbers of random breath tests or speed checks.

The purpose of the targets is to provide focus for road safety improvement, by motivating stakeholders, improving management of safety programmes, and enabling monitoring of outcomes. Although it is asserted that the numbers of deaths from road accidents are "unacceptable"[70], it is generally accepted that road transport should continue.

4.6.3 Member State Cost-Benefit Analysis

Many countries use CBA to help select appropriate programmes to reduce road accidents. One of the key elements is the monetary valuation of road accident fatality risks. Figure 4.2 shows the official monetary valuation of preventing a fatality (VPF) in road accidents in several countries including 16 EU MS[71]. The median value is EUR1.2m (2002 prices), but the most notable aspect is the wide variation. Some of this variation is due to differences in methodology for estimating VPF. Another important difference is that wealthier countries (i.e. those with higher gross national income per capita) tend to use larger VPFs and also tend to have lower accident risks (measured in fatalities per person or per unit traffic).

Figure 4.2 Official Road Accident VPF in Selected Countries



[69] EC Safety Net, "Quantitative road safety targets", 2009.
[70] Ibid p3
[71] EC Safety Net, "Cost-benefit analysis", 2009.

Harmonised valuations of fatalities and injuries have been proposed[72], based on a common value of EUR1.5m adjusted in proportion to real per capita income at purchasing power parity exchange rates for each country[73], but these are only proposed when no national study of willingness-to-pay is available, and do not appear to be used in practice. A fully harmonised VPF (i.e. the same value used in all MS) is not adopted, because it would fail to take account of their ability to pay for risk reduction.

Different countries use different decision criteria in their cost-benefit analyses. The most common ones are NPV, BCR and IRR[74].

4.7 Other Transport RAC

4.7.1 Aviation Transport

In the field of aircraft design, the European Joint Aviation Authorities (JAA) have adopted as risk target that a catastrophic failure should not occur more often than 1.0×10^{-9} per flight hour. Other targets have been specified for less serious effects. This is based on the overall historical frequency of serious accidents and an arbitrary apportionment to aircraft systems and individual failure modes[75].

In the field of air traffic management (ATM), EUROCONTROL has adopted a target level of safety that "*the maximum tolerable probability of ATM directly contributing to an accident of a Commercial Air transport aircraft of 1.55 x 10^{-8} accidents per flight hour.*" This is based on the overall historical frequency of serious accidents, an estimate of the contribution from ATM and a reduction to ensure that traffic growth is compensated by a corresponding improvement in safety of individual flights[76], following the principle explained in Section 3.2.8.

4.7.2 Maritime Transport

In the maritime field, uniform safety rules are established by the International Maritime Organisation, and a risk-based approach, known as Formal Safety Assessment (FSA) is used to help evaluate new rules[77]. FSA follows the HSE tolerability of risk framework (Section 3.2.3), and uses individual risk RAC based on UK tolerability limits (Section 4.3.8) and FN RAC that reflect the average contribution to GDP for each ship type. In the ALARP region, the RAC is an ICAF of $3m[78].

4.7.3 Pipeline Transport

In pipeline transport, national authorities apply their own RAC based mainly on their approaches to major hazard installations. In the Netherlands, the individual risk and FN RAC for transport are used (Section 4.3.5). The FN criteria are applied to the highest risk kilometre

[72] HEATCO deliverable 5, "Proposal for harmonised guidelines", EU project developing harmonised European approaches for transport costing and project assessment, 2006.

[73] Nellthorp J. et al, "Valuation Conventions for UNITE", UNITE (Unification of accounts and marginal costs for transport efficiency), University of Leeds, 2001.

[74] HEATCO deliverable 5, op cit

[75] DNV, "Risk Acceptance Criteria for Technical Systems and Operational procedures", Det Norske Veritas report 24127328/03 for European Railway Agency, 2010.

[76] ibid

[77] IMO, "Consolidated text of the Guidelines for Formal Safety Assessment (FSA) for use in the IMO rule-making process", Maritime Safety Committee MSC 83/Inf2, International Maritime Organization, 2007.

[78] IMO, "Formal Safety Assessment: Decision Parameters including Risk Acceptance Criteria", Maritime Safety Committee MSC 72/16, International Maritime Organization, 2000.

of the route. In the UK, the individual risk criteria are used (Section 4.3.8), and FN criteria have been developed for the average risk per kilometre affecting a community[79].

4.8 Candidate Approaches

Based on the review above, the following are considered candidates for use in a harmonised approach to TDG:

- Uniform application of ADR/RID/ADN without Chapter 1.9. Very few MS make use of Chapter 1.9 of ADR/RID/ADN to apply additional provisions. Therefore, a possible method of harmonisation would be to remove this chapter altogether, which would in effect prohibit local restrictions and remove the need for RAC. This illustrates an extreme "light-touch" regulatory approach.
- Expert judgement approach, which is implicitly used in all countries that adopt restrictions on TDG without using explicit RAC.
- Consequence approach, as used in Germany for fixed installations. In principle this could be applied to TDG.
- Risk matrix approach, as used in France. In principle the same approach could be applied to TDG.
- Individual risk and FN criteria, as used in Flanders, the Netherlands, Switzerland and the UK. The numerical differences between these national applications (i.e. the fact that the FN criteria are all somewhat different) are considered separately as part of the evaluation of this approach.
- The ALARP approach, as used in France, the Netherlands and the UK, consisting of mainly qualitative cost-benefit balancing.
- The ACDS scrutiny level, i.e. FN criteria that scale with the quantity transported to identify individual trades with justifiable societal risk. This is a simple approximation to scaling according to the contribution to GDP, as used in maritime transport.
- The road tunnel approaches for DGs, as used in Austria, the Czech Republic, Germany, Italy and Slovenia, which combine FN criteria with a preliminary screening based on fatality rate and a subsequent risk ranking of alternatives.
- The European rail CSTs, which consist of current values of risk per unit exposure in each MS, combined with a limit on the variation between MS. To apply this approach to TDG, some apportionment would be needed, comparable to the target for technical failure.
- The road safety targets, as used in many European countries, which consist of aspirational trends in number of fatalities in each MS, combined with cost-benefit analysis to optimise safety improvements.

It is anticipated that an optimal approach might combine different elements of these approaches, so the fact that they overlap to some extent is not considered a problem.

[79] Schork, J.M. et al, "Societal Risk Criteria and Pipelines", *Pipeline & Gas Journal*, vol 239, no 10, 2012.

5 EVALUATION OF APPROACHES

5.1 Introduction

The candidate approaches from Section 4 are now evaluated in the following ways:

- Are they aligned with the principles for RAC proposed in Section 3?
- How far are they already in use for TDG in the EU?
- Do their current users consider they are suitable for a harmonised approach?
- Would they reduce the inconsistencies that exist in the current non-harmonised approach?
- What are their overall strengths and limitations with respect to other challenges in setting harmonised RAC?

Based on this evaluation, a harmonised approach is proposed in Section 6.

5.2 Alignment with Principles

The principles selected in Section 3 to underpin RAC for TDG were:

1. Justification of activity – the risks of the activity should be justified by its benefits (in terms of goods transported, value added, jobs etc) for the society as a whole.
2. Optimisation of protection – the risks should be minimised by appropriate safety measures, taking account of their benefits (in terms of risk reduction) and costs, and also of established good practice.
3. Equity – the risks should not be unduly concentrated on particular individuals or communities.
4. Aversion to catastrophes – the risks of major accidents (including multiple-fatality, high cost or widespread impacts) should be a small proportion of the total.
5. Assessment threshold – negligible risks should be exempted from detailed assessment.
6. Continuous improvement – overall risks should not increase, and preferably should reduce.

The candidate approaches from Section 4 address these in the following ways:

- The removal of Chapter 1.9 of ADR/RID/ADN could be considered a type of optimisation of protection, or a high assessment threshold, but it would not address the other principles.
- The expert judgement approach can implicitly address all these principles, although in practice it often does not explicitly address any of them.
- The consequence approach can include an assessment threshold (e.g. the storage quantities in the Seveso Directive). It implicitly addresses equity, catastrophe aversion and optimisation of protection.
- The risk matrix approach can include catastrophe aversion and an assessment threshold. It does not explicitly address the other principles, but may have sufficient flexibility to address equity and optimisation of protection implicitly.

- Individual risk criteria directly address equity between individuals, and FN criteria can address equity between communities as well as catastrophe aversion. Both can be used to express assessment thresholds.
- The ALARP approach adds a method of optimising protection.
- The ACDS scrutiny level (i.e. an FN criterion that scales with the quantity transported) adds an attempt to address the justification of an activity.
- The road tunnel approach (i.e. the preliminary screening based on fatality rate and a subsequent risk comparison of alternatives) is a different way of adding an assessment threshold and optimisation of protection.
- The European rail CSTs address continuous improvement. Since they are based on risk per unit exposure, they can also be considered ways of addressing the justification of an activity.
- The road safety targets (i.e. aspirational trends in number of fatalities, combined with CBA) combine continuous improvement with a method of optimising protection.

In conclusion, most of the candidate approaches address one or more principles. Some only address them implicitly. Comprehensive coverage of all principles could be obtained by combining several approaches.

5.3 Existing Application

The candidate approaches from Section 4 are already in use to the following extent:

- The uniform application of ADR/RID/ADN without any restrictions under Chapter 1.9 is the stated approach to TDG in 7 MS according to the survey in Section 4.1.
- The expert judgement approach is implicitly used in all countries that adopt restrictions on TDG without using explicit RAC, which amounts to 7 MS according to the survey in Section 4.1. It might also be in use in others in combination with explicit quantitative RAC.
- The consequence approach is used in Germany for fixed installations.
- The risk matrix approach is used in France for fixed installations.
- Individual risk and FN criteria are used in Belgium (for fixed installations), the Netherlands and Switzerland. They have also been used on specific transport projects in Denmark, Italy and the UK.
- The ALARP approach (or equivalent) is used in France, the Netherlands, Switzerland and the UK.
- The ACDS scrutiny level (i.e. FN criteria that scale with quantity transported) was developed in the UK but is not currently in use anywhere.
- The road tunnel approach (i.e. the preliminary screening based on fatality rate and a subsequent risk comparison of alternatives) is used in Austria, the Czech Republic, Germany, Italy, Norway and Slovenia.
- The European rail CSTs are adopted by all MS, although without any specific targets for DG.

- The road safety targets (i.e. aspirational trends in number of fatalities, combined with CBA) are used in many European countries, including at least 12 MS identified in Section 4.6.2 above.

In conclusion, all the approaches would be familiar to at least one MS. The only approach that is currently in use in all of them is the rail CST, although this is not specifically for DG.

5.4 Proposed for Harmonisation

The survey in Section 4.1 asked RAC scheme owners whether their approach could be used as part of harmonised EU RAC. The only positive replies were:

- France – in respect of principles, not parameters. This refers to a risk matrix approach.
- Netherlands - in its full application this combines individual risk and FN criteria, including adjusting individual risk limits on specific routes, together with an ALARP requirement and other judgemental RAC. This covers several of the candidate approaches from Section 4.8.
- Slovenia – this refers to the road tunnel approach, although its originator, Austria, did not consider it suitable for a harmonised approach. Probably both recognise that changes would be needed to apply to other transport modes.
- Spain – this refers to a judgement approach to develop a permitted route network.

It appears that the only approaches considered immediately suitable as harmonised RAC are approaches used in the Netherlands and Spain. It is significant that these are very different to each other, being mainly quantitative in the Netherlands and based on judgement in Spain.

5.5 Reduction of Inconsistencies

The following inconsistencies and unintended impacts are identified in the current approach, in which there are no harmonised RAC for TDG:

- Unequal restrictions - different RAC can lead to different restrictions on TDG for similar situations in different locations.
- Unequal costs - different RAC create different costs in obtaining approval for similar TDG operations in different countries.
- Change of route – a RAC applied in one location, which leads to a restriction in TDG, may result in the operator using a different route or the industry using a different source of materials. This may alter the risk pattern, which in some cases may increase the overall risk.
- Change of mode – a RAC applied to one transport mode, which leads to a restriction in TDG, may result in the TDG switching to a different *mode* with fewer restrictions. This may alter the risk pattern, which in some cases may increase the overall risk.
- Change of supply pattern - a RAC applied to a fixed installation, which leads to a restriction in its operations, may result in a change in its supply pattern, which may alter the risk from TDG.
- Complex regulations – without harmonised RAC, there is a tendency to improve safety by adding requirements to ADR/RID/ADN, which tend to grow more complex while the

motivation for each regulation tends to become obscure. This may form a barrier to market entry.

These are considered in detail in Appendix II. DNV's conclusions are:

- Unequal restrictions - some of the candidate approaches are more likely to deliver the same restrictions in similar situations, but some differences are expected to remain, even with the most advanced harmonisation, and even in the extreme case of removal of Chapter 1.9 of ADR/RID/ADN. In principle, increased transparency in harmonised RAC should allow the differences to be progressively reduced.
- Unequal costs - most of the candidate approaches would impose similar costs in each country, but only if consistent a risk analysis methodology was required.
- Change of route - most of the candidate approaches would resolve this inconsistency, but only if the study had a wide mandate, covering the complete transport route.
- Change of mode - most of the candidate approaches would resolve this inconsistency, but only if the study had a wide mandate, covering the all transport modes.
- Change of supply pattern - some of the candidate approaches would resolve this inconsistency, but only if the study had a wide mandate, covering fixed installations and TDG.
- Complex regulations – all the approaches (except removal of Chapter 1.9 of ADR/RID/ADN) have the potential to reduce the problem by providing a systematic way of addressing specific risks through justified safety improvements.

In conclusion, most of the approaches would reduce some of the inconsistencies that exist in the current approach, but none would address them all.

5.6 Response to Other Challenges

Before attempting to develop harmonised RAC, it is appropriate to consider the main challenges that such criteria might face. These challenges are not limited to the inconsistencies that exist in the current approach. A good set of RAC should help avoid the inconsistences that exist in the current approach, without introducing any new inconsistencies. This section therefore identifies the key challenges for harmonised RAC, so as to help evaluate the candidate approaches. The strengths and weaknesses of any harmonised approach are to a large extent determined by their performance in addressing these challenges.

The following challenges are considered:

- Variability. Good harmonised RAC should respond appropriately to:
    - Increases in TDG activity
    - Increase in population
    - Health & wealth variations
    - Population characteristics
    - Differences in hazards
    - Uncertainties in risks

- Public accountability. Good harmonised RAC should be sensitive to:
    - The local regulatory context
    - The need for transparency
    - The need for proportionality in risk control
    - The public demand for action when accidents occur
- Practical implementation. Concerning technical issues of implementation, good harmonised RAC should have the following characteristics:
    - Not be tied to a specific analysis methodology
    - Allow subsidiarity of assessment within Member States
    - Consistent with the Seveso Directive
    - Coverage of full scope
    - Freedom from unintended effects
- Effectiveness. This addresses whether the RAC do what they are intended in the areas of:
    - Effectiveness in improving safety
    - Cost-effectiveness
    - Environmental impacts
    - Impacts on infrastructure

These challenges are discussed in detail in Appendix II. DNV's conclusions are:

- Variability. The more advanced risk-based RAC are best able to respond appropriately to the challenges of variability, and CBA is able to take account of variations in health and wealth.
- Public accountability. The more judgemental approaches are the most flexible and can be responsive to the local regulatory context. The rail CSTs can be considered the most proportionate, as they are based closely on historical experience. All RAC approaches have problems with transparency.
- Practical implementation. Most approaches have strengths in some areas but are weak in other areas.
- Effectiveness. None of the approaches can be shown to be effective at improving safety. Although all approaches have problems in these areas, the ALARP approach is best able to address environmental impacts, and CBA is best able to address impacts on infrastructure.

In summary each approach is beneficial in some respects against these challenges, but no one approach has overwhelming strengths or limitations.

It is therefore concluded that no one approach can be chosen as the best. Instead, a synthesised approach is developed, combining elements from all of the candidate approaches, and structured according to the principles from Section 3.

6 PROPOSED HARMONISED APPROACH

6.1 Proposed Harmonised RAC

DNV's proposed harmonised approach to RAC includes seven distinct elements:

1. Threshold criteria, expressed as an expectation value of fatalities per year. Below this, detailed risk assessment and further risk reduction would not be required.
2. Individual risk criteria, expressed as maximum tolerable risks of death per year for the most exposed individuals. Above this, the risk would not be acceptable.
3. Societal risk criteria, expressed as FN curves for the most exposed communities. Above this, measures to reduce catastrophe risk should be investigated.
4. Scrutiny level, expressed as an expectation value of fatalities per tonne of DG transported over a route. Above this, justification of the transport would be needed, and additional restrictions or safety measures should be investigated.
5. ALARP criteria, consisting of either qualitative or cost-benefit criteria for evaluation of additional restrictions or safety measures.
6. Improvement target for TDG, expressed as an expectation value of fatalities per year from all modes of TDG. This would be used to monitor performance and propose additional restrictions or safety measures.
7. Improvement target for DG, expressed as an expectation value of fatalities per year from all production and transport of DG. This would be a possible way of monitoring and improving consistency with requirements for fixed installations.

The numerical sequence is not critical, but is based on a progression from simple screening tools (RAC 1 and 2), via more advanced screening tools addressing societal risks (RAC 3 and 4), then pragmatic management tools for individual trades (RAC 5) to strategic management and monitoring tools for the network as a whole (RAC 6 and 7). In practical application, entirely different sequences would apply (see Sections 6.4 and 6.5).

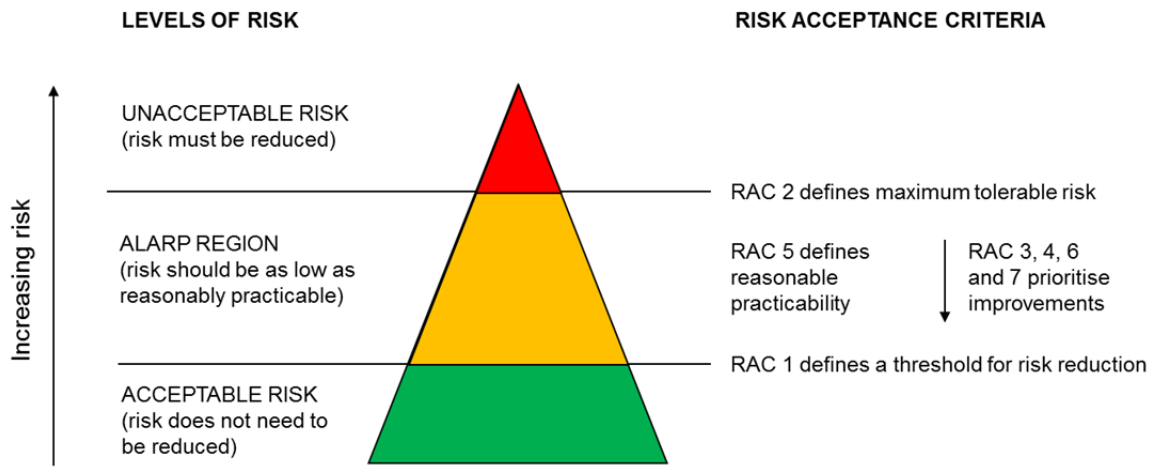
The set of harmonised RAC can be simplified by grouping according to their criticality as follows:

- Only two of the RAC (RAC 2 and 5) determine the need for additional restrictions or safety measures.
- One RAC is aimed at minimising analysis effort (RAC 1).
- The other RAC simply help focus improvement efforts (RAC 3, 4, 6 and 7).

The relationships are summarised in Figure 6.1.

In most TDG cases the core of the evaluation would be the ALARP criteria (RAC 5). In simple terms, provided risks have been considered on a broad scale, and are not exceptionally high by any of the other RAC, a restriction on TDG can only be justified if it is necessary to make the risks ALARP, i.e. if the costs of the restriction are outweighed by its benefits in terms of risk reduction, or if it is judged to comprise part of good operating practice.

Figure 6.1 Summary of Harmonised RAC



6.2 Development of Harmonised Values

This section considers how specific values for the RAC would be developed. The precise values of all these RAC would need to be harmonised. Alternatively, national differences would need to be justified as methods of producing a harmonised risk result given the legal and political context of each MS. Suitable practical bases for these RAC might be:

- Threshold criteria (RAC 1) – could be based on expert judgement or established thresholds from tunnel risk criteria (Section 4.4).
- Individual and societal risk criteria (RAC 2 and 3) - could be based on background risks or references cases, as explained in Section 3.3. Alternatively, established values from MS could be used.
- Scrutiny level (RAC 4) – could be based on the background risk per tonne of DG transported. Alternatively, the scrutiny level from the ACDS risk criteria could be used (Section 4.3.8).
- ALARP criteria (RAC 5) – quantitative cost-benefit criteria could be based on established values used by MS for road transport (Section 4.6.3), or qualitative criteria for reasonably practicability could be based on judgement.
- Improvement targets (RAC 6 and 7) – could be based on historical risk trends, as for the CSTs used in the rail industry.

6.3 Levels of Implementation

This section considers how the above RAC would be applied in practice. Because they are a complex set, this requires a relatively complex process to evaluate a proposed additional restriction on TDG.

The full evaluation would need to take place on two levels:

- A network risk assessment, evaluating the whole TDG network. This would show whether the network was meeting its targets for continual improvement (RAC 6); and whether the risks from international trades were justified by their benefits (RAC 4). It

would propose priorities for risk reduction, which would give direction to local risk assessments, but would not normally conclude on the need for specific risk reduction measures.

- Local risk assessments, evaluating specific risk reduction measures on individual TDG trades or at specific locations. This would show whether the risks exceeded the threshold requiring detailed evaluation (RAC 1); whether individual and societal risks arising from the specific TDG trade were acceptable (RAC 2 and 3); and whether all reasonably practicable risk reductions had been adopted (RAC 5). Either qualitative or quantitative assessment would be possible. It would conclude on the need for additional restrictions or other risk reduction measures for the specific trade or location.

The following sections consider how the evaluation would work in practice in each level.

6.4 Network Risk Assessment

This section considers how RAC would be implemented at the network management level. This would require an assessment of overall TDG risks at the European level, described here as a "network risk assessment".

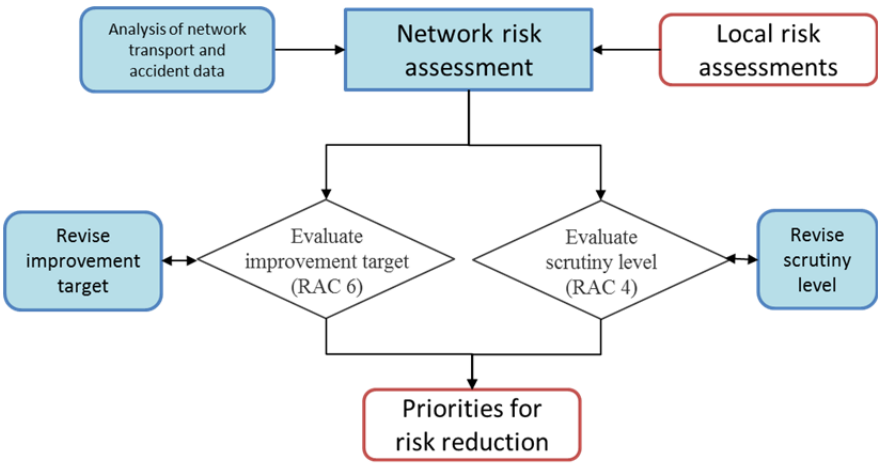
The network risk assessment would address overall risks from the complete European TDG network. It could be coordinated by a European agency with responsibility for the transport network as a whole. DNV presumes this would be the Trans-European Transport Network Executive Agency (TEN-T EA), under the policy direction of DG-MOVE. Preliminary implementation could be through an EU research project, to demonstrate its practicality. Alternatively, it could be devolved to MS, addressing TDG risks within each country, with co-ordination by the above agencies. This would be similar to the approach used in the railway Common Safety Targets (CSTs).

The purpose of the network risk assessment is to promote continuous improvement of safety levels in TDG as a whole, by monitoring trends, highlighting the main risk contributors, informing MS whether they are contributing sufficiently to the overall improvement targets, and proposing additional actions. Practical improvements, such as additional restrictions or other safety measures, would apply to individual trades and are best evaluated at a local level, following the principle of subsidiarity. Therefore the network risk assessment would set priorities for risk reduction, but the decision on the need for additional restrictions would be the responsibility of local risk assessments.

The following description explains how the network risk assessment would contribute to implementing the harmonised RAC. Figure 6.2 provides a summary of the process.

The network risk assessment would begin with a network-wide analysis of risks. This analysis could be relatively coarse, and might be based mainly on historical accident experience, combined with other data on current TDG activities. For example, it might show the overall risk (in terms of fatalities per year) in each transport mode and each MS. The analysis must be sufficiently detailed to show the trend and the main risk contributors within each MS. It is not necessary to analyse the risks on each transport route and add them up, although that could be a way of doing the assessment if that information was available (e.g. as in the Netherlands). As experience was gained in conducting local risk assessments, the results from these could be used to form a more detailed network risk assessment.

Figure 6.2 Network Risk Assessment



The evaluation of the network risks would use the following RAC:

- The TDG improvement target (RAC 6). This RAC drives the need for the network risk assessment because it can only refer to the total, not to individual TDG trades. The network risk assessment would estimate the current overall risk levels, set a realistic improvement target, and monitor progress, as for the CSTs. Based on the target compliance and an understanding of the main risk contributors, the priorities for risk reduction could be set in each MS. The improvement target could also be revised if compliance was too easy or too difficult, consistent with its aim to motivate improvements.
- The scrutiny level (RAC 4). This RAC requires knowledge of the risks over the whole length of a transport route. This might be available from a local risk assessment or from the network risk assessment. The scrutiny level indicates where the risks are high compared to the benefits (in terms of quantities of DG transported), and hence where justification of the transport is needed. This might indicate where lower risk options are available, or where additional restrictions or safety measures may be effective. These form other priorities for risk reduction, which would need to be assessed in a local risk assessment. Again, the scrutiny level could also be revised if it highlighted too many or too few trades.

In some cases (not shown in Figure 6.2), it might also address the following RAC:

- Individual and societal risk at hot-spots (RAC 2 and 3). "Hot-spots" where many TDG trades superimpose their risks might be critical for acceptability of TDG as a whole, if individuals or communities experienced high cumulative individual or societal risks. These would be evaluated at a network level, assuming the local level would only address individual trades, not the combined total.
- The DG improvement target (RAC 7). Ultimately, a network risk assessment could address DG production as well as transport risks. The method and aims could be as for RAC 6 above, but with a wider scope covering production installations as well.

The main output from the network risk assessment would be a list of priority areas for risk reduction. These priorities might be transport modes, accident types, contributing causes or "hot-spot" locations. The RAC used at the network management level are not sufficiently

precise to decide whether or not specific restrictions are needed (or in the case of unacceptable "hot-spots", to decide which TDG trades these restrictions should apply to). All they can do is recommend types of restrictions or general areas of application for local study. Only the local risk assessment is sufficient to decide on actual restrictions.

6.5 Local Risk Assessment

This section considers how RAC would be implemented at the local management level. This would require an assessment of the need for an additional restriction on a specific TDG trade or at a specific location, described here as a "local risk assessment".

The local risk assessment could be carried out by the transport operator, or by the proposer of the additional restriction on TDG. The former would be analogous to the Safety Report produced by operators in response to the Seveso Directive. It would require operators to show that all possible risk reduction measures had been reviewed and all measures necessary to make the risks ALARP had been adopted. However, this would be a considerable burden on the transport operator, who would not normally have sufficient expertise for a full risk assessment.

Because TDG is already governed by extensive regulations (i.e. ADR/RID/ADN), it is more appropriate to place the burden of proof on the proposer of the additional restriction. For example, RID requires the "competent authority of the Contracting State" to provide evidence of the need for such measures, and both RID and ADR provide guidance on risk assessment for these authorities. Although the competent authority would not normally have access to the necessary information, it is presumed that sufficient co-operation exists with the transport operator to obtain this. Therefore the following assumes that local risk assessment would be performed by the competent authority in the MS.

The following description explains how the local risk assessment would contribute to implementing the harmonised RAC. Figure 6.3 provides a summary of the process.

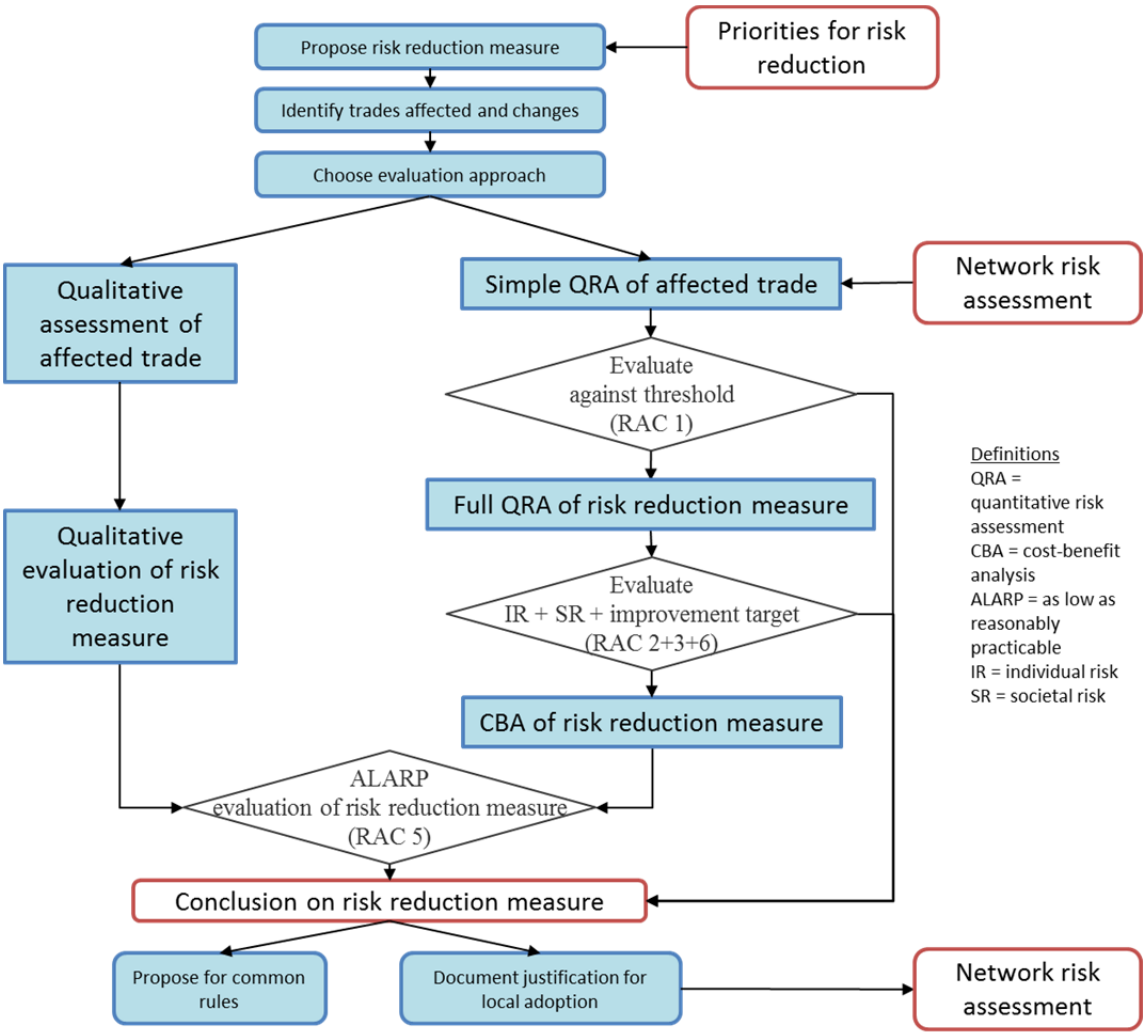
The local risk assessment starts from a proposed restriction or another risk reduction measure. The first step is to identify which TDG trades this would affect, and what changes might result if it was implemented. This scope for the local risk assessment should cover all affected trades, modes and routes.

