

Disasters and Emergencies in Switzerland 2020

National risk analysis methodology



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Federal Office for Civil Protection FOCP

This report documents the methodological approach used in the national risk analysis 'Disasters and Emergencies in Switzerland 2020' (DES 2020). The methodology ensures the systematic and comparable analysis and evaluation of hazards and their associated risks, and the generation of transparent results.

IMPRINT

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Summary

The present report, which details the methodology used in the national risk analysis 'Disasters and Emergencies Switzerland' (DES for short), forms the basis of the updated and expanded national risk analysis DES 2020.

The report describes the general conditions and the three-step methodology used in DES 2020, namely (1) risk identification and hazard selection; (2) risk analysis and scenario development; and (3) risk evaluation and risk presentation.

The methodology ensures that the risk analysis of the hazards covered in the DES 2020 is systematic, and that the assessed risks can be compared and are transparent.

The DES methodology is the result of a best practice approach. It was first used in the risk report from 2012 and published as version 1.03 in 2013. The 2.0 version, which is used here, is by and large the same as the original version. However, major changes were made to plausibility assessments for maliciously induced events. In addition, some marginal cost calculations and scales were adapted in response to more recent findings.

The method report is geared primarily to those in charge of the risk assessments for DES, but is equally useful for a wider circle of users interested in a tried and tested approach to risk analysis.

The report is divided into five sections:

Section 1 (Introduction) provides an overview of the objectives and target readership, the development of and adjustments to the national risk analysis methodology and the methodology report.

Section 2 (Risk identification and hazard selection) describes the procedure used to identify the relevant hazards and compile them in a hazard catalogue. It also sets out the process used to select the hazards which will undergo a more in-depth risk analysis.

Section 3 (Risk analysis and scenario development) explains the scenario-based approach applied to the risk analysis and the ranking of the analysed scenarios on an intensity scale.

Section 4 (Risk evaluation and risk presentation) sets out the risk evaluation method. It notably includes the use of expert elicitation to estimate the extent of damage, likelihood of occurrence (for non-maliciously induced events – also called non-deliberate events) and plausibility (for maliciously induced events – also called deliberate events) of the scenarios under consideration. It also details how risks are presented.

Section 5 (Interpretation of the results) deals with the different aspects that must be taken into account when interpreting the results and performing a risk assessment, such as fuzziness, risk aversion and sensitivity analyses.

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1 Introduction

‘Disasters and Emergencies in Switzerland’ (DES), Switzerland’s national risk analysis, is a core component of emergency and disaster preparedness, and foundational to national disaster management and civil protection activities. DES makes it possible to identify hazards of relevance to Switzerland, determine the risks they pose and make informed decisions on the appropriate emergency and disaster prevention and preparedness measures. DES is a helpful tool for risk dialogue, risk comparisons, risk prioritisation and preparedness planning. It is also part of the documentation for emergency responder training and drill and exercise planning.

DES is a three-step method:

- risk identification and hazard selection
- risk analysis and scenario development
- risk evaluation and risk presentation.

The products of all three steps detail the procedure used and the results. (FOCP, 2019; 2020a, 2020b, 2020c)

1.1 Objectives and target audience

The ultimate objective of DES is to provide risk-based planning assumptions for emergency and disaster preparedness, based on a transparent and comparative outline of the risk landscape.

The primary target audience are federal experts and the multi-agency emergency management teams operating at the cantonal, regional and communal levels. Equally, DES products are used in various programmes and projects that address risk-related issues.

DES lays the groundwork for better coordination of disaster management planning and development in Switzerland. Its method and products facilitate a more systematic approach to disaster and emergency preparedness and foster a more comprehensive risk culture.

The method, presented below, describes the risk assessment procedure and bases used in DES 2020. Thanks to this method, the risks for each hazard can be determined in a consistent manner and compared in a comprehensible and transparent way. Objective comparisons are critical for civil disaster management. There are two main reasons for this: the breadth of the hazards involved and the need for the civil protection system to use its limited resources in a targeted and efficient manner.

