Guide for risk estimation

Multimodal

Risk management framework for inland transport of dangerous goods

The present document is a non-legally binding guidance of the European Union Agency for Railways.
It is without prejudice to the decision-making processes foreseen by the applicable EU legislation.
Furthermore, a binding interpretation of EU law is the sole competence of the Court of Justice of the European Union.

**Risk management framework for inland transport
of dangerous goods**

Guide for risk estimation

(Version applicable to the voluntary implementation scheme during the test phase period 2018-2020)

Version 1.0/2018

EUROPEAN
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FOR RAILWAYS

Practical information for users

This guide is one of the guides composing the Framework for the risk management of inland transport of dangerous goods (inland TDG). It may be used in combination with the guide for decision-making, or independently.

It is of voluntary application for any category of user and the users take full responsibility for its use.

The method proposed in this guide is an aid to risk analysts. It was developed by experts having good knowledge of current risk estimation practices and a strong practical experience of risk estimation for the inland transport of dangerous goods by rail, road and inland waterways.

During the three year development process the experts have considered many risk situations for which risk estimations were performed that they have worked with during their professional career. On this basis they have agreed on the harmonised risk estimation method proposed in this guide.

Users are strongly encouraged to implement this method to improve the quality, transparency, and recognition of their risk estimations by stakeholders. The method is applicable to the three inland modes of transport, establishing a level playing field approach to the risks posed by the three modes while also fully taking into account their differences in terms of accident scenarios and risk profile.

The guide may be implemented by a wide range of users (not only risk estimation specialists) for a wide range of risk situations, for example:

▶ Companies may use this guide for estimating their level of business risk or study the relevance of new risk control measures as part of their safety management activities, or apply it at the request of an authority or within a responsible care[1] action,

▶ Professional bodies may disseminate this guide as an harmonised method which may be better recognised in the various contexts where their members are required to demonstrate the efficiency of their risk control measures,

▶ Local, National, Regional or International authorities and agencies may use this guide for analysing existing risk levels or justifying the relevance of new risk control measures as part of their own legal obligations,

▶ International and European Union regulators may use this guide as an aid to evaluate relevant amendments to harmonised Transport of Dangerous Goods legislation with the aim of improved control of risks.

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[1] Responsible Care is a voluntary commitment by the global chemical industry to drive continuous improvement and achieve excellence in environmental, health and safety and security performance

During the period 2018-2020, the voluntary implementation of the harmonised method is considered as an improvement phase during which any individual user may provide feedback and report on lessons learnt[2] to the Expert Users and Development Group established within this Framework. User reference material and tools that are mentioned in this guide are available via the webpage https://www.era.europa.eu/activities/transport-dangerous-goods/inland-tdg_en

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[2]   Please provide feedback using the contact template available on the dedicated webpage.

Acknowledgements

Note: a list of contributing experts and organisations is given in the framework guide.

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1. Introduction

This guide describes a multimodal risk estimation method intended for a large variety of users.

The guide is composed of two main parts:

▸ Part A presents the overall risk estimation method and the tasks that a 'non-expert' user should perform to implement the harmonised risk estimation method. This section allows the user of the guide to deliver a harmonised description of the given risk estimation situations[1] that are to be assessed.

▸ Part B introduces more detail in the actual steps of risk estimation (calculation of risk indicators) that an 'expert' user might wish to know. This permits the definition of complex risk estimations and allows the user to benefit from all the possibilities offered by the method, including checking and correcting the default calibration of the risk estimation model.

A number of activities linked to the process of improvement and development of the Inland TDG risk management framework will take place in 2018, in particular:

▸ Workshops will continue as part of the dissemination of the harmonised risk estimation method,

▸ An Inland TDG website will be set up in order to facilitate access to the framework and to all relevant material the user may need, including that for the implementation and development of the framework,

▸ An 'Expert Users and Development Group' (EUDG) will be established and will contribute to the detailed specification of a risk estimation web application. This activity will inform the decision about making an application publicly available to assist users in the implementation of this guide.

With this version of the guide some tools (harmonised templates) for the description of use cases and the setting of default values of parameters have been created. As these tools might evolve during the process of improvement of the framework, it is recommended to use the latest updated version of these templates which will be made available on the Inland TDG website here. This guide should be used in combination with the other guides of the framework.

Its application is voluntary for any category of user and use case. The user takes full responsibility for its use.

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[1]   A risk situation is described by the user with the help of use-case description templates. It incorporates any user-defined correction factors applied to describe the situation, including the effect of user-defined safety measures.

Part A:

Overview of the harmonised approach to TDG risks and the harmonised description of a case study

2. Risk estimation approach

2.1. Overview

One of the most widely used approaches to the estimation of risks uses the bow tie format for the description of the causes and the consequences of preselected events.

The guide uses this approach and tries to establish, where necessary, harmonised ways of quantifying or qualifying TDG risks. It also shows where assumptions have been made and where it was necessary to use harmonised expert judgement.

The sections of this guide cover the different steps required for risk estimation, considering potential dangerous goods events (DG events), their potential causes and their potential consequences.

Figure 1: Bow-tie approach
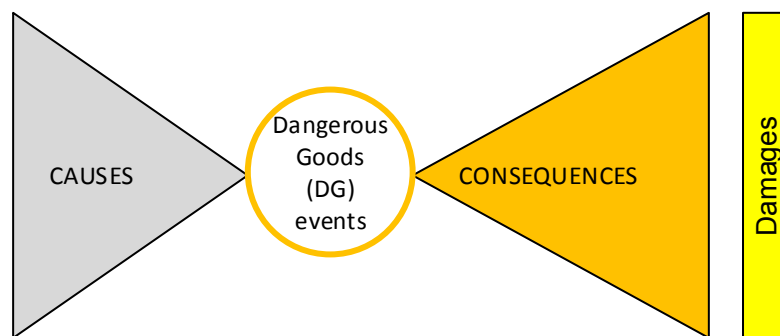
For the inland TDG risk management framework the bow-tie is deliberately centred on the most important events that the dangerous goods experts are seeking to prevent or mitigate, namely dangerous goods events with or without release of the dangerous substance from its safe containment. In this respect the 'non release' DG event is also considered, mainly in order to consider the specific impact such events have on transport operations that are more significant than normal freight - non-DG - events.

The outcome of DG events (damage) may be insignificant or very severe depending on the circumstances. The results and the severity of their impact (damage) depends on the sequence of events (consequences) involving (or not) the dangerous substance under consideration, the variable nature of the hazards and the types of vulnerability which may be affected by or protected from these hazards. The consequences also depend on the size and characteristics of potential DG releases in the environment.

The variability of hazardous situations and risk which may occur from normal transport of dangerous goods operations may also be summarised by the following figure:

Figure 2: Risk estimation method
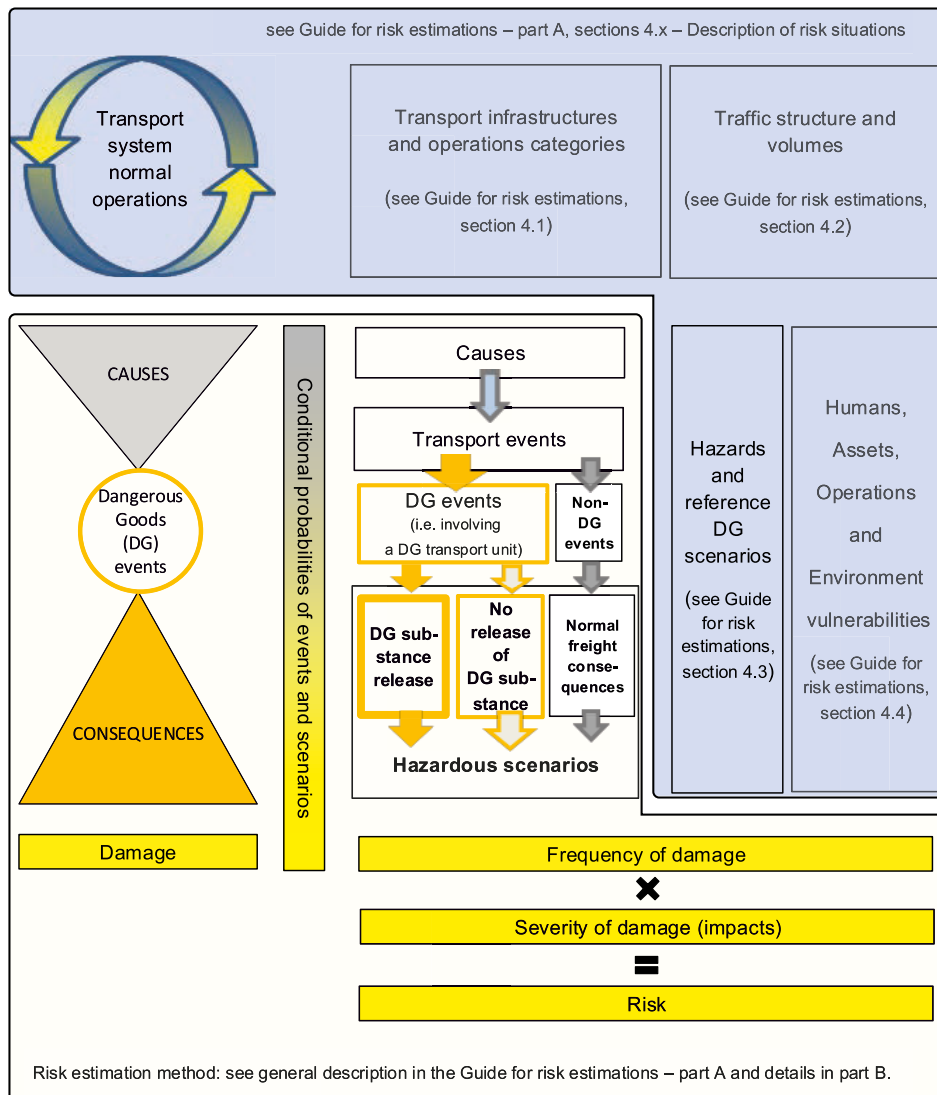
In accordance with the above approach the general formulation of risk is given by the following formula.

Risk = Frequency of damage x Severity of damage

Damage indicators (impacts) assorted with their related frequencies of occurrence are used for estimating the risk posed on each type of vulnerability for each predefined type of hazardous scenario.

Risk indicators   =   Frequency of predefined type of impact

X

Severity of predefined type of impact

Risk indicators are estimated in the same way for each type of vulnerability considered (human, assets, operations, and environment) and each type of hazardous scenarios considered (DG event with release, DG event without release, Normal freight - non-DG - event).

The process of risk estimation has been established to permit a harmonised estimation of the predefined risk indicators in table 1.

Table 1: Definition of risk indicators (R (EVENT TYPE, IMPACT TYPE))

	Impact on Human (health)	Impact on Assets	Impact on Operations	Impact on Environment
DG event with release	R(DGR, N FAT) R(DGR, N INJ)	R(DGR, N ITEMS) R(DGR, COSTS)	R(DGR, N HRS) R(DGR, COSTS)	R(DGR, N SQM) R(DGR, COSTS)
DG event without release	R(DGNR, N FAT) R(DGNR, N INJ)	R(DGNR, N ITEMS) R(DGNR, COSTS)	R(DGNR, N HRS) R(DGNR, COSTS)	R(DGNR, N SQM) R(DGNR, COSTS)
Normal freight events	R(FRT, N FAT) R(FRT, N INJ)	R(FRT, N ITEMS) R(FRT, COSTS)	R(FRT, N HRS) R(FRT, COSTS)	R(FRT, N SQM) R(FRT, COSTS)

Legend: Refer to the framework glossary for the definition of abbreviations

The way for the user to describe a risk situation in order to perform a harmonised risk estimation is set out in chapter 4.

The way the harmonised risk estimations are modelled, including relevant and accessible *input data* to be used with a set of *risk estimation formulas* is described in part B of this guide.

> Important note:
>
> As planned in the framework improvement process described in section 6 of the framework guide, use case examples should be published regularly on the ERA webpage dedicated to the Inland-TDG risk management framework in order to assist the user in the practical understanding of each of the risk estimation description and estimation steps.

2.2.   Steps of the overall risk estimation process

When using this guide the following sequence of actions is required in order to perform the risk estimation for a given situation.

Two main phases have to be considered:

▸ The description of the risk situation to be assessed (see section 2.2.1),

▸ The estimation of the risks posed by the described situation (see section 2.2.2).

2.2.1. Steps for describing a risk situation

The following steps must be performed by the user to describe a given risk situation.

Table 2: Steps for the user description of studied risk situations

Steps for the description of a given risk situation		Task	Applicable section of this guide
1		Analyse - risk situation being considered - objectives of the decision-making case.	Refer to Guide for decision-making
2	a	Consider the harmonised risk estimation approach and the link with a decision-making process.	2.1 and 3.1
	b	Consider whether specific information / data should be collected before the next steps.	2.3 and 2.4
3		General description of: - risk situations (reference situation and target situation) - risk management options.	3.2 and 3.3
4	a	Description of the transport infrastructure	4.1.1 and 4.1.2
	b	Description of the transport operations	4.1.3 and 4.1.4
	c	Description of the traffic volumes and structure	4.2
	d	Description of the relevant hazards and reference DG scenarios.	4.3
	e	Identification of the relevant mapping distance. Description of the vulnerabilities located within the mapping distance	2.4.4.1 4.4
5		Information on multimodal case studies	5
6		Definition of: - relevant risk estimation indicators - relevant result formats for the situation being considered - harmonised formatting of results	6

For details on each of the above steps refer to the sections indicated in the table.

2.2.2. Steps for estimating the risks indicators

Based on the user's description of the situation being considered (blue box inputs), the following steps are taken to estimate the risks indicators quantitatively.

Figure 3: Risk estimation workflow described in Part B of the Guide on risk estimation
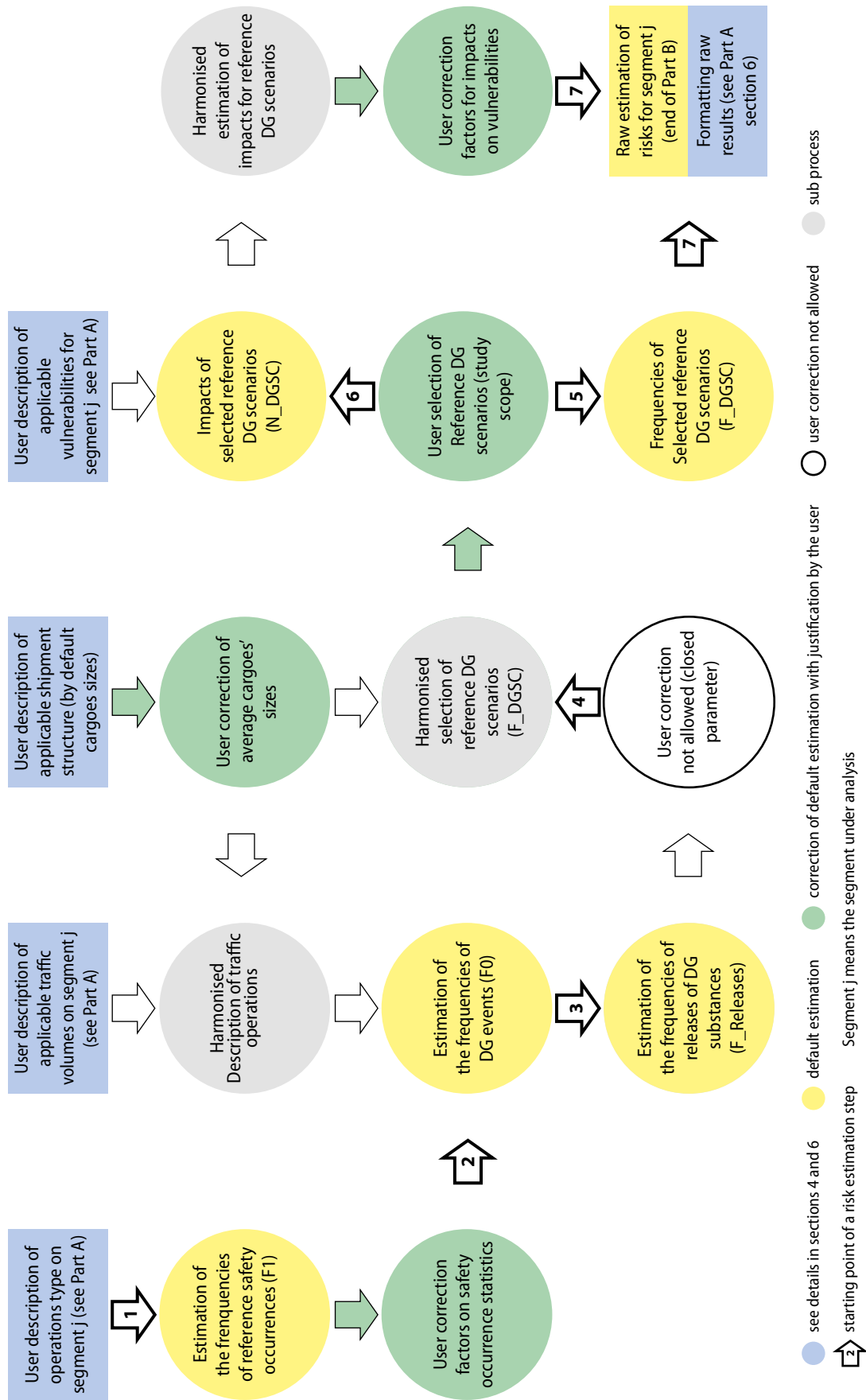
At the end of the risk estimation process (output blue box) the risk indicators are formatted in a harmonised way.

Table 3: Steps for the estimation of risk for a given risk situation

Steps of the risk estimation		Objectives	Applicable section of this guide
1	a	(Default) Estimation of the reference frequency of transport events (F1).	7.1
	b	(User) Correction of default F1 frequency setting, if applicable to the risk estimation scope and objectives. All corrections must be justified	7.1.4 and 7.1.5
2	a	(Default) Estimation of the DG events frequency (F0), with or without release.	7.2.1 and 7.2.6
	b	(Default) Estimation of the probability of involvement of a dangerous goods unit/cargo in a transport event (P1 = P(DG UNIT)).	7.2.2 to 7.2.5
	c	(User) Setting of correction factor (CF_F0) to the proposed default F0 frequency, if applicable to the situation being considered. All corrections must be justified	7.2.7
3		(Default) Estimation of the probability of DG release (P(RELEASE_SIZE))	7.3
4	a	(Default) Selection of reference DG scenarios.	7.4.1
	b	(User) Checking the relevance of the list of applicable reference DG scenarios.	7.4.1
		(User) Listing of potential missing relevant DG scenarios (specific to the situation being considered).	
5		(Default) Estimation of the frequency of reference DG scenarios	7.5
6	a	(Default) Estimation of the severity of damage (impacts) for reference DG scenarios	7.6
	b	(User) Correction of the severity of damage	7.6.3
7		Calculation of risk indicators	7.7

Detailed information about each step of the risk estimation process referred to in this section is given in part B of this guide.

2.3.   Preparation of relevant user-specific data

As with any process of risk estimation, the harmonised risk estimation model requires information to be input relating to the risk situation being assessed by the user of this guide.

In many circumstances assumptions will have to be made by the user in order to best reflect the situation under consideration using the most relevant data inputs. This phase must be carefully considered by any user as it is the first step in the correct use of the guide. Most relevant data inputs should be defined by the users according to their own risk analysis.

As obtaining relevant data is known to be the 'critical path' for any risk estimation exercise, this framework offers the user two processes to facilitate this:

▸ where possible, the harmonised risk estimation proposes default reference values for the user to allocate to input parameters (see Annex V),

▸ more reliable data through improved collection of information on transport events. This started during the framework development with an initial structured survey of the relevant parameters, including identifying databases where some data may already be available. (see Annex I of the framework guide)

These two processes may, in the future, give the user of the guide easier access to relevant data and in turn facilitate the performance of risk estimation exercises. However this is conditional on an improvement of the current legal framework related to the collection of data on incidents and accidents and on the availability of the information gathered.

Important note:

▸ All risk analyses, no matter what method used, are associated with uncertainties and these can be of different kinds. Uncertainties associated with data, methods and models can significantly influence risk estimation results. Therefore, it is important to get a good understanding of where the uncertainties are and make a realistic judgement of the nature and the magnitude of these.

▸ When necessary, to improve the quality of the results obtained with the model described in this guide, and in order to meet the objectives of the decision-making case under consideration, the user should implement the options available to customise the harmonised model. Steps 1b, 2c, 4b and 6b are particularly relevant.

▸ The quality and relevance of the risk estimations obtained with the harmonised model shall always be checked by the user, and the user takes responsibility for the results, including how risk estimation uncertainties may influence the decision making.

2.3.1. Checking the availability of information

To check the availability of the information needed for a given use case the user must consider the list of input parameters applicable to the harmonised risk estimation model in annex V. The user needs to identify:

▸ the relevant parameters for which no default values are proposed by the model, and,

▸ the relevant parameters whose default values need to be corrected to reflect the risk situation being considered, in the context of the objectives of the decision-making case.

Explanations are given in the following sections regarding the setting of user-specific values for parameters of the harmonised risk estimation model.

2.3.2. Default, open and fixed values of parameters

The following principles apply concerning 'Default', 'Open' and 'Fixed' values.

The following categories of parameters are defined:

▸ Parameters with values set by default:

  o DEFAULT / OPEN: the set value can be changed by the user,

  o DEFAULT / FIXED: the set value cannot be changed by the user.

▸ OPEN: parameters with values which are not set by default and thus shall be determined by the users.

'Default values' are defined and adopted collectively by the Expert Users and Development Group. The scope of validity of each default value is recorded for each parameter in the list of parameters made available <u>here</u>.

The use of suggested values for 'default/open' parameters is the full responsibility of the risk analyst, who should check the relevance of the proposed values for the risk situation studied.

Default values are only valid for risk estimations having the same scope as the scope of the information which has been used to set the default values, for example EU railways statistics (see annex I.1.1 for parameter F1_RL_NET_ALL) or French F1 statistics that are relevant for marshalling yard segments (see annex I.1.1 for parameter F1_RL_MYS_ALL).

When the scope of the 'default' setting or the proposed value(s) are not relevant for the case being considered then the risk analyst must either:

▸ define values for the most relevant parameters that best reflect the risk estimation situation in respect of the decision-making objectives (This action is referred to as 'correction of the default setting' in the present guide); or

▸ check and justify that the use of the proposed default values does not affect the quality of the decision-making.

For '**default/fixed**' values of parameters the user should use the proposed values as defined or, where they are clearly not applicable, send a 'change request' to the EUDG with appropriate justification (see framework guide section 6 for details).

Where 'no default value' is proposed the risk analyst shall determine and justify that the value(s) of parameters are relevant and set consistently with the description of the studied risk situation. In this case the user of the harmonised model is requested to keep available the source of information used to set the value of this parameter for interested stakeholders.

It is important that the risk analyst identifies, as soon as possible, the parameters for which relevant values have to be determined in order to achieve good quality risk estimations and related decisions, as described above.

Details of the categories of parameters used as data inputs to the harmonised risk estimation model are given below.

The next two tables provide the list of actions the user and/or the Expert Users and Development Group (EUDG) can take to set the values for the model's parameters.

Table 4: Actions to be taken by users or EUDG for setting values of parameters, depending on the status of the parameters.