The next step in the process is to choose whether to perform a qualitative or quantitative evaluation. A quantitative evaluation is appropriate for distinct, large changes in risks. It requires a full quantitative risk assessment (QRA) and cost-benefit analysis (CBA), and it is important that the TDG restriction can be quantified in this way, otherwise a qualitative evaluation would be preferred.

The first RAC to be applied in a local risk assessment is the threshold criterion (RAC 1). This is intended to identify low-risk trades, for which detailed risk assessment and further risk reduction are not required. The aim is to avoid detailed studies of trades and restrictions that cannot make any significant reduction in overall risk. However, there is a paradox in that it is necessary to know the risk level in order to apply the RAC. This could be obtained in an approximate way from the network risk assessment, if available, or from a simple local risk assessment otherwise. If the risk is below the threshold, it may be appropriate to switch to a qualitative risk assessment, or an evaluation of the additional restriction using expert judgement alone, bearing in mind that its risk level is negligible. Alternatively, it may be

appropriate to adopt only the measures required by ADR/RID/ADN (or in a tunnel apply only the requirements applicable to the open road).

Figure 6.3 Local Risk Assessment



The next RAC to be applied in a local risk assessment are the individual risk criteria (RAC 2). If the risk from the individual TDG trade alone exceeded the individual risk RAC, the conclusion would be that the trade was unacceptable unless the risk was reduced, and that this reduction should be made regardless of cost. This implies a need for funding, which the TEN-T EA can provide. It would still be appropriate to identify the restrictions that allowed the RAC to be met most cost-effectively. In practice, truly unacceptable individual risks are very unusual in TDG, and are more likely to indicate inappropriately chosen RAC.

In principle, the societal risk criteria (RAC 3) should be applied in the same way. However, the uncertainties associated with societal risk criteria are so great that they should be treated as guidelines, indicating when further measures to reduce catastrophe risk should be investigated.

Individual and societal risk RAC should really apply to the cumulative risks from all TDG trades affecting an individual or community. Calculation of these cumulative risks may be impracticable for operators of individual trades (since the other trades may be operated by their competitors). However, the competent authority should be able to do this. Alternatively,

it may be possible for the local risk assessment to provide the contributions to individual and societal risk along the route, and leave the cumulation of risk and evaluation by the RAC to the network risk assessment.

These RAC are expected to affect decisions only rarely. Individual risk RAC may be critical for high concentrations of TDG, or at temporary stop areas. Societal risk RAC may be critical for DG with large effect zones near dense population, or at large temporary stop areas. In such rare cases, they may prevent further increases in TDG activity without safety improvements. The question of how to manage such cases is properly part of the network risk assessment.

The local risk assessment may also consider the improvement target (RAC 6). This may provide justification to avoid the CBA that is required for a quantitative application of RAC 5. If the local risks are already reducing at a rate that meets RAC 6, there is then no reason to impose further risk reduction measures. Conversely, if the local risks do not meet RAC 6, there is a strong argument to adopt risk reduction measures. Unless its costs are very high, it may be appropriate to conclude on the risk reduction measure based on these risk arguments alone.

The final RAC to be applied in a local risk assessment are the ALARP criteria (RAC 5). The RAC could be qualitative, or might be expressed as ICAF, NPV or BCR criteria. These are expected to be the "driving" RAC in most practical cases.

The main output from the local risk assessment is a conclusion on whether a proposed additional risk reduction measure is necessary to make the risks acceptable. In general, this would be because it exceeded cost-benefit criteria, or because it was judged reasonably practicable. In extreme cases, a risk reduction measure may be necessary irrespective of cost, in order to bring the risks within the individual risk RAC.

If the additional restriction is necessary, it could be implemented in two ways:

- As an additional requirement for ADR/RID/ADN. This would be appropriate if it appeared beneficial in general, in a way that was not unique to a particular location.
- As a local restriction under Chapter 1.9 of ADR/RID/ADN. This would be appropriate if it appeared beneficial only because of the unique features of a particular location. In this case, the justification for the requirement should be reported as required under Chapter 1.9 of ADR/RID/ADN, and reviewed by the network risk assessment to ensure that network implications have been correctly included in the assessment.

6.6 Practical Challenges

This section explains how the proposed implementation scheme would address the main practical challenges involved in harmonised RAC, which are considered to be as follows:

- How to manage the complexity of the harmonised approach? The harmonised approach is very complex compared to existing approaches by most MS. The complexity can be minimised by emphasising that the ALARP criterion is the main limiting RAC. The challenge of gaining acceptance of the approach by MS is considered in Section 8 below.
- How to manage different legal and regulatory contexts? There are substantial differences in the approach of different countries to regulation of risks, and direct application of harmonised RAC in these different contexts would not produce the intended harmonisation of risks (see Appendix II.6.8). In particular, the legal systems

of some MS insist that all possible measures are taken to eliminate risks, and so non-zero risk thresholds would be unacceptable. This critical issue can be accommodated by giving MS freedom in the local risk assessments to use RAC that reflect their own regulatory and legal context, provided their consistency is checked at the network level. For example, it is possible for MS to adopt different RAC, provided the overall effects on specific restrictions are consistent. For example the Netherlands and Flanders may have different societal risk RAC or ALARP criteria, but would be expected to have similar restrictions on driving in reduced visibility. Meanwhile, Italy may have a target of zero risk, provided that the judgemental implementation of this produces restrictions that are similar to those in other MS. It would be the responsibility of the network risk assessment to check such consistency issues and challenge differences in RAC where they did not seem to produce consistent results.

- How to reach agreement on specific values for the RAC? Because of different regulatory and legal contexts in each MS, it seems unlikely that agreement on specific RAC could easily be obtained. However, provided MS agree on the broad approach outlined here, and on the RAC at the network level, this would make precise agreement at the local level less important. By giving MS freedom to adjust RAC to suit their local regulatory and legal context, this avoids any short-term need to agree on specific RAC at local level. Eventually, as experience reveals the practical effects of different RAC, it may be possible to specify harmonised RAC for specific risk assessment methodologies. This is considered as one of the organisational steps in Section 7 below.
- How to avoid unintended effects? Any RAC may cause unintended effects if applied rigidly (see Appendix II.6.16). The harmonised RAC are therefore recommended as guidelines not rigid rules. It is acknowledged that this reduces the practical degree of harmonisation, but it is considered essential for acceptance, as considered in Section 8.
- How to harmonise with fixed installations? TDG is part of an integrated production and distribution system for dangerous goods, and so it would be impossible to eliminate all inconsistencies in risk evaluation without harmonising the RAC with those for fixed installations. This would require the following steps:
    - At the network level, it would be necessary to assess the complete risks from production and transport of DG, in order to show that the combined total met the DG improvement target (RAC 7). This network-wide risk assessment could again be relatively coarse, and might be based mainly on an analysis of historical accident experience in production as well as transport of DG. This would require a very wide remit in the implementing agency. It may therefore be best implemented as a research project in the first instance.
    - At the local level it would require a combined assessment of production and transport risks in the vicinity of fixed installations. This would have important legislative implications, which are considered in Section 7. In practical terms, the RAC would be the same as for the local transport risk assessment considered above (RAC 1, 2, 3 and 5). The units of all these RAC have been chosen so that they are not specific to transport, although there may be a need to adjust the specific values if fixed installation risks were included. As for transport, the ALARP criteria would be expected to be most important for most decisions. This could also be applied to transport within fixed installations.

- Whether to harmonise with pipelines? Pipelines are another mode of TDG, imposing risks on individuals and communities in the same way as TDG by road, rail and inland waterways. It would therefore appear desirable to harmonise the RAC with those used for pipelines. Unlike the other transport modes, the scope for mitigation of pipeline risks is greatest in the design phase rather than during operation. Otherwise, there are no major technical obstacles to such harmonisation. However, several MS at the public workshop during Task 4 expressed the view that regulation of pipelines had progressed to a state where harmonisation with other modes would not be beneficial. Therefore, this option is not pursued further in this study.
- How to take account of non-fatality impacts? In principle, the ALARP approach is able to take account of all non-fatality impacts, including injuries, damage to property and infrastructure, and environmental impacts, either through quantification or judgement (see Appendix II.6.19). In practice this is very challenging, but no better approach is available.
- How to evaluate increases in TDG activity? The treatment of increases in TDG activity would be a key issue in practical development of harmonised RAC, especially for the ALARP criteria. There are several possible solutions to this (see Appendix II.6.2), each with strengths and limitations. For the present report it is sufficient to conclude that it is feasible for a harmonised approach to address this challenge.
- How wide a mandate is needed? The reduction of the inconsistencies that exist in the current approach depends on the choice of a suitably wide scope (or mandate) for the local risk assessments. For example, where an additional restriction may alter transport routes, the scope of the risk assessment should cover all affected routes. If the precise effects of a restriction could not be predicted, then it would be desirable to adopt monitoring arrangements, and plan to reconsider the decision on the restriction if appropriate. The adoption of a broad scope and/or on-going monitoring would have significant costs, especially if quantitative RAC were to be used. This seems to be an unavoidable price of avoiding the inconsistencies of the current non-harmonised approach. It is included in the cost impacts considered in Section 8 below.
- How to take account of network effects in the local risk assessment? In principle, a purely local study may conclude that risk reduction is required without taking account of the impacts on the network as a whole. The proposed implementation includes three limits on this:
    - The local risk assessment should identify all trades affected by the proposed risk reduction measure.
    - The network risk assessment should provide initial estimates of the impacts beyond the border of the MS performing the local assessment.
    - The Commission should review the results of the local risk assessment to ensure cross-border effects have been represented correctly.
- How to harmonise risk assessment methodology? For a harmonised evaluation of risks it is essential to have a harmonised risk analysis methodology as well as harmonised RAC. Establishing such a methodology has been a major challenge in countries that have adopted RAC, and would be an even greater challenge across the EU. This is considered as one of the organisational steps in Section 7 below.

- How to obtain data? Both local and network risk assessments would require collection of data on TDG activity and incidents. At the public workshop during Task 4, several MS identified the lack of data as a critical obstacle to implementing harmonised RAC. Very few MS have such data, and collecting it could be a significant burden for the administrations. This is considered as one of the organisational steps in Section 7 below.
- How to ensure acceptable quality in the risk assessment? Quality requirements are not part of the scope of the present study, although they can be considered types of qualitative RAC. Where local risk assessments are being performed by different MS as part of a harmonised approach, it is important that they are all performed to an equivalent quality standard. This is considered as one of the organisational steps in Section 7 below.

7 LEGISLATIVE IMPLICATIONS

7.1 Existing Legislation

This section considers what legislative changes would be needed to implement the network and local risk assessments described above. First, it considers the existing legislative basis of comparable approaches in the different transport modes.

Road transport already has an approach that is very similar to the combination of network and local risk assessments proposed above. Road accident risks are revealed through internationally reported accident statistics, and a common improvement target has been set by the Commission. These targets are promulgated through communications from the Commission, which encourage MS to align their national road safety strategy to the common objective (Section 4.6.1). At the local level, improvements are evaluated by judgement or CBA. This approach follows the principle of subsidiarity, and requires no specific legislation. It can be considered very effective, given that most MS have adopted consistent strategies and the overall road accident risk continues to decline.

Rail transport has a similar approach. In this case, risks were calculated by MS following a Common Safety Method adopted by the Commission, and Common Safety Targets have also been set (Section 4.5.1). In this approach, EC Regulations on CSM/CSTs are used to promote consistency between MS. This is appropriate for rail transport, since access to the railway is more closely managed than for the road. Furthermore, total societal risks are much lower than for road, and hence there is a greater need to define a uniform approach to risk estimation.

Inland waterway transport does not have any comparable approach.

Pipeline transport does not have any comparable RAC approach, but the network risks have been estimated in a report for the Commission[80]. At the local level, 75% of MS that responded to a survey reported that their legislation required hazard identification and risk assessment as part of the safety management system[81]. This suggests that MS have adopted consistent strategies, despite there being no EU legislation on risk assessment for pipelines. It can be considered a successful approach, given that the network risk assessment indicated a declining trend in pipeline incidents.

Practical implementation of the network and local risk assessments would require activity and incident data. The existing legislation for this is considered as follows:

- Activity data - European regulations already require statistical reports from MS on goods transport by road and rail that identifies the activity (transport operations, tonne-km and vehicle-km) for each category of DGs in each country[82]. This appears to provide sufficient detail for the network risk assessment, so no changes are proposed.
- Incident data - Chapter 1.8.5 of ADR/RID/ADN already requires reporting of occurrences involving DGs (including accidents, releases and near-misses) to the competent authority in the MS. EU legislation on Common Safety Indicators for

[80] COWI, "Assessing the case for EU legislation on the safety of pipelines and the possible impacts of such an initiative", Report for European Commission Directorate-General Environment, 2011. http://ec.europa.eu/environment/seveso/pdf/study_report.pdf

[81] ibid

[82] Regulation (EU) No 70/2012 of the European Parliament and of the Council of 18 January 2012 on statistical returns in respect of the carriage of goods by road.

railways includes requirements to report the numbers of dangerous goods accidents[83]. Although this does not require sufficient detail for the network risk assessment, the number of reported incidents is currently small[84], and may not justify increasing the required level of detail. In the short-term, it is expected that the necessary data would be obtained from MS or operators. Ultimately, legislative changes may be needed to collect more useful data.

7.2 Policy Options

7.2.1 Option A – New Directive

A new EU directive on TDG safety would define a policy of conducting local and network risk assessments, but would allow MS to adopt their own legislation as necessary to achieve this objective. Where MS intend to apply restrictions on TDG, it would require them to make a risk assessment coving the complete scope of changes in TDG that may result, and supply the results to the Commission for use in the network risk assessment. The harmonised RAC could be specified in associated regulations. This is similar to the approach currently used in rail transport.

The main advantages of this option are:

- It would be very comprehensive, specifying the approach within a single legal instrument covering all transport modes.
- It would follow the principle of subsidiarity, allowing MS to take account of their individual regulatory and legal contexts. This has been identified as an important characteristic when implementing harmonised RAC.
- It would be likely to ensure that the local risk assessments take place, because a directive is legally binding on MS. However, some variation in quality may be expected because of subsidiarity.

The main disadvantages of this option are:

- It would be a demanding approach, requiring detailed justification from the Commission. It would require an impact assessment which would be more comprehensive than Section 8 of the present study. It would also be likely to create fairly complex discussions, and hence would need considerable time to put into practice.
- It could be considered impracticable for MS to comply with the directive until the methodology had been agreed and necessary data had been collected. It would therefore not be effective in the short-term.
- It would depend on the Commission having resources to prioritise the directive and the network risk assessment, which does not appear likely at present.
- It would be multi-modal, which may require some reorganisation within DG-MOVE, and if so would cause further delays and resource issues.

Overall, the directive is considered suitable for the medium to long term, but is unlikely to have any effect on the existing problems for many years.

[83] Directive 2009/149/EC of 27 November 2009 amending Directive 2004/49/EC of the European Parliament and of the Council as regards Common Safety Indicators and common methods to calculate accident costs

[84] European Railway Agency, "Intermediate report on the development of railway safety in the European Union", 15 May 2013.

7.2.2 Option B – New Regulation

A new EU regulation on TDG safety would require MS to perform local risk assessments, and would specify exactly how this should be done. This would be legally binding and applicable in all MS. It would specify the methodology and the harmonised RAC. It would be equivalent to the CSM legislation for railways, although extended to cover safety improvements, to address dangerous goods specifically, and to cover other transport modes.

The main advantages of this option are:

- It would be very comprehensive, specifying the approach within a single legal instrument covering all transport modes.
- It would be likely to ensure that the local risk assessments take place, because a regulation is legally binding on MS.

The main disadvantages of this option are:

- It would be a demanding approach, requiring detailed justification from the Commission. It would require an impact assessment which would be more comprehensive than Section 8 of the present study. It would also be likely to create fairly complex discussions, and hence would need considerable time to put into practice.
- It would not follow the principle of subsidiarity, and so would not allow MS to take account of their individual regulatory and legal contexts. This is considered a significant disadvantage when implementing harmonised RAC.
- It could be considered impracticable for MS to comply with the directive until the methodology had been agreed and necessary data had been collected. It would therefore not be effective in the short-term.
- It would depend on the Commission having resources to prioritise the directive and the network risk assessment, which does not appear likely at present.
- It would be multi-modal, which may require some reorganisation within DG-MOVE, and if so would cause further delays and resource issues.
- The similarity to legislation for railways is considered a disadvantage, as it would be likely to add complexity and confusion to the existing CSM legislation.

Overall, a regulation is considered less effective than a directive for TDG safety.

7.2.3 Option C – Amended Directive

A possible way of obtaining the required local risk assessments would be to amend the existing Directive on the inland transport of dangerous goods[85]. This Directive applies to TDG by road, by rail or by inland waterway within or between MS, and in effect applies ADR/RID/ADN to TDG within MS. It already authorises MS to apply restrictions on the grounds of transport safety (Article 5), and could be amended to require this to be justified by a qualitative or quantitative risk assessment following the procedure described above, and subject to consultation/approval by other MS for network-level impacts.

The main advantages of this option are:

[85] Directive 2008/68/EC of the European Parliament and of the Council of 24 September 2008 on the inland transport of dangerous goods

- It would be very comprehensive, specifying the approach within a single legal instrument covering all transport modes.
- It would follow the principle of subsidiarity, allowing MS to take account of their individual regulatory and legal contexts. This has been identified as an important characteristic when implementing harmonised RAC.
- It would be likely to ensure that the local risk assessments take place, because a directive is legally binding on MS. However, some variation in quality may be expected because of subsidiarity.

The main disadvantages of this option are:

- It would be difficult to explain the requirements if they were part of an existing directive, and is less likely to result in the required changes in practice.
- It could be considered impracticable for MS to comply with the directive until the methodology had been agreed and necessary data had been collected. It would therefore not be effective in the short-term.
- It would depend on the Commission having resources to prioritise the directive and the network risk assessment, which does not appear likely at present.
- It would be multi-modal, which may require some reorganisation within DG-MOVE, and if so would cause further delays and resource issues.

Overall, the amended directive is considered suitable for the medium to long term, but is less effective than a new directive.

7.2.4 Option D – New Recommendation

The Commission could adopt a policy explaining the harmonised RAC and the need for local and network risk assessments, and promote it to MS through a recommendation rather than a regulation or directive. A recommendation would propose that all MS adopt the harmonised RAC and implement them through local risk assessments, but would not impose any legal obligation. This is similar to the approach currently used in road transport.

This option would include:

- Adjustment of the Commission's existing policy on road safety to include TDG risks explicitly. This could conveniently be implemented at the next revision of the road safety policy. It would require a common target for TDG risks by road, which would be easier to develop after completing the network risk assessment.
- Adjustment of the CSTs for rail safety to include TDG risks explicitly. This could conveniently be implemented at the next revision of the CSTs. Setting CSTs for rail TDG would be easier after completing the network risk assessment.

The main advantages of this option are:

- It would be comprehensive, specifying the approach within a single EU policy covering all transport modes.
- It would follow the principle of subsidiarity, allowing MS to take account of their individual regulatory and legal contexts. This has been identified as an important characteristic when implementing harmonised RAC.

- It would not require legislative changes, which would minimise costs and avoid the need for detailed justification from the Commission.

The main disadvantages of this option are:

- It would be relatively unlikely to ensure that the local risk assessments take place, because a recommendation is not legally binding on MS.
- It could be considered impracticable for MS to comply with the recommendation until the methodology has been agreed and necessary data has been collected.
- It would be multi-modal, which may require some reorganisation within DG-MOVE.

Overall, the recommendation is considered suitable as a short-term action, although it is unlikely to ensure a response from all MS. It could be a step towards developing a directive.

7.2.5 Option E – UN Guideline

The Commission could adopt a policy as in Option D, and promote it to MS by amending the guidelines for calculation of risks under Chapter 1.9 of ADR/RID/ADN. At the public workshop during Task 4, this was advocated by the Netherlands as the most suitable approach.

The main advantages of this option are:

- It would follow the principle of subsidiarity, allowing MS to take account of their individual regulatory and legal contexts. This has been identified as an important characteristic when implementing harmonised RAC.
- It would not require legislative changes, which would minimise costs and avoid the need for detailed justification from the Commission.

The main disadvantages of this option are:

- It would require amendments to existing guidelines for each transport mode.
- The necessary changes in the guideline may be difficult to achieve, as many contracting states of ADR/RID/ADN are outside Europe
- It would be relatively unlikely to ensure that the local risk assessments take place, because the existing guidelines are not currently followed by most MS.
- It could be considered impracticable for MS to comply with the guideline until the necessary data has been collected.
- It would not directly address the network risk assessment, so would need to be combined with other organisational steps (see Section 7.3).

Overall, the UN guideline is considered suitable as a short-term action, although it is unlikely to ensure a response from all MS. It could be a step towards developing a directive.

This option could be pursued in parallel to the other options. As an early step, the Commission could explain the approach to the UNECE/OTIF Joint Meeting, and incorporate improvements in response.

7.2.6 Option F – EU Guideline

The Commission could adopt a policy as in Option D, and promote it through an independent guideline document, produced by the Commission, in consultation with MS.

The main advantages of this option are:

- It would be comprehensive, specifying the approach within a single guideline covering all transport modes.
- It would follow the principle of subsidiarity, allowing MS to take account of their individual regulatory and legal contexts. This has been identified as an important characteristic when implementing harmonised RAC.
- It would not require legislative changes, which would minimise costs and avoid the need for detailed justification from the Commission.

The main disadvantages of this option are:

- It would be relatively unlikely to ensure that the local risk assessments take place, because the existing UN guidelines are not currently followed by most MS.
- It could be considered impracticable for MS to comply with the guideline until the necessary data has been collected.
- It would not directly address the network risk assessment, so would need to be combined with other organisational steps (see Section 7.3).

Overall, the EU guideline is considered suitable as a short-term action, although it is unlikely to ensure a response from all MS. It could be a step towards developing a directive.

This option could be pursued in parallel to the other options. One possible method of making the guideline more effective would be to develop it into a European Standard (EN). Although standards are not legally binding, they have considerable authority, and are a powerful way of encouraging consistent performance. There is an international standard for risk management (ISO 31 000), but standards are not commonly used for risk assessment methodology or criteria, because the necessary consensus is difficult to develop, and would take a minimum of 3 years to progress.

7.3 Organisational Steps

All the options would also require the Commission to take the following organisational steps:

- Analyse the data on TDG activity and incidents that has been collected under existing legislation, in order to produce accident frequencies suitable for the network and local risk assessments. Ultimately this data could be improved or replaced with data gathered under a new directive.
- Develop a suitable methodology for the network and local risk assessments, to ensure that the selected priorities for risk reduction receive support from the MS. This methodology could eventually be included in guidelines or a new directive.
- Conduct an initial network risk assessment as a research study, using voluntary assistance from MS. This is similar to the approach currently used in pipeline transport. This experience would help frame the methodology and data collection requirements.
- Develop a process for setting the specific values of the harmonised RAC. This process should be iterative, revising the RAC as their practical implications become clear. This is considered less urgent because the harmonisation of principles is the key first step.

- Communicate with MS the priorities for risk reduction that are selected in the network risk assessment, and receive the results of local risk assessments of TDG restrictions.
- Review periodically the harmonised RAC, in the light of practical changes to TDG restrictions that they support, and adjust the RAC if necessary.

7.4 Conclusion

The conclusion from the review of options above is that the most effective one, in terms of ensuring that the required risk assessments are carried out and the harmonised RAC applied, would be a new directive on TDG safety (Option A). This would specify the harmonised RAC and the method of implementing them through network and local risk assessments, and require MS to gather suitable data and share the results of their local studies. However, it is acknowledged that this would require time and considerable resources to develop the methodology and necessary data, and to implement the directive and the required legislation. It is therefore the preferred option for the medium to long term.

DNV's analysis of the existing EU and international legislation indicates that there is no fundamental legislative obstacle to implementing the harmonised RAC approach that has been proposed in this study. In other words, nothing in the existing legislation prohibits this approach. It is therefore possible for the Commission to promote the approach to MS through policies and guidelines that require no changes to legislation.

In the short-term, to encourage progress towards the long-term goal, it would be possible to pursue several options in parallel (Options D, E and F). Through these options, the Commission could adopt a policy explaining the harmonised RAC and the need for local and network risk assessments, and promote it to MS through a recommendation and UN or EU guidelines. The organisational steps, which would be needed for either approach to work, can be initiated by the Commission without any need to wait for legislation. This would have the advantage of increasing understanding of how harmonised RAC would work in practice, and clarifying the challenges that the new directive would ultimately aim to overcome.

8 IMPACT ASSESSMENT

8.1 General Approach

This section attempts to predict the impacts of the harmonised RAC if implemented through the preferred legislative options. It addresses the likely response of Member States, which determines whether or not the approach can be implemented as planned. On the assumption that the approach is implemented, it then considers the following impacts, which are believed to be the significant ones for harmonised RAC among the checklist in the Commission's impact assessment guidelines[86]:

- Social impacts
  - Public safety
- Economic impacts
  - Internal market
  - Business costs
  - Public authorities
  - Specific transport modes
  - Transport infrastructure
- Environmental impacts
  - Climate change
  - The environment

8.2 Response of Member States

8.2.1 Comments in Survey of Approaches

The survey of existing approaches (introduced in Section 4.1 and documented in full in Appendix I) requested MS to recommend approaches to harmonising RAC, and this produced several general comments:

- Austria advised: "*not to be too enthusiastic*".
- Belgium advised: "*flexibility for the MS to handle specific situations in accordance with the EU-recommendations*".
- Denmark advised: "*it should be up to the relevant national authority to decide, which RAC should be used. Any developed RAC as the basis for transport restrictions in DG should only be guidelines and should not be obligatory.*"
- France advised: "*RAC ultimately is not only of technical nature*".
- Sweden advised: "*For countries using RAC in other decision processes it's maybe not that difficult to adapt it to this case. For those countries not using RAC as regulatory or mandatory base for risk evaluation a harmonized approach isn't easy and maybe not possible, since it needs to be used in all decision processes regarding risks, not only concerning DG transport restrictions.*"
- UK advised: "*The priorities of EU MS vary in accordance with individual government policy.*"

These comments indicate the likely response to harmonised RAC by the national authorities who would have responsibility for implementing them.

[86] EC SEC(2009) 92, "Impact Assessment Guidelines", 15 January 2009

8.2.2 Comments in Public Workshop

In Task 4, DNV and DG-MOVE held a public workshop with representatives of Member States, and received feedback on the proposed approach. Notes on the learning from this workshop are included in Appendix I.

Italy advised that a non-zero risk threshold would not be acceptable due to its own legal interpretation of responsibility to avoid risk. In France, some local administrations take the same view. At first sight, these legal interpretations seem incompatible with the risk-based approach, as in effect they demand risk reduction, regardless of its effectiveness or global impacts. However, it is possible that harmonised RAC, if implemented through a directive, could ultimately be used as a legal basis for a demonstration that responsibility for risk management had been appropriately discharged.

Meanwhile, any harmonised approach would conflict with current practice in MS who have already adopted their own RAC (unless the RAC are identical). This includes the most proactive MS in the area of RAC, whose opinions carry much weight. It can also be expected that MS who do not currently use RAC will not welcome mandatory requirements to do so. This includes the MS who would be most difficult to motivate to use RAC. Similarly, MS who reject non-zero risk will inevitably object to practical risk thresholds. Any change in approach inevitably incurs cost for the MS, as well as legal and political difficulties. Therefore it is essential to ensure that the change is justified and that the principle of subsidiarity is respected (see Appendix II.6.13).

8.2.3 Response to Concerns

In order to respond to the concerns of MS, the harmonised RAC proposed in this study are rather flexible, with the intention that as far as possible MS should be allowed to continue with their existing approaches. The focus of the harmonisation is therefore to interpret these different approaches as alternative ways of justifying conclusions that are either the same or at least different for logical and defensible reasons. The apparent complexity of the harmonised RAC results in part from the effort to accommodate these different approaches.

Specific areas of flexibility in the proposed harmonised method include:

- The three basic options for applying RAC that were observed in the survey of practice are all permitted:
    - Use of ADR/RID/ADN with no additional restrictions and no RAC. This option is intended to apply to low-risk TDG or in MS with limited confidence in risk-based approaches.
    - Expert judgement, i.e. an agreement of relevant experts on additional restrictions or other safety measures in specific situations, provided this is based on a structured and documented consideration of risks and the measures necessary to make them ALARP. This option is appropriate for MS with confidence in qualitative approaches, and it has the advantage that it can take account of impacts that are difficult to quantify, such as damage to infrastructure and environmental impacts. It can also be used by MS who reject non-zero risks, while still allowing TDG on a judgemental basis.
    - Explicit quantitative RAC. i.e. a quantitative assessment, using a harmonised assessment procedure and corresponding RAC, to advise on the need for

additional restrictions or other safety measures. This option is appropriate for high-risk TDG, or MS requiring risk-based approaches in all areas.

- The key ALARP criterion ensures that costs and benefits of TDG restrictions are taken into account, but allows MS to do this in qualitative or quantitative form, using whichever RAC they prefer.
- The use of network-wide risk assessment to set priorities for risk reduction means that risk reduction effort is focussed on locations where large gains can be made, without causing excessive costs for low risk activities.
- The combination of a scrutiny level with more limiting individual and societal risk criteria means that risks can be allowed to increase in cases where TDG activity is expanding, while also ensuring that individual citizens and communities are protected from excessive risks.
- The focus on harmonising the method of risk evaluation rather than the specific values of RAC in individual countries is believed to be the most effective way of accommodating the different regulatory styles which would otherwise form a major barrier to harmonisation.

These features are expected to minimise the adjustment costs for MS and industry, and hence increase the probability that MS will accept the proposed approach. Furthermore, the legislative options considered in Section 7 emphasise organisational steps and short-term options that allow the harmonised approach to be developed progressively as far as possible without conflicting with the legal framework in individual MS.

However, it is acknowledged that this flexibility does reduce the level of harmonisation that can be achieved by the proposed approach. This is taken into account when considering its impacts below.