The method report is geared primarily to those in charge of the risk assessments for DES, but is equally useful for a wider circle of users interested in a tried and tested approach to risk analysis.

1.2 History of Switzerland’s national risk analysis

In 2008 a project was launched to develop a national risk analysis. Since then, the FOCP has incorporated the analysis into its ongoing activities. This work process comprises multiple steps: the identification of relevant hazards; the construction of new scenarios; the updating of the risk assessments and impact and risk diagrams; and the review and further development of the methodological bases.

Work on the latest update – DES 2020 – began in 2017 and ended in 2020. A total of 143 experts were involved in the largely workshop-based process; in some cases, they also provided their input by correspondence.

The method used in DES was first published in 2013 (FOCP, 2013a). It was developed by experts from the public administration, academia and the private sector, and validated in a joint workshop (FOCP, 2011). It draws on earlier analyses for civil protection in Switzerland, e.g. KATANOS (FOCD, 1995) and KATARISK (FOCP, 2003), as well as comparable work in other countries (BBK, 2010; Cabinet Office, 2008, 2010, 2012; DHS, 2011; Ministry of the Interior and Kingdom Relations, 2009). The development process additionally drew on international standards and guidelines (ISO/PAS 22399, 2007; European Commission, 2010).

The method adopted in DES 2020 is a revised version of the one used in 2013 (FOCP, 2013a). Section 1.3 details the changes that were made; most were prompted by comparable publications released by the United Kingdom (Cabinet Office, 2017) and Singapore governments. The revision also drew on ISO norm 31000 (ISO 31000:2018) and the Dutch National Risk Assessment (ANV, 2019).

1.3 Methodological changes

The methodology used to assess the plausibility of maliciously induced events (also called deliberate events) has been radically reworked. Changes were made to several marginal cost rates and damage scales. The new procedure and adjustments were incorporated in DES 2020.

1.3.1 Plausibility assessment

The original method to assess the plausibility of maliciously induced events was used in DES 2012 (FOCP, 2013b) and DES 2015 (FOCP, 2015a, 2015b) and generated satisfactory results. However, the 2015 risk report also recommended improvements, including a clearer definition of the criteria and more transparent assessments.

In DES 2020, the expert-based Delphi method has been supplemented by an indicator-based approach. Like its predecessor, the new technique was developed by various expert groups and validated in workshops. The national risk analyses of the United Kingdom (Cabinet Office, 2017) and Singapore similarly apply an indicator-based approach. The FOCP took certain elements from both reports and adapted them to the context in Switzerland. The Federal Intelligence Service (FIS) and the Federal Office of Police (fedpol) were also involved in the development process.

Following discussions between the experts, the decision was taken to reduce the plausibility classes from eight to five. In addition, the qualitative descriptions in DES 2020 are now graded more finely (from 'highly plausible' to 'hardly plausible') than those used in DES 2015 (from 'relatively plausible' to 'hardly imaginable'). As a result, the plausibility class descriptions in DES 2020 and DES 2015 do not translate one for one. Nonetheless, a comparison of the relative ranks in the risk diagrams and of the impacts remains possible.

1.3.2 Marginal costs

Adjustments were also made to the marginal costs, based on findings from various studies undertaken since DES 2015. They are as follows:

- Marginal costs for *I1 – Fatalities* were increased from CHF 5 million to CHF 6 million per fatality.¹ As in 2015, CHF 1 million of the marginal costs per fatality is assigned to indicator *Ec2 – Reduction of economic performance*.
- Marginal costs for *I2 – Injured / sick people* are still calculated as 10% of the marginal costs per fatality (excl. the share assigned to *Ec2*). They now amount to CHF 500,000 per individual who is sick or injured (DES 2015: CHF 400,000).