	Default value: setting proposed by the harmonised model		No default value: setting proposed by the model	Improvement process (see framework section 6 for details)
	Open value	Fixed value	Open value	
Actions applicable to the users of the risk estimation guide				
User may not change the proposed value. This allows stakeholders to recognise the risk estimation result.	N/A	▮	N/A	N/A
User must set the value to best reflect the risk situation under consideration	N/A	N/A	▮	N/A
User must check whether the proposed value can be used for the decision-making situation under consideration or should be corrected to better reflect the relevant risk estimation situation	(EU average setting)	N/A	N/A	N/A
User may report an issue with the proposed default value setting or propose an improvement	N/A	▮	N/A	User 'change request' sent to EUDG

Legend: ▮ *: Possible action from the user, N/A: Action not applicable. (See list of parameters with their status in annex V).*

Table 5: Actions to be taken by EUDG (only) for setting values of parameters depending on their status

	Default value: setting proposed by the harmonised model		No default value: setting proposed by the model	Improvement process (see framework section 6 for details)
	Open value	Fixed value	Open value	
Actions that may be taken by the Expert Users and Development Group (EUDG)				
Expert users group may consider setting a default value, if relevant, when information is available	N/A	N/A	▮	
Expert users group may improve a default value when information is available	▮	▮	N/A	EUDG review of default value setting
Expert users group may change the harmonised risk estimation model, using new parameters	▮	▮		EUDG review of model parameters

Legend : ▮ *:Possible actions from EUDG, N/A: Action not applicable. (See list of parameters with their status in annex V)*

Using the above principles and tables, the risk analyst can readily check:

▸ whether proposed default values can be used or whether corrections to the risk estimation case being considered are justified,

▸ the missing input data that needs to be collected before implementation of the harmonised risk estimation model can continue,

▸ the justification for sending a request to the EUDG to establish new default values or model parameters in accordance with the framework improvement process described in section 6 of the framework guide.

2.3.3. Qualitative approach

Within this framework the qualitative approach is a verbal expression of 1) damage frequency and 2) damage severity.

To follow this harmonised qualitative approach the user describes the risk situation being considered in accordance with the process described in section 2.2.1.

This description is a common element in both the qualitative and quantitative ways of using the guide. The 'use case' description templates should also be used for the qualitative approach, even if the user chooses to limit the level of detail to the minimum.

The qualitative approach of risk estimation results from the application of the default risk model setting. The user can perform a risk study and obtain risk indicators as presented in section 6 without having to provide complex corrections based on quantitative information.

To enable quantified risk indicators to be expressed in a qualitative manner it is intended to develop harmonised conversion tables using named categories of frequency and severity as described in annex VI. It is intended that this approach to qualitative estimation will be further developed by the EUDG.

2.4. Modelling of a user case study (mapping and meshing)

As with any process of risk estimation, the harmonised risk estimation model requires input information relating to the risk situation to be assessed.

In many circumstances assumptions will have to be made by the user in order to best reflect the situation being assessed with the most relevant data inputs, including a certain level of simplification where necessary.

This section covers the general principles of converting of a real-world situation into information that can be used by a risk calculation model.

The following principles are used:

▸ 'Mapping' is defined as being the description of a real case with the help of use case description templates.

▸ 'Segment' is defined as being a linear portion of the transport infrastructure under consideration. The user allocates homogeneous values to infrastructure, operations, traffic or vulnerabilities within the respective description templates.

▸ 'Merged mapping segmentation' is the use by a risk estimation (IT) application of homogeneous segments that take into account all user segment inputs.

▶ A 'Calculation grid' is used to convert the 'Merged mapping segmentation' into elementary calculation cells which are used by a risk estimation (IT) application to apply risk estimation formulas.

The user defines the 'Mapping' and 'Segments' with the help of templates while 'Merged mapping segmentation' and 'Calculation grid' are performed by a risk estimation (IT) application.

2.4.1.   Extracting information from a real Map (user task)

The basic approach to the description of case study can be explain using the following satellite view:

Figure 4: Example of use case description from a satellite view

Several pieces of information required for the estimation of risks can be extracted from the above view. However the following explanations do not replace the need for competence and training for the user in order to implement this guide correctly.

Only a brief explanation of the description method is given below, based on this example.

2.4.2.   Transport infrastructure segments (user task)

Transport infrastructure segments are used to describe the main shape of the infrastructure (red line) in both directions of traffic. The user needs to define a reference "direction 1" that applies throughout the description of the case study.

Once chosen, the user describes each infrastructure segment by defining start and end points. Each segment is located between two other segments, with the exception of the first and last segments; these are located at the start and end points of direction 1 respectively.

Figure 5: Description of the infrastructure and operation type
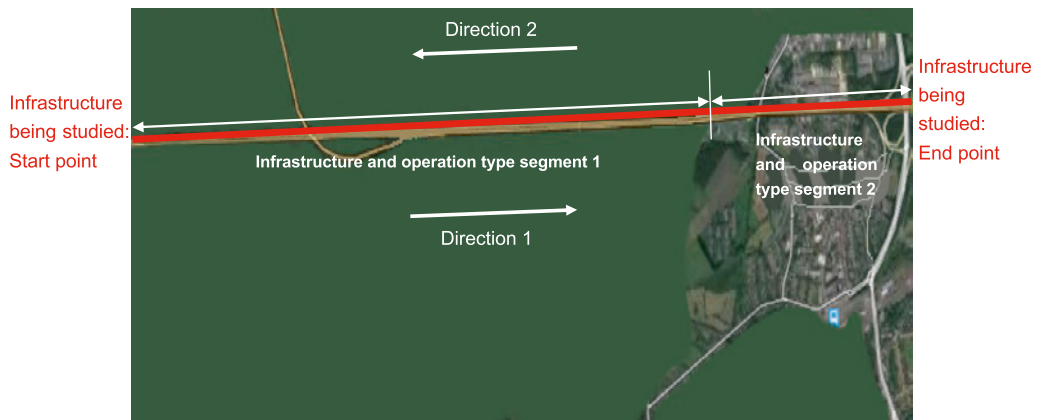
For this step the user needs to choose the predefined segment types which best represent the type of infrastructure and operation, using the definitions given in section 4.1. In this case, as an example:

▸ Infrastructure segment 1: Road infrastructure, Countryside operation type,

▸ Infrastructure segment 2: Road infrastructure, Urban operation type.

2.4.3. Traffic segments (user task)

To map the applicable traffic (Figure 6) the user shall use the dedicated template and the input parameters predefined in section 4.2. The user shall describe, as much as possible, homogeneous segments from the point of view of the volume of traffic applicable to each segment described. At this stage the (user described) traffic segments do not need to correspond to the infrastructure segments. The information on the infrastructure and operation type and the information on traffic can be merged automatically later on by a risk estimation (IT) application..

The figure below shows that, in this example, road entries and exits exist on the infrastructure being considered, therefore the traffic volume and characteristics may change. In this case the user is describing segments with traffic composition in both directions, as follows:

▸ Traffic segment 1:

   o traffic composition 1 in direction 1,

   o traffic composition 1 in direction 2

▸ Traffic segment 2:

   o traffic composition 2 in direction 1,

   o traffic composition 2 in direction 2

▸ Traffic segment 3:

   o traffic composition 3 in direction 1,

   o traffic composition 3 in direction 2

Figure 6: Description of the traffic operated
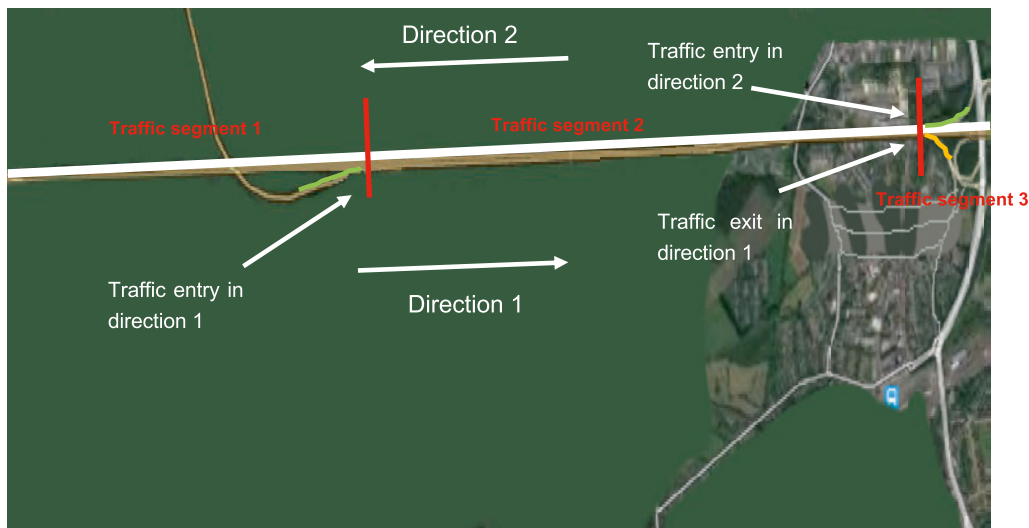
2.4.4.   Vulnerability segments (user task)

2.4.4.1. Mapping distance for the description of vulnerabilities

Depending on the DG Class of goods being carried that is applicable to the risk situation being studied (see description of DG traffic in section 4.2) and the detailed DG hazard properties, the risk analyst should, firstly, determine the applicable DG scenarios in accordance with section 4.3.

Next, the risk analyst should consider the available reference material for the applicable scenarios made available here. For each reference DG scenario the pre-calculated tables provide the distances of effects considered by the model for the estimation of risks. Section 7.6 gives more detail for the description of the pre-calculated tables and the distance of effect of hazardous scenarios.

When a DG scenario is not available in the proposed reference material the user may use the template for pre-calculated tables for the description of the missing scenarios, including the relevant distance of effect which is determined by the risk analyst. The risk analyst should also notify the corresponding tables to the EUDG which will be able to review and, where relevant, make available new harmonised reference material for the DG scenarios being considered (see 'change request' in section 6 of the framework guide). On this basis, the available reference DG scenarios will be regularly updated in accordance with the framework improvement process.

The value to be used by the risk analyst for the mapping distance of the vulnerabilities for a given risk situation, as described above, is the highest value of the distance of effect of all the DG scenarios that are applicable to the risk situation under consideration.

Once the user as determined the applicable mapping distance, the description of vulnerabilities should be performed in accordance with the method described in sections 2.4.4.2 and 4.4.

2.4.4.2. Mapping categories (linear and surface densities, 1D, 1D+)

In practice two categories of vulnerability mapping can be used:

▸ Linear density of vulnerabilities,

▸ Surface density of vulnerabilities,

The same method is applicable to each category of vulnerability: Human (VH), Assets (VA) and Environment (VE).

Linear densities are used only for vulnerabilities located within the premises of the infrastructure under consideration, taking into account the width of the infrastructure.

Surface densities are used to describe vulnerabilities that are located in the area surrounding the infrastructure premises.

In 1D mode only one zone per direction is considered for each segment.

Figure 7: Description of the mapping distance and vulnerability segments around the described infrastructure (1D method)
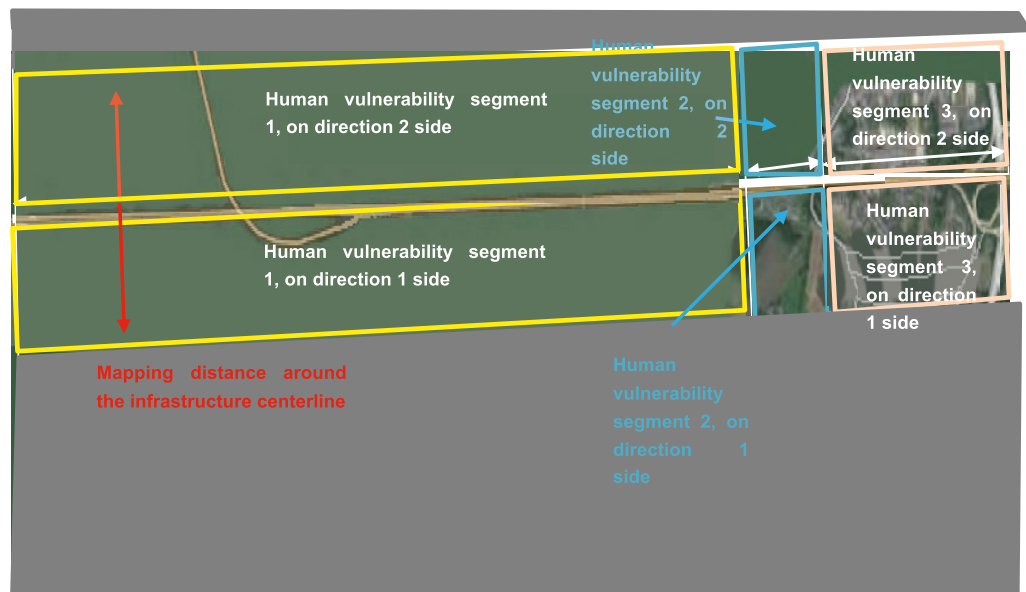
In 1D+ mode, 10 different zones in each direction can be used by the user to differentiate the density of the vulnerabilities within each segment. Within a zone a given density of vulnerability is allocated a constant value. By convention, the user defines the limit of each zone as a distance from the infrastructure centreline.

Figure 8: Description of vulnerability segments around the described infrastructure (1D+ method)
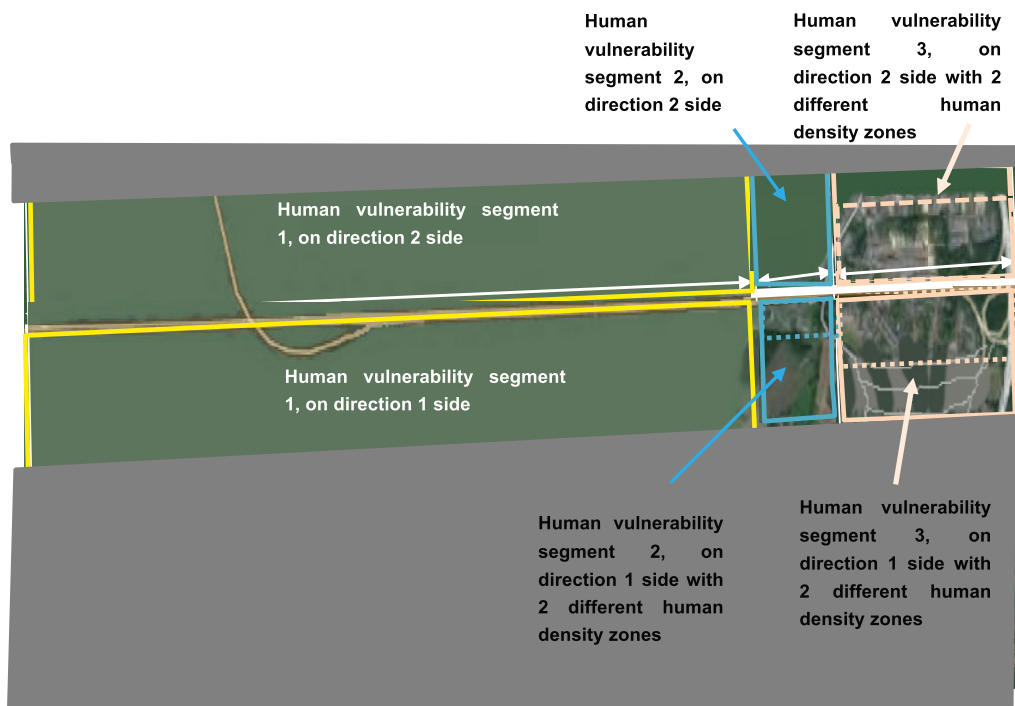
Each segment is described using either the 1D or 1D+ method. Therefore, depending on the length of each segment and the method used, the description of vulnerabilities can go from the minimum level of detail up to a quite detailed description that localises vulnerabilities. This is done by using a short segment that locates the vulnerability in one specific zone.

The default categories of vulnerability (both linear and surface density) considered by the model are indicated in section 4.4.2.

2.4.4.3. Time-dimension mapping (NoTimeDependency – NTD mode, Time of Day – ToD mode)

In practice two categories of time-dimension mapping can be used.

The simplest approach is to consider that no parameter of the risk estimation is dependent on the time of day. This is the NoTimeDependency mode (NTD).When required by the nature of the risk situation the user may describe relevant parameters relating to the time of day. This is the TimeofDay mode (ToD).

When the user wishes to describe time dependencies, the 'ToD' marked tools shall be used.

2.4.4.4. Level of detail of mapping

Basic descriptions of case studies using only 1D or 1D+ approach are feasible but these have limitations.

In practice complex and curved routes surrounded by highly heterogeneous vulnerabilities cannot reasonably be mapped except where it is possible to use Geographic Information System resources. And even in such a case, only a genuine 2D calculation grid can deliver accurate risk estimations.

The 1D and 1D+ description approaches need to be used with due regard to the risk estimation objectives and required accuracy. They provide a simplified approach which can be used, in principle, when:

▶ route curvatures are small compared to the effective distance of the DG scenarios that are applicable to the case study (see section 4.3.), and

▶ surrounding vulnerabilities can be considered to be quite homogeneous within the effect distance of the DG scenarios that are relevant to the case study,

However, for an initial approach, some indication of risk estimation level can be assessed with the 1D and 1D+ approaches, especially when it is not possible to model a whole network of a given infrastructure due to the size of the calculation grid which would result from the mapping.

On this topic, user experience is necessary to find the right balance between the complexity of the mapping, the objectives of the risk estimation case study, the available risk estimation engines and the computing resources.

2.4.5. Merged mapping segmentation (risk estimation engine task)

The mapping of segments within each dedicated description template is carried out independently by the user. This approach allows the user to concentrate on the variation of the relevant parameters independently within each description template.

Based on the user inputs, the risk estimation model will use homogeneous segments which can be worked out by the risk estimation formulas of a risk estimation engine.

This file is called 'merged mapping segmentation' and is produced by the risk estimation engine tool which allocates corresponding homogeneous values of the input parameters relating to infrastructure and operations, traffic characteristics and vulnerability densities.

Figure 9: Merged mapping into homogeneous characteristic segments based on the user description of segments
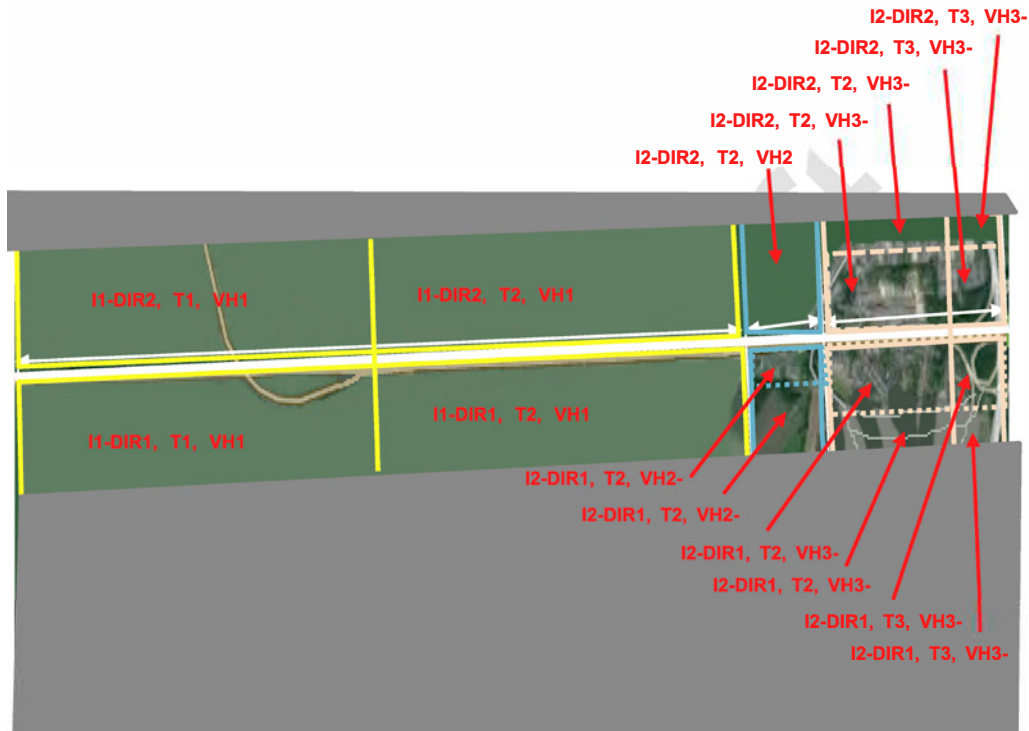
Legend: I=infrastructure segment; DIR=Direction; T=Traffic segment; VHx-y= Human vulnerability segment x in density zone y

2.4.6. Calculation grid (risk estimation engine task)

Risk estimation (IT) applications generally use a calculation grid to perform risk estimation calculations. This grid is automatically defined by the application on the basis of the description of the risk situation being studied, as compiled by the user and converted into the merged input file.

This functionality is necessary to ensure correct risk estimation, in particular the estimation of the impacts of hazardous areas on vulnerabilities: on the one hand, hazardous areas have various shapes and dimensions (circular, elliptical, rectangular, triangular; ranging from a few metres to several kilometres). On the other hand the user can locate vulnerabilities with a degree of precision ranging from very small to very large segments.

Figure 10: Setting out a calculation grid for estimating risks
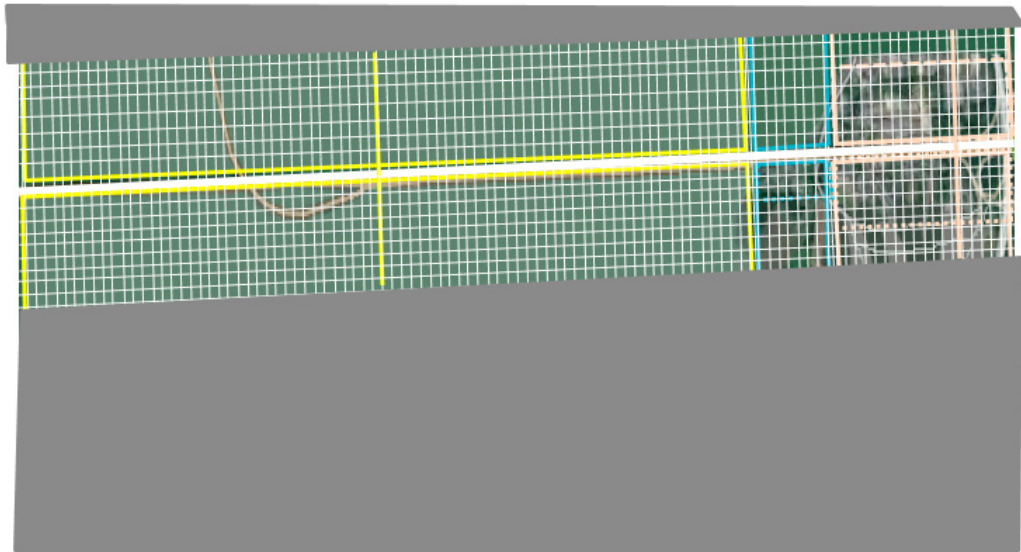
In principle, the finer the grid the more numerically accurate the risk estimation will be, allowing better estimation of the impacts of hazardous areas of various shapes in every grid cell. However a fine grid is irrelevant if the mapping of vulnerabilities is not sufficiently detailed to support it.