8.3 Impact on Public Safety

The likely impacts of RAC on safety have been reviewed (Appendix II.6.17), concluding that it is not possible to demonstrate that any improvement in safety would result from adopting harmonised RAC. However, it is also important to ensure that safety levels do not deteriorate in the future, especially as TDG changes and the population grows. Harmonised RAC would contribute to this objective, although the precise effects are difficult to identify.

RAC are also enablers for a more systematic use of risk assessment and CBA in managing TDG safety, and their contribution to public safety is closely linked to that of risk assessment itself.

Part of the aim of introducing harmonised RAC is to reduce inconsistencies in the current system, which may cause increased risk in some cases (Section 5.5), and the proposed RAC are expected to reduce some of these inconsistencies. However, RAC also have the potential to cause unintended effects that may increase risks (see Appendix II.6.16). The net effect is expected to be positive, but is not expected to be large.

In conclusion, harmonised RAC are considered to be a contribution to maintaining the current levels of risk in TDG, and helping to ensure that they do not increase in the future. They are not expected to achieve any major reduction in risk.

8.4 Impact on the Internal Market

One of the objectives of the European internal market is to ease the movement of freight. Part of the strategy for realising this vision is[87]:

> "*The objective for the next decade is to create a genuine Single European Transport Area by eliminating all residual barriers between modes and national systems, easing the process of integration and facilitating the emergence of multinational and multimodal operators*."

One of the specific initiatives in the Roadmap for the Single European Transport Area is:

> "*Streamline the rules for the intermodal transport of dangerous goods to ensure interoperability between the different modes*."

Harmonised RAC can be seen as a contribution towards these objectives. Additional restrictions on TDG, where their justification is absent or understood only by one MS, can be seen as a barrier to the free movement of goods. Restrictions that are more stringent for one transport mode than another are clearly a barrier to interoperability between the modes. One of the ways of achieving streamlined rules could be to evaluate all additional restrictions using harmonised RAC. In some cases, this may result in the removal or prevention of unjustified restrictions on TDG. In other cases, where restrictions are adopted, harmonised RAC can be seen as providing "mutual recognition" of the justification process.

The positive impact on the internal market is considered to be one of the main benefits of harmonised RAC. It is acknowledged that the flexibility built into the proposed approach (e.g. the freedom to use qualitative or quantitative risk assessment) does reduce the level of harmonisation that may be achieved in practice. However, the potential benefits are still substantial.

8.5 Impact on Business Costs

The economic contribution of TDG itself in Europe is not easily quantified, but much of the activity is associated with the European chemicals industry, which employs 1.2 million workers and contributes €539 billion to the EU economy[88]. Any impact from RAC on this business therefore has the potential to be very large.

Any change in risk assessment methodology can be expected to cause some cost for organisations involved in risk management. The implementation scheme proposed above for harmonised RAC places most of the burden on the government authorities rather than individual TDG operators. Nevertheless, they will require data and assistance from operators, and operators may choose to align their internal processes with the harmonised process, or alternatively may wish to argue that local circumstances justify a different approach. There is therefore inevitably some additional cost for operators arising from the requirement for local risk assessment.

The chosen implementation scheme is intended to minimise cost by using a flexible methodology, as discussed above. In cases where operators are currently experiencing difficulties in making use of risk assessment, a clear methodology including harmonised RAC

[87] EC COM (2011) 144 final, "Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system", 28 March 2011.

[88] CEFIC (2013), "Facts and Figures 2012", The European Chemical Industry Council http://www.cefic.org/Facts-and-Figures/ (accessed 2 December 2013)

may resolve these problems and produce some cost savings. Where operators are not currently using risk assessment, the additional costs may be significant. However, it is expected that most TDG operators are already using risk assessment of some form, and therefore the additional costs of using harmonised RAC will be small.

A much larger impact on business costs may result from the removal or prevention of unjustified restrictions on TDG, or the optimisation of restrictions taking account of costs, as required by the ALARP criterion (RAC 4 above). Such RAC are expected to require only cost-effective restrictions, and this may be very beneficial in preventing restrictions being imposed on operators that cannot be justified in terms of their safety benefits.

Avoiding unjustified restrictions may affect operating costs as a whole for operator, whereas the costs of the additional risk assessment affect only the costs of their safety management function. Therefore the net effect is expected to be large and positive. It is recognised that this benefit will only occur in the long-term, once the restriction is present (or absent), and that the costs will occur in the short-term, as the risk assessment is carried out. In this sense, the harmonised approach is a type of investment by the operators, which is expected to be beneficial in the long-term.

8.6 Impact on Public Authorities

The implementation scheme proposed above for harmonised RAC places most of the burden for conducting the risk assessment on the competent authorities of each MS. If restrictions are proposed, it can therefore be expected to cause them additional costs. However, risk assessment is already required to justify restrictions under ADR and RID, so it is not strictly an additional burden.

At the public workshop during Task 4, France advised that without adequate data, harmonised RAC could lead to complex and expensive analysis. Furthermore, Belgium expressed concern that the harmonised approach could create a requirement for additional risk assessment, which would be a significant additional burden. The present study assumes that the proposed directive is worded and sequenced in a way that addresses these important concerns.

Although the implementation scheme has been chosen to minimise cost as far as possible, the costs of performing a risk assessment of additional restrictions could be large, especially if the restriction affected TDG movements over a large area. However, the flexibility in the recommended approach allows MS to avoid all costs if they adopt no additional restrictions on TDG. Nevertheless, if the network risk assessment evaluated the MS as a priority for risk reduction then at least a qualitative risk assessment would be required, and this would be an additional cost.

Harmonised RAC would provide a benefit to the same authorities by defining an agreed way of balancing interests between members of the public who demand restrictions on TDG and TDG operators who demand freedom of movement. However, most authorities have already developed their own method of resolving these conflicts, and may not welcome a new harmonised method that is (or appears to be) different.

Overall, the cost to public authorities could be larger than to any other stakeholder group, which is why their likely reaction was considered first (Section 8.2), although the cost is not strictly additional.

8.7 Impact on Specific Transport Modes

Some differences between the three transport modes in the use of RAC for justifying restrictions on TDG were noted in the survey in Section 4.1. It is therefore appropriate to consider whether the harmonised RAC, if implemented through the preferred legislative options, would have disproportionate effects on particular transport modes.

Each MS has a dedicated safety authority for rail, but no equivalent for road and inland waterways. The European Commission has already adopted a Common Safety Methodology to assess changes to the railway system in each MS, whereas road transport safety is managed more independently by each MS, and inland waterways safety is assessed only in MS that make extensive use of risk assessment.

These differences mean that harmonised RAC are likely to be adopted relatively easily in the railways, whereas road transport and inland waterways will require more adjustment, which is also likely to happen relatively slowly due to the lack of central coordination. However, the cost impacts may not be very different, because the threshold criterion (RAC 1) implies that inland waterways and many road transport cases can make use of low-cost qualitative risk assessment, and only cases where risk is concentrated on major road and rail routes require the more expensive quantitative risk assessment.

Another possible impact on transport modes might arise if some TDG shifted from one mode to another. Alternatively, harmonised RAC might cause the removal or prevention of unjustified restrictions on TDG, with the effect that ongoing modal shifts might be halted or reversed. This is one of the unintended effects of the current non-harmonised approach, which harmonised RAC were intended to address (Section 5.5).

It is difficult to predict exactly what modal shifts might occur or might be halted as a result of harmonised RAC. If they did occur, the harmonised RAC would provide a powerful justification. Therefore, no major unwanted effects on individual transport modes are anticipated.

8.8 Impact on Transport Infrastructure

One of the main drivers of additional restrictions on TDG has been the need to protect key parts of the transport infrastructure against damage, notably tunnels and bridges. Dangerous goods accidents have the potential to damage these in a way that forces prolonged closure for repairs, with severe consequent impacts on congestion, journey times, fuel consumption and greenhouse gas emissions. It is therefore important that the harmonised RAC take account of the need for this protection.

At present, there are some similarities and some differences in the ways this is achieved in different MS (Section 4.4). Many use a combination of a threshold RAC, an FN criterion and the ALARP approach. Since all of these are included in the current harmonised approach, it is anticipated that any changes will be small. However, this will need careful review to minimise any unintended impacts.

8.9 Impact on Climate Change

Transport, particularly road transport, is a major contributor to greenhouse gas emissions, and emission reduction is an important part of the European transport strategy. Some additional restrictions, particularly those on tunnels, may have the effect of increasing journey lengths and hence fuel consumption with associated greenhouse gas emissions. If harmonised

RAC cause the removal or prevention of unjustified restrictions of this type, this would reduce the associated emissions. However, the overall effect at a European level would be small.

Optimisation of restrictions, taking account of cost, safety, greenhouse gas emissions and other environmental impacts can in principle be obtained in an ALARP framework, either by quantifying all impacts and using a CBA definition of ALARP, or by systematic expert judgement. Either approach has its weaknesses, but their main strength is that they allow climate change impacts to be considered explicitly when deciding on transport restrictions. This is expected to ensure that the effects are beneficial or at least that any adverse effects are fully justified.

8.10 Impact on the Environment

Transport causes a range of impacts on the environment beyond the greenhouse gas emissions considered above. These include noise, visual impact and the local impacts of exhaust emissions. Some additional restrictions, particularly those on tunnels, may have the effect of increasing or spreading environmental impacts. If harmonised RAC cause the removal or prevention of unjustified restrictions of this type, this would reduce the associated environmental impacts. However, the overall effect at a European level would be small.

Optimisation of restrictions, taking account of these environmental impacts can in principle be obtained in an ALARP framework as above, although it is difficult to include environmental impacts in the evaluation in a satisfactory way. However, any impacts on the environment from harmonised RAC are expected to be small.

8.11 Conclusion

The following summarises the assessment of the impacts of the harmonised RAC if implemented through the preferred legislative options:

- Public safety - harmonised RAC are considered to be a contribution to maintaining the current levels of risk in TDG, and helping to ensure that they do not increase in the future, but are not expected to achieve any major reduction in risk.
- Internal market - a positive impact, which is considered to be one of the main benefits of harmonised RAC.
- Business costs - the net effect is expected to be large and positive in the long-term, although in the short-term there will be costs before any benefits occur.
- Public authorities - if restrictions are proposed, there will be a significant cost of performing risk assessments, but this is already required to justify restrictions under ADR and RID, so it is not strictly an additional burden.
- Specific transport modes - no major unwanted impacts on individual transport modes are anticipated.
- Transport infrastructure - any impacts are expected to be small.
- Climate change - impacts are expected to be beneficial, and any adverse effects will be fully justified.
- The environment - any impacts are expected to be small.

Overall, there will be costs to public authorities and (in the short-term) to TDG operators. In the long-term, beneficial impacts on the internal market are expected to dominate.

9 CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

This study has analysed the feasibility of defining and using harmonised risk acceptance criteria (RAC) in decision-making for justification of safety measures in the inland transport of dangerous goods (TDG) in Europe.

The study concludes that it is feasible to define and use harmonised RAC for justification of safety measures in TDG, provided these are interpreted as guidelines rather than rigid rules. Implementation through the preferred legislative options appears to be practical, and to deliver a beneficial combination of impacts.

9.2 Limitations

However, there are some major limitations in the proposed approach, which limit the degree of harmonisation that can be achieved in practice. These limitations have been avoided in the present study, but ultimately they would have to be addressed as part of a practical implementation. The following limitations are considered critical:

- The very diverse approaches adopted by MS in their current use of RAC mean that it would be difficult for all MS to switch to a single harmonised approach. Therefore the proposed approach is relatively flexible, aiming to facilitate adoption by MS. An inevitable consequence of this is that it limits the degree of harmonisation that would be achieved in practice. This is considered to be an acceptable compromise in an attempt to gain acceptance from a majority of MS.
- There are substantial differences in the approach of different countries to regulation of risks, and direct application of harmonised RAC in these different contexts would not produce the intended harmonisation of risks. The present study has focussed on the feasibility of a harmonised approach to RAC, while leaving the specific values of the RAC to future discussion. However, it may never be appropriate to harmonise specific values of the RAC to be used in local risk assessments. Provided the adopted restrictions are identical, or different for justifiable reasons, this is considered to be acceptable.
- Lack of data on TDG activity and incidents is seen as a critical obstacle to implementing harmonised RAC. Therefore the present study makes recommendations to improve data collection and analysis in addition to harmonising RAC.
- The cost burden of the proposed implementation method falls mainly on government authorities in each MS, and to a lesser extent on TDG operators. This burden should be compensated in the long-term by improvements in the internal market, but it is possible that this benefit will not be sufficient motivation for the MS to conduct the local risk assessments of TDG restrictions that are a key part of the practical implementation. This is considered a major risk for the successful implementation of the harmonised RAC.

9.3 Recommendations

To implement the proposed harmonised approach, DNV recommends the following changes to EU policies and legislation:

- A new directive on DG safety in all transport modes. This would include road, rail and inland waterways. It would state the harmonised RAC and explain how they are intended to improve safety. Where MS intend to apply restrictions on TDG, it would require them to make a risk assessment coving the complete scope of changes in TDG that may result, and supply the results to the Commission for use in the EU level network risk assessment. It would also specify a common methodology for the risk assessment, and principles for collecting the necessary data.
- Adjustment of the Commission's existing policy on road safety to include TDG risks explicitly. This could conveniently be implemented at the next revision of the road safety policy. It would require a common target for TDG risks by road, which would be easier to develop after completing the network risk assessment.
- Adjustment of the CSTs for rail safety to include TDG risks explicitly. This could conveniently be implemented at the next revision of the CSTs. Setting CSTs for rail TDG would be easier after completing the network risk assessment.

In addition, DNV recommends the Commission should take the following organisational steps:

- Analyse the data on TDG activity and incidents that has been collected under existing legislation, in order to produce accident frequencies suitable for the network and local risk assessments. Ultimately this data could be improved or replaced with data gathered under the new directive.
- Develop a suitable methodology for the network and local risk assessments. This methodology could eventually be included in the new directive.
- Conduct an initial network risk assessment as a research study, using voluntary assistance from MS. This experience would help frame the methodology and data collection requirements.
- Develop a process for setting the specific values of the harmonised RAC. This is considered less urgent because the harmonisation of principles is the key first step.
- Communicate with MS the priorities for risk reduction that are selected in the network risk assessment, and receive the results of local risk assessments of TDG restrictions.
- Review periodically the harmonised RAC, in the light of practical changes to TDG restrictions that they support, and adjust the RAC if necessary.

A new directive is most appropriate for the medium to long term, because it would require time and considerable resources to develop the methodology and necessary data, and to implement the required legislation. Therefore, to ensure that progress is made in the short-term, the first three organisational steps are recommended for immediate implementation. This would have the advantage of increasing understanding of how harmonised RAC would work in practice, and clarifying the challenges that the new directive would ultimately aim to overcome.

10 ACRONYMS

ACDS	Advisory Committee on Dangerous Substances
ADN	European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways
ADR	European Agreement concerning the International Carriage of Dangerous Goods by Road
ALARA	as low as reasonably achievable
ALARP	as low as reasonably practicable
ATM	air traffic management
BCR	benefit/cost ratio
CBA	cost-benefit analysis
CSM	common safety method
CST	common safety targets
DG	dangerous goods
DG-MOVE	Directorate-General for Mobility and Transport
DNV	Det Norske Veritas
EU	European Union
FN	frequency-number of fatalities
FSA	formal safety assessment
GAME	globalement au moins équivalent
GDP	gross domestic product
HSE	Health and Safety Executive
ICAF	implied cost of averting a fatality
ICRP	International Commission on Radiological Protection
IR	individual risk
IRR	internal rate of return
ISO	International Organization for Standardization
MS	Member State
NPV	net present value
OECD	Organisation for Economic Co-operation and Development
OTIF	Intergovernmental Organisation for International Carriage by Rail
QRA	quantitative risk assessment
RAC	risk acceptance criteria
RID	Regulations concerning International Carriage of Dangerous Goods by Rail
SR	societal risk
TDG	transport of dangerous goods
TEN-T EA	Trans-European Transport Network Executive Agency
UK	United Kingdom
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
VPF	value of preventing a fatality
USA	United States of America

APPENDIX I

Survey of Approaches to Harmonised Risk Acceptance Criteria for Transport of Dangerous Goods in Europe

Table of contents

I.1 INTRODUCTION

I.1.1 Objectives

This appendix aims to identify the RAC that are used in practice by EU Member States and other relevant countries. The following groups of applications are included:

- RAC for TDG – approaches to justification of restrictions applied to transport activities in addition to the ADR/RID/ADN regulations.
- RAC for installations - approaches to justification of restrictions applied to industries processing or producing DGs.
- RAC for temporary stop areas - approaches to justification of restrictions applied to road parking, harbours, multi-modal platforms, marshalling yards etc.

I.1.2 Outline

1. A draft survey was developed and agreed with the European Commission and selected experts in the transport of dangerous goods to determine that the survey addressed the key areas of concern and could be completed in a reasonable time.
2. A list of Member State contacts was created and the survey distributed. This was followed up by local contact from DNV offices in the Member State where necessary.
3. The responses to the survey were analysed and Member States grouped according to common approaches to the use of RAC.

DNV's approach to each of these tasks is presented in the following sections.

I.1.3 Survey Development

In order that the maximum number of responses were received from the survey, and being mindful of the additional burden that a large survey can place on an already pressed Member State representative, DNV designed the survey to be concise and easy to complete. It was intended to capture what RAC were employed in a Member State and to then provide a means of exploring this further should it be warranted.

The survey was constructed using an electronic template that could be completed by e-mail or filled in by DNV based upon information provided. The survey consisted of short, open-ended questions, defining relevant information, asking for an outline of the approaches used, and for reference materials with further information. A few closed questions were included to ensure that a null response could not be misinterpreted as indicating an absence of criteria.

A draft survey form was consulted with dangerous goods experts in the United Kingdom and Sweden and with representatives of the European Commission. Specific feedback was sought on the completeness of the questionnaire and its ease of completion, on the basis that a greater response will be received from an easy to compete survey.

The responses received were predominantly positive with constructive suggestions for improvements. This resulted in a final survey form being developed. This is shown in Annex One together with the letter of introduction kindly provided by the European Commission to support the study.

I.1.4 Survey Administration

A critical task in undertaking a survey of this nature is in identifying appropriate individuals to respond to the survey, and encouraging them to respond in a reasonable timescale. Based on previous experience in cross-European surveys, DNV used a staged approach, as follows:

a. Existing lists of appropriate individuals in relevant organisations in each MS were obtained, covering DG transport and general safety authorities.

b. The survey was administered by DNV's core project team in London. This involved distributing the survey to the list of identified transport of dangerous goods experts and safety authorities, following up with new contacts suggested by these and sending a series of reminders about the survey.

c. Follow-up by team members in local DNV offices.

In total 234 experts and Member State representatives were contacted regarding the survey covering the EU Member States, Norway and Switzerland, and representatives of the transport and dangerous goods industries. These comprised the Members and Observers of the Railways Interoperability and Safety Committee, the Members and Observers of the Committee on the Transport of Dangerous Goods, the National Safety Authorities, and the European Railway Associations. Contact was made by e-mail and e-mails were deliberately grouped by country so that all experts and Member state representatives could see who had been contacted in their country and thus coordinate their response as appropriate. The exception to this was the representatives of the transport and dangerous goods transport industry who received their own single collective e-mail, again to enable them to coordinate a response should they wish to do so.

A period of six weeks was allowed for a response to the survey. Reminders were sent out to all Member States who had not responded after three and five weeks and again once the response deadline had expired stating that even though no response had been received DNV remained very interested in any response that they would care to make. Similar reminders were sent to the industry representatives.

Local office contact was made five weeks into the survey with those Member States who were yet to respond and who were anticipated to have substantial transport of dangerous goods. This sought to explain the purpose of the survey and encourage a response.

I.2 RESPONSES

The responses to the survey are summarised in Table I.1 below. In terms of the target of the EU 27 plus Norway and Switzerland an overall response rate of 86% was achieved from the Member states. To complement this DNV has prepared, based upon its own knowledge, a response to cover the Channel Tunnel Safety Authority and some transport modes not addressed by a given Member state response. Additionally two responses from the industry sector were received; one from CEFIC (European Chemical Industry Council) and the other from CER/UIC (Community of European Railways/International Union of Railways).

Table I.1 – A Summary of the Member State Responses Received.

Member State or Organisation	Response Provided to Survey	Response to Survey Provided by DNV	Comment
Austria	✓		
Belgium	✓		
Bulgaria	✓		
Channel Tunnel Safety Authority	✓	✓	Not formally part of project scope. CTSA and Eurotunnel later confirmed the survey response provided by DNV.
Croatia	×		Not formally part of project scope
Cyprus	×		
Czech republic	✓	✓	Response for road completed by DNV following review of UNECE[1] website.
Denmark	✓		
Estonia	✓		
Finland	✓		
France	✓		
Germany	✓		
Greece	✓		Response compiled by DNV following e-mail contact with Member State representatives
Hungary	✓		
Ireland	✓		Response for road compiled by DNV following e-mail contact with Member State representatives
Italy	✓		
Latvia	✓		
Lithuania	✓		
Luxembourg	×	✓	Response for road completed by DNV following review of UNECE website.
Malta	×		
Netherlands	✓		

[1] UNECE – The United Nations Economic Commission for Europe. The body responsible for the ADR and ADN regulations.

Member State or Organisation	Response Provided to Survey	Response to Survey Provided by DNV	Comment
Norway	✓		
Poland	×		
Portugal	✓		
Romania	✓	✓	Response for road completed by DNV following review of UNECE website.
Slovakia	✓	✓	Response for road completed by DNV following review of UNECE website.
Slovenia	✓		
Spain	✓		
Sweden	✓		
Switzerland	✓	✓	Response for road completed by DNV following review of UNECE website and DNV's own knowledge
United Kingdom	✓		
CER/UIC	✓		
CEFIC	✓		Response constitutes DNV notes of a meeting held with CEFIC 10th June 2013

It should be noted that the CEFIC response comprises the notes of a face to face meeting between DNV and CEFIC (10th June 2013) as recorded by DNV and sent to CEFIC for comment/agreement.

In terms of the coverage achieved from the survey all countries with significant movement of dangerous goods have responded with the exception of Poland. The remaining Member States who have not responded are states with limited potential to impose additional restrictions on dangerous goods that might affect other Member States. As such it is concluded that the survey responses constitute a comprehensive coverage of the use of risk acceptance criteria in deciding on any restrictions to the transport of dangerous goods in the European Union, Norway and Switzerland.

I.3 ANALYSIS

The responses to the survey are provided in the Annex 2 below and summarised in Table I.2. All of the respondents indicated that the transport of dangerous goods was undertaken within their territory.

The first observation that is evident from the responses is that the transport of dangerous goods is not managed in a consistent way either within Member States or between them. Some Member States have provided separate responses to the survey by transport mode (such as Belgium) in which differing departments are separately responsible, whilst others have indicated that the management of dangerous goods varies by the classification of the goods (such as Ireland) in which radioactive materials fall under a differing responsibility to other classes of dangerous good. Transport of dangerous goods by rail was particularly well represented in the survey responses partly because each Member State has, under EU law, a dedicated safety authority for rail but no equivalent in road and inland waterways. Indeed for road the responses received have come from road authorities but also civil emergency planning authorities and general transport ministries.

Whilst this distribution of responsibility within the Member States undoubtedly represents that Member State's view of how dangerous goods risk should best be managed it does indicate a wide and diverse set of opinions. Often each transport mode is treated separately and the issue may be viewed as one of general transport, land use planning, civil emergency or economics. Additionally it would appear that little link is made to the requirements of the Seveso II directive and that the transport of dangerous goods is not considered in an end to end or transport corridor basis. This observation has been derived from the fact that few survey responses refer to the Seveso directive.

The central questions in the survey relate to whether the Member State uses risk acceptance criteria in deciding to impose additional restrictions on dangerous goods transport beyond those in ADR, ADN and RID. This simple question elicited a wide variety of responses with only three Member States comprehensively indicating that they used risk assessment and risk acceptance criteria in supporting decisions to restrict dangerous goods transport (the Netherlands, Portugal and Switzerland).

Other Member States such as Norway and France provide a methodology or methodologies for assessing the risks without providing risk acceptance criteria. In this instance the risk is often compared to that of the same transport corridor without dangerous goods on it or to an already existing corridor that is deemed acceptable[2]. Denmark employs this approach in determining restrictions for the Øresund transport link. As a part of the project to construct the tunnel/bridge a safety target was set by the construction consortium based upon the current individual and societal risk found in Denmark and Sweden. Whilst this approach is possible for new build projects it is not applied to existing assets and in this case local restrictions are often made by local decision and not with reference to nationally applicable risk acceptance criteria.

Road tunnels are considered as a special case in several Member States and specific risk assessment methodologies exist to assess the risk of dangerous goods transport through them.

[2] In French law an unacceptable level of risk can result in additional dangerous goods restrictions or can be linked to planning restrictions, effectively prohibiting or limiting development in the area of the transport corridor.

The most widely used of these is the DG-QRAM tool developed by UNECE and PIARC[3]. Whilst this tool is a standard one it does not have associated risk acceptance criteria and hence Member States apply their own. Both Austria and Slovenia report using this tool and applying an individual risk criterion in determining if any restrictions are necessary. In the Slovenian case it is reported that this criterion is effectively exported to Slovenia by Austria as it applies to a joint tunnel that runs between the two Member States. Any restriction justified at the Austrian end by the applied risk acceptance criterion is effectively applied at the Slovenian end as well. Road tunnel risk assessment is also used in Germany. Guidance on RAC is found in a research report and can be used to inform decision making, but no formal risk acceptance criteria are mandated. Similarly in the Czech Republic guidelines on risk acceptance criteria exist but are not mandated and have resulted in no restrictions.

The approach taken by the United Kingdom represents another methodology. In this case an impact analysis or cost benefit analysis is created with respect to a specific restriction. The prevailing government policy is then used to determine which restriction, if any, represents an appropriate response to the risk. No actual risk acceptance criteria are employed as such.

Only Germany reported applying any additional restrictions to transport of dangerous goods by inland waterway. Additionally in Germany the Ordinance on the Transport of Dangerous Goods by Road, Rail and Inland Waterways (GGVSEB 2013) places a general obligation on the transport of dangerous goods to consider modal shift. Specifically transport of certain dangerous goods by road should be confined to the motorway network if possible and then only if equivalent transport by rail or inland waterway is unacceptable. In neither case is risk assessment or risk acceptance criteria applied.

One quarter of the responding Member States report no use of risk acceptance criteria and no additional restrictions beyond those in ADR, ADN and RID. The most common situation in the Member States is not to impose restrictions on dangerous goods transport beyond the requirements of ADR, ADN and RID and consequently not to employ risk acceptance criteria, or to use local decision making. Consequently a harmonised approach is apparent across all member states for transport of dangerous goods by inland waterway and across seven Member States for road and rail transport of dangerous goods.

Table I.2 seeks to summarise and simplify the current situation. It represents DNVs interpretation of the various Member State surveys across each of the three modes considered and whether a risk methodology or risk acceptance criteria are used. It is of necessity a simplification for many Member States but it does provide a broad overview or grouping of the basic approaches taken by the Member States.

The Netherlands and Switzerland both employ the use of a quantitative risk acceptance criterion for transport, as do Austria and Slovenia for road tunnels. France, Norway and Germany employ risk assessment but currently this is used to inform a decision only and no risk acceptance criterion is legally mandated. Portugal reports the use of a simple risk threshold and a request has been made regarding further details of this in order to understand whether this is a quantitative or qualitative approach.

Seven Member States report a reliance on the ADR, ADN and RID requirements alone and consequently have neither restrictions nor RAC and the Channel Tunnel Safety Authority has

[3] The World Road Association

used a comparative methodology comparing DG transport with non DG transport to determine what restrictions to apply.

Table I.2 – DNV's Interpretation and Simplified Summary of the Survey Results

RAC	Count	Member State	Comment
No Restrictions, No RAC	7	Bulgaria, Czech Republic, Estonia, Greece, Hungary, Latvia, and Slovakia	In effect RAC is harmonised between all seven Member States as all rely solely on the provisions in ADR, ADN and RID and do not make use of chapter 1.9.
Some Restrictions, Implicit RAC	6	Finland, Ireland, Lithuania, Romania, Spain, and Sweden	Expert judgement is applied at a local level.
	1	Belgium	Expert judgement is applied at a local level. The Flemish region of Belgium is currently engaged in a project to develop a quantitative approach and associated RAC.
Some Restrictions, Explicit RAC	2	Denmark and Italy	RAC are applied to specific projects.
	1	United Kingdom	Impact analysis reflecting the prevailing government policy is employed.
	1	Channel Tunnel Safety Authority	Qualitative approach comparing DG with non-DG traffic on the same route.
	1	France	A risk matrix exists but no RAC are defined in law. Comparison is made to other routes to determine the need for restrictions.
	1	Norway	Risk methodologies are used but no formal RAC exist. Comparison is made to other routes.
	1	Germany	A risk methodology is employed for road tunnels and RAC are provided in guidance/research report, but not in law.
	1	Portugal	Simple risk threshold.
	2	Austria and Slovenia	Quantitative RAC for road tunnels based upon individual risk. RAC and risk methodology fully harmonised

RAC	Count	Member State	Comment
			between the two countries.
	2	Netherlands and Switzerland	Quantitative RAC based upon societal and individual risk.

It is the remaining Member States where DNV has applied a judgement. Denmark, Italy and the United Kingdom are considered to apply RAC to specific projects in determining if restrictions on the transport of dangerous goods are required. While these reflect government policy in the United Kingdom they are not considered to be legally mandated and are anticipated to vary from project to project. Finally Belgium, Finland, Ireland, Lithuania, Romania, Spain and Sweden are considered to use implicit RAC in employing local judgement based decision making to determine if a restriction is required. Romania in its response to the survey did indicate that there were no RAC or restrictions applied, however an analysis of the restrictions in place for road transportation in Romania indicate a framework that does facilitate local decision making; specifically the requirement to obtain a licence from the authorities in advance specifying the route and restrictions to be used for a particular movement. In Spain a roadmap for the transport of dangerous goods is made based upon the reports submitted by the transporters' safety advisors. Decision making in this case would again seem to DNV to be local, based upon what is acceptable and avoiding of population where possible, rather than against RAC.

Where a Member State has a risk methodology for determining if a restriction is necessary then this may be considered a systematic approach as compared to expert judgement being applied at a local or project level, which may vary by expert, locality or project. Table I.3 provides DNV's simplified view of which approaches in the Member States are systematic and which are harmonised between one or more Member States. Table I.4 then extends this to consider the potential for the approaches used in the Member States to be harmonised.