- Marginal costs for indicator *En1 – Damaged ecosystems* were adjusted in the line with the assumptions in the FOCP critical infrastructure protection (CIP) guide. The July 2018 version estimates the value of damage at CHF 330,000 CHF per km², per year.
- Marginal costs for indicator *S2 – Diminished public order and domestic security* were increased from CHF 300 to CHF 500

1.3.3 Scales of damage indicators

In the damage indicator scales, the class limits must have the same monetised value for all indicators. Consequently, adjustments had to be made to the scales for indicator *S1 – Supply shortfalls and disruptions*.

Indicator *S4 – Damage to and loss of cultural property* was also adjusted. In DES 2020, damage classes have been increased from five to six; only the highest class – A6 – now covers cultural objects of international importance, down from three classes in 2015. Accordingly, changes were made to the descriptions of the other damage classes.

¹ The higher marginal costs are based, among others, on the Federal Office for Spatial Development (ARE) study '*Empfehlungen zur Festlegung der Zahlungsbereitschaft für die Verminderung des*

Unfall- und Gesundheitsrisikos' (Ecoplan, 2016). It determined that the value of statistical life (VOSL) was CHF 6.2 million (2016 figures).

2 Risk identification and hazard selection

The risk identification process relies on a ‘hazard catalogue’ (FOCP, 2019) detailing all civil protection-relevant hazards that could significantly affect Switzerland or could cause extensive damage. The hazards featured in the national risk analysis are drawn from this catalogue and undergo a deeper risk analysis for DES purposes.

2.1 Risk identification based on the FOCP hazard catalogue

The hazard catalogue assigns hazards to one of three categories: natural, technological and societal. All could, in principle, occur in Switzerland or have a significant impact on the country.

The hazard catalogue is reviewed periodically – usually every 5–6 years. Experts from the federal and cantonal administrations, as well as members of the academic community and private sector are involved in this process. The 2019 hazard catalogue is the result of a consultative workshop attended by 56 participants.

Another point of reference for the hazard catalogue is the civil protection trend analysis (Roth et al., 2014; Hauri et al., 2020), conducted by the FOCP and the Center for Security Studies at the ETH Zurich. This study identifies the medium- and long-term trends of relevance to civil protection and analyses their impact.

The hazard catalogue also draws on studies of emerging risks. They include SONAR, published every year by Swiss Re (Swiss Re, 2020), the Global Risks Report of the World Economic Forum (WEF, 2020) and the UN Global Risk Assessment (UNDRR, 2019).

2.2 Hazard selection

Several criteria are used to determine the hazards that will undergo further analysis.

Hazards and events are selected which have led, at least once, to a disaster or emergency in Switzerland (e.g. earthquakes and flooding). Also included are major loss

events in other countries which could occur in Switzerland (e.g. a widespread blackout). A further category includes events that could potentially lead to a disaster or emergency situation (e.g. a dirty bomb or other serious terrorist attack).

This means that the scope of the catalogue extends to hazards that require a coordinated response from civil protection partners or the deployment of a multi-agency emergency management team. The competent authorities are also consulted on whether other hazards should be studied and analysed and, if so, which ones.

Every review cycle, checks and any necessary changes are made to the list of hazards, which will undergo a more detailed analysis as part of DES.

3 Risk analysis and scenario development

Once the selection has been made, a scenario-based risk analysis is performed for each hazard. First, the fundamentals are established and a range of scenarios of differing intensities are built; those which fall into the ‘major’ category (see Section 3.2) are developed in greater detail. One of the main products generated by this analysis are the hazard files (see Section 3.3).

3.1 Scenario-based approach

In disaster management, scenario development is an instrument that is frequently used to establish the bases for preparedness efforts. In DES, scenarios are built for each hazard chosen for the risk analysis; these outline the trajectory that an event might follow.

Scenarios are not the same as forecasts. Rather, they serve to provide a framework for assessing the different courses that a disaster or emergency could take. Developing possible scenarios for each hazard makes it possible to anticipate how such an event could evolve and the effects it might have. This means that the potential impact of an event is identified before it actually happens.²

The extent of damage and the likelihood of occurrence is determined for each scenario. This information is then used to determine the risk of the given hazard.