Therefore a good risk estimation must start with compatible mapping of segments by the user.

2.4.7. Process of risk estimation (risk estimation engine task)

The detailed specification of a harmonised risk estimation engine started in 2018, in accordance with the European Union Agency for Railways work programme and in collaboration of the Expert Users and Development Group.

The information below draws together the main strands of current risk estimation practice which should be offered in the future by a harmonised risk estimation engine.

*2.4.7.1. 1D, 1D+ – Calculation of DG scenarios' impacts **without** considering wind rose*

For the 1D approach the main assumption is the equal probability of all directions of impact, representing an effect distance of a given degree of severity. As a consequence the shape representing hazardous areas is circular.

Using this assumption the impact of the hazard is calculated in each grid cell affected by the hazardous area.

Taking each grid cell in turn the severity of impact of the hazard under consideration is calculated for the vulnerabilities that are located in that cell.

The sum of the impacts of a considered event for each cell impacted by this event provides the contribution of this event to the consequence measure N of the F/N curves.

Then F/N curves can be constructed for:

1) a selection of infrastructure segments or the whole infrastructure,

2) selected DG scenarios or all DG scenarios,

3) specific types of impact, and

4) when monetised, economic impacts.

Within a given cell the sum of all 'received' impacts at the applicable frequency allows estimation of 'individual risk indicators' for the vulnerabilities that are continually present in the considered cell (24 hrs/day, 7 days/week).

2.4.7.2. 1D, 1D+ – Calculation of DG scenarios' impacts **considering wind roses**

When considering the influence of wind roses, the 1D and 1D+ approaches need to model two influences:

▸ Some DG scenarios are not influenced by wind rose, for example explosions from explosives are considered as having a circular hazardous area in all circumstances,

▸ Dispersion of fumes, smoke, and toxic substances are influenced by wind direction and atmospheric stability.

Harmonised pre-calculated tables of impacts incorporate the influence of weather conditions and wind roses as they model the expected distance of effect for DG scenarios under several conditions of weather stability.

Logically the use of wind rose information should be combined with data about the orientation of the segment being considered and the location of the vulnerabilities for which the estimation of risks is performed, this is particularly relevant when the infrastructure being considered is composed of significantly curved routes.

When used, wind rose/weather stability information is integrated into 1D and 1D+ modelling by estimating the impact of hazardous areas on vulnerabilities that are located in each given angular sector within the impact distance. Day and night variation may also be considered as wind roses/weather stability normally change between day and night.

Based on this approach the impact of hazardous areas is calculated in each of the impacted grid cells and evaluated to give the relative frequency of impact, as well as F/N curve estimates.

2.4.7.3. 2D - Calculation of DG scenarios' impacts with consideration of a wind rose

This guide does not describes full 2D or 3D risk estimations but only simplified 1D and 1D+ approaches.

For 2D approaches weather stability, wind rose and genuine 2D descriptions of vulnerabilities are used to estimate the risks from DG scenarios.

In general the implementation of a full 2D approach is necessary for **local risk estimation** at specific points of a network but is impractical for manual implementation on an entire network without the use of the simplifications that are offered by the 1D+ and 1D approaches. When the approach offered by 1D and 1D+ templates is not relevant then the user should try preparing required data with the help of IT application, including geographical information systems and implement a full 2D risk estimation approach.

2D approach will be considered for the specification of the risk estimation (IT) application by ERA and the EUDG members as foreseen in the framework improvement activities.

2.4.7.4. Time / Day / Season dependencies

Time dependencies vary in nature and may be taken into account in 1D, 1D+ or 2D approaches in various ways.

For example, peak hours are common features of any transport system and most human activities. Based on the description of the traffic, queuing effects in the vicinity of DG events may be taken into account. Human activities and the associated presence of human vulnerabilities at certain periods of the day and night can also be taken into account.

Wind rose information (2D approach only) is also time-dependent as it is different for day- and night-time.

Seasonal variations of risk situations may also be considered by the user of the guide when necessary.

Some existing models permit the description to use the annual average of daily traffic and/or the average presence of human vulnerabilities during a day.

3. Risk estimation for a given decision-making case

3.1. Role of risk estimation within a decision-making process

In general, risk estimation is performed with the intention of taking decisions concerning risk control measures or to check the risk levels of different situations.

It means that the implementation of this guide (blue boxes in the figure below) normally starts within a risk management project, which may require the implementation of the Guide for decision-making (orange boxes), when necessary.

Figure 11: Risk estimation within a decision-making optimisation cycle
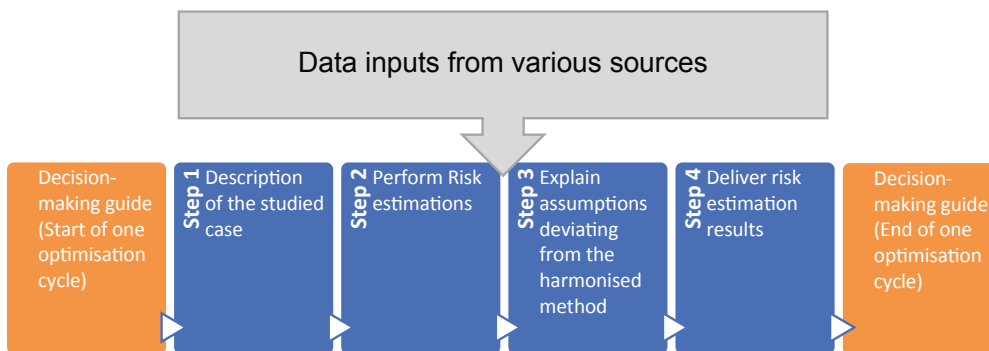
The information used for the definition of a risk situation to be assessed may be provided by a decision-maker, or independently by the user of the risk estimation guide.

In any case, the general objectives of the risk management exercise – the reference risk situation, the target risk situation and the options to reach the target risk situation – should be clearly described.

Sections 2 and 3 of the Guide for decision-making provide assistance for the harmonised analysis of the decision-making case and the approach to the risk management objectives.

Important notes:

A principle of segregation of roles was used to establish the framework of guides, in particular avoiding the potential mixing of roles of risk analyst and decision maker.

The guide for risk estimation has a principal objective of allowing the delivery of harmonised risk estimation that is better recognised by stakeholders.

It is important that the risk estimation results produced by the user of this guide are not biased by making assumptions that compromise potential future decisions, for example by deliberately aligning the risk results with preferred options.

The harmonised decision-making process is covered by the Guide for decision-making, which is compatible with the risk estimation results produced in accordance with this guide to risk estimation.

Although the two guides may be used independently, it is important to note that the framework is designed to ensure overall consistency of the harmonised risk management approach, including for default data setting, the risk estimation model and the decision-making process.

3.2. Decision-maker mandates for the users of this guide

Important note:

This section is also applicable when a decision making case is self-defined by the user of this guide, as mentioned in the previous section.

It must be noted that several risk estimation loops may be necessary to complete a full decision-making optimisation process, depending on the complexity of the decision to be taken.

For example, in complex projects, the decision-maker may not always know how to achieve a target risk situation at the beginning of the decision-making project or which risk control options (safety measures) will achieve the desired target.

This is why, at the beginning of a decision-making project, the purpose, objectives and risk management options should be studied in accordance with the process described in section 3 of the Guide for decision-making, resulting in one or more risk estimation requests to adequately inform the decision-making process. This is particularly important when a mandate is addressed to the risk analyst by the decision-maker, but it is also recommended that risk analysts uses this method in case of risk management on their own initiative.

When this step defining the risk management objectives has been completed the user of this guide is responsible for delivering the best possible, well justified, risk estimations for the different risk situations to be assessed.

It is possible that during the performance of the risk estimations, new options for managing the risks are identified by the risk analysts. In this case the risk analysts should either inform

the decision-makers – and possibly obtain a revised mandate from the decision-maker – or update the risk management options description.

In any case, in order to obtain the full benefit of this framework the risk estimation results shall be transparent and independent from any other decision made about the risk management options being considered. Taking this perspective, risk estimations shall be factual inputs to the process of decision-making, reflecting as accurately as possible the potential effects of proven risk control options (safety measures).

In order to facilitate transparent, accurate and traceable exchange of information between the risk analysts and decision-makers, the package of information described in the following section should be recorded for each risk situation that is assessed, including options.

3.3. Package of information for each risk situation to be assessed, and options

The user of the risk estimation guide shall use the following information packages to describe **each risk situation** for which the estimation of risk indicators is needed:

a. The detailed description of the transport infrastructure and transport operations being considered, using the template Use case – Infrastructure and operations description in accordance with the explanations given in section 4.1 Harmonised description of the infrastructure.

b. The detailed description of the dangerous goods traffic, normal freight traffic and surrounding passenger traffic (when applicable, according to the risk management objectives) being considered. This description is formulated by using the template Use case – traffic description in accordance with the explanations given in section 4.2.

c. The list of selected DG scenarios (see section 4.3) using the table of allocation of DG scenarios assorted with their indicative distance of effect (see section 4.4).

d. The detailed description of vulnerabilities considered as relevant for the assessed risk situation/option and located within the mapping distance. This description uses the template Use case – Human vulnerabilities description in accordance with the explanations given in section 4.4. Harmonised description of Vulnerabilities.

The above information constitutes the basic packages of information required for the estimation of risk indicators.

One package of information will then correspond to one risk situation/option assessed as follows:

1) Reference risk situation   ->   Reference information package

2) Risk management Option 1   ->   Modified information package 1

3) Risk management Option 2   ->   Modified information package 2

….

This approach facilitates the traceability of changes between different risk situations,

e. The user should explain in a note:

‣ the changes made between two information packages representing two different risk situations,

‣ the parameters whose default values were corrected to better reflect each assessed situation, including the justification of the corrections made.

If the user of the guide modifies the default settings of the model they should develop their risk estimations in accordance with the following rules:

1) use the default harmonised values of the model parameters whenever possible,

2) justify any user settings and correction factors which are applied.

> Important note:
>
> When the users of this guide identify limitations that mean the proposed harmonised model cannot be used to describe a particular risk situation they should report them.
>
> In such cases the user may send a change request to be considered by the Expert Users and Development Group for incorporation into a subsequent version of the harmonised framework in accordance with the principle of maintenance and continuous improvement as described in section 6 of the Framework guide.

3.4. Modelling of a risk control (safety) measure

In first instance the modelling of user-defined risk control measure (or safety measure) in the harmonised risk estimation model requires an analysis of the expected safety improvement, including considering potential drawbacks, and taking into account the fact that the model calibration (default reference setting) already implicitly takes into account the effect of pre-existing safety measures.

3.4.1. With changes made to the parameters used for the description of a given risk situation (use case description templates)

When the expected safety improvements are clearly defined by the risk analysts then the effect of the risk control measure can be modelled using the harmonised model by changing the relevant parameters of the description package and/or setting correction factors.

Any (open) parameter that is used by the risk estimation model may be used to reflect the effect of a given measure.

For example, the most common possibilities are:

‣ To compare two different routes by comparing two different infrastructure situations,

‣ To compare two different traffic situations by using traffic parameter descriptions,

‣ To compare two different distributions of the vulnerabilities along a route by using the vulnerabilities description,

‣ Or a combination of the above possibilities.

3.4.2. With correction factors

More complex risk control measures may also need to be described by the user by setting relevant correction factors to relevant frequencies, or by relevant estimation of impacts within the model. This approach is detailed in the steps described in chapter 7 of this guide.

The list of model parameters and permitted corrections is available at this address. The list identifies whether a parameter is used to estimate of the severity of damage to vulnerabilities or to estimate frequencies.

3.5.   Minimum requirements for risk estimation

To estimate the risks of the activities within the scope of a case study, the user shall:

▸ provide a description package for each assessed risk situation,

▸ list all the hazards that are not taken into account by the model but which are relevant for the use case, based on a risk analysis exercise (not covered in this guide),

▸ list all the vulnerabilities that are not taken into account by the model but which are relevant for the use case, based on a risk analysis exercise (not covered in this guide),

▸ list the risks that are not taken into account by the model, based on a risk analysis exercise (not covered in this guide),

▸ provide information on risk control measure tested and clearly describe how this measure is modelled using the available parameters of the model, including the potential use of correction factors,

▸ deliver the above information and the corresponding results of the risk indicators to the decision-makers, and to any interested party on request.

Important note:

This guide proposes a method to estimate risk indicators based on an harmonised approach to the description of risk situations.

However this guide does not describe the risk analysis techniques to be used by the risk analyst to ensure relevant risks have been identified before describing a risk situation that is to be estimated in accordance with this guide.

From this perspective the risk analysis step is not fully covered in this guide.

4. Harmonised description of a risk situation

When carrying out the steps required for the description of a given risk situation, risk analysts shall know at least the basic information applicable to the assessed risk situation as defined in chapter 3.

A given risk situation is described by a package of information as described in section 3.3.

The following sections introduce detailed information on the parameters making up the harmonised description of a risk situation; harmonised templates align, when possible, with the proposed default settings of the values of the parameters.

Important notes:

During the second phase of the TDG Roadmap it is intended to start the development of a web application to assist users in the implementation of this guide for user-specific risk situations.

Until this application becomes available, this guide provides information at the methodological level and includes some harmonised tools (templates) for assisting users.

Link to templates and tools

4.1. Harmonised description of the infrastructure and operations

For this step the user considers both the infrastructure on which TDG operations take place and the type of operation. The harmonised model considers predefined pairs of infrastructure/operation categories applicable to the whole transport chain.

These categories are defined in the following sections.

4.1.1. Default – Infrastructure parameters

By default the risk estimation model take into account several categories of infrastructure on which the transport of dangerous goods chain is organised. The definition of the type of infrastructure is linked to the category of operation taking place on them.

The document Default - Infrastructure and operation parameters contains the predefined description of different modes of transport, infrastructure categories and transport operation categories.

Predefined characteristics for the following categories of infrastructure are available to the user of the risk model:

4. Harmonised description of a risk situation

Road segments

Mode	Infrastructure category	Transport operation category	Definition
RD	n/a	NET	(generic) Road segment representative of all possible categories of infrastructure and operations on a road network (NET)
RD	ORD	ALL	(generic) Road segment representative of operations performed on all categories of open roads (ALL)
RD	ORD	URBAN	Road infrastructure segment open to road vehicle traffic in urban area
RD	ORD	SUBURBAN	Road infrastructure segment open to road vehicle traffic in suburban area
RD	ORD	COUNTRY SIDE	Road infrastructure segment open to road vehicle traffic in countryside
RD	ORD	HIGHWAY	Highway road infrastructure segment open to road vehicle traffic
RD	PRK	n/a	Parking road infrastructure segment open for temporary stopping of road vehicles
RD	HLT	n/a	Logistical road infrastructure segment open to road vehicles for loading / unloading / transloading of packaging
RD	FLU	n/a	Filling/emptying road infrastructure segment for operation with road tanker vehicles
RD	USR	OTHER	User defined infrastructure segment for the road mode of transport

Railway segments

Mode	Infrastructure category	Transport operation category	Definition
RL	n/a	NET	(generic) Railway segment representative of all possible categories of infrastructure and operations of a railway network (NET)
RL	OLN	ALL	(generic) Railway segment representative of operations performed on all categories of open lines (ALL)
RL	OLN	URBAN	Railway infrastructure segment open to railway vehicle traffic in urban area
RL	OLN	SUB-URBAN	Railway infrastructure segment open to railway vehicle traffic in suburban area
RL	OLN	COUNTRY SIDE 1	Railway infrastructure segment open to railway vehicle traffic in countryside with 1 line of traffic
RL	OLN	COUNTRY SIDE 2	Railway infrastructure segment open to railway vehicle traffic in countryside with 2 lines of traffic

Railway segments

RL	STSD	ALL LOCATIONS	Railway infrastructure segment for stations and sidings used by railway vehicles for temporary stops
RL	STSD	ENTRY	Entry part of a Railway infrastructure segment for stations and sidings
RL	STSD	WITHIN	Inner part of a Railway infrastructure segment for stations and sidings
RL	STSD	EXIT	Exit part of a Railway infrastructure segment for stations and sidings
RL	MYS	ALL LOCATIONS	Railway infrastructure segment for marshalling yard open to railway vehicles for reception, uncoupling, shunting and departure of trains
RL	MYS	RECEPTION	Railway infrastructure segment for marshalling yard reception
RL	MYS	UNCOUPLING	Railway infrastructure segment for marshalling yard wagon uncoupling area
RL	MYS	SHUNTING	Railway infrastructure segment for marshalling yard wagon shunting operations to form new rakes
RL	MYS	DEPARTURE	Railway infrastructure segment for marshalling yard where trains are formed with new rakes of wagons, including train pre-departure checks
RL	HLT	n/a	Railway infrastructure segment for specific infrastructure open to railway vehicles outside the railway network, dedicated to loading / unloading railway freight vehicles with packaging
RL	FLU	n/a	Railway infrastructure segment for specific infrastructure open to railway vehicles outside the railway network, dedicated to filling / emptying railway tank wagons
RL	USR	OTHER	User defined infrastructure segment for the railway mode of transport

Inland waterways segments

Mode	Infrastructure category	Transport operation category	Definition
IWW	n/a	NET	(generic) Inland waterways segment representative of all possible categories of infrastructure and operations of an inland waterways network (NET)
IWW	OWW	ALL	(generic) Inland waterways segment representative of operations performed on all categories of open inland waterways (ALL)
IWW	OWW	CEMT-I	Inland waterways infrastructure for category I vessels
IWW	OWW	CEMT-II	Inland waterways infrastructure for category II vessels

4. Harmonised description of a risk situation

Inland waterways segments

IWW	OWW	CEMT-III	Inland waterways infrastructure for category III vessels
IWW	OWW	CEMT-IV	Inland waterways infrastructure for category IV vessels
IWW	OWW	CEMT-V-a	Inland waterways infrastructure for category Va vessels
IWW	OWW	CEMT-V-b	Inland waterways infrastructure for category Vb vessels
IWW	OWW	CEMT-VI-a	Inland waterways infrastructure for category VIa vessels
IWW	OWW	CEMT-VI-b	Inland waterways infrastructure for category VIb vessels
IWW	OWW	CEMT-VI-c	Inland waterways infrastructure for category VIc vessels
IWW	OWW	CEMT-VII	Inland waterways infrastructure for category VII vessels
IWW	WTG	n/a	Watergate segment of an inland waterway infrastructure
IWW	HRB	n/a	Harbour area of an inland waterway infrastructure
IWW	HLT	n/a	Loading / Unloading / Transloading area of an inland waterway harbour infrastructure
IWW	FLU	n/a	Filling / Emptying or Loading / Unloading area of an inland waterway harbour infrastructure
IWW	USR	OTHER	User defined infrastructure segment of an inland waterway

Multimodal segments

Mode	Infrastructure category	Transport operation category	Definition
MMP	n/a	NET	(generic) Multimodal platform segment representative of all possible categories of multimodal platforms and operations within a network (NET)
MMP	RDRL (Road/Rail) or RDIW (Road/Inland waterways) or RLIW (Rail/Inland waterways) or RDRLIW (Road/Rail/ Inland waterways)	ALL	(generic) Multimodal platform segment representative of all categories of operations performed on the selected category of infrastructure (ALL)
MMP	RDRL or RDIW or RLIW or RDRLIW	RECEPTION	Reception area of a multimodal platform (MMP) operating with the declared modes of transport
MMP	RDRL or RDIW or RLIW or RDRLIW	TRANSLOADING	Loading/Unloading/Transloading cargo area of a multimodal platform operating with the declared modes of transport

Multimodal segments

MMP	RDRL or RDIW or RLIW or RDRLIW	FORMATION	Formation (of vehicles) area of a multimodal platform operating with the declared modes of transport
MMP	RDRL or RDIW or RLIW or RDRLIW	DEPARTURE	(vehicle) Departure area of a multimodal platform operating with the declared modes of transport

Important note:

The predefined categories of infrastructure and operations segments listed above are used to allocate default reference values to the safety performance of transport operations as monitored with relevant transport statistics (see section 7.1).

4.1.2. Use case – Infrastructure description

Based on the predefined characteristics of the different categories of infrastructure, the user of the risk estimation model will define the 'Use case' infrastructure. This is facilitated by the use of the template document Use case – Infrastructure and operation description

This template allows the user to define the category of infrastructure segments on which the TDG risk estimations will be performed.

Figure 12: Provisional template for an infrastructure and operations category description. See https://www.era.europa.eu/activities/transport-dangerous-goods/inland-tdg_en for the latest updates.

4.1.3. Default – Transport operation parameters

The risk estimation model take into account several categories of transport operation:

▸ Operations involving dangerous goods substances and containments. Typically these categories of operations relate to the **processing of substances and containments during filling/emptying operations**.

▸ Operations for **Handling / Loading / Transloading / Stowing** dangerous goods packaging during shipment and **loading / unloading operations** before / after carriage. These operations are considered separately from the carriage phase.

▸ **Traffic operations** with vehicles carrying, or having carried, dangerous goods. This traffic is mixed with passenger and non-dangerous goods freight traffic on transport infrastructures.

▸ Logistics operations related to **specific phases of transport operations where manoeuvres / shunting / parking of vehicles / vessels are necessary**. Shunting yards, truck parks and inland ports are the areas that are principally concerned with these types of operations, and shall be considered as a part of the transport chain.

▸ Other operations specific to a given mode of transport.

By default the risk estimation model considers that the above types of operations are directly linked to the type of transport infrastructure locations, as follows:

▸ On open line (OLN) segments: *traffic operations* mixing passenger/freight and dangerous goods carriage services. For this category, sub-categories of transport operations are defined to take into account the capacity of the infrastructure in terms of traffic, for example the number of lines/tracks (URBAN, SUBURBAN, COUNTRYSIDE, HIGHWAY) or the inland waterways categories (CEMT categories).

▸ On park (PRK) segments: specific road transport operations consisting of *temporary stops and manoeuvres* of road vehicles, mixing passenger/freight and dangerous goods road vehicles in parking areas.

▸ On logistical (HLT) segments: *handling / loading / unloading / transloading operations* with the loadings in/on freight vehicles, including transport operations with packaged dangerous goods,excluding filling/emptying substances and processing of mixtures.

▸ On filling/emptying (FLU) segments: *filling/emptying dangerous substances operations* with various type of tanks/tank-batteries carried/mounted on vehicles, including tanker vehicles.

▸ On stations and sidings (STSD) segments: operations with railways vehicles and trains for *temporary stops* of vehicles / rakes of vehicle / trains and simple *manoeuvres / reformation* of trains.

▸ On marshalling yard (MYS) segments: transport *manoeuvre operations* relating to the reception/shunting/formation of trains.

▸ On logistics/watergate (WTG) segments: transport *specific manoeuvre* consisting of entering another water level of an inland waterway network.

▸ On logistics/harbour (HRB) segments: specific types of vessel transport *manoeuvre*, if necessary assisted with tugboats, in order to join/leave allocated moorings.

▸ On multi-modal platform (MMP) segments: transport *manoeuvre and operations* relating to the reception / loading / unloading / transloading / formation and departure of vehicles / trains / vessels.

4.1.4. Use case – Transport operation description

When defining the infrastructure segment type in accordance with section 4.1 the user may apply default values corresponding to the segment type, where available.

These values may be corrected by the user for the best fit with the description of the risk situation.