Table I.3 – DNV's Interpretation of the Survey Results with Respect to Whether they are Systematic and Harmonised

		Systematic Approach Used	
		No	Yes
Harmonised with Another Member State	Yes	Bulgaria, Czech Republic, Estonia, Greece, Hungary, Latvia, Slovakia	Austria, Slovenia
	No	Belgium, Denmark, Finland, Ireland, Italy, Lithuania, Romania, Spain, Sweden, United Kingdom,	France, Germany, Netherlands, Norway, Portugal, Switzerland

Table I.4 - DNV's Interpretation of the Survey Results with Respect to Whether they are Systematic and their Potential for Harmonisation

		Systematic Approach Used	
		No	Yes
Capable of Being Harmonised with Another Member State	Yes	Bulgaria, Czech Republic, Estonia, Greece, Hungary, Latvia, Slovakia	Austria, Belgium[4], France, Germany, Netherlands, Norway, Slovenia, Switzerland
	No	Denmark, Finland, Ireland, Italy, Lithuania, Romania, Spain, Sweden, United Kingdom	Portugal

In conclusion the analysis indicates that whilst a number of differing approaches to the use of RAC in determining restrictions on the movement of dangerous goods are evident in the European Union the most common situation is a reliance on the prescriptive standards described in RID, ADR and ADN to manage the risk arising from dangerous goods transport.

[4] Harmonisation is deemed capable in regard to the research project currently being undertaken in the Flemish region.

I.4 RESTRICTIONS IN ADR, ADN AND RID

The survey findings indicated that most commonly Member States in the European Union do not impose additional restrictions on the transport of dangerous goods beyond those in RID, ADR and ADN and hence do not employ risk acceptance criteria, or do so on the basis of local decision making. To seek confirmation of this DNV undertook to survey the transport restrictions that exist in the EU, Norway and Switzerland. The motivation for this was to check that the various Member State representatives who completed the survey had correctly understood the questions and to assess how the imposed restrictions relate to the reported use of RAC.

Chapters 1.9 of ADR, ADN and RID cover the use of transport restrictions imposed by a Member State on its territory for road, inland waterway and rail respectively. ADR and ADN require that these additional restrictions are published: the UNECE website provides a means of notifying these restrictions. A review of this website confirms that there are no additional restrictions notified for the transport for dangerous goods by inland waterway. Eighteen of the surveyed countries have notified additional restrictions for road transport of dangerous goods.

Table I.5 – A Summary of Road Restrictions

	General Restriction	Tunnel Restriction	Other Notifications
Austria			Mandates the use of warning lamps, escort vehicles and a minimum distance to the vehicle in front for specific tunnels.
Belgium	Additional panel to be provided on the vehicle carrying dangerous goods and tunnels to be marked with their restrictions. Dangerous goods transport restricted to the motorway network.	Tunnels are categorized in accordance with Chapter 1.9.5 of ADR.	Provisions for marking of intermediate bulk containers. Notified norm for the inspection and testing of pressure vessels.
Czech Republic		Tunnels are categorized in accordance with Chapter 1.9.5 of ADR. All tunnels are category A (no restrictions).	
Denmark		Tunnels are categorized in accordance with Chapter 1.9.5 of ADR.	Requirements for the transport of gas cylinders containing dangerous goods and fitted with quick release valves.
Finland	Transport of dangerous goods is allowed in areas indicated by signage. Restrictions on the use of ferries to transport dangerous goods over waterways.[5]		

[5] This is not a restriction on transport of dangerous goods by inland waterway, but rather considers the use of a lorry containing dangerous goods using a ferry to cross an area of water between two roads. Hence, its' being notified as a restriction under ADR.

	General Restriction	Tunnel Restriction	Other Notifications
France	Local traffic restrictions for dangerous goods are indicated by road signs.	Restrictions apply to the Frejus and Mont Blanc tunnels.	
Germany		Tunnels are categorized in accordance with Chapter 1.9.5 of ADR.	Restrictions on the transport of damaged Lithium batteries, transportable pressure equipment, salvaged pressure receptacles, seamless sample pressure receptacles, gas cylinders with quick release valves used for dangerous goods transport and gas cylinders for use with hot air balloons.
Luxembourg	Restrictions on specific dangerous goods on specific roads.		
Netherlands	A comprehensive set of restrictions on types of dangerous goods, tunnels that may be used and routes including the use of emergency stop devices, training, inspection and documentation. Restrictions on transportation of dangerous goods when visibility due to weather is limited or road surface is slippery. Requirements concerning the use of ferries to cross waterways.[6]	Tunnels are categorized in accordance with Chapter 1.9.5 of ADR.	
Norway	Route specific restrictions on the transport of dangerous goods at certain times of day.	Tunnels are categorized in accordance with Chapter 1.9.5 of ADR.	Transport of dangerous goods in seamless sample pressure receptacles.
Portugal	Route specific restrictions on the transport of dangerous goods at certain times of day.		

[6] This is not a restriction on transport of dangerous goods by inland waterway, but rather considers the use of a lorry containing dangerous goods using a ferry to cross an area of water between two roads. Hence, its' being notified as a restriction under ADR.

	General Restriction	Tunnel Restriction	Other Notifications
Romania	Restrictions relating to the time of day that dangerous goods transport may occur. Requirement to obtain a notice for the movement including details of the route that is approved by the authorities.		
Slovakia	No restrictions. Details of the competent authorities for ADR in Slovakia.		
Slovenia			Restrictions relating to a tunnel shared with Austria (see Austria above).
Spain	Network of routes for dangerous goods described. Restrictions on certain routes by time of day.		Recommended parking sites for dangerous goods in Spain. Norm notified for the inspection and testing of negative pressure tanks.
Sweden	Restrictions when transporting dangerous goods across rivers and fjords by ferry[7].	Tunnels are categorized in accordance with Chapter 1.9.5 of ADR.	Restrictions for the transport of damaged lithium batteries.
Switzerland	Swiss ordnances largely reflect the provisions of the ADR with additional local requirements such as driver training and the driver to avoid consuming alcohol for 6 hours before returning to work.	Tunnels are categorized in accordance with Chapter 1.9.5 of ADR.	Norm notified for the inspection and testing of negative pressure tanks.
United Kingdom		Tunnels are categorized in accordance with Chapter 1.9.5 of ADR.	Restrictions for the transport of damaged lithium batteries, valves for fire extinguishing assemblies and LPG cylinders for hot air balloons.

To support the imposition of restrictions against Chapter 1.9 of ADR a General Guideline for the Calculation of Risks in the Transport of Dangerous Goods by Road was developed by the Working Party on the Transportation of Dangerous Goods[8]. No reference to the use of this guide has been identified in the review of the notified restrictions, although it is of course possible that it has been used as a preparatory tool. This is relevant to this study as the guide considers the use of RAC in deciding if a restriction is appropriate.

[7] This is not a restriction on transport of dangerous goods by inland waterway, but rather considers the use of a lorry containing dangerous goods using a ferry to cross an area of water between two roads. Hence, its' being notified as a restriction under ADR.

[8] UNECE, "General Guideline for the Calculation of Risks in the Transport of Dangerous Goods by Road. An introduction to the basic principles of risk assessment for chapter 1.9 ADR", 2008. http://www.unece.org/fileadmin/DAM/trans/danger/publi/adr/Calculation%20of%20risks_e.pdf

The transport of dangerous goods by rail is governed by the RID. Chapter 1.9 of RID again permits the use of local transport restrictions by Member States but in this case the restriction must be supported by evidence of the need for the measure and again a Generic Guideline for the Risk Assessment[9] has been developed as a means of providing this evidence. There is no requirement for these restrictions to be notified and as such no central register of them exists. To achieve an overview of what these restrictions might be DNV undertook a brief review of the Network Statement provided by some of the main railway infrastructure managers across the EU (Table I.6). Whilst this review cannot be considered a comprehensive overview of transport restrictions related to dangerous goods it does provide illustrative examples of the restrictions.

Table I.6 – A Sample of Rail Restrictions

Country and Infrastructure Manager	Restriction
Austria OBB	No restrictions
Belgium Infrabel	Dangerous goods are prohibited at Antwerp north/south junction on line 23 (Antwerp-Berchem and Antwerp-Luchtbal) and the north/south junction at Brussels line 0 (Brussels-Midi and Brussels-Nord).
Bulgaria	Restrictions to dangerous goods trains apply at railway stations.
Czech Republic SZDC	It is prohibited to handle dangerous goods in areas of natural curative springs or spas and dangerous goods are prohibited in certain line sections associated with these.
Denmark Banedanmark	Specific rules apply to dangerous goods transport in the Great Belt and Øresund Tunnel.
Germany DBNetz	Restrictions apply to the stabling of trains carrying dangerous goods, a ban on two trains carrying dangerous goods from meeting, certain routes are prohibited, trains carrying dangerous goods should divert around conurbations, and trains carrying dangerous goods should avoid staying in passenger stations, changing traction unit or shunting movements.
Finland	No restrictions are in place. It is recommended not to park dangerous goods trains in densely populated or groundwater areas. Avoid tracks with spike fastenings or 43 kg rail. A safety analysis must be undertaken for yards handling considerable quantities of dangerous goods. Western and domestic traffic the internal regulation on the frost proofing of structural materials for tanks exceeds that quoted in RID. Eastern traffic SMGS will additionally apply.
Italy RFI	Dangerous goods trains must only travel between terminalisation and handling facilities suitable for dangerous goods.
Netherlands Prorail	The handling and stabling of dangerous goods trains in a railway yard is only permitted under the terms of the environmental permit for that yard. Dangerous goods are prohibited in the Rijswijk tunnel.
Norway JBV	No restrictions
Poland PLK	No restrictions
Spain ADIF	It is prohibited for a dangerous goods train to pass through a town where an alternative bypass exists. Stabling of dangerous goods trains at inhabited stations should not be planned. Detention of dangerous goods trains in tunnels over 100m long should not be planned.

[9] OTIF "Generic Guideline for the Calculation of Risk inherent in the Carriage of Dangerous Goods by Rail" approved by the RID Committee of Experts on 24 November 2005.

Country and Infrastructure Manager	Restriction
Sweden Trafikverket	Dangerous goods trains are prohibited from the tunnel in Helsingborg central (train station) and the tunnel in Glumslov. Alternative routes are available.
United Kingdom High Speed 1 Network Rail	Special instructions and work instructions to be issued specific to the movement of a particular dangerous goods train. A risk assessment may be undertaken. A dangerous goods train may not be in the Severn tunnel at the same time as any other train. An alternative route exists.

As with the restrictions applicable to the transport of dangerous goods by road under ADR there is no commonality of the type of restriction between differing countries and no explicit link made between the imposed restriction and any risk based justification or the use of RAC.

There is equally no commonality of restriction between transport modes evident in some countries. For instance in Germany no restrictions are imposed for dangerous goods transport by road (other than in tunnels) or inland waterway, but are in existence for rail.

In comparing the identified restrictions with the responses received to the survey of the Member States some discrepancies are evident. The Czech Republic reported that they did not impose restrictions or employ any RAC however they have provided a notification for rail and for road tunnels. The notified restriction on road tunnels is to classify all tunnels as "A" which is unrestricted to the movement of dangerous goods. The restrictions for rail are similarly minor and relate to the handling of dangerous goods (rather than their transport) in areas associated with natural springs which is an environmental risk. Bulgaria similarly reports no restrictions or RAC but the Bulgarian rail infrastructure manager provides a restriction on dangerous goods trains at railway stations. Both this and the Czech case are considered sufficiently minor that they do not significantly contradict the responses provided by the Member States.

The response to the survey by Romania related to the rail mode and indicated no restrictions or RAC. The road response was completed by DNV based upon the information contained on the UNECE website. Whilst this did not indicate the use of RAC it does impose a restriction on the movement of dangerous goods by time of day and the requirement for a transport operator to obtain a notice from the authorities for the movement that details the route to be taken. DNV believes that this approach is best described as local decision making as it allows the authorities to apply such restrictions as are seen fit at a particular location. It is for this reason that DNV has chosen to describe the situation in Romania as Local Decision Making as opposed to no restrictions which the rail response alone would support.

Finally, it is worth noting that the table of identified restrictions for road indicates that only 18 of the 28 Member States that are in scope of this study choose to apply any restrictions. Accepting that the Czech road restriction is not a restriction in practise means that 39% of the Member States in the study do not employ any road restrictions on the movement of dangerous goods. Where restrictions are imposed there is no explicit link made to a risk analysis, risk acceptance criterion or risk based argument that justifies the restriction.

This reflects the responses received in the survey of Member States in that the most common response was either that local decision making (i.e. judgement) was employed or that there

were neither additional restrictions nor risk acceptance criteria. In conclusion DNV considers that the identified restrictions are consistent with the responses received back from the Member States to the survey.

I.5 DISCUSSION

This part of the study is primarily a data gathering stage in that it seeks to identify:

- What is the existing use of risk acceptance criteria across the EU plus Norway and Switzerland in managing dangerous goods risk.
- What additional restrictions have resulted from the application of these risk acceptance criteria beyond those contained in RID, ADR and ADN.

The first of these objectives was successfully completed by the use of the survey of Member States which achieved an 86% response rate including representation from across the various geographical regions of the European Union. Experience of previous surveys indicates that this represents a very high response rate and as all major regions of the European continent are included in the responses the survey findings can be considered representative. Indeed, with the exception of Poland the non-responding states are generally those with limited transport of dangerous goods within their borders.

The survey indicated that the use of risk acceptance criteria was not widespread in relation to the transportation of dangerous goods. With the exception of road tunnels few Member States reported that they employed risk assessment in determining if a restriction was necessary. The most common response was Member States reporting that they solely used the requirements of RID, ADR and ADN in managing risks from the transportation of dangerous goods and that these are often managed separately by mode.

The restrictions imposed by Member States under chapter 1.9 of RID, ADR and ADN have been identified where possible. The intent is that these restrictions are based upon an assessment of the risks involved and guidelines to this effect have been produced by the responsible working groups in UNECE[10] and OTIF[11]. However, there has been no indication to date that the additional restrictions are based upon anything other than expert judgement and return of experience in setting the restrictions. For example the Netherlands restricts movement of dangerous goods when visibility is restricted or conditions are slippery. Other states will experience fog and ice but do not have the same restriction. Several states restrict movement of dangerous goods at specific locations such as tunnels at certain times of day which means that the dangerous goods will either have to take an alternative route or remain parked for some hours potentially exposing a local population to an increased risk. Indeed many of the imposed restrictions would appear to be addressing a local environmental or economic risk rather than a safety one.

Dangerous goods tend not to be transported over large distances because of the risks they present. However, if they were to be transported across the European Union then they would experience a wide variety of differing restrictions as they go between states ranging from no restrictions, to preferred routes and parking places in Spain, weather related restrictions in the Netherlands, time of day based restrictions in several countries and other local restrictions in France as examples. However the risk presented would remain largely the same. A similar situation exists for rail with some restrictions, such as those detailed in the environmental permit for marshalling yards in the Netherlands, again being specific to a locality.

[10] UNECE – The United Nations Economic Commission for Europe. The body responsible for the ADR and ADN regulations.

[11] OTIF - *L'Organisation intergouvernementale pour les transports internationaux ferroviaires or* Intergovernmental Organisation for International Carriage by Rail. The body responsible for the RID regulations.

Several Member State responses to the survey indicate a preference for the deterministic approach set out in RID, ADR, and ADN. However, it is apparent that this approach is not entirely followed and that the presence of specific local restrictions at junctions, tunnels and areas of groundwater means that a simple adherence to the RID, ADR and ADN is insufficient. Those states that do report the use of risk acceptance criteria in determining if additional restrictions are needed clearly have a number of historical restrictions still in force as the reported risk acceptance criteria appears to have little direct link to many of the restrictions that have been imposed.

ANNEX ONE – THE SURVEY FORM AND COVERING LETTER

SURVEY OF RISK ACCEPTANCE CRITERIA FOR TRANSPORT OF DANGEROUS GOODS IN EUROPE

Country	
Scheme owner The organisation or government department that manages the DG transport restrictions described below.	
DG transport activity in country? Please delete as applicable.	Road / rail / inland waterway
Are DG transport restrictions used? Please delete as applicable.	ADR/RID/ADN regulations only Additional provisions under Section 1.9 of ADR/RID/ADN Other restrictions (please specify)
Description of DG transport restrictions. A brief outline of the restrictions that apply in the country.	
Are risk acceptance criteria (RAC) used? Please delete as applicable.	For restrictions on DG transport activities For restrictions on industries processing or producing DGs (where these may have knock-on impacts on transport) For restrictions on temporary stop areas (road parking / harbours / multi-modal platforms / marshalling yards / others) For restrictions on road tunnels/rail tunnels
Description of RAC. A brief outline of the RAC that are used to impose restrictions. Note: RAC may include simple risk thresholds, limiting curves or distributions of risk, complex methodologies or other equivalent controls.	
Reference documentation. Title/URL of further explanation of the RAC	
Could the RAC above be used as part of harmonised EU RAC? Please mention any relevant limitations.	Yes / no
Problems in applying RAC. Please mention any experience in applying RAC or meeting DG restrictions or cross-border issues that may be relevant in harmonising RAC for DG transport in EU.	
Approach to harmonising RAC for DG transport. Please recommend any approach that might be suitable.	
Contact for further discussion. Name/email/telephone	

EUROPEAN COMMISSION
DIRECTORATE-GENERAL FOR MOBILITY AND TRANSPORT

Directorate B - European Mobility Network
B.2 - Single European Rail Area
The Head of Unit

Brussels,
MOVE/B.2/GR/jt D(2013)

To the attention of the Members and Observers of the Railways Interoperability and Safety Committee, Members and Observers of the Committee on the Transport of Dangerous Goods, the National Safety Authorities, European Railway Associations and other relevant stakeholders consulted by Det Norske Veritas AS

Subject: **Investigation into Harmonised Risk Acceptance Criteria for Transport of Dangerous Goods.**

Dear Sir/Madam,

With the present letter, I am pleased to inform you that Directorate-General for Mobility and Transport of the European Commission has charged Det Norske Veritas AS to undertake an Investigation into Harmonised Risk Acceptance Criteria for Transport of Dangerous Goods in the European Union.

This investigation will focus on the feasibility of defining and using harmonized risk acceptance criteria in decision-making for justification of restrictions on the inland transport of dangerous goods in Europe. The use of the criteria will be analysed from the point of view of supporting the adoption of transport mode-specific provisions by the relevant decision-makers and of specific local and regional additional provisions.

Consultants are currently performing a survey of the risk acceptance criteria used in practice by EU Member States, CH and NO, contracting parties to the COTIF and at UNECE levels for the justification of restrictions for transport, production and processing of dangerous goods.

The research will be conducted during the period May 2013-June 2013. The results will be presented and discussed in a workshop late in 2013. More details can be found in the terms of reference of the study, available on the web page:

http://ec.europa.eu/transport/facts-fundings/tenders/doc/specifications/2012/s56-090535-specifications.pdf

Commission européenne/ Europese Commissie, 1049 - Bruxelles/ Brussel, BELGIQUE/ BELGIË - Tel. (+32-2) 299.11.11.
Office: DM28 4/50. Tel.: direct line (+32-2) 296.82.40. Fax (+32-2) 299.02.62.

In the framework of such an exercise, a stakeholder consultation is carried out with the aim of completing/updating the set of available information to be used as input in data analysis as well as contribution in the evaluation.

Any assistance from your Organisation will be highly appreciated.

The consultant will require a great deal of details facts and business' independent opinions, which he will treat with the utmost discretion. The European Commission will publish the final report; however, the information will be treated in such way to maintain anonymity of the source.

In this activity, the consultants have been granted a large autonomy. Therefore, the European Commission is not responsible for the content of the information transmitted by the consultants and, in any case, it cannot constitute any formal commitment on behalf of the European Commission.

For any question related to this study, please contact Mr Rigon (tel. +32.2.296.81.96, Giordano.Rigon@ec.europa.eu).

Yours sincerely,

S. Prout

Sian Prout

ANNEX TWO – THE SURVEY RESPONSES

Country	Austria
Scheme owner	Several departments have the responsibility, please see contacts below.
DG transport activity in country?	Road / rail / inland waterway
Are DG transport restrictions used?	ADR/RID/ADN regulations only Additional provisions under Section 1.9 of ADR/RID/ADN Other restrictions (please specify): transport of fissile material is forbidden for war use and in connection with energy generation
Description of DG transport restrictions.	1.9.3 b), 1.9.5.3.8 ADR 1.9.3 b) RID
Are risk acceptance criteria (RAC) used?	For possible future restrictions on road tunnels according to 1.9.5.1 ADR
Description of RAC.	see DG-QRAM
Reference documentation.	DG-QRAM
Could the RAC above be used as part of harmonised EU RAC?	No
Problems in applying RAC.	Lack of concrete transport data and representative accident statistics Validity of scenarios questionable Lack of alternatives Improvement by changing the basis of the calculation instead of taking reasonable measures
Approach to harmonising RAC for DG transport.	Not to be too enthusiastic
Contact for further discussion.	Othmar.Krammer@bmvit.gv.at (for the moment) Friedrich.Kirchnawy@bmvit.gv.at (from 29.7.) Friedrich.Wiesholzer@bmvit.gv.at (tunnels, DG-QRAM) Bernd.Birklhuber@bmvit.gv.at (inland waterways)

Country	Belgium
Scheme owner	F.O.D. Mobiliteit en Vervoer
DG transport activity in country?	Inland waterway
Are DG transport restrictions used?	ADN regulations only No additional provisions under Section 1.9 of ADN
Description of DG transport restrictions.	
Are risk acceptance criteria (RAC) used?	No. There is 1 risk based rule in the ADN itself (9.3.4) but it has to do with ship construction and not with transport restrictions
Description of RAC.	
Reference documentation.	
Could the RAC above be used as part of harmonised EU RAC?	
Problems in applying RAC.	
Approach to harmonising RAC for DG transport.	
Contact for further discussion.	Henk Croo F.O.D. Mobiliteit en Vervoer tel. 0032/3/2290043 mail henk.croo@mobilit.fgov.be

Country	**Belgium**
Scheme owner	Ministry of Mobility and Transport DG Road Transport & Traffic Safety (Federale Overheidsdienst Mobilieit en Vervoer DG Wegvervoer & Verkeersveiligheid)
DG transport activity in country?	Road
Are DG transport restrictions used?	ADR regulations Additional provisions under Section 1.9 of ADR: - Traffic signs C24b and C24c; restriction of transport of certain dangerous goods - Tunnel restrictions - Obligation to take motorways
Description of DG transport restrictions.	ADR regulations Tunnel restrictions based on ADR 1.9.5 Supplementary restrictions based on ADR 1.9.2: 1)Ministerial Decree of 22-01-2010: restriction of transport of certain dangerous goods – traffic signs C24b and C24c. 2)Royal Decree of 01-12-1975, Article 48bis: obligation to take motorways http://www.unece.org/trans/danger/publi/adr/country-info_e.html
Are risk acceptance criteria (RAC) used?	No
Description of RAC.	**For restrictions on DG transport activities** : A risk assessment methodology for the inland transport of dangerous goods is being developed as a part of the TWOL - project of the Flemish Region : Vlaamse Overheid – Departement Leefmilieu, Natuur en Energie, Contact: Marc Bogaert - marc.bogaert@lne.vlaanderen.be The external safety is taken into account; influence the transport of dangerous goods versus environmental planning. At present this project is not finished and no risk acceptance criteria are yet proposed. **For restrictions on road tunnels / rail tunnels:** regional competence (Brussels, Flemish and Walloon Region) – in accordance with the Tunnel Safety Directive
Reference documentation.	Please contact the Flemish Region marc.bogaert@lne.vlaanderen.be
Could the RAC above be used as part of harmonised EU RAC?	No
Problems in applying RAC.	- How remediate existing situations? - What if there are no or little alternative routes (for example due to high density of population)? - How to communicate to the citizens?
Approach to harmonising RAC for DG transport.	RAC that are usable in the entire EU. Flexibility for the member states to handle specific situations in accordance with the EU-recommendations.

Contact for further discussion.	Federale Overheidsdienst Mobiliteit en Vervoer Dienst Reglementering Voertuigen Sabine Vercruysse – 0032 2 277 39 04 – sabine.vercruysse@mobilit.fgov.be Michaël Bogaert – 0032 2 36 11 – michael.bogaert@mobilit.fgov.be ADR class 1: Federale Overheidsdienst Economie, KMO, Middenstand en Energie – Centrale Dienst Springstoffen – Dhr. Corbaye – Tel: 02/277 62 09 – explo@economie.fgov.be ADR class 7: Federaal Agentschap voor Nucleaire Controle (FANC) - Dienst Invoer en Vervoer – Tel: 02/289 21 81 – transport@fanc.fgov.be Flemish Region: Vlaamse Overheid – Departement Leefmilieu, Natuur en Energie, Contact: Marc Bogaert - marc.bogaert@lne.vlaanderen.be

Country	Belgium
Scheme owner	NSA BE- Department for Railway Safety and Interoperability → **Competent for RID**
DG transport activity in country?	Rail
Are DG transport restrictions used?	Traffic restriction by the IM
Description of DG transport restrictions.	DG forbidden on line 0 in Brussels and on line 25 in Antwerp (passengers, stations and tunnels). Regulation : RSEIF (règle de sécurité en matière d'exploitation de l'infrastructure ferroviaire) 5.2, points 8.3 and 9.1.
Are risk acceptance criteria (RAC) used?	No
Description of RAC.	
Reference documentation.	
Could the RAC above be used as part of harmonised EU RAC?	
Problems in applying RAC.	-
Approach to harmonising RAC for DG transport.	
Contact for further discussion.	Caroline Bailleux NSA BE – SSICF +32 2 277 39 16 Caroline.bailleux@mobilit.fgov.be

Country	Bulgaria
Scheme owner	Railway Administration Executive Agency (RAEA).
DG transport activity in country?	Rail
Are DG transport restrictions used?	In Ordinance No 46 for the transport of dangerous goods by rail in Bulgaria, issued by the Minister of Transport and Communications (in force as of 01.01.2002), only the restrictions referred to in RID are prescribed/applied. Bulgaria does not use other restrictions (additional provisions) as per items 1.9.1. and 1.9.2. of RID. Article 6 (4) of Regulation No 46 provides, on condition that safety is not compromised, that RAEA is entitled to authorize temporary exemptions from the requirements of RID with a view to performance of tests on the territory of Bulgaria, which are necessary for determination of the conditions for transport of dangerous goods not specified in RID. Also the "Rules for train movement and shunting activities in railway transport" issued by the infrastructure manager of Bulgaria State Enterprise "NRIC" specify the rules for "Inclusion of wagons loaded with dangerous goods into the trains " (Articles 74- 80) and the number of axles (precautionary distance) for providing distance from the wagons loaded with dangerous goods from the train locomotive, from the carriages with people / from the escort etc.
Description of DG transport restrictions.	We use only restrictions included in RID and temporary restrictions, as follows: Ordinance № 46, Art. 6 (4) "As long as safety is not compromised, RAEA is entitled to authorize temporary exemptions from the requirements of RID and Annex II of SMGS with a view to performance of tests on the territory of the Republic of Bulgaria, which are necessary to determine the conditions for transport of dangerous goods not specified in RID and in Annex II of SMGS, so that in case of positive result from the these tests the conditions can be proposed as amendments or modifications to RID and to Annex II of SMGS. For these exceptions and for the measures taken for safe transport of such goods, the European Commission shall be notified."
Are risk acceptance criteria (RAC) used?	In Bulgaria there are no RAC developed for transport of dangerous goods by rail.
Description of RAC.	In Bulgaria there are no RAC developed for transport of dangerous goods by rail.
Reference documentation.	None
Could the RAC above be used as part of harmonised EU RAC?	No
Problems in applying RAC.	We cannot specify.
Approach to harmonising RAC for DG transport.	We cannot specify such an approach.
Contact for further discussion.	Official e-mail of RAEA: iaja@mtitc.government.bg Phone: (+359 2) 9 409 428 Mr. Daniel Nedelkov – Director of Directorate "Regulation" e-mail: dnedelkov@mtitc.government.bg Phone: (+359 2) 9409 575; Fax: (+359 2) 987 67 69

Country	Channel Tunnel Safety Authority UK/France
Scheme owner	Eurotunnel
DG transport activity	Rail (freight shuttle carrying road vehicles)
Are DG transport restrictions used?	Yes - ADR/RID regulations with additional provisions.
Description of DG transport restrictions.	Additional restrictions beyond ADR/RID to reflect the specific risks of the tunnel are contained in Eurotunnel's operating rules Volume F "Carriage of Dangerous Goods". These take account of confinement, the difficulty of dispersing heat or pressure in the tunnel, the proximity of HGV drivers, and the remoteness of emergency response. Ultimately they are presumed to be based on judgement. A risk-based approach was applied in 2012 to reconsider the carriage of UN3077 which was previously prohibited.
Are risk acceptance criteria (RAC) used?	Yes - for reconsidering restrictions on rail tunnel.
Description of RAC.	A qualitative bow-tie approach showed the relative risk of accidents was indistinguishable from the risk with non-DG freight shuttles.
Reference documentation.	"Formulation of a risk-based approach to the Eurotunnel Policy on the Transport of Dangerous Goods", Confidential Report for Eurotunnel by Det Norske Veritas and Environmental Scientifics Group, 5 Jan 2012.
Problems in applying RAC.	In 2012 the Channel Tunnel Safety Authority agreed the re-acceptance of UN 3077 into Eurotunnel's DG Policy.
Could the RAC above be used as part of harmonised EU RAC?	Partly - the comparison with non-DG vehicles may be appropriate. However, qualitative risk comparison is suitable for intra-modal applications but not cross-modal applications.
Approach to harmonising RAC for DG transport.	The report considers 4 other risk strategies for decision-making on DG transport, some of which may be suitable.
Contact for further discussion.	Sarah Collyer, Dangerous Goods Safety Advisor, Eurotunnel. Tel: 01303 283805 Sarah.Collyer@eurotunnel.com

Country	Czech Republic
Scheme owner	Drazni urad, National safety authority, responsible only for chapter 6.8
DG transport activity in country?	Rail
Are DG transport restrictions used?	RID
Description of DG transport restrictions.	RID is applicable for rail transport, we do not have any additional restrictions
Are risk acceptance criteria (RAC) used?	We do not use any RACs.
Description of RAC.	We do not use any RACs.
Reference documentation.	We do not use any RACs.
Could the RAC above be used as part of harmonised EU RAC?	No
Problems in applying RAC.	We do not use any RACs.
Approach to harmonising RAC for DG transport.	
Contact for further discussion.	Kodym@ducr.cz

Country	Czech Republic
Scheme owner	
DG transport activity in country?	Road
Are DG transport restrictions used?	ADR
Description of DG transport restrictions.	ADR is applicable for road transport, there are no additional restrictions. Tunnels are assessed using DG-QRAM and classified in accordance with 1.9.5 of ADR. Currently all tunnels are category A i.e. no restrictions on dangerous goods apply.
Are risk acceptance criteria (RAC) used?	We do not use any RACs.
Description of RAC.	We do not use any RACs.
Reference documentation.	We do not use any RACs.
Could the RAC above be used as part of harmonised EU RAC?	No
Problems in applying RAC.	We do not use any RACs.
Approach to harmonising RAC for DG transport.	
Contact for further discussion.	

Completed by DNV following a review of the restrictions notified under section 1.9 of ADR and as reported on the UNECE website.