3.2 Scenario intensity

In DES, each hazard is characterised according to three scenarios of differing intensity – or escalation – levels. This approach ensures that not only one but several possible courses of an event are considered when analysing the hazard.

For each of the three levels of intensity – significant, major and extreme – a scenario is built for each hazard. The intensity of these events, as well as the extent of the damage they could cause are considerably greater than those for

everyday events (e.g. sporting or traffic accidents). Consequently, the response to them requires the coordinated deployment of the entire pool of civil protection resources.

Intensity levels are determined by the characteristic of the hazard in Switzerland and by the reference framework provided in the national risk analysis.

In DES, the ‘major intensity’ scenario is described in detail and forms the basis of the risk evaluation (cf. Fig. 1, p. 13). Applying the same intensity level across all scenarios makes it possible to compare the risks of different hazards.

The three intensity levels are defined as follows:

- **Significant**
A scenario that is considerably more serious than an everyday event. These scenarios are, for example, relevant for communal and cantonal hazard and risk analyses.
- **Major**
A scenario of great intensity. Their incidence in Switzerland could be even higher, and the course they take more severe.
- **Extreme**
A scenario of extreme intensity. The occurrence of this type of event in Switzerland is not entirely beyond the realms of possibility.

Hazard-specific parameters are used to characterise the different levels of intensity. These are factors which influence the impact that an event has, e.g. wind speed in the case of storms; duration in the case of a blackout; duration as well as spatial extent for *droughts*. As the intensity of the event rises, e.g. the higher the magnitude of an earthquake is, the greater the impact it has. However, the intensity–damage increase is not the same for all hazards. For example, the effects of a spreading forest fire do not increase to the same degree as those caused by a protracted blackout.

² A recent research paper categorises the DES methodology as a ‘storyline’ approach (Shepherd et al., 2018). Storylines are particularly useful for analysing risks in which interaction of several influencing factors can cause serious damage and thus lead to a disaster or emergency situation. They go beyond standard modelling of probabilistic approaches because they vividly capture a hazard and

take multiple effects into account. This guards against bogus inaccuracy and helps avoid surprises (Shepherd, 2016). Storylines also facilitate the necessary risk dialogue in politics, business, the media and the population.

Table 1: Description of the main values for the scenarios of “significant”, “major” and “extreme” intensity, using three hazards in the domains nature, technology and society as examples.

Intensity	Earthquake	Dam accident	Animal disease outbreak
1 – significant	Magnitude approx. 5.5 Intensity (EMS) VII (building damage) No aftershocks Damage radius 25 km Radius of damage epicentre 5 km Low infrastructure density Time: afternoon	Overflowing due to blocked spillway Season: start of summer Advance warning: a few hours Small villages in flood area (several hundred inhabitants at risk)	Individual regions in Switzerland affected Appears first in surrounding countries (advance warning) The causative agent is known Low infection rate
2 – major	Magnitude approx. 6.5 Intensity (EMS) IX (destructive) Aftershocks occur Damage radius 80 km Radius of damage epicentre 25 km High infrastructure density Time: late spring, weekdays in the morning	Spillover due to rock slide into the reservoir Season: autumn (reservoir full) Populated valley in the flood area (large village, a number of farms and individual industrial businesses; a few thousand people at risk in total) Advance warning: a few days Time of occurrence: daytime	Whole of Switzerland affected Appears first in surrounding countries (advance warning) The causative agent is known High rate of infection
3 –extreme	Magnitude approx. 7.0 Intensity (EMS) XI (devastating) Aftershocks occur Damage radius 120 km Radius of damage epicentre 40 km High infrastructure density Time: winter, at night	Failure due to unexpected geological movement of an abutment No warning signs; advance warning limited to time it takes for dam water to reach populated area Almost entire content of dam emptied in a matter of minutes Densely populated valley in the flood area	Whole of Switzerland affected Occurs first in Switzerland (no advance warning) The causative agent is known or unknown High rate of infection