In the event that the operation under assessment does not conform with the predefined categories, the user may use the segment type 'USR / OTHER' in order to define the characteristics of the considered operation.

4.2. Harmonised description of DG traffic

4.2.1. Default – traffic structure

In order to perform risk estimation it is necessary to estimate the possible rate of occurrence of transport operation events. The rates of occurrence depend on the structure of the traffic and in particular of the presence/absence of certain categories of load.

By default the risk estimation model considers that transport operations are performed in mixed traffic compositions, composed of passenger, non-DG freight and DG freight services.

In addition the model considers the following categories of dangerous goods loads:

▸ Big tanks/bulk containments,

▸ Medium tanks/bulk containments,

▸ Small packed goods and articles.

For each type of loading an average weight is predefined per class of dangerous goods. Even if this approach is not perfectly representative of actual transport operations it allows a fair macro description of traffic structures. In turn, this allows estimation of the probability that a safety occurrence involves a given type of DG class and load size. The default load size cannot be set by the user (it is a closed parameter) because it depends only on the design of the authorised freight vehicle. However the user can break down the means of transport for carrying the volume of goods specified in a given use case.

The predefined (Default) characteristic of the traffic structure is based on EU transport statistics. This means that, by default, the model will provide risk estimates that are relevant for studies having their scope in an EU region.

The default traffic structure also considers the daily volume of traffic by time of day for passenger, normal freight and DG freight transport. This is an open parameter which can be specified by the user.

For each class of dangerous goods the ten most-transported goods, as classified by UN number, are also predefined in the model. This parameter allows better definition of the DG scenarios in terms of representative substances.

Predefined characteristics of the EU traffic structure are recorded in the document 'Default – traffic parameters'.

However, users are permitted to adapt the traffic characteristics for another study scope in accordance with the use case being considered. These adaptations are made with 'Use case' dedicated forms that allow the user to adapt 'Open' parameters of the risk estimation model.

4.2.2. Use case – traffic description

For studies having their scope in an EU region the user may apply the default traffic setting.

For other scopes of application the user should check the applicability of the default setting or modify the default setting with values applicable to the case being studied, using the template 'Use case – traffic description'.

Figure 13: Provisional template for traffic description. See https://www.era.europa.eu/activities/transport-dangerous-goods/inland-tdg_en for the latest updates.

This template allows the description of the following parameters:

▸ Transport volumes for passenger services, normal freight services and DG freight services,

▸ Details of the DG traffic structure in relation to the breakdown of DG traffic by class of dangerous goods,

▸ Details of the DG traffic structure in relation to the share of loading by mode, in order to carry the defined volume of DG traffic,

▸ Detailed information on DG traffic in relation to the ten most transported UN numbers by volume,

▶ Details of the peak traffic hours.

Each element of the detailed traffic information can be specified for each segment of the risk situation being considered.

However, when the required information is not available for a given risk situation, the user of the model may decide to use predefined 'default' values of DG transport traffic based on EU statistics. In this case only the transport volume parameters need to be described by the user.

4.3. Harmonised description of hazards and reference DG Scenarios

Important notes:

▶ The users of this guide shall base their descriptions of relevant hazards on their own risk analysis.

▶ Once the user has developed a correct **risk analysis** for the use case being considered, the harmonised risk estimation method establishes conventions for **describing the considered (harmonised) risks and estimating the corresponding risk indicators.**

▶ Although the **harmonised risk estimation method cannot ensure that the user has performed the necessary risk analysis correctly**, the risk estimations provided by the model allow comparison of the results obtained with other use case results that have been performed using the model.

▶ The user of this model is wholly responsible for ensuring, so far as is reasonable, that it covers the hazards and risks which must be identified during the risk analysis step (not covered by this guide).

4.3.1. Preliminary comments on Hazards and Risks

Hazards are defined as a potential source of harm/damage. The risks posed by the transport of dangerous goods arise from the potential exposure of vulnerabilities to harmful effects.

The risk from a given activity transporting dangerous goods essentially arises from the transport activity being performed, the categories of hazards involved and the vulnerabilities that are potentially exposed.

In order to keep the framework manageable a reduced set of hazards and vulnerabilities is considered, and presented in the following table.

Table 6 : List of the main risks considered by the estimation method (combination of hazards and vulnerabilities)

Hazards / Vulnerabilities	Human (any person using the infrastructure, working on the infrastructure or facilities, or being in the vicinity)	Assets (transport infrastructure and transport facilities, including vehicles, built environment)	Operations (transport activity)	Environment (the estimation model considers some potential pollution of soil/water/air)
Mechanical (collision, projectile impact, friction...)	Fatalities or injuries caused by mechanical impact	Damage caused by mechanical impact	Disruption of operation due to transport system/facilities damage	
Overpressure / Deflagration / Detonation	Fatalities, explosive blast injuries, burns, spread of fire from site of origin	Structural collapse and/or damage caused by pressure waves	Disruption of operation due to transport system/facilities damage	-
Heat flux	Fatalities or injuries caused by exposure to heat	Fire spread from site of origin	Disruption of operation due to transport system/facilities damage	-
Intense light	-	-	-	-
Toxicity through inhalation, contact or ingestion	Fatalities or injuries caused by inhalation of toxic substances or smoke	-	Disruption of operation due to transport system/facilities damage or pollution	Environmental damage (pollution to land, air and water, intoxication wildlife or livestock)
Corrosive effects	Fatalities or injuries caused by inhalation, ingestion or exposure through skin contact of corrosive material.	-	Disruption of operation due to transport system/facilities damage or pollution	Environmental damage
Oxidation	Combination of explosion, heat, smoke/fumes, potential toxic impacts	-	Disruption of operation due to transport system/facilities damage or pollution	-
Virus / Bacteria	-	-	-	-
Oxygen depletion	Fatalities or injuries caused by asphyxiation	-	-	-
Electric shock	-	-	-	-

High sound pressure	-	-	-	-	-
Electromagnetic flux	-	-	-	-	-
Radionuclides flux (all types of contamination)	Exposure to people leading to injury and/or illness. Fatalities or injuries caused by inhalation, ingestion or absorbed through skin contact of radioactive material.	Contamination of built environment	Disruption of operation due to transport system/facilities. Contamination	Exposure to animals leading to injury and/or illness. Contamination of natural environment	-
Other	-	-	-	-	-

Important notes:

1) **Not all** combinations of Vulnerabilities and Hazards have the potential to result in tangible and significant impacts. As an example, toxic clouds have, in general, no significant impact on the built environment but may have major consequences for the human environment. Combinations that are not considered by the model are marked '-' in the table above; however it does not prevent the risk assessor from estimating these risks where they are relevant to a given use case.

2) The table gives a qualitative description of the risks being considered. These risks can be also expressed in quantitative ways by the risk estimation model, and – when data are available – economic risks can be estimated by monetising the impacts.

4.3.2. Default - Hazards and DG scenarios

In order to allow the use of a harmonised risk estimation model a *Table of hazards and of reference DG scenarios* has been established. This table is available <u>here.</u>

This table indicates the likely DG scenarios which may occur during a DG transport event involving a release and that are considered by the harmonised risk model for each class of dangerous goods (classified in accordance with chapter 2 of the Classification of RID/ADR/ADN regulations).

This table is used by the risk estimation model to determine a default list of relevant DG scenarios from the traffic description provided by the user of the model.

More details on the use of this table are given in section 7.4 and annex III.

4.3.3. Default – Pre-calculated reference DG scenarios

The estimation of the distance of effects of hazardous DG scenarios is highly complex in itself and requires many coherent assumptions, including consistency between the estimation of the severity of impact and the estimation of the corresponding frequency of occurrence.

This is why the framework uses pre-calculated reference DG scenarios for the estimation of the distances of effects, in order to estimate consistently the severity of impacts that are also linked to the estimation of the applicable frequencies of occurrence.

With this method the estimation of the severity of impact and the corresponding frequencies are consistently estimated and the assumptions regarding correctly- or over-estimated (conservative approach) risks can be transparent and well-controlled.

The reference material for the pre-calculated reference DG scenarios are available to risk analysts <u>here</u>. The risk analyst has to select the applicable pre-calculated reference DG scenarios with the help of the '*Table of allocation of TDG scenarios*'. This table and the corresponding pre-calculated reference DG scenarios will be regularly updated with the aim of improving the applicability of the method to the different types of DG carriage with relevant and harmonised distances of effect.

More details of the pre-calculated reference DG scenarios are given in section 7.6 and annex III.

4.3.4. Use case – Hazards and DG scenarios

By default, any risk estimation will take into account the list of reference DG scenarios relevant for the use case 'DG traffic' described by the user.

However, a default reference DG scenario may not cover all of the specific scenarios which should be considered by the risk analyst in a given case study.

The user of the guide should therefore check, in accordance with the analysis made by the risk analyst, whether the list of DG scenarios proposed by the allocation table of reference DG scenarios does cover correctly the potential list of scenarios applicable to the risk situation being studied.

If not, the user should identify and list any other scenarios applicable to the risk situation being studied.

> **Therefore it is the responsibility of the user to check and, if necessary, add relevant DG scenarios to the 'default' risk estimation scenarios, and so to augment the list of DG scenarios being considered by the user for a given case study**.
>
> Note: For each scenario being considered a related frequency of occurrence will have to be determined in order to be able to assess the risks.

This is the reason why the user of this guide should complete the following table to identify clearly the DG scenarios which need to be considered in addition to the default list of scenarios.

Table 7: List of additional DG scenarios identified by the user for the case being studied

List of additional DG scenarios identified by the user	Class of DG	UN numbers	Description of the DG scenario risk
User DG scenario 1			
User DG scenario 2			
…			

4.3.5.   Use case – Pre-calculated DG scenarios

For each DG scenario which is not already available in the list of reference material the risk analyst may notify the EUDG of the pre-calculated DG scenarios that are relevant to the risk situation being considered (see 'change request' in section 6 of the framework guide).

On this basis, the EUDG which will review and, where relevant, make available new harmonised reference material for the DG scenarios that have been evaluated.

4.3.6.   Minimum requirements

The user of this guide is responsible for checking and updating the proposed risk estimations, if necessary, and adding to the list of 'default' DG scenarios to be considered in a given case study.

As a minimum the user shall establish a 'qualitative' list of hazards relevant to the case study and shall consider whether other hazards in addition to those included on the harmonised list are relevant to the case study.

The table of additional DG scenarios identified by the user shall be provided to the decision-maker for information.

4.4. Harmonised description of Vulnerabilities

The harmonised risk estimation model defines Vulnerabilities as human, operations, transport (technical) systems, and the built and natural environment that are potentially impacted by dangerous goods events. These vulnerabilities may be harmed/damaged if exposed to the hazardous areas potentially existing during dangerous goods events.

4.4.1. Categories of Vulnerabilites

In accordance with the information identifying the dangerous goods hazards (section 4.3.1) the Vulnerabilities considered by the model are categorised as following:

▸ Human vulnerabilities,

▸ Asset vulnerabilities,

▸ Operational vulnerabilities,

▸ Environmental vulnerabilities.

To facilitate the mapping of applicable vulnerabilities in accordance with this section it is necessary to have an idea of the distance over which the effects of DG scenarios may affect vulnerabilities.

For details on mapping refer to section 2.4.4.

The indicative distance of effects may be obtained from the reference material for the pre-calculated reference DG scenarios made available here.

4.4.2. Default – Vulnerabilities parameters

The description of vulnerabilities shall be described by the user of the risk estimation model for each segment of the described case study falling within the relevant distance of effects.

Default values allocated to predefined vulnerabilities are established using the 'default' settings documents. The values allocated to the various parameters for vulnerabilities are based on average statistics for the EU region.

The predefined parameters are summarised in the following tables.

Table 8: Human vulnerabilities

Predefined parameters	Description	Units	Potential sheltering effect
People living in the vicinity of transport facilities (Residents)	Density of population potentially present in hazardous areas and locations	(Number / km²)	% of people inside buildings

People using nearby public infrastructure (Workers, Commuters, Tourists…)	People potentially present in hazardous areas and locations, in addition to residents.	(Number / km²)	% of people inside buildings or vehicles
Users of transport facilities	Number and location of users potentially present in hazardous areas	(Number / km) In addition, (People queuing in the vicinity of hazardous areas are estimated from the description of traffic and infrastructure provided by the user of the model)	% of people inside buildings or vehicles
Staff members operating transport facilities	Number and location of workforce potentially present in hazardous areas	(Number / km)	% of people inside buildings
People in specific locations (e.g. public infrastructure)	People potentially affected by hazardous areas, in addition to residents or workers	(Number) and (Location: distance from the infrastructure centreline)	% of people inside buildings

'Default' settings of Human vulnerabilities will be recorded in the document 'Default – Human vulnerabilities parameters'

Table 9: Asset vulnerabilities

Predefined parameters	Description	Unit
Infrastructure	Damage estimated from the description of the infrastructure defined by the user	Distance damaged (km), Value / km (million euro)
Infrastructure equipment	Damage estimated from the description of the infrastructure defined by the user	Distance damaged (km), Value / km (million euro)
Vehicles using the infrastructure	Damage estimated from the traffic and operational volumes described by the user	Number of damaged vehicles, Value / vehicle (million euro)
Specialised vehicles operating transport facilities	Damage estimated from the traffic and operational volumes defined by the user	Number of damaged vehicles, Value / vehicle (million euro)
Built environment	The default settings predefine three categories of built environment: • URBAN, • SUBURBAN, • COUNTRYSIDE	Number of buildings per km² Value/km² (million euro)
Specific buildings/public facilities	Number, location and specific value defined by the user	Number of specific buildings/facilities. Value / specific building (million euro) Location

'Default' settings of Asset vulnerabilities will be recorded in the document 'Default – Assets parameters'

Table 10: Operational vulnerabilities

Predefined parameters	Description	Unit
Traffic disruption	(estimated by the model using the information on traffic and operational volumes defined by the user)	Duration of disruption (hours) Volume of service interrupted (for example passenger.hours or train.hours) Value of the service per hour (euro)
Disruption of public services	(estimated by the model using the information on surrounding environment and public facilities defined by the user)	Duration of disruption (hours) Volume of service interrupted Value of the service per hour (euro)
Interventions by emergency services	(estimated by the model using the information on surrounding environment and public facilities defined by the user)	Duration of intervention (hours) Volume of intervention Value of the intervention per hour and per staff involved
Loss of payload	Loss of payload estimated from the number of transport units impacted by hazardous areas	Value/unit (euro)

'Default' settings for Operational vulnerabilities will be recorded in the document 'Default – Operational parameters'

Table 11: Environmental vulnerabilities

Categories of natural environmental vulnerabilities	Description	Unit
Specific natural environment	Type and location of sensitive environment (if possible referencing applicable protection laws) Types of pollution/ impacts to be prevented Types of pollution/ impacts potentially resulting from the list of hazards in section 4.3.1	Extent of environment surrounding the transport infrastructure (km²) Value/km² for decontamination/ recovery (million euro)
Other natural environment	List of types and location of pollution/ impacts to be prevented List of types of pollution/ impacts potentially resulting from the list of hazards in section 4.3.1	Extent of environment surrounding the transport infrastructure (km²) Value/km² for decontamination/ recovery (million euro)

'Default' settings for Environmental vulnerabilities will be recorded in the document 'Default – Environmental parameters'

4.4.2.1. Use case – Vulnerabilities Description

In accordance with the definition of the vulnerabilities considered by the risk estimation model users will define their 'Use case' vulnerabilities with the templates made available here.

▶ 'Use case – Human vulnerabilities description',

Figure 14: Provisional template for vulnerabilities description.

(This is a screenshot only: see https://www.era.europa.eu/activities/transport-dangerous-goods/inland-tdg_en for the latest version of the accompanying reference materials.)

▶ 'Use case – Asset vulnerabilities description',

▶ 'Use case – Operational vulnerabilities description',

▶ 'Use case – Environmental vulnerabilities description'.

Asset, Operational and Environmental description templates and default reference values will be developed further by the EUDG in accordance with the framework improvement process. Templates will be regularly updated and supplemented, and made available at the following address: https://www.era.europa.eu/activities/transport-dangerous-goods/inland-tdg_en

When describing the vulnerabilities that are applicable for a given use case the user of the risk estimation model should use 'default' settings where applicable, and modify the values of the parameters, where necessary, to best reflect the use case.

Some parameters for the Operational and Asset vulnerabilities are derived automatically from the data submitted by the user for the Use Case – Infrastructure, and to define traffic and operational volumes.

For example:

▸ Human and Built environment vulnerabilities take account of the type of infrastructure segment defined by the user (Urban, Suburban, Countryside…),

▸ Operational disruptions are derived from the information on traffic and operational volumes,

▸ Transport system vulnerabilities are derived from the information on traffic and operational volumes and from the type of infrastructure segment,

▸ …

This is why the vulnerabilities described by the user only require information to supplement that already included in the Use Case - Infrastructure and operational description. When describing vulnerabilities the user may also define sheltering measures that protect vulnerabilities from hazardous effects. However the default setting for the risk estimation model does not include sheltering effects.

Finally, the user may describe the location of vulnerabilities more precisely by using the 1D+ detailed description. This option allows the user to describe the location of the relevant vulnerabilities using the distance from the centre line of the transport infrastructure. This option gives more accurate risk estimation than the full 1D default method, but the description requires far more effort.

With this option the user may define various types of local vulnerability that the default model does not take into account, such as:

▸ Power supply installations

▸ Potable water supply installations,

▸ Diverse types of public amenity:

  o Hospitals,

  o Entertainment venues,

  o Public gardens…

▶ Diverse types of local infrastructure of vital economic importance, for example:

o Tunnels,

o Bridges,

o Stations…

4.4.3. List of Vulnerabilities not considered by the model

After the user has described the vulnerabilities that make up the use case in accordance with the previous sections it is recommended that the user compiles a list of **the vulnerabilities which are not considered by the model,** using the table below.

This list will allow the user to inform the decision-makers in a transparent way of the relevance of the harmonised risk estimation model, and will allow future versions of the model to consider new types of vulnerability which may not be modelled in the current version.

Table 12: List of vulnerabilities to be considered in addition to those defined in the model

List of vulnerabilities considered in addition to the harmonised model	Qualitative description	Quantitative description (if applicable)	Comments
Name of additional vulnerability 1			
Name of additional vulnerability 2			
…			

4.4.4. Minimum requirements

The user of the guide shall:

▶ report the maximum distance of effect which was used for mapping vulnerabilities,

▶ describe the vulnerabilities using the applicable harmonised use case description template,

▶ establish the list of vulnerabilities that are not considered by the harmonised model but that have been identified by the risk analyst as relevant for the case study.

5.   Multimodal case studies

The description of use case allows the use of road, railway and inland waterway mode segments. It allows the comparison of risks between various transport plans, if necessary.

In the case of a multimodal case study – for example, the assessment of risk transfer effects between two modes of transport – any vulnerabilities that are applicable to at least one mode should be taken into account, in order to allow meaningful comparison of the risk estimates.

Any implications of modal shift should be clearly identified, starting with the definition of the study mandate. Particular attention should be paid to the definition of the scope of the case study.

6. Formatting risk estimation results

The following sections describe how to format the risks estimated by the model for any modelled risk situation.

6.1. Raw results

For every cell of a calculation grid, and for the different applicable categories of vulnerability, the risks are estimated in terms of the frequency with which the vulnerabilities in the cell are impacted (f) and the corresponding severity of impact (s).

6.2. Individual risk

For the human vulnerability category, raw results can be expressed in terms of individual risk (IR).

In this risk management framework individual risk corresponds to the estimate of the annual likelihood that a person present at one given location in the vicinity of the infrastructure being studied is killed as the result of a transport event, including DG scenarios.

This risk estimation category is also commonly used for land use planning activities.

The definition of individual risk may be generalised to apply to other types of vulnerability, for example the likelihood that buildings or other types of vulnerability are impacted at a predefined level of severity (severity quantum).

6.3. Frequency/Severity curves (F/S)

Frequency/Severity curves are a generalised formulation of well-known F/N curves generally used for human societal risks. When applied to human vulnerabilities, F represents the frequency at which N fatalities result from one given hazard.

In this framework, F is the cumulative frequency per year that at least N people are killed due to the occurrence of a transport event, including DG scenarios.

For each situation studied by the risk analyst, the risk estimation results can be formatted in terms of 'generalised' F/S curves considering different types of vulnerability:

▶ Human, (F/N curve)

▶ Assets,

▶ Operational,

▶ Environmental.

The comparison of different risk situations/transport routes (evaluating the reference situation, target situation and the options to achieve the target) will allow the user to identify the regions of an F/S curve where the differences between one situation and another affect the risk profile of the situations being studied. Examples are given in section 6.4.3.

6.4. Evaluating the effectiveness of risk control measures

The effectiveness of risk-control measures for a given risk situation can be assessed in several ways, using individual risk indicators or F/S curves.

6.4.1. With Individual Risk indicators

Indicators of risk level are derived by estimating the individual risks in each grid cell.

It is assumed that the individual risk is constant in a given grid cell, provided that all the parameters influencing the individual risks are constant over the area of the cell.

An average individual risk may be estimated at any given distance from the infrastructure centreline within a segment that has been described by the user. In the same way average individual risks can be estimated for a given transport route.

The lower the value of the indicator when assessing the effect of risk-control measures then the lower will be the level of individual risk.

6.4.2. With Risk level indicators

Risk level indicators can be estimated as a localised cumulative risk for every grid of a cell. The risk indicator $r_{Vi,j}^{cell}$ gives a measure of the risk within a cell to the vulnerability Vi that is posed by the scenario Scj. It is estimated using the following formula:

$$r_{Vi,SCj}^{cell} = (F \times S)_{Vi,SCj,cell}$$

with $\{loc\}$ being a sample of grid cells, the sum of the risks over these cells is given by:

$$R_{Vi,SCj}^{\{loc\}} = \sum_{\{loc\}} r_{Vi,SCj}^{\{loc\}}$$

These risk level indicators (Rlevel) can be aggregated in several ways depending on the way the sample has been defined, as follows:

‣ over a segment,

‣ over a route.

When applied to human vulnerabilities it provides an indication of the safety risk to people for the location being considered.

The lower the value of the indicator when assessing the effect of risk-control measures then the lower will be the level of individual risk.

6.4.3. With Frequency-Severity curves

As discussed in the previous sections, F/S curves give a representation of the likelihood of 'a given level of impact' resulting from a given event.

F/S curves can be aggregated for a given zone of a route, for an entire route, or for the whole risk situation being studied. The aggregation can be performed for one type of event (such as one DG scenario) or for a given set of scenarios.

Comparing two F/S curves can give interesting information about the effects of a given risk control measure. Some examples are given below.