Country	Denmark
Scheme owner	Trafikstyrelsen (Danish Transport Authority)
DG transport activity in country?	Rail
Are DG transport restrictions used?	Additional provisions under Section 1.9 of ADR/RID/ADN
Description of DG transport restrictions.	The restrictions concern the tunnel of the fixed link across the Great Belt and the tunnel of the fixed link across Øresund. The restrictions comprises of two specific aspects. One of the aspects regards limitation of the amount of explosives to be carried through the tunnel(s) and the other aspect regards safety distances between wagons and between big containers loaded with dangerous goods to be carried through the rail tunnel(s).
Are risk acceptance criteria (RAC) used?	For restrictions on rail tunnels
Description of RAC.	The purpose of above mentioned restrictions is to secure and preserve the construction of the two tunnel(s).
Reference documentation.	http://www.piarc.org/en/order-library/6741-en-Towards%20development%20of%20a%20risk%20management%20approach.htm
Could the RAC above be used as part of harmonised EU RAC?	Do not know
Problems in applying RAC.	-
Approach to harmonising RAC for DG transport.	-
Contact for further discussion.	Iram Akbar ia@trafikstyrelsen.dk +45 41 78 03 43

DNV Note: The PIARC report "Towards Development of a Risk management Approach" cites the risk acceptance criteria applied, as design criteria, to the Øresund link as being:

- Risk Acceptance Criteria on the ALARP (As Low As Reasonably Practical) domain;
- for road: less than 33 fatalities per 1 billion passages of the Link;
- for rail: less than 4 fatalities per 1 billion passages of the Link;
- User Risk as individual risk and societal

These are only applicable to this link.

Country	Denmark
Scheme owner	Danish Ministry of Justice Danish National Police (Danish Ministry of Transport)
DG transport activity in country?	Road
Are DG transport restrictions used?	ADR regulations. Additional provisions under Section 1.9 of ADR.
Description of DG transport restrictions.	1.9.3 (b). Prescribed routes for certain dangerous goods in densely populated areas. The police are responsible for designating prescribed routes. 1.9.5. Tunnel restrictions through the Øresund tunnel (between Denmark and Sweden): Tunnel category B from 23.00 to 06.00 and tunnel category E from 06.00 to 23.00.
Are risk acceptance criteria (RAC) used?	No detailed information available.
Description of RAC.	No detailed information available.
Reference documentation.	http://www.piarc.org/en/order-library/6741-en-Towards%20development%20of%20a%20risk%20management%20approach.htm
Could the RAC above be used as part of harmonised EU RAC?	No
Problems in applying RAC.	No detailed information available.
Approach to harmonising RAC for DG transport. .	It should be up to the relevant national authority to decide, which risk acceptance criteria should be used. Any developed risk acceptance criteria as the basis for transport restrictions in dangerous goods should only be guidelines and should not be obligatory.
Contact for further discussion.	Lars Erik Tamborg, let@brs.dk, +45 45 90 62 09. Danish Emergency Management Agency

DNV Note: The PIARC report "Towards Development of a Risk management Approach" cites the risk acceptance criteria applied, as design criteria, to the Øresund link as being:

- Risk Acceptance Criteria on the ALARP (As Low As Reasonably Practical) domain;
- for road: less than 33 fatalities per 1 billion passages of the Link;
- for rail: less than 4 fatalities per 1 billion passages of the Link;
- User Risk as individual risk and societal

These are only applicable to this link.

Country	Estonia
Scheme owner	Ministry of Economic Affairs And Communications Road and Railways Department
DG transport activity in country?	Road / rail
Are DG transport restrictions used?	ADR/RID and SMGS
Description of DG transport restrictions.	No other restrictions than ADR and RID and SMGS
Are risk acceptance criteria (RAC) used?	No
Description of RAC.	None
Reference documentation.	None
Could the RAC above be used as part of harmonised EU RAC?	No
Problems in applying RAC.	None
Approach to harmonising RAC for DG transport.	No recommendations
Contact for further discussion.	Jaak Ideon Executive Officer of Transportation and Traffic Division of Road and Railways Department (for ADR) + 372 625 6499 jaak.ideon@mkm.ee Kristi Kuldma Executive Officer of Railways Division of Road and Railways Department (for RID) +372 639 7619 kristi.kuldma@mkm.ee

Country	Finland
Scheme owner	Ministry of Transport and Communications, Finland
DG transport activity in country?	Road / rail
Are DG transport restrictions used?	ADR/RID Additional provisions under Section 1.9 of ADR Other restrictions (please specify) Road (1.9.3): road transport restrictions in a certain area or road or in a section of a road, to follow prescribed routes for example to avoid residential areas
Description of DG transport restrictions.	On a well-founded proposal by a municipality, the Ministry may restrict the transport of dangerous goods in a certain area, road or section of a road if the transport there may cause significant danger to persons, the environment or property. When issuing the restriction it shall be ensured that no more restrictions are placed on the possibilities to transport dangerous goods than are necessary for the elimination of the danger caused by the transport. The municipality shall disseminate information on a restriction concerning its area. Please refer to the annex for the requirements for these restrictions. For the municipalities that have restrictions, please refer to the web pages of the Ministry: www.lvm.fi/vak.
Are risk acceptance criteria (RAC) used?	No.
Description of RAC.	
Reference documentation.	
Could the RAC above be used as part of harmonised EU RAC?	No
Problems in applying RAC.	
Approach to harmonising RAC for DG transport.	
Contact for further discussion.	Mari Suominen/mari.suominen@lvm.fi/ +358 295 34 2306 address: Eteläesplanadi 16, Helsinki, PO Box 31, FI-00023 Government.

Country	France
Scheme owner	CENTRALLY Ministère de l'écologie du développement durable et de l'énergie. Direction générale de la prévention des risques/ Mission Transport de Matières Dangereuses LOCALLY Traffic restriction may be defined by whatever authority is responsible for local road management for instance the mayor of a city when it covers the city road network
DG transport activity in country?	Road / rail / inland waterway
Are DG transport restrictions used?	Additional provisions under Section 1.9 of ADR/RID/ADN
Description of DG transport restrictions.	The restrictions are listed in the order of the categories in the following case Traffic deviations may be issued by local authorities for road transport but they are usually quite straightforward and provide an alternative route (not based on formalized RAC) Requirements in Seveso like facilities concerning the access to loading/unloading points may concern means of transport Temporary stop areas (road parking / harbours / multi-modal platforms / marshalling yards) where a big concentration of DG occur must be subject to a risk analysis provided by the infrastructure manager to the local authority (Préfet). The result of this analysis may lead to restrictions concerning the way the infrastructure is managed. These however have to stay within the boundaries defined in RID ADR and related EU directives. Building restrictions may also be decided where lethal effects are over a certain probability and the traffic cannot be moved to other routes. Tunnel restrictions are defined according to 1.9.5 and 8.6 of ADR.
Are risk acceptance criteria (RAC) used?	For restrictions on industries processing or producing DGs (where these may have knock-on impacts on transport). For restrictions on temporary stop areas (road parking / harbours / multi-modal platforms / marshalling yards / others).
Description of RAC.	Each dangerous phenomenon is described using two parameters: probability of occurrence and number of people exposed to lethal or irreversible effects. The couple (probability, effect) is defining the risk. RAC are set up in matrix where each combination is characterised as acceptable or not This is finally equivalent to F/N curves but with a discrete progression. A default method for assessing probabilities and effects is provided but if more precise and accurate data are available the infrastructure manager may justify using another method.

Reference documentation.	Code de l'environnement articles L. 551-2 à L. 551-6 articles R. 551-1 à R. 551-13 Arrêté du 18 décembre 2009 relatif aux critères techniques et méthodologiques à prendre en compte pour les études de dangers des ouvrages d'infrastructures de transport où stationnent, sont chargés ou déchargés des véhicules ou des engins de transport contenant des matières dangereuses ; Circulaire du 4 mars 2010 relative aux études de dangers remises an application de l'article L. 551-2 du code de l'environnement (circulaire modifiée le 15 novembre 2012 : circulaire relative à la rédaction des études de dangers remises en application de l'article L. 551-2 du code de l'environnement)) ; Circulaire du 19 novembre 2012 relative aux mesures de maîtrise des risques et au porter à connaissance à mettre en œuvre dans le cadre des études de dangers remises en application de l'article L. 551-2 du code de l'environnement ; Arrêté du 15 juin 2012 fixant la liste des ouvrages d'infrastructures routières, ferroviaires, portuaires ou de navigation intérieure et des installations multimodales soumis aux dispositions de la partie réglementaire du code de l'environnement portant application de l'article L. 551-2 du code de l'environnement.
Could the RAC above be used as part of harmonised EU RAC?	Probably yes when talking about principles. Probably no when talking about parameters.
Problems in applying RAC.	The concrete application of the above mentioned law is recent. We are not in the state to identify precise cross border issues. Some local risk acceptance issues have occurred.
Approach to harmonising RAC for DG transport.	RAC ultimately is not only of technical nature. However no sound decision can be made without having defined harmonized method for assessing fundamental measurement of risk such as - Probability calculation - Effect calculation Experience has shown that different institutes may produce very different answers to the same question depending on the initial assumptions the assessment has made. No realistic RAC may ever be defined before having rationalized the initial evaluation steps .
Contact for further discussion.	Claude.pfauvadel@developpement-durable.gouv.fr 33 (0)1 40 81 87 66

Country	Germany
Scheme owner	Federal authorities (Rail and inland waterways) and authorities of states (Länder) (road)
DG transport activity in country?	Road / rail / inland waterway
Are DG transport restrictions used?	ADR/RID/ADN regulations Additional provisions under Section 1.9 of ADR/RID/ADN (see: http://www.unece.org/trans/danger/publi/adr/country-info_e.html#Germany)
Description of DG transport restrictions.	http://www.unece.org/trans/danger/publi/adr/country-info_e.html#Germany
Are risk acceptance criteria (RAC) used?	No legally binding RAC are existing; for restrictions on road tunnels criteria are outlined in a research project
Description of RAC.	
Reference documentation.	
Could the RAC above be used as part of harmonised EU RAC	
Problems in applying RAC.	
Approach to harmonising RAC for DG transport.	
Contact for further discussion.	Helmut.Rein@bmvbs.bund.de

DNV note : At the workshop of 14th February 2014, held to feedback to interested parties the results of the project, Germany were able to provide further detail on restrictions related to Inland Waterway transport. Based upon the guidelines of the Central Commission for the Navigation of the Rhine special regulations exists for vessels carrying dangerous goods. Specifically the following regulations apply:

- Passing of locks and ship lifts
- Prohibition of berthing and berthing areas
- Minimum distances to other vessels
- Reporting duties
- Use of ports and refuges

https://www.elwis.de/Schifffahrtsrecht/Verzeichnis-Rechtsverodnungen-Gesetze/index.html

The information received indicates that these guidelines apply equally to all ADN Contracting parties.

Country	Greece
Scheme owner	Ministry of Infrastructure, Transport and Networks (YME)
DG transport activity in country?	Road
Are DG transport restrictions used?	ADR regulations only
Description of DG transport restrictions.	ADR is applicable for road transport, we do not have any additional restrictions
Are risk acceptance criteria (RAC) used?	We do not use any RACs.
Description of RAC.	We do not use any RACs.
Reference documentation.	We do not use any RACs.
Could the RAC above be used as part of harmonised EU RAC?	No
Problems in applying RAC.	We do not use any RACs.
Approach to harmonising RAC for DG transport.	
Contact for further discussion.	Ευδοκία Ευαγγελάτου <e.evangelatou@yme.gov.gr>

Completed by Jonathan Ellis following e-mail correspondence (25th June 2013) with Evdokia Evangelatou

Country	Hungary
Scheme owner	National Transport Authority Road, Rail and Shipping Office Railway Department
DG transport activity in country?	Rail
Are DG transport restrictions used?	RID regulations only
Description of DG transport restrictions.	RID regulations are in use in Hungary.
Are risk acceptance criteria (RAC) used?	No
Description of RAC.	-
Reference documentation.	-
Could the RAC above be used as part of harmonised EU RAC?	-
Problems in applying RAC.	-
Approach to harmonising RAC for DG transport.	-
Contact for further discussion.	László Vas / vas.laszlo@nkh.gov.hu / +3614771523

Country	Ireland
Scheme owner	Iarnród Éireann – Irish Rail
DG transport activity in country?	Rail
Are DG transport restrictions used?	RID regulations Infrastructure manager's rules for using the railway infrastructure
Description of DG transport restrictions.	RID applies, plus infrastructure manager's rules, including: Fire precautions and safe storage; Restricted conveyance of Class 1 and Class 7 substances; Restrictions on use of certain wagons; Wagon brakes and fire protection; Prohibition of un-braked wagons; Protective distances on dangerous goods trains; Prohibition on certain trains meeting in a tunnel.
Are risk acceptance criteria (RAC) used?	No
Description of RAC.	
Reference documentation.	
Could the RAC above be used as part of harmonised EU RAC?	
Problems in applying RAC.	
Approach to harmonising RAC for DG transport.	
Contact for further discussion.	Donal Casey donalcasey@rsc.ie ++353 87 66 95 314

Country	Ireland
Scheme owner	Department of Jobs, Enterprise and Innovation
DG transport activity in country?	Road
Are DG transport restrictions used?	ADR regulations
Description of DG transport restrictions.	None
Are risk acceptance criteria (RAC) used?	No
Description of RAC.	
Reference documentation.	
Could the RAC above be used as part of harmonised EU RAC?	
Problems in applying RAC.	
Approach to harmonising RAC for DG transport.	
Contact for further discussion.	Frank Mooney frank.mooney@djei.ie

Form completed by Jonathan Ellis of DNV following e-mail correspondence with Frank Mooney 26th June 2014

Country	Italy
Scheme owner	Ministry of Infrastructure and transport related to safety items - Ministry of Interiors related to security and emergency items
DG transport activity in country?	Rail
Are DG transport restrictions used?	ADR/RID/ADN regulations only Additional provisions under Section 1.9 of ADR/RID/ADN
Description of DG transport restrictions.	
Are risk acceptance criteria (RAC) used?	For restrictions on industries processing or producing DGs (where these may have knock-on impacts on transport) *(Ref Ministry of interiors related issues – emergency plans)* For restrictions on temporary stop areas (road parking / harbours / multi-modal platforms / marshalling yards /others) *(Ref Ministry of interiors related issues – emergency plans)*
Description of RAC.	Depending on area under evaluation, all methods of RAC are used.
Reference documentation.	None
Could the RAC above be used as part of harmonised EU RAC?	Not Applicable
Problems in applying RAC.	Difficulties connected to wideness of contests / area of application.
Approach to harmonising RAC for DG transport.	Tuning RAC according to the contest of application
Contact for further discussion.	Directorate General for Railway Transport Via G. Caraci, 36 00157 – Roma (ITALY) dtt.dgtfe@mit.gov.it

Country	Latvia
Scheme owner	Ministry of Transport of the Republic of Latvia
DG transport activity in country?	Road / rail
Are DG transport restrictions used?	ADR/RID/ regulations only
Description of DG transport restrictions.	None
Are risk acceptance criteria (RAC) used?	No
Description of RAC.	
Reference documentation.	
Could the RAC above be used as part of harmonised EU RAC?	No
Problems in applying RAC.	
Approach to harmonising RAC for DG transport.	
Contact for further discussion.	marianna.heislere@sam.gov.lv

Country	Lithuania
Scheme owner	Ministry of Transport and Communications of the Republic of Lithuania
DG transport activity in country?	Road / rail
Are DG transport restrictions used?	ADR/RID regulations only Other restrictions – Annex 2 "Regulations Concerning Carriage of Dangerous Goods" of the Agreement on International Goods Transport by Rail (SMGS)
Description of DG transport restrictions.	Provisions of Annex 2 of SMGS are similar to RID
Are risk acceptance criteria (RAC) used?	-
Description of RAC.	-
Reference documentation.	-
Could the RAC above be used as part of harmonised EU RAC?	No
Problems in applying RAC.	-
Approach to harmonising RAC for DG transport.	-
Contact for further discussion.	Mr Aleksandr Tolstoj Water and Railway Transport Policy Department Environment Protection and Emergency Prevention Division Chief specialist E-mail aleksandr.tolstoj@sumin.lt

Country	Lithuania
Scheme owner	The State Railway Inspectorate Under The Ministry Of Transport
DG transport activity in country?	Rail
Are DG transport restrictions used?	Additional provisions under Section 1.9 of RID Other restrictions (SMGS agreement)
Description of DG transport restrictions.	In addition to RID there are restrictions for minimal number of empty or loaded with non-dangerous goods cars between locomotive, coach or cars of DG. SMGS agreement.
Are risk acceptance criteria (RAC) used?	-
Description of RAC.	-
Reference documentation	-
Could the RAC above be used as part of harmonised EU RAC?	No
Problems in applying RAC.	Additional provisions were added based on SMGS agreement for transportation of goods using 1520mm track gauge
Approach to harmonising RAC for DG transport.	-
Contact for further discussion.	Laurynas Venčkauskas laurynas.venckauskas@vgi.lt +370 674 52898

Country	Luxembourg
Scheme owner	
DG transport activity in country?	Road
Are DG transport restrictions used?	Additional provisions under Section 1.9 of ADR
Description of DG transport restrictions.	Restrictions on certain routes
Are risk acceptance criteria (RAC) used?	No
Description of RAC.	-
Reference documentation	-
Could the RAC above be used as part of harmonised EU RAC?	No
Problems in applying RAC.	
Approach to harmonising RAC for DG transport.	-
Contact for further discussion.	

Completed by DNV following a review of the restrictions notified under section 1.9 of ADR and as reported on the UNECE website.

Country	Netherlands
Scheme owner	Ministry of Infrastructure and Environment
DG transport activity in country?	Road / rail / inland waterway
Are DG transport restrictions used?	ADR/RID/ADN regulations Additional provision under Section 1.9 of ADR/RID/ADN is the so called 'Basisnet' (Base transport Network) to guarantee transport safety in populated areas. Other restrictions: for rail transport of the toxic gas chlorine specific restrictions apply. Other measures on voluntarily basis (e.g. separation of flammable gases and liquids)
Description of DG transport restrictions.	• Individual risk (IR) - the annual probability that an unprotected person will die as a result of an accident involving hazardous materials at a certain spot if that person resides there for a full year. The risk is visualised on a map by dots which act as spatial contours. • Societal risk (SR) – a measure for the cumulative annual probability that a group of people dies as a direct result of their presence in the influence area of an establishment or transport route if an incident happens with hazardous materials. This is visualised on a logarithmic scale by using the FN curve. The SR limit value is a guidance and the competent authority decide on its acceptability. • By means of the "Wet Basisnet" (parts of) routes are indicated where the individual risk may not exceed 10^{-6} per year • By means of the "Wet Basisnet" (parts of) routes may be indicated where the individual risk may not exceed 10^{-7} respectively 10^{-8} per year, to avoid an unacceptable societal risk. • For chlorine transport by rail special additional operational requirements apply in the Netherlands like speed limitation, train composition, supervision and notification. • Furthermore voluntary agreements (covenants) with companies are made to improve safety.
Are risk acceptance criteria (RAC) used?	For restrictions on DG transport activities For restrictions on industries processing or producing DGs For restrictions on road tunnels/rail tunnels an official risk calculation method is available (RWSQRA). .
Description of RAC.	Risk calculations (Individual risk and Societal Risk) are required and a calculation protocol is available (HART). In addition, a safety zoning of about 30 metres is applicable which is based on the occurrence of a pool fire.
Reference documentation.	For more explanation on "Basisnet" see: • http://www.otif.org/fileadmin/user_upload/otif_verlinkte_files/05_gef_guet/02_RID_fach/02_2012/CE_2012-INF_03_E.pdf • http://www.youtube.com/watch?v=1A00hjWm4Wg • http://www.unece.org/fileadmin/DAM/trans/doc/2013/dgwp15ac1/ECE-TRANS-WP15-AC1-13-BE-inf7e.pdf
Could the RAC above be used as part of harmonised EU RAC?	Yes. The risk calculation method (RBMII) is also available.
Problems in applying RAC.	New and unexpected developments in industry and related transport as well as urban development in the vicinity of the transport route are still in study.
Approach to harmonising RAC for DG transport.	Exchange of information and data to harmonize risk modelling/ calculation.
Contact for further discussion.	Bert Wolting/ bert.wolting@rivm.nl / 3130 274 4587
Further observations	Further development of risk calculation methods (statistics, modelling, measures, etc.) is on-going

Country	Norway
Scheme owner	Norwegian Directorate for Civil Protection
DG transport activity in country?	Road / rail
Are DG transport restrictions used?	Additional provisions under Section 1.9 of ADR
Description of DG transport restrictions.	Tunnel restrictions according to ADR 1.9.5
Are risk acceptance criteria (RAC) used?	For restrictions on road tunnels
Description of RAC.	Risk assessment shall show that risks are significant. Comparisons of risks shall be made with between alternative routes for the transport of dangerous goods through or not through the tunnels in question. Several methods are allowed for an assessment. No formal threshold value is given for acceptable risk.
Reference documentation.	The following publications from the Norwegian Public Roads Administration (NPRA): "Håndbok 021 Vegtunneler", http://www.vegvesen.no/_attachment/61913/binary/249783, "Veileder for risikoanalyse av vegtunneler (Revidert), http://www.vegvesen.no/_attachment/61037
Could the RAC above be used as part of harmonised EU RAC?	No. It lacks precision. This RAC may be revised according to recent NPRA report number 161, which suggests introductions of quantitative RAC based on ALARP or FN curves.
Problems in applying RAC.	Tunnels are treated as a special case in the ADR. There is a high focus on tunnel safety in Europe. However this might have a tendency to lead to the RAC to be lower for tunnels than for the rest of the transport network. A RAC that only focus on local risk in a tunnel might justify a restriction, however the transport enterprises might adapt to the restriction by choosing much longer routes which overall will increase the risks to society. It is important to assure that the total societal risk does not increase as a result of a local restriction.
Approach to harmonising RAC for DG transport.	To justify restrictions, the risk assessments must first demonstrate that the suggested restrictions will reduce the total societal risk (taking probable adaption into account). If this is the case, then an (preferable) quantitative evaluation of local risk can be made with ALARP as RAC. Use of ALARP as RAC will probably lead to local variations in acceptable risk across EU, which we not see as a big problem.
Contact for further discussion.	Jan Øistein Kristoffersen jan.kristoffersen@dsb.no +47 33412763

Country	Portugal
Scheme owner	IMT, I.P.
DG transport activity in country?	Road / rail
Are DG transport restrictions used?	ADR/RID regulations only Additional provisions under Section 1.9 of ADR/RID
Description of DG transport restrictions.	Published in the national official journal of 1.6.1998, 28.7.1999 and 16.2.2006
Are risk acceptance criteria (RAC) used?	For restrictions on DG transport activities For restrictions on road tunnels
Description of RAC.	Simple risk thresholds
Reference documentation. Title/URL of further explanation of the RAC	-
Could the RAC above be used as part of harmonised EU RAC?	No
Problems in applying RAC.	Not applicable
Approach to harmonising RAC for DG transport.	-
Contact for further discussion.	'eacandido@imt-ip.pt'; 'jafranco@imt-ip.pt'; 'pftaveira@imt-ip.pt'

Country	Romania
Scheme owner	Romanian Railway Safety Authority / Department for Control, State Inspection, Staff Authorization and Certification, Industrial Branches Authorization
DG transport activity in country?	Rail
Are DG transport restrictions used?	RID regulations only
Description of DG transport restrictions.	The presented RID
Are risk acceptance criteria (RAC) used?	Not yet
Description of RAC.	-
Reference documentation.	Don't have yet
Could the RAC above be used as part of harmonised EU RAC?	-
Problems in applying RAC.	-
Approach to harmonising RAC for DG transport.	It is necessary to establish a working group to promote a harmonized EU RAC and appropriate risk management transport of dangerous goods
Contact for further discussion.	**Mihaela CARABINEANU** – Director of NSA Romania / carabineanu@afer.ro **Dan Marcel BARBUT** – Chief Inspector/ danbarbut@afer.ro / 0040758760065

Country	Romania
Scheme owner	Romanian Road Transport Authority
DG transport activity in country?	Road
Are DG transport restrictions used?	ADR and Order Number 2059/2004
Description of DG transport restrictions.	Requirement to obtain a licence to move dangerous goods specifying the route to be used and restricting movements to certain times of day.
Are risk acceptance criteria (RAC) used?	No
Description of RAC.	-
Reference documentation.	
Could the RAC above be used as part of harmonised EU RAC?	-
Problems in applying RAC.	-
Approach to harmonising RAC for DG transport.	
Contact for further discussion.	

Completed by DNV following a review of the restrictions notified under section 1.9 of ADR and as reported on the UNECE website.

Country	Slovakia
Scheme owner	Ministry of Transport, Construction and Regional Development of the Slovak Republic
DG transport activity in country?	Rail
Are DG transport restrictions used?	RID regulations only No additional restrictions
Description of DG transport restrictions.	None for rail
Are risk acceptance criteria (RAC) used?	None used for rail
Description of RAC.	Not applicable
Reference documentation.	Not applicable
Could the RAC above be used as part of harmonised EU RAC?	No
Problems in applying RAC.	Not applicable
Approach to harmonising RAC for DG transport.	
Contact for further discussion.	Mikulas Sedlak Mikulas.sedlak@mindop.sk

Country	Slovakia
Scheme owner	
DG transport activity in country?	Road
Are DG transport restrictions used?	ADR regulations only No additional restrictions
Description of DG transport restrictions.	None for road
Are risk acceptance criteria (RAC) used?	None used for road
Description of RAC.	Not applicable
Reference documentation.	Not applicable
Could the RAC above be used as part of harmonised EU RAC?	No
Problems in applying RAC.	Not applicable
Approach to harmonising RAC for DG transport.	
Contact for further discussion.	

Completed by DNV following a review of the restrictions notified under section 1.9 of ADR and as reported on the UNECE website.

Country	Slovenia
Scheme owner	Ministry of Infrastructure and Spatial Planning Transport Directorate Road Transport Division
DG transport activity in country?	Road
Are DG transport restrictions used?	ADR/RID/ADN regulations only. Additional provisions under Section 1.9 of ADR/RID/ADN No other restrictions.
Description of DG transport restrictions.	Additional provisions under Section 1.9 of ADR/RID/AND. Additional provisions are available on website: http://www.unece.org/fileadmin/DAM/trans/danger/publi/adr/1.9/slovenia.pdf
Are risk acceptance criteria (RAC) used?	For restrictions on road tunnels
Description of RAC.	DG-QRAM version 3.61: scenarios 3-13 TuRisMO (RVS 09.03.11): scenarios 1 and 2 of DG-QURAM 1.10^{-3} casualties/year (from Austrian acceptance criteria threshold)
Reference documentation.	DG-QRAM: http://www.piarc.org/en/knowledge-base/road-tunnels/qram_software/
Could the RAC above be used as part of harmonised EU RAC?	Yes. Fire scenarios (DG-QRAM scenarios 1. and 2) should be incorporated in analyses dealing with all possible types of regular traffic accidents HGV included.
Problems in applying RAC.	In Slovenia only tunnel with restriction for DG transport is tunnel Karavanke where DG transports are treated under Austria-Slovenia agreement (escort of DG transports) Other tunnels are risk assessed as acceptable for DG transports with no restrictions, so no practical experiences regarding applying RAC are gained.
Approach to harmonising RAC for DG transport.	Must be determined: • common methodology (for example DG-QRAM) • common acceptance criteria threshold (for example 1.10^{-3} casualties/year as in Austria)
Contact for further discussion.	Mr Alojz Habič alojz.habic@gov.si phone: + 386 (0) 1 478 82 94

Country	Spain
Scheme owner	Dirección General de Ferrocarriles (Spanish National Security Authority)
DG transport activity in country?	Rail
Are DG transport restrictions used?	RID regulations and additional provisions under Section 1.9 of RID (art. 4 Real Decreto 412/2001) Nota: se adjunta el texto del Real Decreto 412/2001. (en este momento esta en proceso de revision)
Description of DG transport restrictions.	See art. 4 RD 412/2001
Are risk acceptance criteria (RAC) used?	For restrictions on temporary stop areas (road parking / harbours / multi-modal platforms / marshalling yards / others) For restrictions on road tunnels/rail tunnels (see art. 4 RD 412/2001. Point 2)
Description of RAC.	En el caso de que existan estaciones de origen, clasificación o destino, que se encuentren en núcleo habitado o situadas a menos de 500 metros de aquél, en los que deba de realizarse un estacionamiento, las empresas de transporte ferroviario habrán de desarrollar un plan de emergencia para, en caso de accidente, efectuar las actuaciones más urgentes para limitar las consecuencias del mismo, de acuerdo con el artículo 4 del Real Decreto 387/1996, por el que se aprueba la Directriz Básica de planificación de protección civil ante el riesgo de accidentes en los transportes de mercancías peligrosas por ferrocarril. For stations at which dangerous goods trains are to be stabled and which are in populated areas or located less than 500 meters from a populated area then the railway companies must develop an emergency plan, which in the case of an accident, details the urgent actions to limit the consequences of the accident, in accordance with Article 4 of Royal Decree 387/1996, which approves the Basic Guideline planning civil protection against the risk of accidents in transport of dangerous goods by rail.
Reference documentation.	Real Decreto 387/1996, de 1 de marzo, por el que se aprueba la Directriz Básica de planificación de protección civil ante el riesgo de accidentes en los transportes de mercancías peligrosas por carretera y ferrocarril. Royal Decree 387/1996 of 1 March, approving the Basic Guideline planning civil protection against the risk of accidents in the transport of dangerous goods by road and rail.
Could the RAC above be used as part of harmonised EU RAC?	Yes
Problems in applying RAC.	
Approach to harmonising RAC for DG transport.	
Contact for further discussion.	esgonzalez@fomento.es

Country	Spain
Scheme owner	Ministry of Development
DG transport activity in country?	Road / rail
Are DG transport restrictions used?	Other restrictions: restriction to transport dangerous goods by road only to certain routes: http://www.fomento.es/NR/rdonlyres/015EE0BC-538F-4350-8F71-873DF44C1519/116856/Modif2013.pdf and prohibition to transport dangerous goods in certain timeframes: http://www.fomento.es/NR/rdonlyres/560E06A2-CEDE-467B-AC68-FE3C3152553A/115038/RIMPAÑO2013.pdf http://www.fomento.es/NR/rdonlyres/B3A97E51-9F08-4332-B444-80FDE089CEC7/115039/RIMPCATALUÑA2013.pdf http://www.fomento.es/NR/rdonlyres/B587E842-7B5A-40A8-A070-480C4E9B7362/115308/RestriccionesTraficio2013.pdf
Description of DG transport restrictions.	See above
Are risk acceptance criteria (RAC) used?	For restrictions on DG transport activities For restrictions on industries processing or producing DGs (where these may have knock-on impacts on transport) For restrictions on temporary stop areas (road parking / harbours / multi-modal platforms / marshalling yards / others): there are recommendations made on road parking areas: http://www.fomento.es/MFOM/LANG_CASTELLANO/ORGANOS_COLEGIADOS/CCTMP/ListadoEstudio.htm For restrictions on road tunnels/rail tunnels: No
Description of RAC.	The roadmap for the transport of dangerous goods is made starting from the information on dangerous goods transport that is given in the annual reports which is made and submitted by the safety advisors
Reference documentation.	
Could the RAC above be used as part of harmonised EU RAC?	To put into force similar procedures in the rest of Europe, it would be necessary to introduce in the ADR/European regulation the obligation for the enterprises to inform the administration who is their safety advisor and the obligation for safety advisors to send their reports to the administration.
Problems in applying RAC.	Cross border issues: In relation to the Somport tunnel, there are special restrictions on the transport of dangerous goods imposed that are fixed jointly with France.
Approach to harmonising RAC for DG transport.	
Contact for further discussion.	Silvia García Wolfrum sgarcia@fomento.es

Country	Sweden
Scheme owner	**Swedish Civil Contingencies Agency (MSB)** - is the competent authority for the transport of dangerous goods by road and rail in Sweden, consultation body for the local traffic regulations regarding DG transports **County Administrative Boards (**21 regional boards) – may issue local traffic regulations for road, concerning DG transport restrictions **Swedish Transport Administration** – may issue restrictions for DG transports on railways
DG transport activity in country?	Road / rail
Are DG transport restrictions used?	Additional provisions under Section 1.9 of ADR/RID
Description of DG transport restrictions.	It's the regional County Administrative Boards who has the authority to restrict DG transports on road. In brief, a decision for justification of restriction of DG transports for road could be based on: • data about the DG transports for the possible restricted road • description of the surrounding area (for example residents, buildings, environment) and a description of the possible consequences • description and analysis of the alternative routes, hence that they are appropriate for the DG transports, if the restriction takes place • valuation if safety measures is an alternative, and if it's more appropriate than restriction • take into account present and forthcoming structure and detailed planning
Are risk acceptance criteria (RAC) used?	No, the use of RAC is not regulated or mandatory, but could be a part as a decision support.
Description of RAC.	None existing for RAC regarding justification of restrictions. There is some regional guidance in planning/building close to DG transport routes (where the distances suggested between the road and the surroundings are based on RAC and ALARP-principle, individual risk and societal risk). The purpose is to justify planning and building near DG transport routes and not justify restrictions on DG transports.
Reference documentation.	
Could the RAC above be used as part of harmonised EU RAC?	No, the criteria might be the same, but they have other purposes than restrictions of the DG transports.
Problems in applying RAC.	For countries using RAC in other decision processes it's maybe not that difficult to adapt it to this case. For those countries not using RAC as regulatory or mandatory base for risk evaluation a harmonized approach isn't easy and maybe not possible, since it needs to be used in all decision processes regarding risks, not only concerning DG transport restrictions. There are also other regulations than an ADR/RID point of view that regulate restrictions of transports in general (and not only DG transports) which doesn't use RAC in its evaluation.