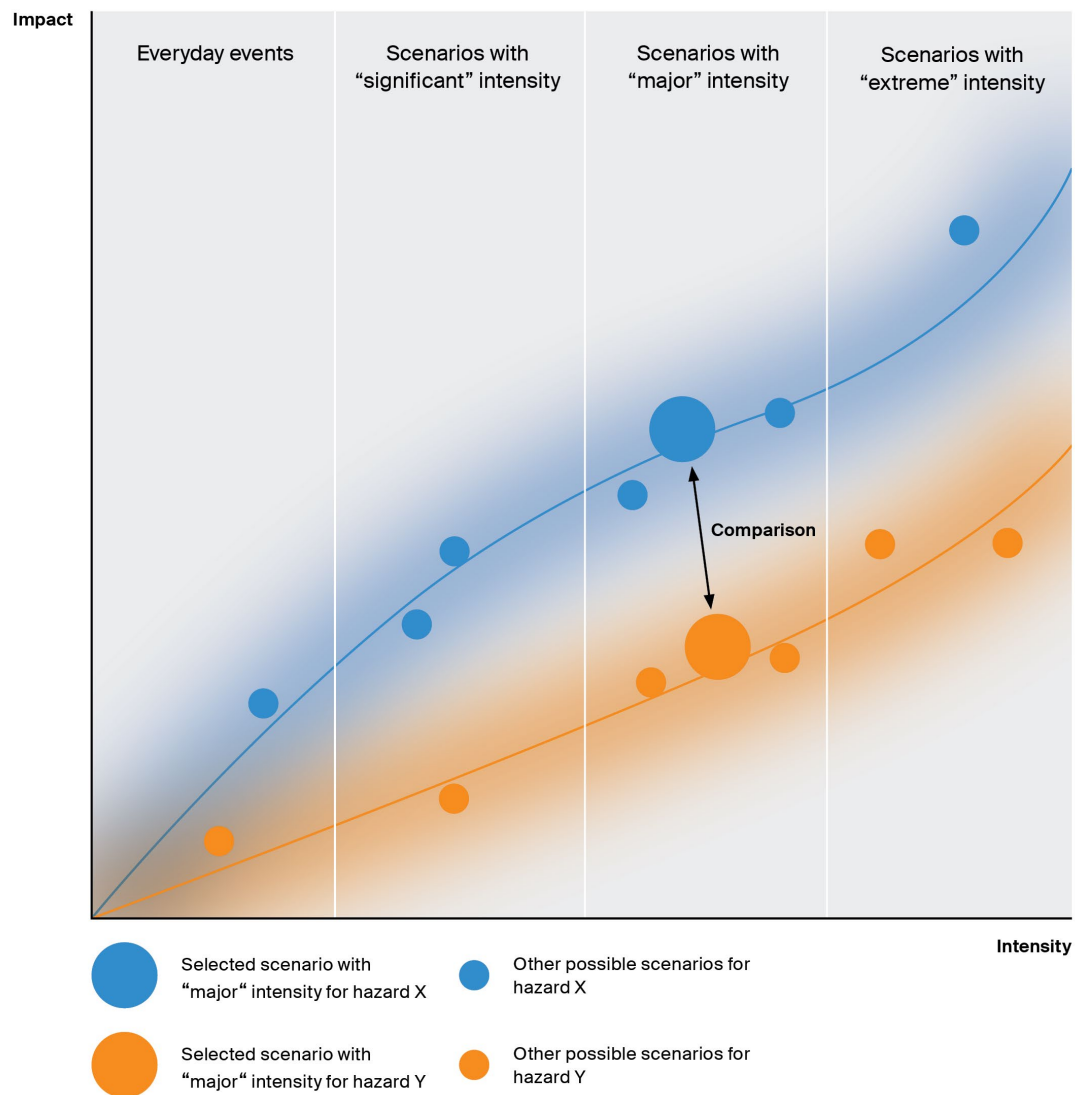


Figure 1: Schematic depiction of the process for selecting and comparing scenarios used in the national risk analysis (DES). From the three scenarios of significant, major and extreme intensity, the scenario “major” was described and evaluated in detail for two different hazards. This makes it possible to compare risk evaluations of multiple hazards in one risk diagram.