Figure 15: Example 1 - Effect of a pure prevention measure that divides the frequency of occurrence of given impacts by 10 (logarithmic scale)
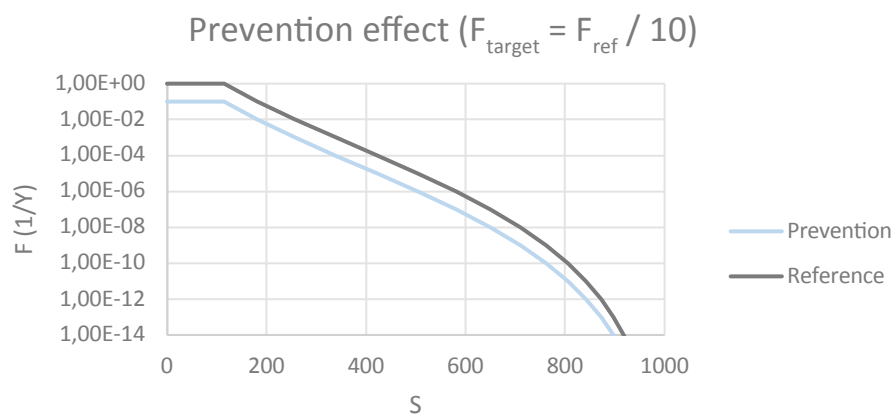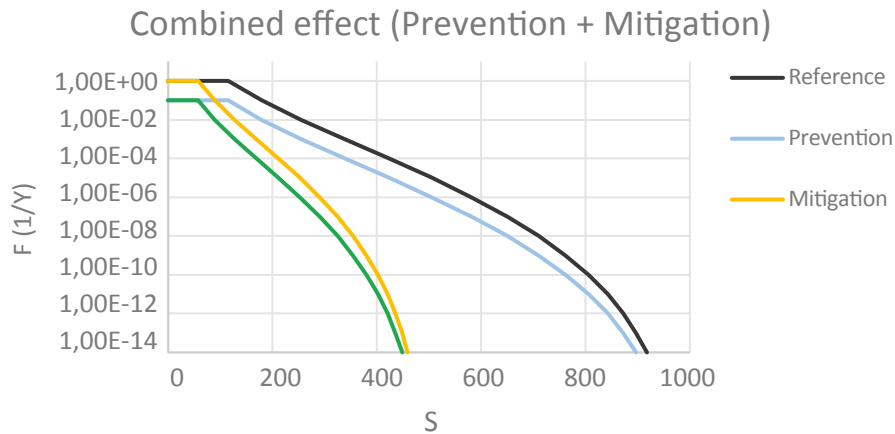

Figure 16: Example 2 - Effect of a pure mitigation measure that divides the magnitude of given impacts by 2 (linear scale) without changing the frequency of occurrence
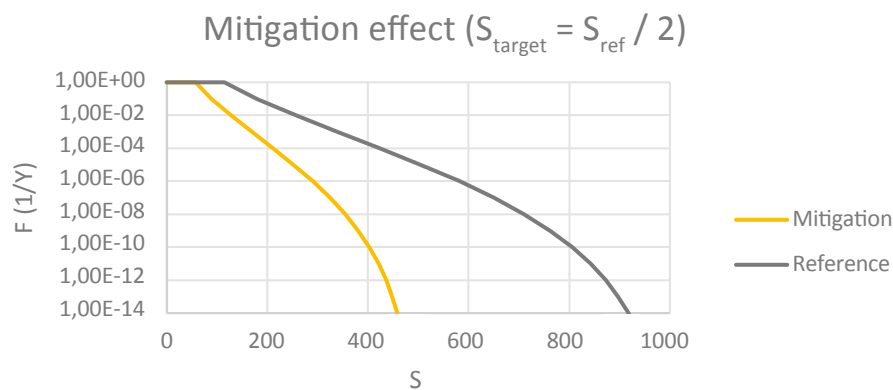
Figure 17: Example 3 - Effect of a measure that combines the two effects described above (green curve)

The above examples illustrate that it is not easy to compare the reduction of risks obtained with different measures. This is why it is helpful to use indicators to assess the effect of the measures applied, as shown below.

6.4.4. Variations in societal risk

The variation in societal risk between two given situations can be evaluated by considering the Expected Value (EV). This is estimated by integrating the F/S curve over the applicable range of F.

Visually, the Expected Value corresponds to the area below the F/S curve and is estimated with the following formula:

$$EV = \int_{fmin}^{fmax} S(f)df$$

When an EV is calculated for comparison with risk situations, the following formula is used to calculate the variation in risk values as a percentage:

$$R(EV)_{variation} = \frac{EV_{target} - EV_{reference}}{EV_{reference}} \text{ x } 100\%$$

The application of this approach to the previous examples is given in the following table.

	Reference situation	Prevention situation (Example 1)	Mitigation situation (Example 2)	Combined measures situation (Example 3)
EV	136.36	13.64	68.18	6.82
$R(EV)_{variation}$	0.00%	- 90.00%	- 50.00%	- 95.00%

This table shows also how difficult it is to assess the risk variations visually, which may lead to inaccurate interpretation. In this example, a visual comparison may lead the user to think that the risk reduction with measure 2 is bigger than with measure 1 when in fact it is the reverse.

6.4.5. Safety-economy test

Refer to the description of this indicator in section 4.3 of the Guide for decision-making.

6.5. Decision-Making Indicators (DMI)

Refer to the description of decision-making indicators in section 4 of the Guide for decision-making.

Part B:
Details on harmonised risk estimations for expert users

Important note:

This part of the guide is written for 'expert users' who want to understand in detail how the proposed harmonised risk estimation model is used to perform estimate risk. It allows expert users to define correction factors that deviate from the default setting of the model.

This part also allows expert users to evaluate the potential limitations of the proposed approach and to report any limitations they identify to the Expert Users and Development Group that has been established for the continuous improvement of the framework (see section 6 of the Framework guide).

7.   Risk estimation steps

As briefly described in section 2.2.2, the following diagram shows the sequence of the main risk estimation steps considered by the risk estimation model.
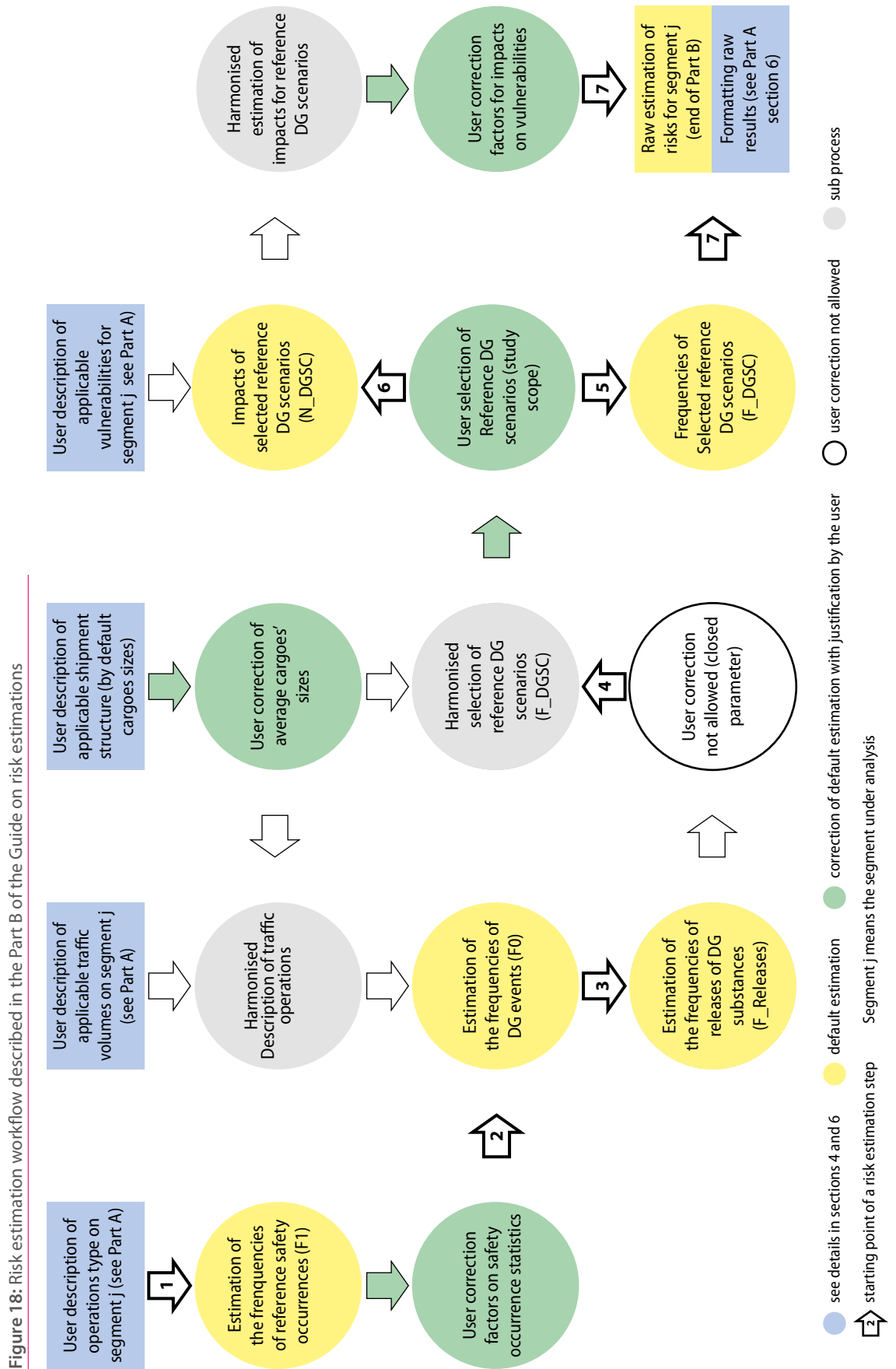
Figure 18: Risk estimation workflow described in the Part B of the Guide on risk estimations

This section of the guide takes the user through the steps for using the description of a risk situation (defined by the user in accordance with part A of the guide) to calculate risk estimates. The main steps are:

1) Estimation of the reference frequency of transport events (F1). This is derived from the infrastructure and operation description made by the user. It includes:

   1a) 'default' frequencies, where possible, and

   1b) user-defined correction factors, if applicable (see details in <u>section 7.1</u>).

2) Estimation of the frequency (F0) of DG events (with or without release of DG substance into, or impact on, the environment). This step uses a sub-process (operational model) to estimate the probability of involvement of a DG transport unit in transport events. This estimate uses the user description of the traffic composition (DG freight, non-DG freight and passenger), volume and structure, as well as the three predefined sizes of cargo (see details in <u>section 7.2</u>).

3) Estimation of the frequency of releases. This is derived from the harmonised default setting of the model. As there is a limited amount of information on this topic the TDG roadmap experts agreed to propose a value of the predefined parameters in order to permit a degree of comparability of the harmonised risk estimation results (see details in <u>section 7.3</u>).

4) Selection of reference DG scenarios. The model suggests relevant reference DG scenarios on the basis of the description of the DG traffic volume and structure made by the user. This uses an harmonised Table of allocation of DG reference scenarios (see annex III). At this stage the user may select other DG reference scenarios that better align the selection proposed by the model with the detailed characteristics of the substances being carried and with the risk management objectives of the case study. The user may also deselect some scenarios, where this is justified (see details in <u>section 7.4</u>).

5) Estimation of frequency of reference DG scenarios. The model estimates the frequency of the selected reference DG scenarios. At this stage the frequency of all types of DG event (with or without release) is considered (see details in <u>section 7.5</u>).

6) Estimation of impact. The severity of potential damage (impact) from all applicable DG events **involving (reference DG Scenarios) or not involving a release in the environment (other DG events)** is estimated, including the impact of the selected reference DG scenarios (see details in <u>section 7.6</u>),

7) Calculation of risk indicators. As a final step, risk indicators are calculated using the combination of frequencies and potential impacts (see details in <u>section 7.7</u>), and formatted in accordance with section 6.

This part B describes in detail these steps in sections 7.1 to 7.7, and includes more complex sub-processes whose description is supplemented with further details in annexes.

Important notes:

It is expected that the development of a web application to assist the user in implementing this guide for user-specific risk situations should start during the second phase of the TDG Roadmap, if resources are allocated.

The specification of a risk estimation IT application to assist users in implementing this guide was initiated in 2018 by ERA, assisted by the Expert Users and Development Group.

Relevant link

7.1. Step 1 – Frequency of transport events (F1)

In this step the user will estimate the frequency of transport events (F1) with the help of F1 reference tables.

The available reference tables can be obtained at the following address: https://www.era. europa.eu/activities/transport-dangerous-goods/inland-tdg_en. It will be regularly updated in accordance with the improvement process described in section 6 of the framework guide.

The name of each F1 reference tables is coded as follows: [geographical scope of the setting]_ F1_[mode].

For example EU_F1_RL gives F1 reference values applicable to the EU region as a whole [EU] for railway transport events [RL].

In each F1 reference table the application scope of individual spreadsheets is coded in the name of the spreadsheet, as follows: F1_[mode]_[infrastructure category]_[operation category].

Using this system permits any user to:

▸ propose a new reference table for the scope of the application;

▸ use proposed default values that are relevant for the risk situation being studied; or

▸ apply any necessary corrections to the proposed values, with justification for the changes.

When the list of available F1 reference tables has increased the user will readily be able to find default values relevant for each case and for each category of infrastructure and operations defined in section 4.1.

7.1.1. Definition of F1

F1 is the frequency of occurrence of the transport events which are considered to be the direct causes of dangerous goods events (see DCs list in F1 tables). Transport event definitions also include, for example, fires and spontaneous DG scenarios that are counted as one category of transport event.

F1 is established for the whole freight transport operation in a given category, including DG freight. It is used as the base frequency for deriving the frequency of occurrence of DG events (F0).

Because F1 is established by using a bigger sample of occurrences (whole freight volume) than DG scenario occurrences alone, it achieves a better estimation of F0 frequencies. This uses an assumption of ergodicity, namely that the behaviour of DG transport operations is statistically similar to non-DG transport operations. This approach is justified because, in practice, transport systems are not exclusively designed for the transport of dangerous goods but for all types of service (passenger and freight) sharing the same transport system.

In this way the user of the harmonised risk estimation method may correct the proposed F1 values provided the corrections are justified and the sample of occurrences used is relevant for the risk situation being considered.

Based on the above definition and assumptions, F1 tables provide information on the list of safety occurrences being considered. They propose default F1 values for various categories of infrastructure and operations.

In the course of the development of the framework a harmonised and multimodal naming system was developed for occurrences (see the list of direct causes (DCs) considered in F1 tables) to facilitate the future development of reference F1 tables by any user.

The nomenclature for the reference safety occurrences recorded in F1_... tables has taken into account existing taxonomies for each Inland surface transport mode: railway[2], road[3] and inland waterway[4] and for each type of operation considered by the risk estimation model.

7.1.2. Default allocation of F1

F1 tables are composed with the following spreadsheets:

▸ One 'F1 summary table' compiling F1 settings proposed for each category of infrastructure and operations, and

▸ One 'F1' spreadsheet for each category of infrastructure and operations.

Four (4) normalisers are used by the model as follows:

▸ years (F1_Y),
  F1_Y = Number of reference safety occurrences per **y**ear,

▸ tons (F1_T),
  F1_T = Number of reference safety occurrences per **t**on carried,

---

[2] For Railways the taxonomy of reference safety occurrences is derived from that used in annex I of Directive (EU) 2004/49, adapted where necessary to suit the multimodal scope of application of this guide.
[3] For Roads the taxonomy of reference safety occurrences is derived from that used in CADAS, adapted where necessary to suit the multimodal scope of application of this guide.
[4] For Inland waterways the taxonomy of reference safety occurrences is derived from the naming systems used in CH and NL, reviewed to give a more generic formulation and adapted where necessary to suit the multimodal scope of application of this guide.

▸ ton.kilometre (F1_TK),
F1_TK = Number of reference safety occurrences per **t**on.**k**ilometre carried,

▸ transport units (F1_TU),
F1_TU = Number of reference safety occurrences per **t**ransport **u**nit operated.

The F1 tables are composed as follows:

▸ **The black area** contains the (raw) information used to establish the safety occurrences to be considered (corresponding to the transport events) for the scope of interest in question.

▸ **The blue area** harmonises the number of occurrences from the harmonised list of transport events considered by the risk estimation model,

▸ **The green area** allows correction of the reference setting, provided it is properly justified by the user,

▸ **The yellow area** reflects the user-corrected setting.

Figure 19: Overview of the F1 reference table EU_F1_RL.

(This is a screenshot only: see https://www.era.europa.eu/activities/transport-dangerous-goods/inland-tdg_en for the latest version of the accompanying reference materials.)

The resulting F1 values are indicated for the different normalisers (Y: year, T: ton, TK: ton. kilometre, TU: transport unit), as shown in the screenshot below.

Figure 20: Example of F1 values for various normalizers

(This is a screenshot only: see https://www.era.europa.eu/activities/transport-dangerous-goods/inland-tdg_en for the latest version of the accompanying reference materials.)

The blue section contains F1 reference values and the yellow section contains the user-corrected F1 values. In the above example no correction was applied by the user (CF_x values set to 1).

7.1.3. Available reference setting of F1

The default setting of F1 uses information on the safety occurrence obtained from the reporting systems that are available, which provide data relating to a given category of infrastructure and transport operation and to a given geographical scope.

Required information and formulas for setting an F1 table

The calibration uses the following information:

▸ Type of infrastructure considered and the scope of operation.

o Recorded in column G of the 'F1_…' table, in accordance with the definition in section 4.1,

▶ Description of the source of information used for calibration:

  o Names of the safety occurrences named in the information source and recorded in column B of the 'F1_…' table,

  o Number of occurrences collected in the information source (NB_COL_OCC), recorded in column C of the 'F1_…' table,

  o The corresponding number of years over which the occurrence was collected (N_Y_REF),

▶ List and number of relevant 'direct causes' considered by the model [DCj]:

  o Harmonised names of the 'direct causes' recorded in column H and I of the 'F1_…' table,

  o Number of occurrences considered as 'direct causes' of DG events by the model (N_ROCC), recorded in column K of the 'F1_…' table,

  o Corresponding reference volumes of operations (Recorded in columns L, M, and N of the 'F1_…' table in cells N_T_REF, N_TK_REF and N_TU_REF.

  o A relevance factor to set the proportion of collected occurrences that correspond to the definition of 'direct causes' in the risk estimation model (RELEVANCE_FACTOR).

    The relevance factor is derived from:

      ▶ the Infrastructure type relevance factor RELEVANCE_INFRA: This factor is set to 100% when the type of infrastructure on which the safety occurrences have been collected corresponds fully with the infrastructure type considered by the given F1 table, as defined in section 4.1, and

      ▶ the Operations type relevance factor RELEVANCE_OPE: This factor is set to 100% when the type of operation for which the safety occurrences have been collected corresponds fully with the operation type considered by the given F1 table, as defined in section 4.1.

    RELEVANCE_FACTOR = RELEVANCE_INFRA X RELEVANCE_OPE

The F1 setting applies the following formulas:

▶ N_ROCC(DCj) = NB_COL_OCC(j) / N_Y_REF * RELEVANCE_FACTOR

▶ F1__Y_REF = sum over j (N_ROCC(DCj)),

▶ F1__T_REF = F1__Y_REF / N_T_REF,

▶ F1__TK_REF = F1__Y_REF / N_TK_REF,

▶ F1__TU_REF = F1__Y_REF / N_TU_REF.

7.1.4. Setting of F1 when no default setting is available

In this case that no default setting is available the user F1 table shall be established in accordance with the method described in the previous section and incorporating the user's own occurrences sample, taking care that the resulting F1 values are representative and robust. Good statistical practices shall be applied.

Information required for the user setting:

▶ Types of infrastructure considered and scope of operations

o Recorded in column G of the 'F1_…' table, in accordance with the definitions of the type of infrastructure and type of operations in section 4.1,

▶ Description of the sources of information used by the user of the guide for establishing the user calibration of F1:

o Names of the safety occurrences as named in the user source of information to be recorded by the user in column B of the 'F1_…' table, for the corresponding predefined harmonised direct causes (DCj),

o The number of years of collection (N_Y_REF_USR), corresponding to the number of occurrences collected (NB_COL_OCC_USR),

o Corresponding reference volumes of operations (Recorded in columns L, M, N of 'F1_…'s tables in cells N_T_REF_USR, N_TK_REF_USR and N_TU_REF_USR),

▶ The number of safety occurrences entered by the user that are considered,

o Number of collected occurrences with the user-defined source of information (NB_COL_OCC_USR), to be recorded by the user in column C of 'F1_…'s tables,

o A relevance factor that makes it possible to set the proportion of collected occurrences that correspond to the definition of 'direct causes' in the risk estimation model. (RELEVANCE _FACTOR_USR).

Applicable formulas:

The same generic formulas as in the previous section apply for the estimation of F1.

7.1.5. User correction factors for changing default setting of F1

The use of correction factors allows the user to (re)calibrate the default setting with a user calibration.

Once the user calibration is fully defined in accordance with the method described in the previous section the user can readily determine the following correction factors:

▶ Correction factor for the yearly number of harmonised occurrences,

▶ Correction factor for the reference tonnage used to establish F1_T,

▶ Correction factor for the reference ton.kilometres used to establish F1_TK,

▶ Correction factor for the reference number of transport units operated to perform the reference operations F1_TU.

With the following formulas:

▶ CF_N_OCC_USR = N_OCC_USR / N_OCC_Reference scope,

▶ CF_F1_T_DCi = N_ T_REF_USR / N_ T_REF_Reference scope,

▶ CF_F1_TK_DCi = N_ TK_REF_USR / N_ TK_REF_Reference scope,

▶ CF_F1_TU_DCi = N_ TU_REF_USR / N_ TU_REF_Reference scope.

Then the applicable correction factors calculated by the user can be introduced in the corresponding cells of the concerned F1 reference table. These corrections will be taken into account in the estimation of user-corrected F1 recorded in the 'F1 summary table'.

Below is an example of user correction (orange cells) of yearly occurrence numbers representing:

▸ doubled collisions (DC1),

▸ tripled derailments (DC11), and

▸ halved 'other' occurrences (DC21).

Figure 21: Example of use of direct cause correction factors in F1 tables

(This is a screenshot only: see https://www.era.europa.eu/activities/transport-dangerous-goods/inland-tdg_en for the latest version of the accompanying reference materials.)

User correction factors CF_DCi_USR; [0..infinity]; (not corrected = 1)	considered safety occurrence: [DCi_USR]	on the railway network as corrected by the user [N_ROCC_USR (freight)]
2	DC1	42.9
1	DC2	0.0
1	DC3	0.0
1	DC4	105.9
1	DC5	0.0
1	DC6	238.2
1	DC7	0.0
1	DC8	0.0
1	DC9	0.0
1	DC10	0.0
3	DC11	61.8
1	DC12	0.0
1	DC13	0.0
1	DC14	0.0
1	DC15	0.0
1	DC16	0.0
1	DC17	5.0
1	DC18	0.0
1	DC19	0.0
1	DC20	0.0
0.5	DC_21	8.6

The resulting corrected F1 (visible in orange cell) is compared to the default F1 setting in the blue cells of the next figure.

Figure 22: Example of effect of correction factors on F1 values

(This is a screenshot only: see https://www.era.europa.eu/activities/transport-dangerous-goods/inland-tdg_en for the latest version of the accompanying reference materials.)

Independently, the reference volume of operations (tonnage, ton.kilometres, transport units operated) may also be corrected by the user.

Below is another example of corrections using user-defined reference operational volumes. In this example the reference yearly tonnage has been doubled while the number of occurrences is unchanged. In this example, reference ton.kilometres have tripled and reference transport units operated have increased by 50%.

Figure 23: Example of effect of traffic volume correction factors on F1 values

(This is a screenshot only: see https://www.era.europa.eu/activities/transport-dangerous-goods/inland-tdg_en for the latest version of the accompanying reference materials.)

Orange cells show the resulting effect on the user-corrected F1 values compared to the default values recorded in the blue area.