Approach to harmonising RAC for DG transport.	For other EU regulations, for example the Seveso directive, the matter of risk evaluation, and how and when a risk is acceptable or not, is something that each nation decides from its own regulations and legal procedures. How a country should evaluate risks should still be a national matter. Cross-border issues could be resolved between the countries involved in order to get a broad risk picture and what the consequences will be if there will be a restriction. A justification to restrict DG transports needs to well supported, but the faith in RAC as "the decision tool" is not without its doubts. It can be used as an input to compare alternatives, but there should always be room for other inputs and issues when motivating a restriction, and not solely based on RAC. There could be cases where maybe the consequence of an accident should be the domination factor for the valuation. There are organisational factors, other than the "technical issues" (for instance the DG transports, the road and the surroundings), for example the rescue services ability to manage an accident, which must also be an issue when there's a need of restriction of DG transports. There could, however, be a need of a common approach or "a standard" for the inputs necessary to the risk analysis to justify a restriction of DG transports. It needs to be more specific than the General guideline for the Calculation of Risks in the Transport of Dangerous Goods by Road from 2008. For instance to use the same types of scenarios, release rates, use same threshold values (for toxicity (AEGL/ERPG), heat radiation and pressure) etc. How the results should be evaluated, to what extent the RAC should have in the justification in a decision, if there are needs of any other data or input to evaluate the risk must be up to each and every other nation and the need of each particular case. See also the Risø report on Assessment of Uncertainties in Risk Analysis of Chemical Establishments why there are some doubts in just applying RAC without defining the "way" http://orbit.dtu.dk/fedora/objects/orbit:90321/datastreams/file_7712279/content
Contact for further discussion.	Jens Hagberg, Swedish Civil Contingencies Agency (MSB) Jens.hagberg@msb.se +46 (0) 10 240 5142

Country	Switzerland
Scheme owner	Office fédéral des routes Division Circulation routière Règles de la circulation / Secteur marchandises dangereuses
DG transport activity	Road and Inland Waterway
Are DG transport restrictions used?	Yes – ADR and ADN regulations with additional provisions.
Description of DG transport restrictions.	Ordinance of 17 April 1985 on the Carriage of Dangerous Goods by Road (SDR provides a transposition of ADR into Swiss law together with the appropriate national conditions and tunnel restrictions. Ordinance of 29 April 1970 on the Carriage of Dangerous Goods on the Rhine (ADNR) for inland waterway. Ordinance of 3 December 1996 on the Carriage of Dangerous Goods by Rail and Cableway (RSD) for rail. When adopting general safety measures, the person responsible for a transport route shall take into account, in particular, the following principles; he shall: a. select a suitable alignment and appropriate construction standards and ensure that the necessary safety distances are maintained; b. design the transport route in such a way that no additional serious impacts arise as a result of the stresses to be expected in the event of a major accident; c. install the necessary safety equipment and take the necessary structural, technical and organisational protective measures; d. install adequate warning and alarm systems; e. monitor equipment and the operation of safety-critical elements of the transport route and carry out regular servicing; f. take the necessary traffic management or control measures for the transport of dangerous goods; g. collect, evaluate and pass on to the staff concerned any information available on the transport of dangerous goods; h. in cooperation with the emergency services, draw up an emergency plan for major accidents and carry out periodic exercises on the basis of this plan.
Are risk acceptance criteria (RAC) used?	Yes.

Description of RAC.	In Switzerland, the Ordinance on Major Accidents requires assessment of risks to the public and the environment from fixed installations and DG transport, including railway installations, transit roads and the Rhine (when used to transport or trans-ship DGs). The Swiss Federal Office for the Environment has published societal risk RAC: • Upper RAC: $F>10^{-3}/N^2$ for $10 \leq N \leq 10{,}000$ fatalities • Lower RAC: $F<10^{-5}/N^2$ for $10 \leq N \leq 1000$ fatalities For risks between these RAC the ALARP principle is applied, with safety measures adopted where cost-effective. The same criteria are applied to fixed installations and to 100m sections of road tunnels
Reference documentation.	Swiss Federal Council, Ordinance on Protection Against Major Accidents, 1991. http://www.admin.ch/ch/e/rs/814_012/index.html
Problems in applying RAC.	
Could the RAC above be used as part of harmonised EU RAC?	
Approach to harmonising RAC for DG transport.	
Contact for further discussion.	M. D. M. GILABERT Weltpoststrasse 5, 3015 Bern adresse postale: CH-3003 BERNE Tel: +41 31 323 42 90 E-mail: david.gilabert@astra.admin.ch

Response compiled by DNV from prior knowledge.

Country	Switzerland
Scheme owner	Federal office of Transport (Responsible for rail sector)
DG transport activity in country?	Rail
Are DG transport restrictions used? .	Many safety measures taken, including by infrastructure managers. Transport restrictions applied in two isolated cases.
Description of DG transport restrictions.	Temporary transport restrictions (1 case) / shunting (1 case) close to football stations during events
Are risk acceptance criteria (RAC) used?	Yes Please note: primary goal of RAC is not to justify transport restrictions, but to determine if the risk is acceptable. If this is the case, only the standard measures must be taken, according to the state of the art. If it's not the case additional, specific safety measures may be required, transport restrictions being one of many possible measures including measure to increase the safety level of the infrastructure. For restrictions on DG transport activities For restrictions on temporary stop areas (marshalling yards / others)
Description of RAC.	RAC are published by the Swiss Federal Office for the Environment and are similar for industry (fixed installations), road and rail (see reference below). They are based on collective risk and are also available for environmental damage (especially surface and underground water pollution). They consist of two lines in a probability - consequences diagram, defining three sectors: acceptable risk / intermediate sector / not acceptable risk. Risk in the intermediate sector may be considered tolerable by the competent authority if other public interests prevail.
Reference documentation.	Swiss Federal Council, Ordinance on Protection Against Major Accidents, 1991. http://www.admin.ch/ch/e/rs/814_012/index.html RAC (available in French, German or Italian): http://www.bafu.admin.ch/publikationen/publikation/00553/index.html?lang=fr
Could the RAC above be used as part of harmonised EU RAC?	Yes
Problems in applying RAC.	
Approach to harmonising RAC for DG transport.	Supportive of the approach detailed at the 1st ERA Workshop on Risk evaluation and assessment in the context of inland transport of dangerous goods – 8/9 October 2014
Contact for further discussion.	Colin Bonnet Federal Office of Transport 3003 Bern colin.bonnet@bav.admin.ch +41 31 323 89 96

Country	**UK**
Scheme owner	DfT
DG transport activity in country?	Road / rail
Are DG transport restrictions used?	Yes: ADR/RID, parts of ADN: and Directives 1999/36/EC, 2008/68/EC and 2010/35/EU. Additional provisions under Section 1.9 of ADR/RID Other restrictions (please specify)
Description of DG transport restrictions.	The restrictions contained within the documents above are transposed into UK domestic legislation.
Are risk acceptance criteria (RAC) used?	For restrictions on DG transport activities For restrictions on road tunnels/rail tunnels
Description of RAC.	The UK takes account of the guidance within the regulatory documents detailed above, e.g. The UK competent authority issues derogations in line with ADR Chapter 1.5. The relevant risk/benefit ratio will vary in accordance with Government policy.
Reference documentation.	See above and in addition: "Guidance Principles for the development of the UN Model Regulations."
Could the RAC above be used as part of harmonised EU RAC?	No As above, the risk/benefit ratio varies according to changes in Government policy.
Problems in applying RAC.	The priorities of EU Member States vary in accordance with individual government policy. The regulatory framework for the safe carriage of dangerous goods is largely deterministic – placing the regulations onto a risk based approach would be highly disruptive to a system that has served society well over many decades.
Approach to harmonising RAC for DG transport.	A clear definition for the term 'Risk Assessment Criteria for the land transport of dangerous goods' would assist.
Contact for further discussion.	Ian Boddington, Dangerous Goods Division, DfT. Ian.boddington@dft.gsi.gov.uk Tel: 020 7944 2762

Harmonised Risk Acceptance Criteria for Transport of Dangerous Goods

Open Discussion with CEFIC

Date: 10th June 2013
Location: CEFIC Offices, Brussels

Those present:

Jos Verlinden – Director Transport and Logistics, CEFIC
Jean-Christophe Hermand – Logistics Department Manager, Total
Steven van de Broek – Essenscia
Jonathan Ellis (JE) – Principal Consultant, DNV
Maarten Bekaert – Head of Department, DNV

1. Meeting Structure

The meeting was convened as an open discussion on the feasibility of harmonising risk acceptance criteria for dangerous goods transport in the EU. This was following the distribution of a survey by JE to the Member States in the EU and CEFIC seeking information on the risk acceptance criteria used in the various EU Member States within the legal framework established by RID, ADR and ADN. The open discussion was intended to form the input of CEFIC to the study.

2. Introduction of the Study

JE provided an overview of the study. This is a feasibility study that covers the inland transport of dangerous goods by road, rail and inland waterway within the EU and EEA states. The study will examine the basis of the risk acceptance criteria used in the various Member States in imposing risk controls on the movement of dangerous goods and consider whether it is feasible to harmonise these. This feasibility will consider both the practicality of imposing a single risk acceptance criterion across the EU and EEA and also the desirability of this in terms of analyzing the potential impacts in terms of risk, environment and modal shift of having differing risk acceptance criteria. For instance if one Member State imposes a restriction on a route in its territory does this then result in an increase in risk elsewhere as dangerous goods are transported across a different route.

3. Open Discussion

An open discussion regarding risk acceptance criteria and their application to the transport of dangerous goods followed. The points of note made were:

- The chemical industry in Europe is highly reliant on the effective and efficient transport of dangerous goods
- The road and rail networks differ in that rail is an inherently smaller network, primarily developed for the transport of passengers between population centres. As such dangerous goods by rail often have to travel through populated areas, where as road transport can divert away from heavily populate areas. Road transport is inherently more flexible than rail.
- A strongly held belief was that rail was a safe mode of transport that experienced fewer releases of dangerous goods than road. However, because of the fact that rail transport exposes a greater number of people to any potential release of dangerous goods, rail accidents would have a greater consequence than the equivalent road accident. In applying any harmonized risk acceptance criteria concern was expressed that this may cause a modal shift away from rail.
- The causes of a release of dangerous goods from rail transport were primarily due to failures of the infrastructure resulting in derailment or collision. As such the frequency of dangerous goods accidents on rail were dependent upon the construction, maintenance and inspection regimes employed by the many Infrastructure Managers and Railway Undertakings in the EU and EEA.
- For road transport accidents were more frequent and had a greater contribution from driver error. Transport of dangerous goods by road into city centres would continue irrespective of any risk acceptance criteria applied as gasoline products would require delivery into city centre petrol stations.

- Any Quantitative Risk Assessment methodology applied would only be as good as the data that was fed into it. The availability and uncertainty of data was called into question.
- For instance no authoritative data existed for the volume of dangerous goods transported in Belgium. Partly this was a consequence of Belgium being a country through which considerable quantities of goods are transited and as such it was difficult to collate data on what was coming into a liberalized rail and road network from outside of the country.
- For chemical plants subject to the SEVESO directive detailed databases of component failures such as valves exist allowing quantitative risk assessments to be made. The equivalent database for rail was not shared with the chemical industry and it was believed that not all railways had such a database to share. Neither was it believed that the road administrations had such a database.
- At present the volume of dangerous goods transport in Europe was increasing. This increase was mostly being absorbed by the road sector reflecting its better flexibility compared to road and inland waterway.
- A withdrawal of single wagon services in some European countries was adversely impacting rail. Not all chemical plants in the EU could accommodate an entire trainload of dangerous goods either physically (having sufficient space) or in order to comply with their authorisation permit. There were few places where rail cars containing dangerous goods could be held. Road represented a greater flexibility.

4. Concluding Remarks
   - The competitiveness of the EU chemical industry is dependent upon an ability to transport dangerous goods safely. As such CEFIC welcomed this feasibility study as contributing to this.
   - CEFIC would be happy to support the workshops planned for the end of the feasibility study including presenting if appropriate.
   - JE thanked CEFIC for a very useful and frank discussion and for the offer to support the workshop.

SURVEY OF RISK ACCEPTANCE CRITERIA FOR TRANSPORT OF DANGEROUS GOODS IN EUROPE

Country	International/Europe
Scheme owner The organisation or government department that manages the DG transport restrictions described below.	**Community of European Railway and Infrastructure Companies (CER) AISBL** **Union international des chemins de fer (UIC).** Synthesis Group Dangerous Goods. As representative bodies, CER is active in European and international discussion on the regulation of the transport of dangerous goods (TDG). UIC closely cooperates with the CER where UIC and CER share the technical (UIC) and political (CER) impacts. We draw attention to: - Negative effects of certain national or local "restrictions" for rail in some Member States - Lack of European harmonization for risk assessment and risk acceptance to justify any derogation provisions in EU legislation (2008/68/UE - RID) - The existence of historical 'national rules' but unjustified constraints that strengthen the regulation, without proper justification (code of practice, reference system, estimate or explicit risk assessment) - The existence of new "restrictions" decided by the states, without complying with the regulatory procedures (Chapter 1.9 of RID) to justify and to notify them, - The existence of rules from other laws (environment, civil protection) inconsistent with the European rail objectives (European market, development of rail) - The lack of notification (except a few countries) of 'national rules' to European competent authorities (European Commission / ERA).
DG transport activity in country?	rail / Intermodal
Are DG transport restrictions used?	ADR/RID/ADN regulations only Additional provisions under Section 1.9 of ADR/RID/ADN Other restrictions (please specify): Most of current existing national provisions are not based on the RID section 1.9 because they have not been notified. Netherlands is an exception as they have recently notified all their national provisions. For explicit quantification of risk, the Netherlands and Switzerland have specific national legislation which provides a comprehensive approach to risks related to transport of dangerous goods. The restrictions imposed in this context do not refer to the common safety method CSM (2009/352/UE). In the framework of its environmental legislation to prevent technological risks, France implements a specific method of risk assessment. It focuses on some local infrastructure for transport (rail yards, tracks ...). It does not refer to the CSM Regulation (2009/352/UE) but was developed in the framework of the Seveso Directive applicable to the industry.
Description of DG transport restrictions. A brief outline of the restrictions that apply in the countries.	Restrictions relate in particular to: - Conditions of shunting Dangerous goods wagon, - Trains composition, - Parking / temporary stay of cars, - Administrative border controls or additional checks (not defined in RID) to be performed by the railway undertakings (RU). Contrary to the road (95/50/EC), the rail does not have a directive harmonizing controls on EU territory. An analysis of the transposition of the Directive 2008/68/UE should allow a better understanding on how the national rules that have to be considered as "restriction" because of their deviation from the RID requirements.

Are risk acceptance criteria (RAC) used? Please delete as applicable.	Practices and national reference systems implicitly refer to Risk Acceptance Criteria (RAC). RACs are linked to the historical development of each network. However, those RAC are different from those defined in European regulation 2009/352/UE and more recently 2013/402/UE. RACs are, to our knowledge, not yet explicitly and systematically used to justify rules that differ from European and international regulations. For restrictions on DG transportation activities : RID regulations are the result of a collective work of States and stakeholders for many decades (recently with the active participation of the European Union). It takes into account many factors (new goods put on the market, accidents, experience sharing, ...) and constraints to harmonize rules with other modes of transport. This standing activity is the opportunity to assess the risks associated with changes in various domains related to Dangerous goods transport. We can therefore consider that RAC (Code of Practice, reference system) are used in the preparation of the RID but they are not formalized according to RAC 2013/402/UE Regulation replacing the 2009/352 / EU. The method of quantification of risk proposed by the OTIF and referenced in the RID has been used in Switzerland and the Netherlands. For restrictions on DGs Producing gold processing industries (Where thesis May Have knock-on impacts on transport) The measures imposed in some countries to industrial sites, particularly under the Seveso Directive (eg limiting the number of cars present in plants) make railway transport unattractive or impossible. For restrictions on temporary stop areas (marshalling yards / others) In some countries, non transport regulation impose operating constraints on marshalling yards without taking into account the impact on the railway system and without a sound assessment of the costs and benefits. Different risk acceptance criteria (RAC) are used. The safety design is inspired by the Seveso Directive even if it does not apply to rail transport. While the overall safety level is generally considered sufficient in the railway, this is not always the case for dangerous goods transport by rail. For restrictions on rail tunnels For some tunnels, specific national rules for the transport of goods are defined, but they generally do only slightly impact operations. The goal is basically to reduce the risk of crossing dangerous goods trains with passenger trains and in some cases to prevent them. Most of the measures are defined during the path allocation and rarely affects the operations. For restrictions on line segments during events with high crowd density For some line segments in Switzerland temporary restrictions are applied, e.g. interdiction of chlorine transports during soccer games on the line segments passing the stadium. National risk acceptance criteria apply.

Description of RAC.	A brief outline of the RAC that are used to impose restrictions. *Note: RAC may include simple risk thresholds, limiting curves or distributions of risk, complex methodologies or other equivalent controls.* As mentioned above, Netherlands and Switzerland have a comprehensive approach to risk assessment, including procedures which may lead to "restrictions". We can consider that in both cases there are actually "acceptance criteria" in the sense of methodologies with corresponding risk thresholds even if the reference system is not the common safety method (2009/352/UE then 2013/402/UE). The method implemented in France is also based on risk acceptance criteria but it is linked to the reference system "Seveso". The application of the method is limited to certain rail infrastructure (eg. "parking" of dangerous goods cars).
Reference documentation Title/URL of further explanation of the RAC	A task force was organised by ERA to collect "national rules". This work should allow to identify the documentations and rules that may be considered as "restrictions". In some countries, in addition to the competent authorities, infrastructure managers also have rules (including parking restrictions or control of railways). It would be interesting to verify if those have to be considered as "national rules" and/or as "transport restrictions".
Could the RAC above be used as part of harmonised EU RAC? Please mention any relevant limitations.	No, as long as there are national approaches on the risks and no harmonized RAC consistent with the transport of dangerous goods challenges. National restrictions come from the history of railway networks (eg. code of practice, National reference system) or from events (eg. accidents). They can also come from the application of other laws (environment, homeland safety/security, ...). Experience shows that they tend to grow and they are rarely reported as requested by the European legislation (2004/49/UE and 2008/57/UE) and international regulation (RID). The fact that the rules are not notified by all Member States might be a consequence of the interpretations of the key concepts of "national rules," "restriction" and " risk acceptance criteria." The risk management process as described in EC-Regulation No. 352/2009 is mandatory to be applied only for significant changes. The term RAC is used only in the context of explicit risk estimation. The understanding of RAC in EC-Regulation No. 352/2009 would have to be modified to suit the needs of the transport of dangerous goods: today RAC (as part of explicit risk estimation) exist for functional failures of technical systems whereas Dangerous goods would need RAC for complete systems.
Problems in applying RAC. Please mention any experience in applying RAC or meeting DG restrictions or cross-border issues that may be relevant in harmonising RAC for DG transport in EU.	As noted above, there is no harmonized RAC for dangerous goods transport which address environmental and social issues. The method (Annex RID, see the website of the OTIF) developed by the RID Committee in the mid-2000s does not answer the problem. Some restrictions are rooted in the application of other laws, particularly environmental and civil protection. They result from the application of RAC somehow outside the area of influence of the railway actors. The "restrictions" are more or less known internationally, even at national level. Sometimes they are considered as "normal rules" because they were defined a long time ago. Removing them could be an issue since the competent authorities or operators may consider it decreases the current level of safety. The "restrictions" are generally considered as a problem (even as an obstacle to the free movement) by railway companies from outside the country. The existence of national rules imposing restrictions can be seen as an obstacle to the establishment of a European market and European interoperability of railway operations. RAC defined in the railway legislation could be questioned by “other” competent authorities. For example, in terms of RAC (see 2.5.1 2009/352/UE), the failure rate of technical systems <10-9 per hour of operation might not be accepted by the competent authorities responsible for the protection of the environment or public security (competent authorities do not always accept yet probabilistic quantification of risk is not really).

	A German study started in 2012 as part of the RID-ADR-DNA Joint Meeting (UN/UNECE). This study didn't allow yet to have a clear and complete vision of the European practices in terms of risk assessment of dangerous goods transport and therefore risk acceptance criteria. A Final Report of the Task Force on National Safety Rules - Activities Results in 2011-2012 was presented at the meeting of Dangerous Goods Transport Committee on June 17 in Brussels. The report does not mention significant progress in the analysis of national practices for dangerous goods transport.
Approach to harmonising RAC for DG transport. Please recommend any approach that might be suitable.	The transport of dangerous goods is part of the rail, and as such it shall comply with the European legislation (2004/49/UE, 2008/57/UE, 2008/68/UE/RID, 2009/352/UE). In terms of RAC it although differs since it is not a technical system that is considered but an entire system. A first step might be to find a consensus on the concept of "restriction" (derogation to the RID requiring additional requirements?). "National rule" as well as "RAC" should also be better defined. The current national rules for safety and interoperability do not cover entirely dangerous goods transport. Transportation restrictions are already regulated by European legislation and RID. It is likely that the harmonized definition of RAC in this field will facilitate action by the competent authorities. In some countries, the infrastructure managers also have rules (including parking restrictions or control of railways undertakings ...). It would be interesting to see whether these rules should be considered as national rules, or as "transport restrictions,". The approach to harmonize the RAC for the Dangerous goods transport can only be effective if in a first step all existing 'restrictions' are transparently notified in all Member States. The precise knowledge of all national practices and the verification of compliance with the EU legislation would be a significant progress. This should also facilitate the development of appropriate explicit RAC. Railway operational experts and dangerous goods experts should cooperate, in particular to collect information on national rules and national and local restrictions. The analysis of national legislation should not be limited to the implementation of the directives 2004/49/UE (Safety) and 2008/57/UE (interoperability), it should also include the application of the Directive 2008/68/UE . Harmonized RAC of dangerous goods transport should wherever possible be part of the common safety method, even if one has to be aware that the scope differs since the scope is a system and not the single failure of a technical system. For defining explicit RAC a definition of the method is necessary. European transport authorities (DGMOVE) should have a closer coordination with the other authorities involved in the dangerous goods transport. Finally, insofar as the "explicit quantification of risk" is one of the main issue, the definition of RAC would require a thorough study of the factor "severity" which should be characterized with the lesson learnt from accidents. See an example of severity scale attached. This "ladder" should be considered as a working document. Its purpose is to illustrate the variability in the severity of events. The documentation (in French) can be provided on request.
Contact for further discussion.	Jean-Georges HEINTZ – UIC - HEINTZ@uic.org - +33 1 53 25 30 28 Jean-Baptiste SIMONNET – CER – jbs@cer.be – 0032 491162182

Example of severity scale:

	Number of event in France between 1982 and 2007		
Ryongchon- North Corea – 22/04/04 161 death, 1300 injuries, 300 M€ of internal and external dammages		10	**Major Disaster**
Laurel – US – 25/01/1979 2 dead, 976 serious and minor injuries, major internal and external damage, significant loss		9	**Disaster**
Mississauga – Canada – 10/11/1979 Damage to equipment, external damage (25M€), 14 light injuries, 220000 evacuated		8	**Major accident**
Voulte - France - 13/01/1993 1000m3 loss, 500 evacuated, 20 light injuries, external damage 10M€, 300m perimeter, internal damage	**7**	7	**Very serious accident**
Idaho - U.S. - 24/07/1999 Some poisoning, internal & external damage, two highways closed during 3h, 8h/3km perimeter, rail traffic closed	**30**	6	**Serious accident**
Vénarey - France - 15/09/1992 20 FREIGHT trains and 10 passenger trains stopped during several hours	**51**	5	**Accident**
Novéant-France -15/01/2005 One worker bothered (in fact water flow)	**110**	4	**RID event** (RID section 1.8.5)
Kogenheim - France - 13/11/1992 Security perimeter, one road closed, traffic stopped, delayed trains	**600**	3	**Quasi accident**
Dole - France - 07/12/2005 2 TGV and 6 regional trains delayed less than an hour	**800**	2	**Critical incident**
Miramas - France - 04/04/2003 Shunting yard disturbed during 1:30	**1000**	1	**Incident**
Valenton – France - 25/01/2001 1 freight train delayd 30'		0	**Non event**

Non-event: deficiencies found and repaired before acceptance for transport.

ANNEX THREE – PUBLIC WORKSHOP

Date: 14th February 2014

Location: European Commission, Brussels

Participants

About 40 attendees, including:

- Representatives of national administrations and national safety authorities;
- Representatives of the European Commission (Mr Aaltonen, Mr Rigon, MOVE);
- European Railway Agency (Mrs Antova), OTIF (Mr Conrad);
- Two experts of the firm DNV GL (Mr Ellis, Mr Spouge); two invited experts of European Chemical Industry Council (CEFIC, Mr Verlinden, Mr Hermand)
- Stakeholders: UIC, CER, UIP, Infrabel (railways), CBA (Chemical Business Association), DSLV (Deutscher Speditions-und Logistikverband).

Agenda

Welcoming of the participants (Mr Rigon, MOVE)

Background and motivation of the study (Mr Rigon, MOVE)

Outline of study methodology and results (Mr Spouge, DNV GL)

Survey of approaches among EU MS (Mr Ellis, DNV GL)

Transport risk assessment - an industry perspective (Mr Verlinden & Mr Hermand, Cefic)

Proposed harmonised RAC (Mr Spouge, DNV GL)

Discussion

Summing up (Mr Rigon, MOVE)

Summary of Discussion

In general, the DNV study was appreciated and methodology considered appropriate. The approach towards harmonisation also was favourably commented.

The DNV proposal for a gradual level of assessment depending on the level of risk was well understood.

However, two major obstacles result from the lack of reliable data and the threshold of 'tolerable risks'. More specifically:

1. Mr Pfauvadel (FR) observed that to make progress in this field accurate statistics is a preliminary requirement and only few MS have good data. He suggested proceeding step by step, giving time to the constitution of a data base. Risk analysis is very complex and expensive: legislative obligations are not acceptable without appropriate tools for satisfying them.

   Mrs Kuehl (BAM, DE) observed that a similar exercise was launched by BAM in 2011, without success.

   Stressing the difficulty of collecting comprehensive accident data, Mr Bogaert (BE) was concerned by the burden that this would represent to the administrations.

2. Mr Margarita (ANSF, IT) stressed that a threshold for low risks would be hardly tolerable. The target pursued by ANSF (Italian NSA) is "0" fatalities in rail. The public reject all risks: all possible measure should be taken to avoid penal pursuit in case of accident.

   A similar problem is increasingly emerging with FR local administrations: the préfets take local restriction in transport of dangerous goods to discharge all responsibilities in case of an accident. They do not care about the consequences outside their administration – if the risk globally increases – but in case of an accident they cannot be blamed for not having taken the necessary measures. Apparently, in IT and FR some jurisprudence is oriented on that direction.

   According to Mr Landenberg (NL), this situation does not play in favour of a legislative initiative for a harmonised approach, as long as people do not make the link between the risk and the use they made of the dangerous goods.

Concerning the policy options, the preferred would be a new Directive involving all transport modes.

Only NL suggested rather soft measures (guidelines) although this option seems little effective.

The new Directive should set at least a common methodology and the principles for collecting data, thus breaking the vicious circle:

> "no data available → no harmonisation → no data collection".

The challenge would be allowing some MS 'allergic to risks' to take more severe restriction while being consistent with the purpose of the new Directive.

APPENDIX II

Evaluation of Approaches to Harmonised Risk Acceptance Criteria for Transport of Dangerous Goods in Europe

Table of contents

II.1 INTRODUCTION

II.1.1 Objectives

This appendix comprises the report on part of Task 2 of the study. The aim of Task 2 is to review the various possible approaches to developing harmonised risk acceptance criteria (RAC) for transport of dangerous goods (TDG), and draw preliminary conclusions on their technical feasibility. This appendix provides the detailed evaluation of candidate approaches for harmonised RAC.