3.3 Hazard files

Hazard files (FOCP, 2020a) are an important product of the risk analysis.

To create a hazard file, the project team first puts together a draft document based on a pre-determined set of guidelines. This work is then corrected and validated by experts from the Federal Administration, the academic community and the private sector. The relevant agencies also participate in the scenario development and review process. The hazard file is finalised once all necessary changes have been made.

The major intensity scenario contains a detailed description of the course of the event and its impact. This is based on known events wherever possible, but also factors in potential developments in the future. The description focuses primarily on the effects that the given scenario is expected to have. Damage indicators are used to quantify the damage to four areas: individuals, the environment, the economy and society.

The sections and respective contents of the hazard files used in DES 2020 are shown in Table 2.

Table 2: DES 2020 hazard files – Content overview

Hazard file DES 2020 Section	Content
Definition	Definition of the hazard, including – in certain cases – distinctions relative to other hazards
Examples of events	Examples of events with major intensity in Switzerland or other countries
Influencing factors	Factors which influence the emergence, evolution and effect of a hazard (source of danger, timing, location, scope, course of event)
Scenario intensity	Outline of the scenario according to three different levels of intensity – significant, major and extreme
Scenario	Detailed description of a major-intensity scenario – initial position / pre-phase – event phase – recovery phase – timeline – spatial extent of the event
Extent of damage	Impact, including impact diagram, on – individuals – environment – economy – society
Risk	Risk diagram for deliberate or non-deliberate events respectively, in each case with all related hazards
Legal bases	Legal bases (Federal Constitution, acts and ordinances)
Additional information	Additional information – about the hazard – about the national risk analysis

4 Risk evaluation and risk presentation

The risk evaluation is the central analytical and participatory component of ‘Disasters and Emergencies in Switzerland’ (DES), Switzerland’s national risk analysis. The risk of each hazard is estimated in individual expert elicitation workshops.

Risk is defined here as the measure of the hazard potential of an event or development. It comprises two factors: extent of damage (negative impact on the population and their livelihoods) and the likelihood of occurrence for non-maliciously induced events (also called non-deliberate events) and the plausibility of maliciously induced events.

The impact of each hazard is estimated by means of 12 damage indicators and its monetary value is expressed as marginal costs.

The two variables – extent of damage (see Section 4.3) and likelihood of occurrence or plausibility, respectively (see Section 4.4, p. 31 and Section 4.5, p. 32) – of different events can be put in relation to each other and be visualized together in a risk diagram. This makes it possible to compare the risk assessments of various hazards.

4.1 General approach

In general, information on the potential impact and likelihood of occurrence or plausibility, respectively of each hazard is derived from existing data as well as other sources such as event analyses, statistics, literature and other scenarios. Where possible, this information is incorporated in the scenarios used in ‘Disasters and Emergencies in Switzerland’ and validated by experts from the federal and cantonal authorities.

Where information is lacking or there are significant uncertainties as to the extent of the impact or the frequency or likelihood of occurrence of scenarios, these are assessed by experts in a workshop setting. The process may also draw on the results generated by frequentist and

other probabilistic models (e.g. event and fault tree analyses) or by means of expert elicitation.³

Expert elicitation⁴ is commonly used in risk analyses. This carefully executed subjective survey (see Section 4.2) makes it possible to estimate risk values (frequency and extent of damage) even when there is insufficient empirical data (Beaudrie et al., 2016).