> Important note: In any case a correction factor requires justification by the user in accordance with the method for setting F1 as described in section 7.1.4 and 7.1.5.

7.1.6. Use of F1 reference values for a given segment of a use case

For each segment described by the user the applicable reference value of F1 for a given category of segment is extracted from the spreadsheet 'F1 summary table' of the user-selected applicable reference F1 table.

Figure 24: Overview of summary spreadsheets for F1 values

(This is a screenshot only: see https://www.era.europa.eu/activities/transport-dangerous-goods/inland-tdg_en for the latest version of the accompanying reference materials.)

By default settings of F1 per type of [MODE_INFRA_OPE] segment — Applicable to EU region setting

(by default - breakdown of reported occurrences per type of infrastructure) ; [0..100%] ; (check sum per mode ok if = 100%) AND (by default - correction factor per type of operation) ; [0..infinity] ; (not corrected = 1)

Mode	Infrastructure category	Operation category	(Occurrence areas names)	(N_OCC/y)	(F1 names)	F1_T (N_OCC/ton)	F1_TK (N_OCC/ton.km)	F1_TU (N_OCC/operated transport unit)	
ROAD SEGMENTS			**ROADS SAFETY PERFORMANCE**					**ROADS SAFETY PERFORMANCE**	
RD	NET	ALL	OCC_RD_NET_ALL	#DIV/0!	F1_RD_NET_ALL	#DIV/0!	#DIV/0!	#DIV/0!	0%
RD	ORD	ALL	OCC_RD_NEL_ALL	#DIV/0!	F1_RD_OLN_ALL	#DIV/0!	#DIV/0!	#DIV/0!	0.00%
RD	ORD	URBAN	OCC_RD_OLN_URBAN		F1_RD_URBAN	#DIV/0!	#DIV/0!	#DIV/0!	1.00
RD	ORD	SUB-URBAN	OCC_RD_OLN_SUBURBAN		F1_RD_SUB-URBAN	#DIV/0!	#DIV/0!	#DIV/0!	1.00
RD	ORD	COUNTRY SIDE 2	OCC_RD_OLN_COUNTRY2		F1_RD_COUNTRY2	#DIV/0!	#DIV/0!	#DIV/0!	1.00
RD	ORD	HIGHWAY	OCC_RD_OLN_HIGHWAY		F1_RD_HIGHWAY	#DIV/0!	#DIV/0!	#DIV/0!	1.00
RD	PRK	ALL	OCC_RD_PRK_ALL	#DIV/0!	F1_RD_PRK_ALL	#DIV/0!	#DIV/0!	#DIV/0!	0.00%
RD	HLT	ALL	OCC_RD_HLT_ALL		F1_RD_HLT_ALL	#DIV/0!	#DIV/0!	#DIV/0!	0.00%
RD	FLU	ALL	OCC_RD_FLU_ALL		F1_RD_FLU_ALL	#DIV/0!	#DIV/0!	#DIV/0!	0.00%
RD	USR	ALL	OCC_RD_USR_ALL	#DIV/0!	F1_RD_USR_ALL	#DIV/0!	#DIV/0!	#DIV/0!	0.00%
RAILWAY SEGMENTS			**RAILWAYS SAFETY PERFORMANCE**					**RAILWAYS SAFETY PERFORMANCE**	
RL	NET	ALL	OCC_RL_NET_ALL	408.33	F1_RL_NET_ALL	2.48E-07	9.87E-10	6.97E-06	100%
RL	OLN	ALL	OCC_RL_OLN_ALL	265.42	F1_RL_OLN_ALL	1.61E-07	6.42E-10	4.53E-06	65.00%
RL	OLN	URBAN	OCC_RL_OLN_URBAN		F1_RL_OLN_URBAN	1.61E-07	6.42E-10	4.53E-06	1.00
RL	OLN	SUB-URBAN	OCC_RL_OLN_SUBURBAN		F1_RL_OLN_SUBURBAN	1.61E-07	6.42E-10	4.53E-06	1.00
RL	OLN	COUNTRY SIDE 1	OCC_RL_OLN_COUNTRY1		F1_RL_OLN_COUNTRY1	1.61E-07	6.42E-10	4.53E-06	1.00
RL	OLN	COUNTRY SIDE 2	OCC_RL_OLN_COUNTRY2		F1_RL_OLN_COUNTRY2	1.61E-07	6.42E-10	4.53E-06	1.00
RL	SDST	ALL	OCC_RL_SDST_ALL	142.92	F1_RL_SDST_ALL	8.67E-08	3.45E-10	2.44E-06	35.00%
RL	SDST	ENTRY	OCC_RL_SDST_ENTRY		F1_RL_SDST_ENTRY	8.67E-08	3.45E-10	2.44E-06	1.00
RL	SDST	EXIT	OCC_RL_SDST_WITHIN		F1_RL_SDST_WITHIN	8.67E-08	3.45E-10	2.44E-06	1.00
RL	SDST	WITHIN	OCC_RL_SDST_EXIT		F1_RL_SDST_EXIT	8.67E-08	3.45E-10	2.44E-06	1.00
RL	MYS	ALL	OCC_RL_MYS_ALL	n/a	F1_RL_MYS_ALL	#DIV/0!	#DIV/0!	#DIV/0!	100%
RL	MYS	RECEPTION	OCC_RL_MYS_RECEPTION		F1_RL_MYS_RECEPTION	#DIV/0!	#DIV/0!	#DIV/0!	0.08
RL	MYS	UNCOUPLING	OCC_RL_MYS_UNCOUPLING		F1_RL_MYS_UNCOUPLING	#DIV/0!	#DIV/0!	#DIV/0!	0.21
RL	MYS	SHUNTING	OCC_RL_MYS_SHUNTING		F1_RL_MYS_SHUNTING	#DIV/0!	#DIV/0!	#DIV/0!	0.70
RL	MYS	DEPARTURE	OCC_RL_MYS_DEPARTURE		F1_RL_MYS_DEPARTURE	#DIV/0!	#DIV/0!	#DIV/0!	0.01
RL	HLT	ALL	OCC_RL_HLT_ALL	#DIV/0!	F1_RL_HLT_ALL	#DIV/0!	#DIV/0!	#DIV/0!	0.00%
RL	FLU	ALL	OCC_RL_FLU_ALL	#DIV/0!	F1_RL_FLU_ALL	#DIV/0!	#DIV/0!	#DIV/0!	0.00%
RL	USR	ALL	OCC_RL_USR_ALL	#DIV/0!	F1_RL_USR_ALL	#DIV/0!	#DIV/0!	#DIV/0!	0.00%
INLAND WATERWAY SEGMENTS			**INLAND WATERWAYS SAFETY PERFORMANCE**						
IWW	NET	ALL	OCC_IWW_NET_ALL	#DIV/0!	F1_IWW_NET_ALL	#DIV/0!	#DIV/0!	#DIV/0!	0%
IWW	OWW	ALL	OCC_IWW_OWW_ALL	#DIV/0!	F1_IWW_OWW_ALL	#DIV/0!	#DIV/0!	#DIV/0!	0.00%
IWW	OWW	CEMT-I	OCC_IWW_OWW_CEMT1		F1_IWW_OWW_CEMT1	#DIV/0!	#DIV/0!	#DIV/0!	1.00
IWW	OWW	CEMT-II	OCC_IWW_OWW_CEMT2		F1_IWW_OWW_CEMT2	#DIV/0!	#DIV/0!	#DIV/0!	1.00
IWW	OWW	CEMT-III	OCC_IWW_OWW_CEMT3		F1_IWW_OWW_CEMT3	#DIV/0!	#DIV/0!	#DIV/0!	1.00
IWW	OWW	CEMT-IV	OCC_IWW_OWW_CEMT4		F1_IWW_OWW_CEMT4	#DIV/0!	#DIV/0!	#DIV/0!	1.00
IWW	OWW	CEMT-V-a	OCC_IWW_OWW_CEMT5a		F1_IWW_OWW_CEMT5a	#DIV/0!	#DIV/0!	#DIV/0!	1.00
IWW	OWW	CEMT-V-b	OCC_IWW_OWW_CEMT5b		F1_IWW_OWW_CEMT5b	#DIV/0!	#DIV/0!	#DIV/0!	1.00
IWW	OWW	CEMT-VI-a	OCC_IWW_OWW_CEMT6a		F1_IWW_OWW_CEMT6a	#DIV/0!	#DIV/0!	#DIV/0!	1.00
IWW	OWW	CEMT-VI-b	OCC_IWW_OWW_CEMT6b		F1_IWW_OWW_CEMT6b	#DIV/0!	#DIV/0!	#DIV/0!	1.00
IWW	OWW	CEMT-VI-c	OCC_IWW_OWW_CEMT6c		F1_IWW_OWW_CEMT6c	#DIV/0!	#DIV/0!	#DIV/0!	1.00
IWW	OWW	CEMT-VII	OCC_IWW_OWW_CEMT7		F1_IWW_OWW_CEMT7	#DIV/0!	#DIV/0!	#DIV/0!	1.00
IWW	WTG	ALL	OCC_IWW_WTG_ALL	#DIV/0!	F1_IWW_WTG_ALL	#DIV/0!	#DIV/0!	#DIV/0!	0.00%
IWW	HRB	ALL	OCC_IWW_HRB_ALL	#DIV/0!	F1_IWW_HRB_ALL	#DIV/0!	#DIV/0!	#DIV/0!	0.00%
IWW	HLT	ALL	OCC_IWW_HLT_ALL	#DIV/0!	F1_IWW_HLT_ALL	#DIV/0!	#DIV/0!	#DIV/0!	0.00%
IWW	FLU	ALL	OCC_IWW_FLU_ALL	#DIV/0!	F1_IWW_FLU_ALL	#DIV/0!	#DIV/0!	#DIV/0!	0.00%
IWW	USR	ALL	OCC_IWW_USR_ALL	#DIV/0!	F1_IWW_USR_ALL	#DIV/0!	#DIV/0!	#DIV/0!	0.00%
MULTIMODAL PLATFORM SEGMENTS			**MULTIMODAL PLATFORMS SAFETY PERFORMANCE**						
MMP	ALL	ALL	OCC_MMPLF_ALL_ALL	#DIV/0!	F1_MMPLF_ALL_ALL	#DIV/0!	#DIV/0!	#DIV/0!	0%
MMP	RDRL	ALL	OCC_RDRL_ALL	#DIV/0!	F1_RDRL_ALL	#DIV/0!	#DIV/0!	#DIV/0!	0.00%
MMP	RDRL	RECEPTION	OCC_RDRL_REC		F1_RDRL_REC	#DIV/0!	#DIV/0!	#DIV/0!	1.00
MMP	RDRL	TRANSBOARDING	OCC_RDRL_HLT		F1_RDRL_HLT	#DIV/0!	#DIV/0!	#DIV/0!	1.00
MMP	RDRL	FORMATION	OCC_RDRL_FORM		F1_RDRL_FORM	#DIV/0!	#DIV/0!	#DIV/0!	1.00
MMP	RDRL	DEPARTURE	OCC_RDRL_PREDEP		F1_RDRL_PREDEP	#DIV/0!	#DIV/0!	#DIV/0!	1.00
MMP	RDIW	ALL	OCC_RDIW_ALL	#DIV/0!	F1_RDIW_ALL	#DIV/0!	#DIV/0!	#DIV/0!	0.00%
MMP	RDIW	RECEPTION	OCC_RDIW_REC		F1_RDIW_REC	#DIV/0!	#DIV/0!	#DIV/0!	1.00
MMP	RDIW	TRANSBOARDING	OCC_RDW_HLT		F1_RDW_HLT	#DIV/0!	#DIV/0!	#DIV/0!	1.00
MMP	RDIW	FORMATION	OCC_RDW_FORM		F1_RDW_FORM	#DIV/0!	#DIV/0!	#DIV/0!	1.00
MMP	RDIW	DEPARTURE	OCC_RDW_PREDEP		F1_RDIW_PREDEP	#DIV/0!	#DIV/0!	#DIV/0!	1.00
MMP	RLIW	ALL	OCC_RLIW_ALL	#DIV/0!	F1_RLIW_ALL	#DIV/0!	#DIV/0!	#DIV/0!	0.00%
MMP	RLIW	RECEPTION	OCC_RLIW_REC		F1_RLIW_REC	#DIV/0!	#DIV/0!	#DIV/0!	1.00
MMP	RLIW	TRANSBOARDING	OCC_RLIW_HLT		F1_RLIW_HLT	#DIV/0!	#DIV/0!	#DIV/0!	1.00
MMP	RLIW	FORMATION	OCC_RLIW_FORM		F1_RLIW_FORM	#DIV/0!	#DIV/0!	#DIV/0!	1.00
MMP	RLIW	DEPARTURE	OCC_RLIW_PREDEP		F1_RLIW_PREDEP	#DIV/0!	#DIV/0!	#DIV/0!	1.00
MMP	RDRLIW	ALL	OCC_RDRLIW_ALL	#DIV/0!	F1_RDRLIW_ALL	#DIV/0!	#DIV/0!	#DIV/0!	0.00%
MMP	RDRLIW	RECEPTION	OCC_RDRLIW_REC		F1_RDRLIW_REC	#DIV/0!	#DIV/0!	#DIV/0!	1.00
MMP	RDRLIW	TRANSBOARDING	OCC_RDRLIW_HLT		F1_RDRLIW_HLT	#DIV/0!	#DIV/0!	#DIV/0!	1.00
MMP	RDRLIW	FORMATION	OCC_RDRLIW_FORM		F1_RDRLIW_FORM	#DIV/0!	#DIV/0!	#DIV/0!	1.00
MMP	RDRLIW	DEPARTURE	OCC_RDRLIW_PREDEP		F1_RDRLIW_PREDEP	#DIV/0!	#DIV/0!	#DIV/0!	1.00
MMP	USR	ALL	OCC_MMPLF_USR_ALL	#DIV/0!	F1_RDRLIW_ALL	#DIV/0!	#DIV/0!	#DIV/0!	0.00%

The user then applies the value of F1 corresponding to the type of segment in terms of mode of transport, category of infrastructure and category of operation.

7.2. Step 2 – Frequencies of occurrence of Dangerous Goods events (F0)

7.2.1. Definition of F0

Within this framework, dangerous goods events (DG event) are any occurrence in which a DG vehicle or a DG cargo is involved, **with or without** release of the dangerous goods substance being carried.

F0 represents the average frequency of dangerous goods events for a given volume of transport operation.

F0 can be normalized against a given number of years, tons, ton.kilometres or transport units operated corresponding to the volume of the transport operation being considered.

7.2.2. Probability of involving a dangerous goods vehicle/cargo (P1)

In the previous step F1 is determined and represents **any type of freight** safety occurrence, whether the events **involve a dangerous goods vehicle / cargo or not**.

In order to determine F0 the model shall determine the probability P1 that a freight safety occurrence involves a dangerous goods vehicle / cargo, that is to say the probability of a DG event.

P1 is fully dependent on the structure of cargo shipments that are considered in a given use case. For example, if DG traffic is not authorised on a given segment of a route then P1 should be set to 0 as no DG cargoes will be present on this segment. On the contrary if a given infrastructure accepts only DG vehicles carrying DG cargoes then any safety occurrence within this infrastructure would be a DG event, thus P1 would be 1.

The operational model determines P1 taking into account the traffic structure described by the user in accordance with part A of the guide.

7.2.3. Default setting for DG traffic compositon in the EU region

By default, the operational model is calibrated with average cargo types and weights used for performing transport operations in the EU.

The following type of cargo are considered by the operational model:

Mode-specific cargoes

▸ CRG_CC_A: Large size Tank or Large size Bulk

▸ CRG_CC_B: Medium size Tank or Medium size Bulk

▸ CRG_CC_C: Bundle of cylinders, Single small receptacle, Articles and packages,

Multimodal cargoes (containers) with

▸ CONT_CC_A: Large size Tank-container

▸ CONT_CC_B: Medium size Tank-container

▸ CONT_CC_C: Bundle of cylinders, Single small receptacle, Articles and packages

The average cargo weights are set by default for each class of dangerous goods and for each type of cargo in the table 'DG CType tonnage' of document 'Default – Traffic parameters'. This parameter is a 'closed' parameter for the user as it is considered that the user will not design the means of transport. Means of transport are defined by international legislation and the default setting may be updated when necessary to take into account new means of transport in an updated version of the model.

In contrast, the average breakdown of the usage of the different cargo types per class of DG is an open parameter which is set by default in the table 'DG traffic - BKD CType' of document 'Default – Traffic parameters' to represent the average breakdown of DG shipments for EU traffic.

This parameter is an 'open' parameter which shall be set by the user in accordance with the traffic structure that is to be considered in the use case.

7.2.4. User setting of DG traffic compositon

The parameter for average breakdown of cargo types used for operating the shipments has a direct and significant influence on the risk estimation results, as most of the time the potential impacts of DG events depend on the quantity of the hazardous substance involved. It is therefore essential that the user describes the considered use case correctly.

The user can set the average breakdown of cargo types used for the operations being considered in table 'DG traffic - BKD CType' of document '<u>Use case – Traffic description</u>'.

However if the user does not do this the average EU region breakdown will apply.

7.2.5. Operational model and calculation of P1

The traffic structure information described by the user is used to estimate P1, taking into account default settings of the cargo weights (DG CType tonnage).

The operational model is briefly described in annex II.

7.2.6. Estimation of F0

F0 can be simply estimated by using the following generic formula, which integrates a calibration factor Correction_F1_F0 and an extra user-correction factor CF_F0:

$$F0 = F1 \times P1 \times CORRECTION\_F1\_F0 \times CF\_F0$$

The correction may be necessary to make the default setting of F1 and the default setting of F0 consistent. In practice the safety performance statistics used for setting F1 and F0 are not necessarily consistent as they may come from databases that have been developed independently for different purposes with different reporting requirements/scopes.

This correction factor is set by default to 1.0 (no correction) however it is envisaged that the Expert Users and Development Group may need to review this setting.

By default the user correction factor CF_F0 is also set to 1, meaning no user correction applies.

The F0 formula is applied for the determination of F0 in each segment of a given use case, for each category of DG cargo considered by the 'operational model'.

7.2.7. User-corrected setting of F0

Important note:

The determination of P1 requires complicated calculations. This is why P1 itself is a 'closed' parameter which cannot be directly corrected by the user.

However, the user can change F0 changed globally using the correction factor CF_F0 in order not to take into account proposed P1 estimations (for example, for maximizing P1 by setting it to 1) in the subsequent steps of the risk estimations.

However, it is not recommended to make use of this option unless it is needed to be able to answer specific questions of a given decision-making mandate.

7.3. Step 3 – Frequencies of occurrence of DG releases (F_DGR)

Fortunately dangerous goods accidents are rare. As a consequence it means that it is difficult to provide robust statistics on the different sizes of release that have occurred in the past and which have to be considered in risk estimations. Some of the risk estimations consider DG scenarios which have never happened in reality but may happen in the future.

The TDG framework establishes a mechanism of regular review and update of the key statistics and it is foreseen that better assumptions will be available in the future. However, some existing databases can be used to refine commonly the statistical breakdown of loss of containment severity.

At the 9th and 10th workshops, attending TDG experts discussed the difficulties of refining such a breakdown and concluded that:

▶ a conventional breakdown should be defined and used for harmonised risk estimations, allowing mutual recognition,

▶ at the same time, the regulatory reporting framework should be reviewed in order to facilitate more accurate setting of the risk estimations in the future,

▶ it is considered that the estimations that currently exist do not provide better settings for the conditional probabilities of the different types of release than the ones proposed in this harmonised framework.

7.3.1. Default – Harmonised categories of DG releases

The following categories of non-release and release will be used:

▶ No release,

▶ Small release,

▶ Limited release,

▶ Continuous release,

▶ Full (quasi instantaneous) release.

The detailed definitions are provided in Table 13.

For this parameter it must be noted that only few sources of information are available and that a follow-up collection of data and analysis should be undertaken to better establish the values of the probabilities applicable to different types of releases. The difficulty of establishing these values comes from the fact that only a limited number of events have occurred in the past compared to the volume of traffic operated, and therefore the samples that are available to establish the values are limited.

Important note:

Events corresponding to the normal operation of pressure relief valves are not considered as releases, as they constitute the normal functioning of a safety device.

Table 13: Definition of the harmonised categories of releases

Release categories	P(RELEASE_SIZE)	Definitions
No release	P(NO_RELEASE)	Any event where **NO** release in the environment of any quantity or any flow rate is observed (smells are considered to fall in the category "small release") **For risk estimation**, only mechanical impacts on relevant assets are considered, as there is no release of substance. Important note: this category of release is not applicable to Class 7 as radiation in the vicinity of a Class 7 DG unit is always present even where there is no leakage of radioactive substances/material
Small release	P(SMALL)	Smells from DG substance residues or drip leaks that have been confirmed after inspection of the cargoes. The flow rate is extremely low. For this category of release it is assumed that an intervention may take place to stop the drip leak with appropriate actions. **For risk estimation**, only disruption of service is considered for this type of release. **No human impact is considered in the harmonised estimation of risks for this category of release because it is assumed that corresponding risks are controlled under workplace health and safety legislation.**
Limited release	P(LIMITED)	Any release that does not flow from the main containment shell and whose volume or flow rate are limited respectively by the size of the emptied volume (for example between two safety valves) and/or by the limited size of the equivalent diameter of the breach, for example a small diameter connecting pipe. It is assumed that the flow rate may be reduced by an intervention of the emergency services after 60 minutes, or is interrupted before this time due to the emptying of volume concerned. **For risk estimation** of the hazardous area the assumed flow rate is based on the equivalent diameter size of a small pipe or equivalent breach, and on the (limited) emptied volume.
Continuous release	P(CONTI)	Any release which would result in emptying the DG substance from the main containment shell (e.g. tank shell) with a continuous flow rate. For this type of release it is assumed that emergency services will intervene and will try to limit the DG release flow rate upon arrival at the event scene. If not interrupted the flow continues until the entire volume of the main containment shell is released. **For risk estimation** it is assumed that the entire containment is emptied without mitigation by the emergency services. The flow rate is defined by the equivalent diameter size of the largest equipment connected to the containment shell or an equivalent breach size in the main containment shell.
Full release	P(FULL)	Any release with very large breach or total rupture of the main containment shell which would lead to a quasi-instantaneous and full release of the DG cargo from its containment (e.g. total rupture of a tank shell). For this type of release it is assumed that intervention of emergency services will not be possible due to the rapid development of the scenario. **The estimation** of the hazardous areas is based on the assumed instantaneous release of the entire capacity of the containment.

At the 9th and 10th TDG workshop it was discussed and confirmed that only a small number of participants are likely to produce data from which the breakdown of the different categories of release may be established, as shown in the detailed analysis in annex II.5.

Until more systematic and improved reporting of DG events allows more accurate values for the parameter P(RELEASE_SIZE), users should use the default values from Table 14 when applying the frequency formula in section 7.5.1.