II.1.2 Candidate Approaches

Based on the survey of approaches and the literature survey (Main Report Section 4), the following approaches are considered candidates for use in a harmonised approach to TDG:

- Uniform application of ADR/RID/ADN without Chapter 1.9. This would in effect prohibit local restrictions and remove the need for RAC.
- Expert judgement approach, which is implicitly used in all countries that adopt restrictions on TDG without using explicit RAC.
- Consequence approach, as used in Germany for fixed installations. In principle this could be applied to TDG.
- Risk matrix approach, as used in France. In principle the same approach could be applied to TDG.
- Individual risk and FN criteria, as used in Flanders, the Netherlands, Switzerland and the UK. The numerical differences between these national applications (i.e. the fact that the FN criteria are all somewhat different) are considered separately as part of the evaluation of this approach.
- The ALARP approach, as used in France, the Netherlands and the UK, consisting of mainly qualitative cost-benefit balancing.
- The ACDS scrutiny level, i.e. FN criteria that scale with the quantity transported to identify individual trades with justifiable societal risk.
- The road tunnel approaches for DGs, as used in Austria, the Czech Republic, Germany, Italy and Slovenia, which combine FN criteria with a preliminary screening based on fatality rate and a subsequent risk ranking of alternatives.
- The European rail CSTs, which consist of current values of risk per unit exposure in each MS, combined with a limit on the variation between MS. To apply this approach to TDG, some apportionment would be needed, comparable to the target for technical failure.
- The road safety targets, as used in many European countries, which consist of aspirational trends in number of fatalities in each MS, combined with cost-benefit analysis to optimise safety improvements.

It is anticipated that an optimal approach might combine different elements of these approaches, so the fact that they overlap to some extent is not considered a problem.

II.1.3 Method of Evaluation

The candidate approaches are now evaluated in the following ways:

- How far are they aligned with the fundamental principles for RAC?
- How far are they already in use for TDG in the EU?
- Do their current users consider they are suitable for a harmonised approach?
- Would they reduce the inconsistencies that exist in the current approach, in which there are no harmonised RAC for TDG?
- What are their overall strengths and limitations with respect to other challenges in setting harmonised RAC?

These questions are addressed in turn in the following sections.

II.2 ALIGNMENT WITH PRINCIPLES

The principles selected to underpin RAC for TDG were (Main Report Section 3):

1. Justification of activity – the risks of the activity should be justified by its benefits (in terms of goods transported, value added, jobs etc) for the society as a whole.

2. Optimisation of protection – the risks should be minimised by appropriate safety measures, taking account of their benefits (in terms of risk reduction) and costs, and also of established good practice.

3. Equity – the risks should not be unduly concentrated on particular individuals or communities.

4. Aversion to catastrophes – the risks of major accidents (including multiple-fatality, high cost or widespread impacts) should be a small proportion of the total.

5. Assessment threshold – negligible risks should be exempted from detailed assessment.

6. Continuous improvement – overall risks should not increase, and preferably should reduce.

The candidate approaches address these in the following ways:

- The removal of Chapter 1.9 of ADR/RID/ADN could be considered a type of optimisation of protection, or a high assessment threshold, but it would not address the other principles.

- The expert judgement approach can implicitly address all these principles, although in practice it often does not explicitly address any of them.

- The consequence approach can include an assessment threshold (e.g. the storage quantities in the Seveso Directive). It implicitly addresses equity, catastrophe aversion and optimisation of protection.

- The risk matrix approach can include catastrophe aversion and an assessment threshold. It does not explicitly address the other principles, but may have sufficient flexibility to address equity and optimisation of protection implicitly.

- Individual risk criteria directly address equity between individuals, and FN criteria can address equity between communities as well as catastrophe aversion. Both can be used to express assessment thresholds.

- The ALARP approach adds a method of optimising protection.

- The ACDS scrutiny level (i.e. an FN criterion that scales with the quantity transported) adds an attempt to address the justification of an activity.

- The road tunnel approach (i.e. the preliminary screening based on fatality rate and a subsequent risk comparison of alternatives) is a different way of adding an assessment threshold and optimisation of protection.

- The European rail CSTs address continuous improvement. Since they are based on risk per unit exposure, they can also be considered ways of addressing the justification of an activity.

- The road safety targets (i.e. aspirational trends in number of fatalities, combined with CBA) combine continuous improvement with a method of optimising protection.

Most of the candidate approaches address one or more principles. Some only address them implicitly. Comprehensive coverage of all principles could be obtained by combining several approaches.

This evaluation is summarised in Figure II.1. The candidate approaches are categorised as aligned, implicitly aligned or not aligned with each principle. As in other evaluation tables below, the evaluations are coloured bright green (the most desirable), pale green (somewhat desirable) or white (not desirable). It is recognised that this is highly simplified.

Figure II.1 Alignment of Candidate Approaches with Principles

	Justification of activity	Optimisation of protection	Equity	Catastrophe aversion	Assessment threshold	Continuous improvement
Uniform codes		Implicit			Implicit	
Judgement	Implicit	Implicit	Implicit	Implicit	Implicit	Implicit
Consequence		Implicit	Implicit	Implicit	Aligned	
Risk matrix		Implicit	Implicit	Aligned	Aligned	
IR + FN			Aligned	Aligned	Aligned	
ALARP		Aligned				
ACDS scrutiny	Aligned					
Road tunnel		Aligned			Aligned	
Rail CST	Aligned					Aligned
Road CBA		Aligned				Aligned

II.3 EXISTING APPLICATION

The candidate approaches are in use to the following extent:

- The uniform application of ADR/RID/ADN without any restrictions under Chapter 1.9 is the stated approach to TDG in 7 MS according to the survey in Task 1.
- The expert judgement approach is implicitly used in all countries that adopt restrictions on TDG without using explicit RAC, which amounts to 7 MS according to the survey in Task 1. It might also be in use in others in combination with explicit quantitative RAC.
- The consequence approach is used in Germany for fixed installations.
- The risk matrix approach is used in France for fixed installations.
- Individual risk and FN criteria are used in Belgium (for fixed installations), the Netherlands and Switzerland. They have also been used on specific transport projects in Denmark, Italy and the UK. The numerical differences between these national applications (i.e. the fact that the FN criteria are all somewhat different) are considered separately as part of the evaluation of this approach.
- The ALARP approach (or equivalent) is used in France, the Netherlands, Switzerland and the UK.
- The ACDS scrutiny level (i.e. FN criteria that scale with quantity transported) was developed in the UK but is not currently in use anywhere.
- The road tunnel approach (i.e. the preliminary screening based on fatality rate and a subsequent risk comparison of alternatives) is used in Austria, the Czech Republic, Germany, Italy, Norway and Slovenia.
- The European rail CSTs are adopted by all MS, although without any specific targets for DG.
- The road safety targets (i.e. aspirational trends in number of fatalities, combined with CBA) are used in many European countries, including at least 12 MS identified in Main Report Section 4.6.2.

In conclusion, all the approaches would be familiar to at least one MS. The only approach that is currently in use in all of them is the rail CST, although this is not for DG. Figure II.2 summarises the extent of existing application, although it is recognised that this is highly simplified and possibly incomplete.

Figure II.2 Existing Application of Candidate Approaches

	Countries using approach						
Uniform codes	Bulgaria	Czech Rep	Estonia	Greece	Hungary	Latvia	Slovakia
Judgement	Belgium	Finland	Ireland	Lithuania	Romania	Spain	Sweden
Consequence	Germany						
Risk matrix	France						
IR + FN	Belgium	Netherlands	Switzerland	Denmark	Italy	UK	
ALARP	France	Netherlands	Switzerland	UK			
ACDS scrutiny							
Road tunnel	Austria	Czech Rep	Germany	Italy	Slovenia		
Rail CST	27 MS but not specifically for DG						
Road CBA	12 MS but not for DG						

II.4 PROPOSED FOR HARMONISATION

The survey in Task 1 asked RAC scheme owners whether their approach could be used as part of harmonised EU RAC. The only positive replies were:

- France – in respect of principles, not parameters. This refers to a risk matrix approach.
- Netherlands - in its full application this combines individual risk and FN criteria, including adjusting individual risk limits on specific routes, together with an ALARP requirement and other judgemental RAC. This covers several of the candidate approaches.
- Slovenia – this refers to the road tunnel approach, although its originator, Austria, did not consider it suitable for a harmonised approach. Probably both recognise that changes would be needed to apply to other transport modes.
- Spain – this refers to a judgement approach to develop a permitted route network.

It appears that the only approaches considered immediately suitable as harmonised RAC are approaches used in the Netherlands and Spain. It is significant that these are very different to each other, being mainly quantitative in the Netherlands and based on judgement in Spain.

II.5 REDUCTION OF INCONSISTENCIES

II.5.1 Current Inconsistencies

The following inconsistencies and unintended impacts are identified in the current approach, in which there are no harmonised RAC for TDG:

- Unequal restrictions - different RAC can lead to different restrictions on TDG for similar situations in different locations.
- Unequal costs - different RAC create different costs in obtaining approval for similar TDG operations in different countries.
- Change of route – a RAC applied in one location, which leads to a restriction in TDG, may result in the operator using a different route or the industry using a different source of materials. This may alter the risk pattern, which in some cases may increase the overall risk.
- Change of mode – a RAC applied to one transport mode, which leads to a restriction in TDG, may result in the TDG switching to a different *mode* with fewer restrictions. This may alter the risk pattern, which in some cases may increase the overall risk.
- Change of supply pattern - a RAC applied to a fixed installation, which leads to a restriction in its operations, may result in a change in its supply pattern, which may alter the risk from TDG.
- Complex regulations – without harmonised RAC, there is a tendency to improve safety by adding requirements to ADR/RID/ADN, which tend to grow more complex while the motivation for each regulation tends to become obscure.

These are considered in turn below.

II.5.2 Unequal Restrictions

A key issue in the current situation with no harmonised RAC is that the different RAC that have been adopted in practice (see Section 4 above) can lead to different restrictions on TDG for similar situations in different locations. Diverse national or local restrictions have been adopted. For example, the Netherlands restricts movement of DG when visibility is restricted or conditions are slippery, whereas other MS do not have this restriction (see Task 1 report). This may create an unfair disadvantage for transport operators in some locations, and gives unequal protection against hazards for citizens in different countries.

Although the RAC may be very different in different countries, their practical effects may be more similar, due to differences in regulatory style (see Appendix II.6.8 below). Nevertheless, this can still be considered a system that lacks transparency.

The responses of the candidate approaches to this inconsistency are summarised as follows:

- The removal of Chapter 1.9 of ADR/RID/ADN would automatically resolve this problem, by applying the same restrictions everywhere. Some inconsistencies might remain in the area of tunnels, where ADR allows different categories.
- The expert judgement approach is likely to continue to deliver different restrictions in different locations. In principle, a harmonisation of expert opinions can be achieved, but it is likely that ADR/RID/ADN have already done this as much as possible.
- The consequence approach would probably deliver equal restrictions.

- The risk matrix approach is likely to deliver different restrictions in different locations because it is very sensitive to the judgement by the practitioners.

- Individual risk and FN criteria should in principle deliver identical restrictions in different locations, but in practice they are very sensitive to risk analysis methodology (see Appendix II.6.12). A harmonised risk analysis methodology (i.e. consistent models and parameters) would therefore also be required.

- The ALARP approach (i.e. a mainly qualitative cost-benefit balancing) is likely to deliver different restrictions in different locations because it is very sensitive to the judgement by the practitioners.

- The ACDS scrutiny level (i.e. FN criteria that scale with quantity transported) has the same response as FN criteria above.

- The road tunnel approach (i.e. the preliminary screening based on fatality rate and a subsequent risk comparison of alternatives) has the same response as FN criteria above.

- The European rail CSTs (i.e. current values of risk per unit exposure apportioned to DG transport) would have the same response as FN criteria above.

- The road safety targets (i.e. aspirational trends in number of fatalities, combined with quantitative CBA) are more likely to deliver the same restrictions in similar situations, but are still sensitive to modelling choices. CBAs of road safety measures in different countries show similar BCRs in some cases, but large differences in other cases, without obvious explanations[1].

DNV concludes that some of the candidate approaches are more likely to deliver the same restrictions in similar situations, but some differences are expected to remain, even with the most advanced harmonisation, and even in the extreme case of removal of Chapter 1.9 of ADR/RID/ADN. In principle, increased transparency in harmonised RAC should allow the differences to be progressively reduced.

Figure II.3 provides an indicative summary of the evaluation of this and other inconsistencies. It divides the candidate approaches into those that are unequivocally beneficial, those whose benefits are sensitive to scope of application or methodology, and those that would have no significant effect.

[1] EC Safety Net, “Cost-benefit analysis”, 2009.

Figure II.3 Reduction of Inconsistencies by Candidate Approaches

	Unequal restrictions	Unequal costs	Change of route/mode	Change of supply	Complex regulation
Uniform codes	Beneficial	Beneficial	No effect	No effect	Negative
Judgement	No effect	Sensitive	Sensitive	Sensitive	Positive
Consequence	Beneficial	Beneficial	Sensitive	Sensitive	Positive
Risk matrix	No effect	Beneficial	Sensitive	Sensitive	Positive
IR + FN	Sensitive	Sensitive	Sensitive	Beneficial	Positive
ALARP	No effect	Sensitive	Sensitive	Beneficial	Positive
ACDS scrutiny	Sensitive	Sensitive	Sensitive	No effect	Positive
Road tunnel	Sensitive	Sensitive	Beneficial	No effect	Positive
Rail CST	Sensitive	Sensitive	Sensitive	No effect	Positive
Road CBA	Sensitive	Sensitive	Sensitive	Sensitive	Positive

II.5.3 Unequal Costs

Another inconsistency in the current situation with no harmonised RAC is that it may create different costs in obtaining approval for similar TDG operations in different countries. This may create an unfair disadvantage for transport operators in some countries.

The responses of the candidate approaches to this inconsistency are summarised as follows:

- The removal of Chapter 1.9 of ADR/RID/ADN would automatically resolve this problem.
- The expert judgement approach may impose similar costs in each country, but this is uncertain. Some national differences may remain, in line with the overall costs of business in each country.
- The consequence approach is expected to have equal costs.
- The risk matrix approach is expected to impose similar costs in each country.
- The other RAC approaches would in principle impose similar costs in each country, but only if a consistent risk analysis methodology was required.

DNV concludes that most of the candidate approaches would impose similar costs in each country, but only if consistent a risk analysis methodology was required.

II.5.4 Change of Route

A possible unintended impact of the current situation with no harmonised RAC is that a RAC applied in one location, which leads to a restriction in TDG, may result in the operator using a different route or the industry using a different source of materials. This may alter the risk pattern, with uncertain impacts on risk. In some cases it may increase the overall societal risk.

For example, if DG is restricted from a tunnel, the alternative supply route avoiding the tunnel might be a longer route passing through urban areas or along steep, narrow roads. This might increase the total societal risk, as well as creating greater cost for the operator and increased greenhouse gas emissions. This problem was highlighted by Norway in its response to the survey in Task 1.

In some cases, there may be a legitimate conflict between different principles underlying the RAC. For example, restrictions at one location might be intended to limit individual risk, and

the increase in societal risk might be considered an acceptable trade-off. However, the trade-off should be made explicit through the RAC, and should not be an uncontrolled result of following one principle while ignoring others.

Another possible explanation might be that a tunnel RAC is controlling risk to infrastructure and the transport network as a whole. However, this should be considered explicitly through RAC that can take account of it, such as ICAF or NPV. If the risk to infrastructure cannot be quantified, it should be considered through an expert judgement approach, rather than using an FN RAC as a surrogate.

The responses of the candidate approaches to this challenge are summarised as follows:

- The removal of Chapter 1.9 of ADR/RID/ADN would only resolve this challenge if tunnel restrictions were also removed. Otherwise it would have no effect.
- The expert judgement approach, if conducted with a narrow mandate, might continue to have the same unplanned effect. However, if given a wide mandate to consider the response of operators to any restriction, it could in principle resolve this challenge.
- The consequence approach would reduce the inconsistencies, but some would remain if there were lower probability events not explicitly modelled.
- The risk matrix approach has the same response as expert judgement above.
- Individual risk and FN criteria would in principle ensure that the risks were acceptable, but only if given a wide mandate to ensure that societal risk is reduced, taking account of probable adaptations by the industry.
- The ALARP approach (i.e. a mainly qualitative cost-benefit balancing) has the same response as FN criteria above.
- The ACDS scrutiny level (i.e. FN criteria that scale with quantity transported) would in principle ensure that the risks were acceptable, but only if the criteria referred to the complete transport route.
- The road tunnel approach (i.e. the preliminary screening based on fatality rate and a subsequent risk comparison of alternatives) resolves this challenge in its final step.
- The European rail CSTs (i.e. current values of risk per unit exposure apportioned to DG transport) would in principle ensure that the risks were acceptable, but only if the apportioned criteria referred to the complete transport route.
- The road safety targets (i.e. aspirational trends in number of fatalities, combined with quantitative cost-benefit analysis) would in principle deliver optimal protection, but only if given a wide mandate.

DNV concludes that most of the candidate approaches would resolve this inconsistency, but only if the study had a wide mandate, covering the complete transport route. This would have a cost burden, which will be considered under cost-effectiveness below. This issue was raised by Italy in its response to the survey in Task 1, which specifically mentioned "*difficulties connected to wideness of context / area of application*".

II.5.5 Change of Mode

A RAC applied to one transport mode, which leads to a restriction in TDG, may result in the TDG switching to a different *mode* with fewer restrictions. This may alter the risk pattern, with uncertain impacts on risk. In some cases it may increase the overall societal risk.

For example, if excessive DG restrictions are applied to road transport, this could make rail transport more cost-effective, which might involve a longer route passing through urban areas. This might increase the total societal risk.

There is also a long-term trend for TDG to use road rather than rail or inland waterway. This is based on the greater flexibility of road transport, in responding to changes in demand, in accessing end-users, and in supplying small quantities of product. However, the risk impacts are not usually monitored.

In general, modal comparisons show no clear preference for transport by any one mode, but on a specific route it is possible that risks are significantly higher by one mode than another. If DG restrictions do not take account of this, it is therefore possible that they could cause sub-optimal modal shifts.

The responses of the candidate approaches to this inconsistency would be as for the change of route above.

II.5.6 Change of Supply Pattern

A RAC applied to a fixed installation, which leads to a restriction in its operations, may result in a change in its supply pattern, which may alter the risk from TDG. For example, the Seveso Directive depends on the quantity of material stored at the site, which may encourage operators to stop DG vehicles at off-site parks, which may be closer to residential areas but subject to fewer controls. Alternatively, it may require supply in small quantities, which favours road over rail, and hence leads to a change of mode. These changes may alter the risk pattern, with uncertain impacts on risk. In some cases it may increase the overall societal risk or the individual risk for people living close to the temporary stop areas.

In general, minimising hazardous inventories is a good safety management principle. However, it is necessary to consider the whole supply chain, and the Seveso Directive at present does not require this.

Similar effects may be unintended effects of restrictions on TDG. For example, several MS restrict movement of DG to certain times of day, which may result in the DG being parked in temporary stop areas, exposing the local population to increased risk. Without considering the total effects, there is no confidence that the measure has reduced overall risk.

The responses of the candidate approaches to this inconsistency are summarised as follows:

- The removal of Chapter 1.9 of ADR/RID/ADN would not resolve this challenge.
- The expert judgement approach, if conducted with a narrow mandate, might continue to have the same unplanned effect. However, if given a wide mandate to consider the response of operators to any restriction, it could in principle resolve this challenge.
- The consequence approach, if applied identically to fixed installations and TDG, would reduce the inconsistencies, but some would remain if there were lower probability events not explicitly modelled.

- The risk matrix approach has the same response as expert judgement above.
- Individual risk and FN criteria, if applied identically to fixed installations and TDG, would in principle ensure that the risks were acceptable, although consistent FN criteria for fixed installations and TDG would not be easily developed.
- The ALARP approach (i.e. a mainly qualitative cost-benefit balancing), if applied identically to fixed installations and TDG, would in principle ensure that the risks were acceptable.
- The ACDS scrutiny level (i.e. FN criteria that scale with quantity transported) would not resolve this challenge.
- The road tunnel approach (i.e. the preliminary screening based on fatality rate and a subsequent risk comparison of alternatives) would not resolve this challenge.
- The European rail CSTs (i.e. current values of risk per unit exposure apportioned to DG transport) would not resolve this challenge.
- The road safety targets (i.e. aspirational trends in number of fatalities, combined with quantitative cost-benefit analysis) would in principle deliver optimal protection, but only if given a wide mandate.

DNV concludes that some of the candidate approaches would resolve this inconsistency, but only if the study had a wide mandate, covering fixed installations and TDG. This would have a cost burden, which will be considered under cost-effectiveness below.

II.5.7 Complex Regulations

Managing safety through incremental development of regulations such as ADR/RID/ADN has a drawback that the regulations tend to grow more complex while the motivation for each regulation tends to become obscure. This is a particular problem when many different hazards are addressed, as in the case of TDG. National and local restrictions that are permitted under ADR/RID/ADN also tend to accumulate and are often not justified or notified, contrary to RID requirements [2]. Some restrictions come from the application of other laws, such as environmental and civil protection.

Strictly, these are problems of a code-based approach, or of an inadequately documented judgemental approach, rather than of non-harmonised RAC. However, in the absence of harmonised RAC there is a tendency to use ADR/RID/ADN to achieve continuous improvement, and this tends to increase the requirements. Eventually, it becomes difficult to remember what each requirement was intended to achieve, and also very difficult to alter or remove them.

National and local restrictions in a non-harmonised system can also be seen as a type of barrier to market entry, as they require greater understanding of the diverse local requirements.

The responses of the candidate approaches to this inconsistency are summarised as follows:

- The removal of Chapter 1.9 of ADR/RID/ADN would make the problem of complexity worse, as there would then be no other way of improving safety.

[2] UIC response to survey in Appendix I

- All the other approaches have the potential to reduce the problem by providing a systematic way of addressing specific risks through justified safety improvements, which would be expected to be consistent in different MS.

DNV concludes that this issue is an argument in favour of any risk-based approach.

II.6 RESPONSE TO OTHER CHALLENGES

II.6.1 Identification of Challenges

Before attempting to develop harmonised RAC, it is appropriate to consider the main challenges that such criteria might face. These challenges are not limited to the inconsistencies that exist in the current approach. A good set of RAC should help avoid the inconsistences that exist in the current approach, without introducing any new inconsistencies. This section therefore identifies the key challenges for harmonised RAC, so as to help evaluate the candidate approaches. The strengths and weaknesses of any harmonised approach are to a large extent determined by their performance in addressing these challenges.

The following challenges are considered:

- Variability. This refers to the response of the RAC to:
    - Increases in TDG activity
    - Increase in population
    - Health & wealth variations
    - Population characteristics
    - Differences in hazards
    - Uncertainties
- Public accountability. This covers various characteristics that are expected from RAC:
    - Regulatory context
    - Transparency
    - Proportionality
    - Reaction to accidents
- Practical implementation. This refers to technical issues in implementing the RAC:
    - Analysis methodology
    - Subsidiarity
    - Consistency with Seveso Directive
    - Coverage of full scope
    - Unintended effects
- Effectiveness. This addresses whether the RAC do what they are intended in the areas of:
    - Effectiveness in improving safety

- Cost-effectiveness
- Environmental impacts
- Impacts on infrastructure

These challenges are discussed in turn below. Task 3 of the present project considers some of these issues in more detail, but focussing on the impacts of the synthesised set of RAC. Task 3 also addresses the legislative implications of a harmonised approach. Task 3 is reported in the main project report.

II.6.2 Increases in TDG Activity

The volume of DGs transported in Europe is currently increasing, and this increase is mostly absorbed by the road sector, due to its greater flexibility[3]. The European chemical industry is highly reliant on TDG. The current supply of fuel to motorists is also completely dependent on road transport of DGs.

A potential problem with harmonised RAC is that many RAC are based on a presumption that risk should be reduced, and may prohibit any increases in risk. This may deter or prevent any additional TDG activity. This may restrict industrial developments that might be to the overall benefit of society, and penalise economic growth.

Because society in general expects life expectancy to increase, there is inevitably pressure to ensure that industrial risks also reduce. If activity is growing, this may be very difficult to achieve without constraining industry. In some cases, this may be a political choice, made explicit through a judgemental approach. In other cases, it may be the unintended result of a restrictive RAC.

This was raised by the Netherlands in its response to the survey in Task 1, which specifically mentioned "*new and unexpected developments in industry and related transport as well as urban development in the vicinity of the transport route*" as an issue still under study.

A good set of RAC should provide a way of justifying increases in TDG activity and identify specific situations when this is unacceptable. The responses of the candidate approaches to this challenge are summarised as follows:

- The removal of Chapter 1.9 of ADR/RID/ADN would in effect ignore this challenge and allow unlimited increase in TDG.
- The expert judgement approach could in principle allow for increases in TDG, but is unlikely to do so consistently.
- The consequence approach could not respond to this challenge (unless the increase in activity was achieved by larger transport units) as it does not consider frequencies.
- The risk matrix approach has the same response as expert judgement above.
- Individual risk and FN criteria, could respond to this challenge in several ways, as discussed below.
- The ALARP approach (i.e. a mainly qualitative cost-benefit balancing) may prohibit risk increases (see below).

[3] CEFIC response to survey in Appendix I

- The ACDS scrutiny level (i.e. FN criteria that scale with quantity transported) in effect manages the societal risk per unit activity, and provides a justification for allowing the overall number of fatalities to rise.

- The road tunnel approach (i.e. the preliminary screening based on fatality rate and a subsequent risk comparison of alternatives) would provide a justification for allowing societal risk to increase, provided other alternatives had higher risks.

- The European rail CSTs (i.e. current values of risk per unit exposure apportioned to DG transport), have the same response as the ACDS scrutiny level above.

- The road safety approach based on CBA would allow the overall number of fatalities to rise, provided the NPV of the new activity is positive.

The possible responses of societal risk RAC to increasing activity can be compared as follows:

- RAC could simply require overall societal risks to reduce. This approach has been adopted in road transport in combination with CBA of risk reduction measures (see Main Report Section 4.6). However, this may not be practicable in TDG, where there is no established downward trend in societal risk.

- RAC could keep the overall societal risks constant, and require new risk controls to compensate for traffic increase. This approach has been adopted in the aviation industry (see Main Report Section 4.7.1). It can be very expensive, and may therefore conflict with the principle of optimising protection. Alternatively, new activity could be rationed to a rate that matches the improvement in risk control.

- RAC could limit societal risks to a level higher than present, in order to allow room for growth, and then ration further activity to a rate that matches the improvement in risk control. This is the Basisnet approach in the Netherlands (see Main Report Section 3.2.5). The permitted growth is arbitrary, and the long-term sustainability of the approach is not proven.

- RAC could manage the societal risk per unit activity, and allow the overall number of fatalities to rise. This approach is used in the CSM (see Main Report Section 4.5.1), and is also reflected in the ACDS scrutiny level (see Main Report Section 3.2.4). Its public acceptability in the context of growing activity has not been proven.

- RAC could allow the overall number of fatalities to rise, provided the risks are ALARP, interpreted as requiring all safety improvements whose marginal benefits outweigh their costs. However, there is a major problem with applying the ALARP approach to risk increases, because it could be argued that reducing the activity to the pre-existing level is “reasonably practicable”, which would in effect prevent any new activities that increased risks.

- RAC could allow the overall number of fatalities to rise, provided the NPV of the new activity is positive. This in effect allows all activities whose overall benefits outweigh their costs. This approach is rarely used, because it requires a CBA of any new activity. The societal benefit of TDG (i.e. the value added) is not routinely quantified, although it could be argued that it is illogical to analyse risks without taking account of the benefits of the activity.

- RAC could allow new activities provided their risk contributions are small in absolute terms. This approach is commonly used, but to be rigorous it requires a threshold criterion. Also, it would be unsuitable for major activities that exceeded the threshold criterion.

- RAC could allow new activities provided their risk contributions are not disproportionate to existing activities. This approach has been used by Eurotunnel to justify revisions to TDG restrictions (see Main Report Section 4.5.2). However, it depends on the view that existing activities involve acceptable risks. It may only be suitable for small changes.

DNV concludes that for TDG, where new trades are periodically introduced but there is no overall trend in activity, and little opportunity for major risk reduction, a small on-going reduction in societal risk might be suitable if applied at the national level. This would still permit increases at a local level, provided they were managed by other RAC such as CBA. Agreement on the precise details of the approach would be a key issue in practical development of harmonised RAC, but for the present report it is sufficient to conclude that it is feasible for a harmonised approach to address this challenge.

Figure II.4 summarises the response of the candidate approaches in this and other areas of variability considered below.

Figure II.4 Responses of Candidate Approaches to Variability Challenges

	Increase in TDG activity/population	Health & wealth variation	Population change/ hazard difference
Uniform codes	No limit	No response	No response
Judgement	Inconsistent limit	Inconsistent response	Inconsistent response
Consequence	No limit	No response	Partial response
Risk matrix	Inconsistent limit	Inconsistent response	Inconsistent response
IR + FN	Inconsistent limit	No response	Consistent response
ALARP	Inconsistent limit	Implicit response	Consistent response
ACDS scrutiny	Justified increase	No response	Consistent response
Road tunnel	Justified increase	No response	Consistent response
Rail CST	Justified increase	Implicit response	Consistent response
Road CBA	Justified increase	Justified response	Consistent response

II.6.3 Increase in Population

Another possible cause of a risk increase might be an increase in the population near to the TDG route, or an increase in the non-DG traffic along the route. This is similar to the increase in TDG considered above, and the candidate approaches respond in a similar way.

II.6.4 Health & Wealth Variations

The variations in wealth and life expectancy across the EU present a challenge to the regulation of TDG, as indeed to all types of harmonised regulations. The costs and benefits of any given safety requirement will be different in each MS, and the appropriate balance (i.e. the RAC) may therefore also differ. From this perspective, health and wealth variations should be reflected systematically in the RAC. This can be justified by the fact that each MS has a different ability to invest in safety measures, and has different opportunities to reduce risks in other ways. In the survey in Task 1, Norway commented that variations in acceptable risk across the EU were not a big problem.

On the other hand, citizens might expect to receive equal protection across the whole of the EU. From this perspective, health and wealth variations are irrelevant, and do not need to be reflected in RAC. Furthermore, the differences in safety requirements in different MS is a type

of unequal restriction that has been identified as an inconsistency in the current approach (see Appendix II.5.2).

A good set of harmonised RAC might respond to this issue by distinguishing between variations in safety requirements that can be justified and those that cannot. This would provide some understanding of current practices, and also a motivation for harmonising safety requirements.

The responses of the candidate approaches to this challenge are summarised as follows:

- The removal of Chapter 1.9 of ADR/RID/ADN would in effect ignore this challenge and adopt identical requirements in all MS.
- The expert judgement approach could in principle allow for national variations, but is unlikely to do so consistently.
- The consequence approach could not respond to this challenge, as it does not take account of national characteristics.
- The risk matrix approach has the same response as expert judgement above.
- Individual risk criteria, if based on background risks, could reflect variations in life expectancy, but in practice are usually harmonised at the same value everywhere, and thus do not respond to this challenge. FN criteria would not respond to this challenge.
- The ALARP approach (i.e. a mainly qualitative cost-benefit balancing) would implicitly allow for national variations. In the survey in Task 1, Norway specifically mentioned the likely variations in risk that would result from the use of ALARP, but did not see this as a major problem.
- The ACDS scrutiny level (i.e. FN criteria that scale with quantity transported) would not respond to this challenge.
- The road tunnel approach (i.e. the preliminary screening based on fatality rate and a subsequent risk comparison of alternatives) would not respond to this challenge.
- The European rail CSTs (i.e. current values of risk per unit exposure apportioned to DG transport), being based on historical experience in each country would implicitly respond to this challenge, but only if variations in historical experience result from variations in wealth and life expectancy in each MS
- The road safety targets (i.e. aspirational trends in number of fatalities, combined with quantitative cost-benefit analysis) can respond to this challenge if the VPF is based on the national income, on willingness-to-pay surveys or on quality of life indicators.