Table 14: Harmonised setting of the conditional probabilities of releases

PROPOSED HARMONISED RELEASE BREAKDOWN – P(RELEASE_SIZE) **(Please use the latest update of the present table available at www.inland-tdg.europa.eu/framework/ tools/Reference_DG_scenarios)**					
(Sources of information: See annex II.5 for the data sources used and the detailed analyses in the relevant documents cited)					
	NO RELEASE	**SMALL RELEASE**	**LIMITED RELEASE**	**CONTINUOUS RELEASE**	**FULL RELEASE**
ROADS (applicable by default to all segments of a case study)	30%	30%	33%	6%	1%
RAILWAYS (applicable by default to open lines)	17%	70%	9%	3.9%	0.1%
RAILWAYS (applicable by default to stations and sidings, and marshalling yards)	32%	58%	8.5%	1.5%	0%
WATERWAYS	In absence of detailed source of information the user of the guide should provide a justified breakdown of the approach taken in respect of the risk situation being considered				
	Note: For this category only mechanical impacts on assets and operations are estimated	*Note: For this category only mechanical impacts on assets and operations are estimated*	*Note: For this category relevant scenarios with limited volume of DG and small outflows are used*	*Note: For this category relevant scenarios with larger breaches/ pipes outflows are used*	*Note: For this category quasi-instantaneous involvement of the full amount of the DG substance being carried is assumed*

7.3.2. User-defined breakdown of DG release categories

In order to allow for continuous improvement of the harmonised setting users should report relevant statistics for each defined category, which may be used in the future.

Such reports should be submitted using the 'change request' process defined in section 6 of the framework guide.

7.4. Step 4 – Selection of reference DG scenarios (DGSC)

The selection of reference DG scenarios is based on the description of the traffic by the user.

Two approaches are possible:

▸ The model selects the applicable reference scenarios from the percentage of DG class(es) described by the user,

or,

▸ The user directly selects the applicable reference DG scenarios for the use case from the description of the UN numbers for the loads.

In both cases the table of allocation of hazards and reference DG scenarios is used.

7.4.1. Allocation of reference DG scenarios from DG classes

For each class of dangerous goods the table of allocation of TDG scenarios provides indications of the applicable categories of DG scenario, taking into account the legal definition of the DG classification, as shown in the following extract from the table.

Figure 25: Overview of the allocation table of reference DG scenarios of class 2.1

(This is a screenshot only: see here for the latest version of the accompanying reference materials.)

The orange part of the table is the entry information (DG hazard properties), which allows the selection of applicable reference scenarios that are recorded in the blue part of the table.

Each row of the table corresponds to a given set of 'DG hazard properties' that are defined in the TDG regulation and which are linked to the reference DG scenarios considered by the harmonised risk estimation.

Each scenario is referenced by the DG class (CLnumber), two letters (column) and a row number (row):

In the example to the left, the scenario is referenced CL21_AA_1.

It corresponds to a Vapour Cloud Explosion scenario: the case made up of a release of the dangerous goods that have been selected, followed by ignition.

For a given row, as shown below:

Figure 26: Detail of the allocation table of reference DG scenarios (1)

(This is a screenshot only: see https://www.era.europa.eu/activities/transport-dangerous-goods/inland-tdg_en for the latest version of the accompanying reference materials.)

DG hazard properties (in accordance with definitions applicable to Table A of Chapter 3.2 RID/ADR/ADN)				CL21RSC	AA		BB		CC	
					Conditional probability of occurrence	Links to reference UN numbers and related distances of impacts	Conditional probability of occurrence	Links to reference UN numbers and related distances of impacts	Conditional probability of occurrence	Links to reference UN numbers and related distances of impacts
Class	Division	Packing group	Classification code		Vapour Cloud Explosion (when ignited)		Gascloud fire (when ignited)		Jet fire/Torch fire (when ignited)	
2	2.1	n.d.	1F	1	0.25	Link	0.25		0.5	

The user can immediately see the list of reference scenarios that are applicable to the dangerous goods being considered, which give the hazard properties and the default conditional probabilities that are considered by the harmonised model for the conditional occurrence of each scenario.

By default the harmonised model considers the list of scenarios in the orange-coloured row marked '(by default)', taking a conservative approach (maximised risk estimation).

Figure 27: Detail of the allocation table of reference DG scenarios (2)

(This is a screenshot only: see https://www.era.europa.eu/activities/transport-dangerous-goods/inland-tdg_en for the latest version of the accompanying reference materials.)

Class	Division	Packing group	Classification code		Vapour Cloud Explosion (when ignited)		Gascloud fire (when ignited)		Jet fire/Torch fire (when ignited)	
2	2.1	n.d.	1F	1	0.25		0.25		0.5	
2	2.1	n.d.	2F	2 (by default)	0.25	Link	0.25	Link	0.5	Link
2	2.1	n.d.	3F	3	0.25		0.25		0.5	

When the user of the framework holds little or no information it is recommended to proceed as follows:

▸ use the list of 'default' scenarios (generally the most conservative approach in terms of risks),

or,

▸ when it is possible, allocate the relevant share of traffic to the applicable hazard properties (rows), and use the corresponding list of reference scenarios,

or, with a less conservative approach,

▸ use a selection of DG scenarios justified by the risk analyst.

When several scenarios can take place consecutively it is indicated as "*possible scenario under relevant conditions*". An example is the 'BLEVE' scenarios which may only take place under

certain conditions (for example after a fire) when planned contingency arrangements or safety equipment have been ineffective at preventing it.

> Important note:
> In any case the risk analyst shall justify the use of the list of DG scenarios that has been selected in the context of the objective of the decision-making case and the assessed risk situation.

7.4.2. Allocation of reference DG scenarios from UN numbers

When the user has a very comprehensive description of the DG traffic, detailing the percentage share of the most-carried UN numbers, it is possible to have a more precise selection of the reference DG scenarios.

In this case it is possible to retrieve the applicable reference scenarios from the allocation table and from the Table A of chapter 3.2 of RID/ADR/ADN for each UN number.

For each UN number the logical sequence is:

UN number provides the corresponding

- ▶ Class, and

- ▶ Hazard properties,

which allows the user to identify the corresponding relevant row of reference DG scenarios.

In this case, the scenarios listed in the relevant row are the ones applicable to the share of traffic that is made up of the UN number being considered.

7.4.3. Reference DG scenarios

The material relating to reference TDG scenarios will be available at the following address of the dedicated webpage.

The user will find the updated version of the table of allocation TDG scenarios and the list of pre-calculated reference TDG scenarios.

It must be noted that the pre-calculated hazardous distances for each of the DG scenarios may also be used as an indication of mapping distances from the location of a transport event. This should be taken into account when mapping potential vulnerabilities (see section 2.4.4).

More details on the available material for pre-calculated hazardous distances are provided in section 7.6.3.

7.5. Step 5 – Harmonised frequencies of selected reference DG scenarios (F_DGSC)

This section explains how the model estimates frequencies of reference DG scenarios by default and how these frequencies may be corrected.

7.5.1. Definition of the frequency F_DGSC

The frequency of a reference DG scenario is the frequency of occurrence of a given reference scenario that is applicable to a given segment of a risk situation which has been described by the user.

Its value is obtained by combining the frequency of a given initial transport event with all the applicable conditional probabilities to estimate the frequency of the reference DG scenario.

The general formulation is the following:

F_DGSC(SCENARIO TYPE) =   F1(TRANSPORT EVENT)
                             x
                             P(DG UNIT)
                             x
                             P(DG CLASS)
                             x
                             P(UNIT CAPACITY)
                             x
                             P(RELEASE SIZE)
                             x
                             P(SPECIFIC CONDITIONS)
                             x
                             P(REFERENCE DG SCENARIO TYPE)

The following table contains brief descriptions of the meanings of the individual elements of the frequency formula. It identifies where the user may find the relevant material to proceed with estimating the frequency of a given scenario.

Table 15a: Elements composing the estimates of the frequency of occurrence of reference DG scenarios

	Frequencies		Conditional probabilities	
Frequency description	**Frequency symbol**		**Conditional probability**	**(Value list)**
Frequency of a transport event for a given type of INFRASTRUCTURE AND OPERATION	F1(INFRA, OPER) See section 7.1			(INFRASTRUCTURE, OPERATION) See section 4.1 for the definitions of the infrastructure and operation types
Frequency of a transport event of a given OCCURRENCE TYPE	F1(OCC_TYPE) See section 7.1		P(OCC_TYPE) Probability of a given type of occurrence (for example collisions)	(OCC_TYPE): see F1 table columns I and J for the applicable list of occurrences (direct causes) numbered from DC1 to DC21.
Frequency of involvement of a DG transport UNIT carrying any class of DG	F0 See section 7.2		P(DG_UNIT) – P1, Estimated by the operational model (P1) using the description of the traffic provided by the user. See annex II.4.	(DG_UNIT): DG_UNIT: see glossary for the definition of a DG unit. NON_DG: occurrence involving non-DG freight cargo.
Frequency of involvement of a DG transport unit carrying DG of CLASS X	F0(DG_CLASS) See section 7.2		P(DG_CLASS) Estimated by the operational model using the description of the traffic provided by the user. See annex II.4.	(DG_CLASS): CL1, CL21, CL22, CL23, CL3, CL41, CL42, CL43, CL51, CL52, CL61, CL62, CL7, CL8, CL9
Frequency of involvement of a DG transport unit carrying DG of class x with a containment of a given CAPACITY	F0(CLASS, UNIT_CAPACITY) See section 7.2		P(UNIT_CAPACITY) Estimated by the operational model using the description of the traffic provided by the user. See annex II.4.	(UNIT_CAPACITY): LARGE, MEDIUM, SMALL
Frequency of occurrence of a DG release of a given SIZE from a DG transport unit carrying DG of class x with a containment of a given capacity	F_DGR(CLASS, UNIT_CAPACITY, SIZE) See section 7.3 and 7.6		P(RELEASE_SIZE)	(RELEASE_SIZE): NO_RELEASE, SMALL, LIMITED, CONT, FULL
			P(SPECIFIC_CONDITIONS) Probability of occurrence of specific conditions favourable to the development of certain types of reference DG scenario See section 7.5.3	(SPECIFIC_CONDITIONS): IMMEDIATE FIRE IGNITION, DELAYED FIRE IGNITION, NO FIRE IGNITION, BLEVE CONDITION, FIREBALL CONDITION, SC_RADIATION, SC_CONTAMINATION, SC_FISSION
Frequency of occurrence of a given type of reference DG scenario	F_DGSC(SC_TYPE) See section 7.5		P(SC_TYPE)	(SC_TYPE): FIRE, POOL_FIRE, JET_FIRE, FLASH_FIRE, EXPLOSION, VCE, BLEVE_FIREBALL, BLEVE, TOXIC_CLOUD, ASPH_CLOUD, CORROSIVE_CLOUD, POLLU_SOIL, POLLU_T_SOIL, POLLU_C_SOIL, POLLU_WATER, POLLU_T_WATER, POLLU_C_WATER, RADIATION, CONTAMINATION, FISSION

7.5.2. Default – Estimation of F_DGSC

When the user does not apply any correction factor to the default values of the relevant parameters, the following settings apply:

Table 15b: Default setting of F_DGSC

F1	Extracted (relevant value) from F1 table for each type of infrastructure and operation
P(DG_UNIT)	Estimated by the operational model on the basis of the information provided by the user regarding the structure and composition of the traffic, including DG and non-DG traffic.
P(DG_CLASS)	
P(UNIT CAPACITY)	(see annex II.2 for details)
P(RELEASE SIZE)	Set to the value given in Table 13
P(SPECIFIC CONDITIONS)	Extracted from the 'Table of conditional probabilities for fires, explosions and BLEVEs' and from the 'Table of specific conditions for Class 7 scenarios' (see section 7.5.3)
P(REFERENCE DG SCENARIO TYPE)	Extracted from the 'Table of allocation of Reference DG scenarios' (relevant value of the parameter 'Conditional probability of occurrence')

7.5.3. Default – Conditional probabilities for Fires, Explosions, BLEVEs and Radioactive scenarios

These scenarios will only occur under specific conditions.

This section describes how to estimate their conditional probabilities of occurrence.

Table 16: Conditional probabilities for the occurrence of Fire, Explosion and BLEVE scenarios

Fire scenarios		
Pre-condition	**Detailed condition(s)**	**Conditional probability of ignition**
Release of Class 1 substance	**If no explosion takes place**, a fire scenario may take place if the released substance is heated by an external source	(overestimated to) 1.0
Release of Class 2 flammable gases	Initial phase: released flammable gases will ignite within a short period of time, as soon as a source of ignition is encountered. These scenarios are already taken into account in the table of allocation of reference DG scenarios. Secondary phase: subsequent fire scenarios may arise; however it is considered that most of the victims/damage will result from the scenarios resulting from ignition that have already been considered.	P(FIRE) = 1.0 (for all flammable gases)
Release of Class 3 substance	Initial phase: released flammable liquids may not always ignite. (Note: the probability of ignition will vary depending on the flammability group. This is represented by the packing group)	(*source CH*) P(IGNITION) = 60% to 70% P(IGNITION) = 0.65 (for all flammable gases)
Release of Class 4, 5, 6, 8, 9 substance	(DG scenarios to be determined)	(to be determined)

Explosion scenarios

Pre-condition	Detailed condition(s)	Conditional probability of ignition
Release of Class 1 substance	Ignition is considered for all possible explosion scenarios. It is considered to be an overestimation of the actual risk.	(overestimated to) 1.0
Release of Class 2	Vapour Cloud Explosions are considered for any *Limited, Continuous* and *Full* release of Class 2	(*source CH*) P(IGNITION) = 82% to 98% P(IGNITION) = 0.9 (for all flammable gases)
Other explosion types	BLEVEs are considered below.	(see below)

BLEVE scenarios

General assumption	It is assumed that a BLEVE can take place when a relevant **candidate** cargo for BLEVE scenarios is present: 1) in the vicinity of: 1a. a large pool fire engulfing the candidate cargo (Hot BLEVE), 1b. a jet fire impinging on the candidate cargo (Hot BLEVE), and/or 2) other types of external fire impacting the candidate cargo (Hot BLEVE), and/or 3) rupture of pressurised tank under certain conditions without **fire** (Cold BLEVE). BLEVEs are characterised by the sudden expansion of a pressurised liquid changing phase to gas when its containment is ruptured, involving pressure waves of greater or lesser severity. When the substance carried is flammable a fireball takes place consecutively to the rapid phase-change expansion.	

The probability of a **hot** BLEVE scenario is estimated with the following formula:

$$P(HOTBLEVE) = P(Candidate)$$
$$x$$
$$[P(POOL\_FIRE \mid LARGE\ CAPACITY)$$
$$+ 1/16\ x\ P(JET\_FIRE \mid LARGE\ CAPACITY)$$
$$+ P(Large\ external\ fires\ of\ non\text{-}DG\ cargo)]$$

(Note 1: the probability of relevant neighbouring cargo in the vicinity of the candidate cargo is estimated with the operational model – P(candidate)

Note 2: the user may chose, when justified, a different ratio to the default '1/16' ratio applied for the conditional probability of the impingment of jet fires on the candidate cargo).

(Candidate) Flammable liquids	Scenario: Sudden expansion with changing phase followed by a fireball	P(HOTBLEVE) with relevant P(Candidate)
(Candidate) Flammable liquefied gas	Scenario: Sudden expansion with changing phase followed by a fireball	P(HOTBLEVE) with relevant P(Candidate)
(Candidate) Non-flammable liquid	Scenario: Sudden expansion with changing phase	P(HOTBLEVE) with relevant P(Candidate)
(Candidate) Non-flammable liquefied gas	Scenario: Sudden expansion with changing phase	P(HOTBLEVE) with relevant P(Candidate)

The probability of a **cold** BLEVE scenario is estimated with the following formula:

$$P(COLDBLEVE) = P(Candidate)\ x\ P(Cold\ BLEVE\ condition)$$

(Note: the probability of relevant neighbouring cargo in the vicinity of the candidate cargo is estimated with the operational model – P(candidate)).

(Candidate) Liquefied gas	Scenario: Sudden expansion with changing phase	P(COLDBLEVE) with relevant P(Candidate)

Table 17: Conditional probabilities for the occurrence of Class 7 scenarios

> Important note:
>
> The definition of the categories of releases defined in section 7.3 is not applicable to the transport of Class 7 material which is regulated by the rules applicable to the carriage of radioactive material (SSR-6) and associated guide (SSG-26) from IAEA.
>
> The specific conditions of occurrence of DG scenarios with Class 7 material takes into account the specific conditions of transport imposed by the above rules.

Radiation		
Pre-condition of the hazardous scenario	Detailed condition(s) of the hazardous scenario	Conditional probability of the hazardous scenario
(to be determined)	(to be determined)	(to be determined)
Contamination		
Pre-condition of the hazardous scenario	Detailed condition(s) of the hazardous scenario	Conditional probability of the hazardous scenario
(to be determined)	(to be determined)	(to be determined)
Fission		
Pre-condition of the hazardous scenario	Detailed condition(s) of the hazardous scenario	Conditional probability of the hazardous scenario
(to be determined)	(to be determined)	(to be determined)

7.5.4. User setting for F_DGSC

The user of this guide should justify any changes they make to the proposed default values for any open parameters used to estimate the frequency of reference DG scenarios.

7.5.5. Minimum requirement to the user

It should be noted that this framework has been developed to improve the estimation of risks. It requires that both the frequencies and the impacts of the scenarios being considered be established. It also means that considering potential impacts without taking into account the associated frequency of occurrence does not correspond to a risk estimation but only gives estimation of potential impacts.

> Important note:
>
> Very rare scenarios (e.g. Meteorites, Aircraft crashes, Lightning strike, Flooding…) or domino effects can potentially lead to the user-specific DG scenarios.
>
> When a user considers such scenarios it is required to justify the frequency associated with the resulting DG scenarios and explain the value given to the contribution to the overall risk estimation.
>
> As a consequence, it means that scenarios whose frequency of occurrence is negligible compared to other harmonised DG scenarios may be disregarded, **for the purpose of risk estimation**, as they would not contribute significantly to the estimation of risks.

7.5.6. Improvement process for F_DGSC

If a user of this guide has suggestions for improving any of the parameters used for estimating the frequency of reference DG scenarios they should send a justified change request to the following address: https://www.era.europa.eu/activities/transport-dangerous-goods/inland-tdg_en.

7.6.   Step 6 – Harmonised impacts of reference DG scenarios (N_DGSC)

The following sections introduce the description of the pre-calculated DG scenarios and their use for the estimation of risks posed to vulnerabilities.

Annex III contains, the list of available reference DG scenarios. When available each scenario in the list may be obtained here.

The list of available reference scenarios will be updated regularly and it is advisable to refer to the latest version of the corresponding webpage.

7.6.1. Reference DG scenarios

DG scenarios are coded as follows:

[Geographical scope]_[Mode]_[DG scenario code]

The geographical scope is the area of use of the corresponding scenario.

The mode is the mode of transport to which the scenario applies. The coding values for the mode are the same as the coding values defined for the infrastructure categories in section 4.1.

The DG scenario code corresponds to the cell referencing from the table of allocation of hazards and reference DG scenarios.

As an example of the above coding, the code NL_RD_CL21_AA_2 means:

▸ [geographical scope] -> NL: reference DG scenario applicable on Dutch territory,

▸ [mode] -> RD: applies to road transport,

▸ [DG scenario code] (see DG scenario coding in section 7.4.1).

  o CL21: involving carriage of DG class 2.1

  o AA: resulting in a Vapour Cloud Explosion

  o 2: of liquefied flammable gas.

7.6.1.1. Information recorded for each reference DG scenario

The information for each reference DG scenario is available on the relevant webpage of the inland-tdg website. It is composed of the following sheets:

▸ The first sheet gives detailed information for:

    o the DG scenario being considered,

    o the DG containment category,

    o the DG release size,

    o the reference models used to calculate the distance of effects,

    o the types of vulnerability being considered.

▸ The rest of the sheets contain the calculated distances below which impacts of a given severity level affect the given category of vulnerability.

7.6.1.2. Consistency between the DG unit capacity and the applicable category of release

It must be noted that the risk analyst is responsible for consistency in defining the DG unit capacity and the category of the release size.

For example, it is evident that a quasi-instantaneous release from a DG unit of 60 tons capacity cannot occur with transport operations that use only small receptacles. The risk estimation model therefore considers only the alternatives given in Table 18.

7.6.2. User-specific DG scenarios

In the first instance, and when relevant, the user should use the reference DG scenarios available on the <u>website</u>.

Should there not be a relevant reference DG scenario for the risk situation being considered the user should complete the template for user-defined pre-calculated DG scenario(s) for each relevant scenario.

To improve the transparency of the risk-based decision-making process user-specific DG scenarios should be shared with interested stakeholders when requested.

If possible, user-specific DG scenarios should also be shared with the EUDG to contribute to the development of harmonised reference material.

Table 18: Applicable release size by capacity of DG containment unit

		Applicable category of releases (see section 7.3) - (not applicable to Class 7)				
		NO_RELEASE	**SMALL**	**LIMITED**	**CONTINUOUS**	**FULL**
Category of DG containment (see section 4.2) involved in the risk situation being considered	LARGE	For transport events in this category only the mechanical impact is estimated. No involvement of the DG substance.	For this type of release a small involvement of DG substances may be considered by the risk analyst in the context of management of workplace health and safety. For transport events in this category the mechanical impact is estimated.	No release from the main containment shell. For this type of release a limited involvement of DG substances may be considered by the risk analyst as being covered by a small capacity release with a small flow rate corresponding to the rupture of a small connecting pipe.	Duration of release x Flow rate ≤ (LARGE) Capacity	Volume of release ≤ (LARGE) Capacity
	MEDIUM				Duration of release x Flow rate ≤ (MEDIUM) Capacity	Volume of release ≤ (MEDIUM) Capacity
	SMALL			Duration of release x Flow rate ≤ (SMALL) Capacity	Duration of release x Flow rate ≤ (SMALL) Capacity	Volume of release ≤ (SMALL) Capacity
USER-DEFINED CAPACITY		(only mechanical impacts are applicable)	(consider mechanical impacts and workplace health and safety risks)	Duration of release x Flow rate ≤ (USER-DEFINED) Capacity	Duration of release x Flow rate ≤ (SMALL) Capacity	Volume of release ≤ (SMALL) Capacity

7.6.3. Estimation of the severity of damage

Reference DG scenarios or user-specific DG scenarios provide distances of effects for hazards (see second spreadsheet of each DG scenario file). This distance and the corresponding expected intensity of the effects on the various type of vulnerability are used to estimate the severity of damage.

At present, the user can directly use the relevant distance of effects proposed by the reference DG scenarios or can justify the use of user-corrected inputs, including the possible use of sheltering factors to model the effect of protection measures.

Important note:

During the course of the framework development it was identified that participating experts are using different distances of effects for similar DG scenarios.

These variations impair the comparability of risk estimation results.

This is why the EUDG will actively work on setting harmonised reference DG scenarios to be used in the application of the framework, in place of user-specific inputs. This task will also consider harmonising the use of sheltering factors.

This workflow should allow for better comparability of risk estimation results in the future.

7.7.   Step 7 – Estimation of risks

The principle behind the estimation of risks in every cell of the calculation grid is described in section 2.4.6.

The list of steps below gives an overview of the principal process for obtaining a risk estimation by using individual risk estimations and F/S curves on the basis of elementary risk calculation within each grid cells.

Phase I: Description steps

▸ Infrastructure

▸ DG Traffic

▸ Vulnerabilities

▸ Segments

Phase II: Preparing risk calculation grid

▸ Merged segments

▸ Grid cells

Phase III: Scope of the desired risk estimation results

▸ For each given DG scenario,

▸ For each given location of the DG scenario occurrence,

▸ For each vulnerability,

▸ For each time period,

▸ For each permutation of weather and wind conditions (if applicable),

Phase IV: Elementary risk estimation in each grid cell

▸ Frequency of impact

▸ Severity of impact

Phase V: First level of aggregation of individual risks and F/S curves

▶ Individual risk in a given cell:

  o   sum of all impacts received within a cell

▶ F/S curve for one DG scenario at one location:

  o   identify cells that are impacted by a given scenario at the given location

  o   sum of impacts for all affected cells

  o   frequency of occurrence of this scenario at this location

  o   building F/S curve for this scenario at each possible location

Phase VI: Second level of aggregation of individual risks and F/S curves

▶ Aggregation of individual risks and F/S curves

  o   within a segment

  o   within an infrastructure

Phase VII: Other levels of aggregation of individual risks and F/S curves

▶ Aggregation of individual risks and F/S curves within other categories is also possible:

  i)   for a given class of DG

  ii) for the whole range of DG traffic under consideration

  iii) for a given period of the day (daytime, night-time…)

  iv) other…

The detailed specification of the harmonised risk estimation process will be developed in collaboration with the EUDG in accordance with the above principles. It will be published on the website when finalised.

8. References and navigation

8.1. References

The list of references for the whole framework is available in the framework guide, in the framework glossary and in underlined additional bibliography.

8.2. Definitions and abbreviations

The list of definitions and abbreviations used throughout the framework is available from the framework glossary.

8.3. List of Figures

8.4.   List of Tables

Annexes

I – Reference F1 settings

At the date of the publication of the framework two F1 reference tables are available as listed in the List of F1 tables, as follows:

▶ EU_F1_RL was developed by the European Union Agency for Railways to set average reference values for EU railways. It is based on the use of Common Safety Indicators and additional assumptions that are necessary to reflect **freight** transport events.

▶ FR_F1_RL applies to French transport events occurring in marshalling yards, based on a French and pan-European review of available data.

I.1 – EU_F1_RL

This table provides reference settings of F1 for the following infrastructure and operational categories:

▶ F1_RL_NET_ALL: covers direct causes relevant to railway freight operations on the EU railway network. It contains the following subsets of operation types:

    o F1_RL_OLN_ALL: freight operations on all categories of open line,

    o F1_RL_STSD_ALL: freight movements in stations and sidings areas.

For other categories of infrastructure or operation the EUDG may develop further reference material when relevant information is available.

For segments of category 'F1_RL_NET_ALL'

F1 was calibrated in accordance with the method described in section 7.1 using the following source of information: the Common Safety Indicators (CSIs), the UIC public reports on safety and Eurostat database.

CSIs (reporting of years 2012 to 2014) were used to set the average yearly number of railway occurrences for passenger + freight services, as reported under the CSI regime.

UIC public reports on safety (2010 to 2013) were used to determine the proportion of (CSI-type) occurrences that are relevant for freight services (proportion of freight occurrences). On

the basis of these data this proportion was set to 20% (RELEVANCY_OPE_EU = 20%), meaning that the current model calibration assumes that 20% of significant accidents reported under the CSI regime involve freight trains operations.

UIC public Safety reports (2010 to 2013) were also used to determine the proportion of occurrences that occur on open lines (RELEVANCE_INFRA =65%) and in stations and sidings.

In accordance with these sources of information the following relevance factors have been set:

▶ In F1_RL_OLN_ALL -> RELEVANCE_INFRA=65%

▶ In F1_RL_STSD_ALL-> RELEVANCE_INFRA=35%

It is therefore assumed that 65% of occurrences reported through CSIs occur on open lines and 35% in sidings and stations.

The corresponding yearly numbers of occurrences are normalised by the applicable tonnage (1.647×10^9 tons) and ton.kilometres (4.137×10^{11}) reported for freight transport in the Eurostat 'rail_go_typeall' database.

F1 values normalised by the number of wagons operated are calculated using the number of wagon operations (5.863×10^7) estimated by the harmonised operational model.

F1_RL_NET_ALL, F1_RL_OLN_ALL, and F1_RL_STSD_ALL have been calibrated on the basis of these data.

By default F1_RL_OLN_URBAN, F1_RL_OLN_SUBURBAN, F1_RL_OLN_COUNTRY1 and F1_RL_OLN_COUNTRY2 are set to F1_RL_OLN_ALL. F1_RL_STSD_ENTRY, F1_RL_STSD_WITHIN and F1_RL_STSD_EXIT are set to F1_RL_STSD_ALL.

I.2 – FR_F1_RL

This table gives the reference setting of F1 for marshalling yards operated in France.

For the segments of type 'F1_RL_MYS_ALL'

F1 was calibrated using data reported in '*Etude de l'accidentologie liée au Transport de Marchandises Dangereuses sur les sites Européens de Triage de Wagons*' (DNV PP063376-1, PP063376-2 and PP063376-3, 10 January 2014). This study was performed on behalf of the French ministry of environment and covers the analysis of safety occurrences in French marshalling yards over the years 2000 to 2012. This study also provides a survey of available data in Europe and can be seen as the most recent European study on TDG occurrences taking place in marshalling yards. This study indicates the most relevant set of data to calibrate the harmonised model is that collected in France for 13 years of operation of French marshalling yards. It is also important to note that some European countries have used these data to calibrate their own risk models.

As a result, the information reported in this study was used in accordance with the method described in section 7.1.4.to calibrate F1 for the following segments:

▶ F1_RL_MYS_ALL

▶ F1_RL_MYS_RECEPTION

▶ F1_RL_MYS_UNCOUPLING

▶ F1_RL_MYS_SHUNTING

▶ F1_RL_MYS_DEPARTURE

> Important note:
>
> FR_F1_MYS setting is the basic frequency of **transport events** in FR marshalling yards and does not integrate the effects of risk control measures applied to specific DG scenarios.
>
> In addition to the basic frequency setting F1, the effect of TE22 and TE25 (see additional bibliography) as a safety measure reduces the probability of occurrence of some DG scenarios. This is taken into account in France to establish F_DGSC for DG scenarios to which TE22 and TE25 is applicable.
>
> This is an example of the use of FR_F1_MYS reference material for the determination of the frequency of transport events combined with the analysis of the potential effect of TE22 and TE25 on the frequency of the DG scenarios being considered.

I.3 – Other reference settings

I.3.1 – Road mode

A harmonised naming system based on CaDaS taxonomy is proposed as a template for collecting information on safety occurrences on the road mode.

The possibility of establishing corresponding F1 calibration with data reported in the CARE database (using CaDaS taxonomy) is being investigated. The relevant framework documents will be updated when this is available.

It is not currently proposed to harmonise rates of occurrence for the road segments, and users of the guide should therefore set their own calibration with appropriate justifications.

I.3.2 – Inland waterways mode

Only a few participants (NL and CH) in the TDG roadmap workshops reported information on typical inland waterway safety occurrences. This information was used to set a harmonised naming system for safety occurrences on the different types of inland waterway segments. However, too little information is recorded in the annual numbers of occurrences and therefore no harmonised rate of occurrence is proposed for the calibration of F1. Users of the guide should therefore set their own calibration with appropriate justifications.

I.3.3 – Multimodal platforms

A harmonised naming system is proposed for a template to collect information about safety occurrences involving multimodal platforms. No harmonised rate of occurrence is proposed for the calibration of F1 due to the absence of relevant data. Users of the guide should therefore set their own calibration with appropriate justifications.

I.4 – Estimation of F1 in a given segment of a use case

The reference settings of F1 in 'F1_..' tables is used to allocate a value for F1 over each segment of a use case, as described by the user in accordance with section 4.1.

From the user description, for segment 'i' the user knows:

▶ The transport operation category of each segment (TYPE_SEG(i))

▶ The reference direct causes (DCj) for each segment
  (list of DCj reported in F1 tables for each segment type)

▶ The reference F1 frequency of the segment type F1_REF(TYPE_SEG(i))

▶ The reference volume of transport which was used to establish the reference F1 value (N_T_REF, N_TK_REF, N_TU_REF),

▶ The volume of transport considered in the use case (N_T_USR, N_TK_USR) (described by the user in 'Use case – Traffic description' document),

▶ The reference number of transport units (N_TU_USR) for each segment is provided by the 'Operational model' or corrected by the user of the F1 tables.

▶ The length of the considered segment li(SEG(i))

On this basis the user can allocate a F1 value applicable to each segment (F1_T_SEG(i)).

Figure 28: Default setting of F1 values over user-described segments of infrastructure
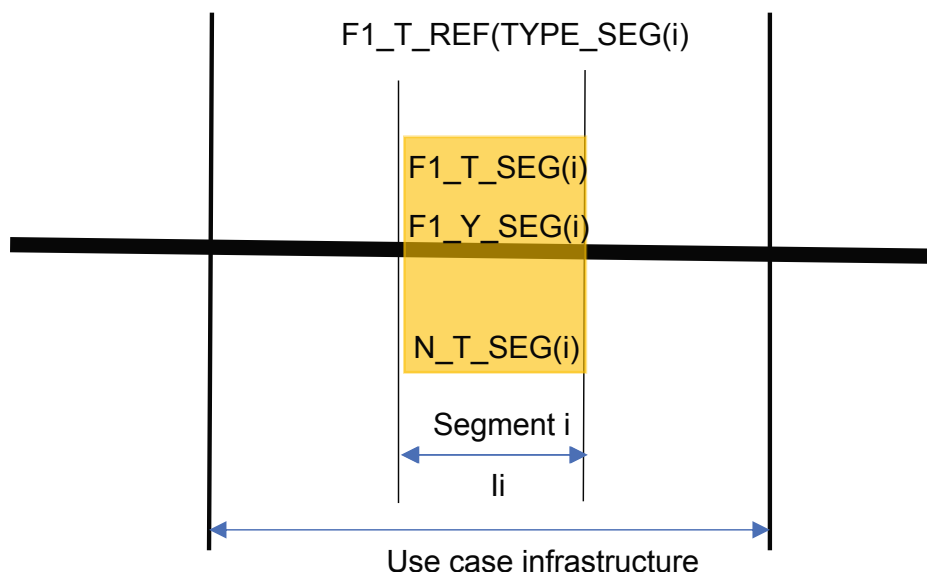
The reference frequency of occurrence in segment i is given by:

$$\text{F1\_T\_SEG}(i) = \text{F1\_T\_REF}(TYPE\_SEG(i))$$

The yearly reference number of safety occurrences in segment i corresponding to the volume of transport (tonnage) over the segment i is given by:

$$\text{N\_OCC}(i)/\text{Y} = F1\_Y\_SEG(i) = \text{F1\_T\_SEG}(i) \times N\_T\_SEG(i)$$

> **Important note:**
>
> If F1_T is not defined for a given type of operation then the reference frequencies normalised in number of transport unit operation (F1_TU) can be used in its place. In this case the same formula applies to calculating F1_Y_SEG(i).

At this stage it is also possible to define F1_Y_SEG_DC(i,j), the frequency of occurrence of the reference direct causes (DCj) for each segment i, using the breakdown of direct causes that is relevant for the segment type.

The applied formula is the following:

$$F1\_Y\_SEG\_DC(i,j) = F1\_Y\_SEG(i) \times N\_ROCC\_USR(j) \, / \, \text{F1\_Y\_REF}(TYPE\_SEG(i))$$

> **Important note:**
>
> Section 6 of the framework guide proposes that, as part of future development, the EUDG will specify the detailed characteristics of a risk estimation engine based on this approach.

II – Transport operational model

II.1 – Harmonised description of transport operations (default)

II.1.1 – Harmonised description of cargo sizes

As agreed at the 10th workshop on TDG risk management, the risk estimation model considers the following categories of cargo sizes:

▶ Capacity category A: Cargo composed of maximum capacity tanks or maximum size bulk cargo represented in the transport model with this symbol:

▶ Capacity category B: Cargo composed of medium capacity cylinders or medium size bulk cargo represented in the transport model with this symbol:

▶ Capacity category C: Cargo composed of articles and packaging represented in the transport model with this symbol:

Default cargo capacities (in tons) and default breakdown of cargo sizes (% of transport tonnage) are allocated for each DG class. The default allocation of cargo size and breakdown is based on EU region transport statistics and is recorded in document 'Default – Traffic parameters' in the tables 'DG CType tonnage' and 'DG traffic – BKD CType':

▶ Default – Traffic parameters,

▶ Generic names of capacities are defined by:

    o [RD, RL, IWW, MMP]_CC_[A, B, C]_T,

The variable part of the name is selected in accordance with the applicable mode and capacity category.

    o Example: RD_CC_A_T means Road cargo with capacity category A expressed in tons.

II.1.2 – User-defined sizes of cargo

The default size of cargo is a 'closed' parameter that cannot be changed by the user because pre-calculated tables of hazardous areas have to be consistent with the potential volume of the DG substance involved and thus the size of cargo (DG substance capacities) and

because, in order to ensure a good level of harmonisation, the pre-calculated tables cannot be corrected by the user.

This is also justified by the fact that typical sizes of cargo are set by international conventions/agreements on the transport of dangerous goods.

II.2 – Breakdown of cargo sizes in transport planning

II.2.1 – Statistical breakdown in EU region (default setting)

For each mode of transport and for each class of dangerous goods the average breakdown of capacity categories is set in accordance with the views of TDG experts who participated in the TDG workshops.

In the future these statistics may be more accurately set by using information reported in electronic transport documents.

For the moment the harmonised default breakdown is set on the basis of expert judgement.

II.2.2 – User breakdown for a given use case (user setting)

Transport planning is one potential risk management measure (for example, avoiding large capacity transport in densely populated areas or during the daytime).

This is why the transport capacity breakdown is an 'Open' parameter can be adapted by the user for each segment of the described transport/operational activity of a given use case.

The user has access to this parameter in the document <u>Use case – traffic description</u> in the table 'DG traffic – BKD CType'.

II.3 – Modelling of given transport/operational planning

The transport/operational model assumes that given transport/operational planning is fully defined in respect of the following elements:

Breakdown of DG tonnage within the total freight tonnage carried:

- o Carrying DG (T_DG %)
- o Not carrying DG (T_NON_DG %); ,

Breakdown of DG transport units into the following predefined cargo categories:

▸ DG cargo, of the categories defined in section II.1.1:

- o Capacity category A (CC_A %); ,

   o Capacity category B (CC_B %); ,

   o Capacity category C (CC_C %); ,

▶ Multimodal DG containers, of the categories defined in section II.1.1:

   o Capacity category A (MM_CC_A %); ,

   o Capacity category B (MM_CC_B %); ,

   o Capacity category C (MM_CC_C %); .

Single or Multiple transport unit Compositions:

▶ Heavy Goods (road) Vehicle with one or more trailers,

▶ Train composed of a given number of wagons (rail mode),

   o Complete DG trains: only composed of DG wagons,

   o Mixed DG trains: composed of DG and non-DG wagons,

   o Normal freight compositions (without DG cargo).

▶ Vessels or rake of vessels carrying one of more Vehicles or Transport units (inland waterways mode).

Default EU multiple unit compositions are defined in the document 'Default – Traffic parameters (DG traffic – BKD CType)', based on EU transport statistics and TDG expert judgment[5].

In addition, the user can define the default composition of the traffic to be considered in a given use case with the document 'Use case – Traffic description(DG traffic – BKD CType)'.

When the above transport/operational characteristics have been set by the user (either using default settings or user-defined settings) the operational model calculates the number of each type of transport unit for each class of dangerous goods being carried and for each type of multiple unit composition that is necessary to transport the defined tonnages with loaded cargoes.

II.4 – Estimation of P1 using the 'operational model'

The 'operational model' is used to estimate various conditional probabilities, based on the characteristics of the traffic as described by the user.

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[5]   In the future this setting may be established using the information recorded in electronic transport documents.

Basically, the operational model provides the following conditional probabilities:

▶ P(DG_UNIT) = P1: probability that a DG unit is involved in a transport occurrence,

▶ P(DG_CLASS): probability that a given DG class is involved in a transport occurrence,

▶ P(UNIT CAPACITY): probability that a given size of DG cargo is involved in a transport occurrence.

Other conditional probabilities that are related to the characteristics of each given mode are estimated by the operational model, for example:

▶ Probability that a transport occurrence involves a complete DG train,

▶ Probability that a given DG class cargo is adjacent to another DG class cargo,

▶ …

The above probabilities are notably used for estimating P(candidate) as described in section 7.5.3.

The detailed specifications of the operational model will be developed by the EUDG as part of the specification of a future risk estimation web application.

II.5 – Calibration of F0 / F1 consistency

The frequencies of the predefined categories of release are analysed in this section. This takes into account the work developed under the auspices of the UNECE/OTIF Working Group on BLEVE and from sources reported by the participating members.

The following tables record the analysis made during the development of the framework, leading to the proposed harmonised conditional probabilities for the different categories of release reported in section 7.3.

Table 19: Analysis of relevant information for the setting of conditional probabilities for the different categories of release – Inland waterways

WATERWAYS							
Sources of information and related setting of the release probabilities			**Relevant information for the breakdown of defined release categories**				
	Source	Scope of the analysis	NO RELEASE	SMALL RELEASE	LIMITED RELEASE	CONTINUOUS RELEASE	FULL RELEASE
No information received on this topic during the TDG roadmap							

Table 20: Analysis of relevant information for the setting of conditional probabilities for the different categories of release - Railways

RAILWAYS							
Sources of information and related setting of the release probabilities			**Relevant information for the breakdown of defined release categories**				
	Source	**Scope of the analysis**	**NO RELEASE**	**SMALL RELEASE**	**LIMITED RELEASE**	**CONTINUOUS RELEASE**	**FULL RELEASE**
Railways (open lines)	UIC-UTP[8] *Note: events corresponding to the normal functioning of pressure relief valves are not considered as releases, as they are a normal functioning of a safety device.*	Railway TDG events of DG Class 2 in France (1998-2014) 49 events on open lines	17/49 (35%)	30/49 (61%)	2/49 (4%)	0/49 (0%)	0/49 (0%)
Railways (sidings, stations and marshalling yards)		Railway TDG events of DG Class 2 in France (1998-2014) 459 events in sidings, stations and marshalling yards	185/459 (40%)	222/459 (48%)	26/459 (5.7%)	26/459 (5.7%)	0/459 (0%)
Railways (open lines)	UIC-UTP[9,10]	Railway TDG events of any DG Class in France (1998-2014) 451 TDG events on open lines	76/451 (16.8%)	311/451 (69%)	43/451 (9.5%)	21/451 (4.7%)	0/451 (0%)
Railways (sidings, stations and marshalling yards)	UIC-UTP[9,10]	Railway TDG events of any DG Class in France (1998-2014) 2433 TDG events in sidings and marshalling yards	805/2433 (33.1%)	1390/2433 (57.1%)	200/2433 (8.2%)	36/2433 (1.5%)	0/2433 (0%)
Railway derailments and collisions on open line	RIVM[11]	Different sources of data are used and combined to draw conclusions: European leak frequencies and Dutch damage frequency of freight wagons.	The conclusions concerning the estimated outflow is probably not applicable to these two categories of event		(Outflow ratio per damaged wagon applicable to the sum of limited and continuous considered occurrences) (7.4% for DG Class 2) (8.8% for DG Class 3)		Important note[12]

8   Source: UIC-UTP – 26/01/2018 – Analyse des données du document UIC/UTP du 28/01/2015 du point de vue des catégories de rejet étudiées dans le cadre du workshop TDG (RID-ADR-ADN) pour les gaz.

9   Source: UIC-UTP – 11/01/2018 – Analyse des données du document UIC/UTP du 28/01/2015 du point de vue des catégories de rejet étudiées dans le cadre du workshop TDG (RID-ADR-ADN).

10   Source: UIC-UTP-SNCF (Document de travail 28/01/2015) communiqué au groupe de travail BLEVE concernant les événements du TMD ferroviaire (France) Données 1998-2014

11   National Institute for Public Health and the Environment, The Netherlands, "towards a new risk-calculation method for the transport of dangerous goods by rail", RIVW report 620550010/2014, sections 8.1 and 8.2

12   RIVM indicated that 'some' events of their data based would fall in this category however the proportion of these releases compared to the other events of the source was not communicated. Therefore it was not possible to allocate a well justified percentage to this category.

Table 21: Analysis of relevant information for the setting of conditional probabilities for the different categories of release - Roads

ROADS

Sources of information and related setting of the release probabilities

	Reference	Scope of the analysis	Relevant information for the breakdown of defined release categories				
			NO RELEASE	SMALL RELEASE	LIMITED RELEASE	CONTINUOUS RELEASE	FULL RELEASE
Roads	UNECE/OTIF Informal working group on BLEVEs	FR reporting in accordance with 1.8.5 (1998-2009) 1371 occurrences (all DG classes)	(No spill) (55%)		622/1371 (Spills of any category) (45%)		
Roads	UNECE/OTIF Informal working group on BLEVEs	FR reporting in accordance with 1.8.5 (1998-2009) Class 2 (249 events, including 165 events with LPG for a volume of traffic of 9 million kilometres)	LPG (no information allowing estimation of small release ratio) (65.7 %)		46/158? (29%?)	10/158? (6%?)	2/158 (BLEVEs) (1.3 %)
			Other Class 2		25/77 (32.5%)		0/77 (0%)

III – Selection of Reference DG scenarios

III.1 – Harmonised DG scenarios

The experts involved in the development process had not harmonised the reference DG scenarios at the time of the publication of the framework of guides, therefore only a list of 'user' specific scenarios is made available at this stage (see section III.2).

It is already anticipated that the EUDG will continue the development of reference DG scenarios, including the establishment of harmonised scenarios. This task is part of the improvement and development process in section 6 of the Framework guide.

In the future it is envisaged that the EUDG should deliver harmonised reference DG scenarios for every relevant cell of the table of allocation of hazards and reference DG scenarios.

Regular updates of the available reference material will be published on the website.

III.2 – User-specific DG scenarios

At the time of the publication of the framework it was possible to establish a first list of DG scenarios that are currently used in (non-harmonised) risk estimation practices in some of the participating countries, and covering the three modes of Inland transport.

This list will be regularly supplemented and updated on the basis of the change requests sent to the EUDG in accordance with the process of improvement of the framework in section 6 of the Framework guide.

The list of available user-specific DG scenarios can be consulted here.

IV – Estimation of DG Scenario impacts

As indicated in annex III, only users' specific material is currently available for reference DG scenarios. This may result in differences in the processes of estimating the corresponding impacts.

Therefore this annex will be further developed with the EUDG and a corresponding detailed methodology will be made available on the inland-tdg website.

V – List of parameters used in the harmonised risk estimation model

As the <u>list of parameters</u> will be updated regularly in accordance with the process of improvement described in section 6 of the Framework guide, please use the link to refer to the currently applicable document.

VI – Conversion tables for quantitative and qualitative risk results

The risk estimation method presented in this guide uses an explicit quantitative approach.

However it might be useful to provide interested parties with verbal scales allowing the conversion of quantitative risk estimation results into qualitative risk estimation results.

At the date of the publication of the framework these conversion tables require further development by the EUDG in accordance with the process of improvement of the framework (section 6 of Framework guide).

The latest update of these tables will be available here.

Risk management framework for Inland transport of dangerous goods:

▸ Framework guide

▸ Guide for decision-making

▸ **Guide for risk estimation**

▸ Framework glossary

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