DNV concludes that the CBA approach would respond to this challenge by systematic variations of VPF in response to national health and wealth variations, while the ALARP approach would do this in a more qualitative way. Combining this approach with others that did not do this would acknowledge the contrasting view that health and wealth variations should be ignored.

II.6.5 Population Characteristics

There are variations in population characteristics across the EU that may affect risks and present a challenge to the regulation of TDG. For example, some countries have houses closer

to the roads, have more open ventilation, greater density of traffic on the roads etc. As with health and wealth variations above, this could be used to justify different safety requirements. Alternatively, it could be ignored, which would achieve uniform safety requirements but non-uniform risks A good set of harmonised RAC might distinguish between variations in safety requirements that can be justified and those that cannot.

The responses of the candidate approaches to this challenge are summarised as follows:

- The removal of Chapter 1.9 of ADR/RID/ADN would in effect ignore this challenge and adopt identical requirements in all MS, with consequent variations in risks.
- The expert judgement approach could in principle allow for national differences, but is unlikely to do so consistently.
- The consequence approach would only partially respond to this challenge as the only population characteristic that it reflects is the distance to the nearest inhabitant.
- The risk matrix approach has the same response as expert judgement above.
- All the other approaches, being based on explicit risk calculations, would take account of this challenge, irrespective of the RAC chosen, if a consistent risk analysis methodology was defined.

DNV concludes that any risk-based approach would respond to this challenge, if a consistent risk analysis methodology was defined.

II.6.6 Differences in Hazards

There are many differences in hazards between the transport modes covered in this study (road, rail and inland waterway), between specific locations (urban, rural, bridge, tunnel etc), and between individual DGs (explosives, flammable liquids, toxic gases etc). A good set of harmonised RAC should be unaffected by such differences.

The responses of the candidate approaches to this challenge are summarised as follows:

- The removal of Chapter 1.9 of ADR/RID/ADN would in effect ignore this challenge.
- The expert judgement approach implicitly takes account of all hazards.
- The consequence approach would require different criteria for each type of consequence, and does not respond well to this type of variation.
- The risk matrix approach has the same response as expert judgement above.
- All the other approaches, being based on explicit risk calculations, would take account of this challenge, irrespective of the RAC chosen, provided the risk analysis methodology converted all the hazards into risks.

DNV concludes that any risk-based approach would respond to this challenge, if a consistent risk analysis methodology was defined.

II.6.7 Uncertainties

There are many uncertainties in risk assessment, and this limits the validity of the risk results and the evaluation using RAC. For example, in the survey in Task 1, Austria specifically mentioned the problem of "*lack of concrete transport data and representative accident*

statistics". CEFIC raised a concern about the availability and uncertainty of data, both for DG transport quantities and for failures during transport.

There are also different ways of allowing for uncertainties in the results. Some argue that the classical approach to risk assessment gives insufficient weight to uncertainties, and that a Bayesian approach would be preferable[4]. The merits of this argument are outside the scope of the present study, but it does have an impact on the choice of RAC. A good set of RAC should be useful in the Bayesian approach as well as in the classical approach to risk. The key differences are explained as follows.

The classical approach to risk assessment estimates the frequency and probability of various events, and sees risk as the combination of both. It may acknowledge uncertainty in each component, which may complicate the comparison with RAC. For example, a classical approach may acknowledge that compliance with RAC is sensitive to uncertainties in the risk estimates, and invite the decision-maker to take account of this.

The Bayesian approach focusses on observable quantities such as the numbers of fatalities, and uses probabilities to express the analyst's uncertainty about how many will result in a particular activity. This embeds uncertainty in the description of risk. The RAC should similarly address an observable quantity and the Bayesian approach gives the probability of it being exceeded.

The candidate approaches have all arisen from classical risk assessment. The ones that would be most meaningful in a Bayesian approach would be the CST and CBA approaches.

II.6.8 Regulatory Context

There are substantial differences in the approach of different countries to regulation of risks, both through regulation and legal precedent. This is partly reflected in the very different RAC adopted in different countries.

For example, the maximum tolerable individual risk to the public is 10^{-4} in the UK and 10^{-6} in the Netherlands. Nevertheless, the practical effects are rather similar. In the UK the RAC are the starting point, and ALARP requirements drive the risks much lower, whereas in the Netherlands the RAC are usually the end of the discussion because "the courts invariably state that, should the government want more safety, it should put stricter levels in the law"[5].

In the area of societal risk, there are again large differences between the two countries, but both are treated as guidelines rather than mandatory requirements. In the UK, an analysis of ports found that all cases complied with the ACDS criteria[6]. In the Netherlands, there have been high-profile cases that do not comply with the criteria, where remedial measures have been postponed because of their high cost[7]. There are also differences in the risk methodologies in the two countries, which complicate the comparison, especially for societal risks.

In effect, the differences in RAC between countries compensate in part for the differences in regulatory style. This can also be seen when comparing countries in North-West Europe, many

[4] Njå, O. & Aven, T., "Trends in risk research on dangerous goods transport", Risk, Reliability and Societal Safety, Aven & Vinnem (eds), Taylor & Francis Group, London, 2007.

[5] Ale, B.J.M., "Tolerable or Acceptable: A Comparison of Risk Regulation in the United Kingdom and the Netherlands", Risk Analysis, vol 25, no 2, 2005.

[6] ACDS "Major Hazard Aspects of the Transport of Dangerous Substances", Health and Safety Commission, Advisory Committee on Dangerous Substances, HMSO, 1991

[7] Ale, B.J.M., "Living with Risk: A Management Question", Reliability Engineering and System Safety, 2005, cited in CCPS op cit.

of which make use of RAC, with countries in Eastern Europe, which on the whole do not use RAC at all but prefer a uniform application of ADR/RID/ADN.

A good set of harmonised RAC should take account of this issue. In fact, these differences constitute an argument *against* harmonised RAC. If harmonised RAC were used within the context of national differences in the regulatory style, the outcome would not be as intended. In fact, the differences in risk between countries could be even greater than in the current non-harmonised system. This was the conclusion of a previous EC initiative on harmonisation of risk-based decision making[8]:

> "*As risk acceptance and the judgement on hazardous activities is a highly contextual topic, the use of acceptance criteria strongly depends on country, on time, on activity, on risks and related benefits. For these reasons, it was generally felt that any successful "standardisation" should focus on the process underlying risk assessment, and not attempt to harmonise risk criteria.*"

A partial response to this challenge might be found in more flexible approaches to RAC, such as expert judgement, risk matrix or the ALARP approach. Other, less flexible approaches would make the situation worse. This is a critical issue for harmonised RAC, and will be considered further in Task 3. Figure II.5 summarises the response of the candidate approaches in this and other areas of public accountability considered below.

Figure II.5 Responses of Candidate Approaches to Accountability Challenges

	Regulatory Context	Transparency	Proportionality
Uniform codes	Not flexible	Partly transparent	Not proportionate
Judgement	Flexible	Partly transparent	Not proportionate
Consequence	Not flexible	Partly transparent	Not proportionate
Risk matrix	Flexible	Partly transparent	Threshold
IR + FN	Not flexible	Partly transparent	Threshold
ALARP	Flexible	Partly transparent	Not proportionate
ACDS scrutiny	Not flexible	Partly transparent	Not proportionate
Road tunnel	Not flexible	Partly transparent	Proportionate
Rail CST	Not flexible	Fully transparent	Proportionate
Road CBA	Not flexible	Partly transparent	Threshold

II.6.9 Transparency

A good set of RAC should be transparent, i.e. clearly explained and well understood by stakeholders, such that it is readily apparent when additional safety measures are needed. This is one of the motivations for developing harmonised RAC. Unfortunately, transparency is a characteristic RAC rarely possess.

Some approaches to RAC, such as expert judgement, risk matrix or the ALARP approach, are relatively simple to explain, yet there are usually elements of judgement at the core of the decision, which makes full transparency impractical.

Other approaches, such as individual risk and FN criteria and cost-benefit analysis, are more systematic and potentially transparent, yet because of the complexity of risks from TDG such criteria tend to be complex and difficult to understand.

[8] Kirchsteiger, K. & Cojazzi, G., "European Commission initiative to promote technical harmonisation on risk-based decision making", Kerntechnik 66 (2001), 1-2 pp65-70.

The responses of the candidate approaches to this challenge are summarised as follows:

- The removal of Chapter 1.9 of ADR/RID/ADN is very clear and simple, but the ADR/RID/ADN codes themselves are complex and the purpose and justification of each requirement are difficult to understand.
- The expert judgement approach is simple in concept, but decisions based on judgement are difficult to explain.
- The consequence approach is relatively simple, but the calculation approach is complex.
- The risk matrix approach has the same response as expert judgement above.
- Individual risk (IR) and FN criteria are systematic and potentially transparent, yet because of the complexity of risks from TDG such criteria tend to be complex and difficult to understand. FN criteria are well-known as sources of confusion. Very few practitioners fully understand all the details within risk calculations.
- The ALARP approach (i.e. a mainly qualitative cost-benefit balancing) has the same response as expert judgement above.
- The ACDS scrutiny level (i.e. FN criteria that scale with quantity transported) has the same response as IR and FN criteria above.
- The road tunnel approach (i.e. the preliminary screening based on fatality rate and a subsequent risk comparison of alternatives) has the same response as IR and FN criteria above.
- The European rail CSTs (i.e. current values of risk per unit exposure), can be seen as a very transparent approach to RAC, although this advantage would be reduced in the case of TDG by the difficulty of establishing the baseline risk levels.
- The road safety targets (i.e. aspirational trends in number of fatalities) have the same response as the rail CSTs, while CBA has the same response as FN criteria above.

DNV concludes that all RAC approaches have problems in this area. Furthermore, the combination of several approaches to combine other advantages, which is adopted in the synthesised approach, may be considered to make the result less transparent.

II.6.10Proportionality

A good set of RAC should be proportionate to the issue under study, i.e. the approach should be quick for small risks and more detailed for larger risks. Unfortunately, estimating the risk level is the most resource-intensive part of a risk assessment, and it is difficult to screen out low risks before this step is complete.

The only one of the candidate approaches that makes an explicit attempt to screen out low risks before making more detailed calculation is the road tunnel approach. Although this requires an estimate of fatality rate for the first screening step, it allows the assessment to be simpler where the risks are lower.

The CBA approach can also be applied in a very simple way once the level of risk is known, as this can show the maximum level of expenditure on safety measures that can be justified, which provides an equivalent threshold. Other approaches with explicit assessment thresholds (see Appendix II.2) have a similar degree of proportionality.

The rail CSTs are in effect proportionate, as they are based on historical experience.

II.6.11Reaction to Accidents

When a major accident occurs in a particular field or in a particular country, there is often a public clamour for additional safety measures. This may be seen as a short-sighted reaction, which is less desirable than a more measured pro-active approach to safety. Alternatively, it may be seen as pragmatic capitalisation on the willingness to invest in safety improvements that briefly exists following such traumatic events.

The role of RAC in such circumstances is to provide a longer-term perspective, helping to ensure that appropriate safety measures are implemented, and that unintended consequences do not result. This is already the aim of the harmonised RAC. There are no significant differences between the candidate approaches in respect of this challenge.

II.6.12Analysis Methodology

In the survey in Task 1, France commented that "*experience has shown that different institutes may produce very different answers to the same question depending on the initial assumptions*". Benchmarking studies have shown risk analysis results ranging over several orders of magnitude[9]. Such differences would inevitably result in inconsistencies even with harmonised RAC.

For a harmonised evaluation of risks it is essential to have a harmonised risk analysis methodology as well as harmonised RAC. In the survey in Task 1, France commented that "*no sound decision can be made without having defined harmonized method for assessing fundamental measurement of risk such as probability calculation and effect calculation*". Slovenia also commented that a common methodology must be determined.

Establishing such a methodology has been a major challenge in countries that have adopted RAC, and would be an even greater challenge across the EU. The details of such a methodology are outside the scope of the present study. Nevertheless, the selected RAC does have a significant impact on the type of risk analysis that is required, and this is considered as follows.

The impacts of the candidate approaches on this challenge are summarised as follows:

- The removal of Chapter 1.9 of ADR/RID/ADN would also remove the need for a harmonised risk analysis methodology.
- The expert judgement approach does not strictly need any risk analysis methodology, but the need for transparency of decisions would require the development of a systematic approach to risks. This could be relatively simple.
- The consequence approach requires only consequence analysis, which is relatively simple.
- The risk matrix approach has the same impact as expert judgement above.
- Individual risk and FN criteria require a full quantitative risk analysis methodology.
- The ALARP approach (i.e. a mainly qualitative cost-benefit balancing) has the same impact as expert judgement above.

[9] Amendola, A., Contini, S. & Ziomas, I., "Uncertainties in a Chemical Risk Assessment - Results of a European Benchmarking Exercise", Journal of Hazardous Materials, 29, pp347-363, 1992.

- The ACDS scrutiny level (i.e. FN criteria that scale with quantity transported) has the same impact as IR and FN criteria above.

- The road tunnel approach (i.e. the preliminary screening based on fatality rate and a subsequent risk comparison of alternatives) has the same impact as IR and FN criteria above.

- The European rail CSTs (i.e. current values of risk per unit exposure), requires only the current overall risks, but these would need to be apportioned to TDG, which would be relatively complex. In fact, one way of performing the apportionment would be to conduct the same risk analysis as needed for the IR and FN criteria.

- The road safety targets (i.e. aspirational trends in number of fatalities) have the same impact as the rail CSTs, while CBA has the same impact as FN criteria above.

DNV concludes that all the approaches, except a uniform application of ADR/RID/ADN, would depend on the development of a risk analysis methodology. The complexity of this methodology would also impact on the cost of performing the evaluation by each method. Figure II.6 summarises the response of the candidate approaches in this and other areas of practical implementation considered below.

Figure II.6 Responses of Candidate Approaches to Implementation Challenges

	Analysis methodology	Subsidiarity allowed	Consistent with Seveso	Full scope addressed	Unintended effects
Uniform codes	Not required	No	No	No	Unlikely
Judgement	Simple	Yes	No	Partly	Likely
Consequence	Simple	Partly	Yes	Partly	Likely
Risk matrix	Simple	Yes	Yes	Partly	Likely
IR + FN	Complex	Partly	Yes	Partly	Possible
ALARP	Simple	Partly	Possibly	Yes	Unlikely
ACDS scrutiny	Complex	Partly	No	Partly	Likely
Road tunnel	Complex	Partly	No	Partly	Possible
Rail CST	Complex	Partly	No	Partly	Unlikely
Road CBA	Complex	Partly	No	Yes	Possible

II.6.13Subsidiarity

An important principle of EU regulations is that decisions should be taken as closely as possible to the affected citizens, and that action should only be taken by the EU when it is more effective than at national, regional or local level. In the case of TDG, it is apparent that some of the issues arising from the current non-harmonised approach (Appendix II.5) apply across national boundaries, and therefore it appears appropriate for the EU to set harmonised RAC.

On the other hand, the differences in regulatory context between Member States (MS) (Appendix II.6.8) raise doubts about whether harmonised RAC would be more effective than national ones. The variations in health and wealth and population characteristics between MS (Appendix II.6.3 and II.6.4) would justify differences in RAC, even within a harmonised approach. In the case of CBA, the preference for willingness-to-pay surveys within the affected population (Main Report Section 4.6.3) is a type of subsidiarity that would lead to different VPFs in different MS.

A good harmonised approach should therefore allow some flexibility for MS to set their own RAC within a common framework, provided that these differences can be justified. This might also be seen as a pragmatic approach to harmonisation, in the context of the large current differences in approaches between MS (Main Report Section 4).

The responses of the candidate approaches to this challenge are summarised as follows:

- The removal of Chapter 1.9 of ADR/RID/ADN does not permit subsidiarity, i.e. it requires identical safety measures in all MS.
- The expert judgement approach allows subsidiarity, i.e. different safety measures in different MS.
- The consequence approach restricts subsidiarity, but does allow some flexibility in its application.
- The risk matrix approach has the same response as expert judgement above.
- The other RAC approaches have the same response as the consequence approach above.

DNV concludes that only the flexible approaches (expert judgement and risk matrix) would allow subsidiarity. The other approaches, except uniform application of ADR/RID/ADN, would allow some flexibility.

II.6.14Consistency with Seveso Directive

TDG does not exist in isolation: it is part of an integrated DG supply and production process, and hence the risks from DG cannot be managed successfully in isolation from the management of safety of fixed installations. In the EU these are covered by the Seveso Directive (Main Report Section 4.3.1). Some of the inconsistencies created by risk management of TDG that is not harmonised with the Seveso Directive have been considered in Appendix II.5.6. Possible ways of harmonising RAC for TDG with the Seveso Directive will be considered in Task 3.

For the present report, it is sufficient to note that harmonisation would be facilitated by RAC that are consistent with the approaches used by MS to comply with the Seveso Directive. This includes risk matrix, consequence and quantitative risk approaches, and possibly ALARP, but it does not include CBA, screening criteria or overall safety targets.

II.6.15Coverage of Full Scope

The required scope of the present study was specified in Main Report Section 1.5. This includes issues such as inland waterways, pipelines, temporary stop areas, transport within fixed installations, injuries and environmental impacts. A good set of RAC should be applicable to the entire scope without needing adjustment or development.

Environmental impacts are considered in Appendix II.6.19 below. The responses of the candidate approaches to other scope challenges are summarised as follows:

- The removal of Chapter 1.9 of ADR/RID/ADN would not address this challenge.
- The expert judgement approach allows all difficult scope issues to be addressed, but is unlikely to do so in a very consistent way.

- The consequence approach would need some adjustment to address the full scope.
- The risk matrix approach would have the same response as the consequence approach.
- Individual risk RAC are automatically applicable to fatalities from any scope but FN RAC may need special development for scopes such as pipelines. They both address only fatalities, although injuries can be included by defining equivalent fractions of fatalities. The risk methodology is not well established for scopes such as inland waterways, and this would imply extra cost and uncertainty.
- The ALARP approach (i.e. a mainly qualitative cost-benefit balancing) is automatically applicable to any scope.
- The ACDS scrutiny level (i.e. FN criteria that scale with quantity transported) is applicable to pipelines but not other scopes such as temporary stop areas.
- The road tunnel approach (i.e. the preliminary screening based on fatality rate and a subsequent risk comparison of alternatives) has the same response as IR and FN criteria above.
- The European rail CSTs (i.e. current values of risk per unit exposure apportioned to TDG), would need additional apportionment for other scopes.
- The road safety targets (i.e. aspirational trends in number of fatalities) would need some modification to address other scopes, while CBA is automatically applicable to any scope.

DNV concludes that all the approaches with explicit risks would require adjustment, and only the ALARP and CBA approaches are automatically applicable to any scope.

II.6.16Unintended Effects

Some industries and governments have made extensive use of targets as a way of motivating better performance, and have experienced unintended consequences, typically resulting in the target being met without the desired performance improvement. Some have concluded that these are not inconsistencies that need to be removed by better targets, but a fundamental problem with targets themselves. For example[10]:

> "*The whole notion of targets is flawed. Their use in a hierarchical system engages people's ingenuity in managing the numbers instead of improving their methods.*"

This criticism can also be applied to RAC, which are forms of targets. From this perspective, the inconsistencies in the current non-harmonised system, as discussed for TDG in Appendix II.5, might be replaced by other unintended effects, even in a fully harmonised system. In the survey in Task 1, Austria specifically mentioned the problem of stakeholders "changing the basis of the calculation instead of taking reasonable measures".

The quotation above refers to numerical targets, but similar criticism can be made of qualitative RAC, including risk matrices. They also tend to focus attention on ways of satisfying the RAC rather than ways of improving safety.

[10] Seddon, J., "Freedom from command and control: A better way to make the work work", Vanguard Consulting, 2003.

This learning might explain why early adopters of RAC, such as the Netherlands and the UK, have increasingly emphasised the softer processes of ALARP and safety management rather than documenting target compliance. A similar trend is seen in the offshore oil & gas industry.

As an example, consider the options for societal risk RAC. If expressed in terms of risks per year on a national basis, this would permit small transport operations with risks that were disproportionate to the quantity or length of transport. If the RAC were expressed in terms of risks per km, this might encourage transport along long routes of low risk intensity, with possible adverse effects (as in Appendix II.5.4). If the RAC were expressed in terms of risks per tonne transported (as the ACDS scrutiny level does), this is unfavourable to DGs with high risk per unit weight (e.g. radioactive materials) and might encourage unnecessary shipment of heavy non-hazardous materials to dilute the risks. If the RAC were related to the value of the shipment, this would complicate information requirements and might encourage unnecessary shipment of valuable non-hazardous materials to dilute the risks. Any form of RAC has the potential to cause unintended effects as operators attempt to comply with it as efficiently as possible.

On the other hand, experience in road transport suggests that quantitative targets can be effective in reducing risks (see Appendix II.6.17 below).

Some steps are suggested to mitigate the unintended effects:

- RAC should use metrics that are as close to the intended performance as possible, to minimise the potential disconnect between target compliance and performance improvement. In this sense, RAC for fatality rates or individual risks are preferable to RAC for consequence zones, risk matrices or FN curves.

- RAC should be realistic and meaningful, to avoid the risk evaluation becoming an artificial exercise. In general, this argues for RAC in the form of fatality rates based on actual experience, as in the rail CST and road safety targets. However, in TDG such risks may be so low that they cannot be made meaningful.

- RAC should be guidelines to support decision-making, not mandatory acceptance criteria. They should be discarded before they produce target compliance that is disconnected from performance improvement.

DNV concludes that any RAC may cause unintended effects if applied rigidly. RAC that are expressed as guidelines (such as ALARP), and use metrics such as fatality rates, are least likely to experience unintended effects.

II.6.17Effectiveness

A fundamental requirement of a good set of RAC is that they should be effective in maintaining and if possible improving safety. Unfortunately, it is very difficult to demonstrate the effectiveness of any particular approach to RAC.

Accident rates have in general fallen throughout EU countries during the period that formal risk assessment has been adopted. Analysis of accident rates in road transport show that countries with quantitative targets have larger reductions in fatalities than countries without targets[11]. However, it would be very difficult to show a causal connection, simply because national income has also increased over this period, and this is critical for the funding of safety

[11] Allsop, R.F., Sze, N.N. & Wong, S.C., "An update on the association between setting quantified road safety targets and road fatality reduction", Accident Analysis and Prevention, vol 43, no 3, 1279-1283, 2011.

improvements. A quantitative target may however be a catalyst that motivates policy makers and stakeholders to support safety improvements.

There is little good information on trends in the risks of accidents during TDG in Europe, which would indicate whether they were following the trend in overall transport safety. A world-wide survey[12] covering road and rail indicated that the number of accidents had increased in each decade up to 2000, but this was attributed to the growth in transport and improved accessibility of information on accidents. Without better information on risk trends, it would be impossible to show whether risk assessment had been effective.

Risk assessment, at least at a qualitative level, is generally believed to be a matter of good practice in the management of hazardous activities. Inquiries into accidents often reveal that risk assessment had been absent or inadequate, and so tend to recommend more systematic risk assessment. This indicates a belief in its effectiveness, although more objective evidence is lacking.

It could be argued that the adoption of risk assessment by some of the countries with the lowest accident rates also demonstrates a belief in its effectiveness. On the other hand, some of these countries have placed less emphasis on QRA and RAC in recent years, which might indicate a loss of such belief. For example, the UK in its response to the survey in Task 1 stated:

> "*The regulatory framework for the safe carriage of DG is largely deterministic – placing the regulations onto a risk based approach would be highly disruptive to a system that has served society well over many decades*."

Furthermore, the majority of countries in the survey in Task 1 do not use RAC for TDG, which might also indicate a lack of belief in its effectiveness.

It is also noted that RAC may be beneficial even if they are not effective at improving safety. For example, individual risk RAC have the benefit of demonstrating to stakeholders that risks are managed and equity is ensured, even if in practice no activity comes close to exceeding them. This may be seen as protection against hypothetical unacceptable risks, or as a symbol of a commitment to the principle of equity. Either approach is an intangible form of effectiveness.

DNV concludes that at present it is not possible to demonstrate the effectiveness of RAC overall. Furthermore, there is certainly no evidence to demonstrate that one approach to RAC is more effective than any other.

II.6.18Cost-Effectiveness

Risk assessments are expensive, and it would be desirable to demonstrate that they not only improve safety but also do so cost-effectively. Despite the lack of information on effectiveness, as discussed above, it may be possible to use CBA to show that some approaches cannot possibly be cost-effective. This would require a simple estimate of risk levels, equivalent to the screening part of the tunnel risk assessment approach. From this, the maximum justifiable expenditure to remove the risk can be determined. This may be sufficient to show that some resource-intensive approaches to risk assessment are not justifiable. However, RAC that justify the removal of expensive restrictions on TDG may be highly beneficial. Meanwhile, the

[12] Oggero, A., Darbar, R.M., Munoz, M., Planas, E. & Casal, J., "A survey of accidents occurring during the transport of hazardous substances by road and rail", 2005.

evaluation of the cost-effectiveness of the candidate approaches is the same as the complexity of the risk analysis methodology, as discussed in Appendix II.6..12.

II.6.19Environmental Impacts

A good set of RAC should not only help maintain or reduce the risks of fatalities in TDG, they should also promote improvements in other impacts, notably environmental impacts including greenhouse gas emissions.

In routine operations, the impacts of TDG on the environment are no different to the impacts of equivalent non-DG transport. The greenhouse gas emissions derive mainly from fuel consumption. The extra contributions from the rest of the life cycle, notably construction, may be important in the case of major safety measures. Nevertheless, it is desirable to take account of environmental impacts because some safety measures, such as alternative routes, may increase emissions while reducing risks, and this may affect the overall evaluation.

The responses of the candidate approaches to this challenge are summarised as follows:

- The removal of Chapter 1.9 of ADR/RID/ADN would not address this challenge. However, it is possible to address environmental impacts directly through uniform codes.
- The expert judgement approach could in principle include environmental impacts. Many such impacts are best addressed qualitatively, but in practice combining them with fatality risks is very difficult.
- The consequence approach might be extended to address local environmental impacts, but these would not distinguish DG from non-DG transport.
- The risk matrix approach can be extended to address environmental impacts, using a different consequence scale, but this is difficult to apply to a complete transport route.
- Individual risk RAC cannot address environmental impacts. FN RAC have been developed for environmental impacts in Switzerland, but this approach is complex and is not widely used.
- The ALARP approach (i.e. a mainly qualitative cost-benefit balancing) can be extended to address the environmental impacts of safety measures.
- The ACDS scrutiny level (i.e. FN criteria that scale with quantity transported) could address environmental impacts, but this would be complex.
- The road tunnel approach (i.e. the preliminary screening based on fatality rate and a subsequent risk comparison of alternatives) could be adapted for environmental impacts based on the distance travelled, but combining with fatality risks would be very difficult.
- The European rail CSTs (i.e. current values of risk per unit exposure) can be extended to address environmental impacts, but this advantage would be reduced in the case of TDG by the difficulty of establishing the baseline risk levels.
- The road safety targets (i.e. aspirational trends in number of fatalities) have the same response as the rail CSTs, while CBA has the same response as the ALARP above. CBA is a technique that allows systematic combination of safety and environmental impacts, but quantification of environmental impacts is difficult at present.

DNV concludes that all RAC approaches have problems in this area. The ALARP approach has the best balance of strengths and limitations.

Figure II.7 summarises the response of the candidate approaches in this and other practical areas below.

Figure II.7 Responses of Candidate Approaches to Practical Challenges

	Environmental impacts	Infrastructure impacts
Uniform codes	Possible	No response
Judgement	Difficult	Difficult
Consequence	Difficult	Difficult
Risk matrix	Difficult	Difficult
IR + FN	Difficult	Difficult
ALARP	Possible	Possible
ACDS scrutiny	Difficult	Difficult
Road tunnel	Difficult	Difficult
Rail CST	Difficult	Difficult
Road CBA	Difficult	Possible

II.6.20Impacts on Infrastructure

Some types of DGs can cause fires or explosions with substantial impacts on the transport infrastructure. This is particularly significant at pinch-points in the transport network, such as tunnels or bridges. Accidents may cause damage that is expensive to repair, or may cause delays or re-routing that also has adverse economic impacts. A good set of RAC should not only help maintain or reduce the risks of fatalities in TDG, they should also take account of the financial impacts of damage to the infrastructure.

The responses of the candidate approaches to this challenge are similar to those considered under environmental impacts above. The CBA approach is more suitable for financial impacts, and has the best balance of strengths and limitations.

II.7 CONCLUSION

The above analysis evaluates the candidate approaches in the following ways:

- Each approach is aligned with different principles from Main Report Section 3. Some, such as the individual risk and FN criteria, are aligned with several principles.
- All the approaches would be familiar to at least one MS. The only approach that is currently in use in all of them is the rail CST, although this is not for DG.
- The only approach considered immediately suitable as harmonised RAC is the Netherlands approach.
- Most of the approaches would reduce some of the inconsistencies that exist in the current approach, but none would address them all.
- Each approach is beneficial in some respects against the other challenges in setting harmonised RAC. No one approach has overwhelming strengths or limitations.

It is therefore concluded that no one approach can be chosen as the best. Instead, the proposed harmonised approach is a synthesis, combining elements from all of the candidate approaches, and structured according to the principles from Main Report Section 3.

The role of the candidate approaches in this harmonised approach is summarised as follows:

- The removal of Chapter 1.9 of ADR/RID/ADN is not adopted as such, but the use of ADR/RID/ADN with no additional restrictions is retained as an optional approach.
- The expert judgement approach is also adopted as an optional approach instead of quantitative RAC.
- The consequence approach is not adopted, as it is only used by Germany for fixed installations, and has no strong advantages for TDG.
- The risk matrix approach is not adopted, as it is only used by France for fixed installations, and has no strong advantages for TDG.
- Individual risk and FN criteria are adopted.
- The ALARP approach (i.e. a mainly qualitative cost-benefit balancing) is adopted.
- The ACDS scrutiny level is adopted in a simplified form as a justification indicator.
- The road tunnel approach is adopted in the form of preliminary screening by a threshold criterion, followed by an ALARP evaluation of alternatives.
- The European rail CST approach is adopted, but with units that are more closely based on the road safety targets (i.e. trends in number of fatalities).
- The road approach of safety targets and CBA is adopted.

The harmonised approach is presented in Main Report Section 6.

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