These estimates are made in a group discussion setting based on the Delphi method (see Section 4.2 on the Delphi method workshop).

The Delphi method is also used to estimate the plausibility of maliciously induced events (see Section. 4.5.3, p. 35).

Such an approach makes it possible to render subjective hazard assessments as objective as possible. The selection of experts to perform the estimates is depending on the information required to capture the different aspects (causes, causal chains, effects etc.) as fully as possible.

4.2 Expert elicitations

In DES the extent of damage and the likelihood of occurrence or plausibility, respectively of scenarios is estimated in expert elicitation workshops. These play a central role throughout the entire DES process.

The composition of workshop participants – public sector, academia and industry – varies according to the scenario,⁵ and is based on recommendations from the FOCP, supplemented by input from the participating expert groups.

Expert elicitation guarantee the consistency, credibility and acceptance of the risk assessments. This is because the outcomes are based on the diversity of education, experience and reasoning within the team rather than the negotiation skills and personalities of those involved. (Frye, 2013)

³ Frequentist probability models based on historically repeatable events are used for earthquakes, floods, etc. Other probabilistic models such as event and fault tree analyses are used to calculate the probability of incidents at technical facilities like nuclear power plants.

⁴ The U.S. Nuclear Regulatory Commission (NRC) defines expert elicitation as ‘a formal, highly structured, and well-documented process for obtaining the judgements of multiple experts’. (Frye, 2013)

⁵ For both DES 2015 and DES 2020, between four and 15 experts took part in each scenario-specific workshop.

The Delphi method is used to produce these estimations. Adjustments are made depending on whether data and preliminary assessments are available for the hazards under consideration. The evaluation of the indicators required for the plausibility assessment is also performed according to the Delphi method.

Owing to the coronavirus pandemic, several expert elicitation workshops were replaced by a written consultative procedure.

Scenarios with no prior risk estimation

For scenarios for which no prior risk estimation has been carried out, a comprehensive estimation of their extent of damage and likelihood of occurrence is performed by expert elicitation. A Delphi-based process is used:

1. All participants are briefed on the workshop's aim and schedule, as well as the scenario they will assess and the method that will be applied.
2. The experts read the hazard file synopsis (i.e. the hazard file minus the risk evaluation). All outstanding questions and ambiguities are resolved.
3. The experts individually estimate the impact with respect to the 12 damage indicators and the hazard's likelihood of occurrence. These estimates can be expressed in two ways: either as concrete values or with reference to the damage extent classes for the individual damage indicators in DES (see Section 4.3.4, p. 19 and onwards, as well as Table 8, p. 40–41), for the likelihood of occurrence classes (see Table 5, p. 32) and for the plausibility indicators (see Section 4.5.3, p. 35).
4. The workshop moderators from the FOCP collect the individual estimations and present them to the expert group. This process reveals the range and distribution of the estimates.
5. During a moderated process, the experts explain their estimations, beginning usually with the lowest and highest values. Individual estimations can then be adjusted. Where possible, the group agrees on a concrete value or on an extent or likelihood class. If there is no consensus, the average value of the estimations is retained.
6. All individual estimations performed by the experts, key discussion points and agreed values are documented.

Scenarios with a prior risk estimation

For scenarios for which there is a prior risk estimation or for which their likelihood of occurrence has been derived either from the literature (e.g. *solar storm*) or from expert groups (e.g. for a *hazmat rail accident* or *NPP incident*), the existing estimations are validated and, where necessary, adjusted by means of expert elicitation. The procedure is the same as the Delphi-based procedure described above.

Plausibility estimations

The first step in estimating the plausibility of scenarios of maliciously induced events is the expert elicitation of the plausibility indicators; this is performed in a workshop setting and according to the same Delphi method described in Section 4.5. The next step is the discussion and validation of the plausibility indices for all maliciously induced events; this also takes place in a plenary workshop setting.⁶ Here, plausibility estimations from the individual workshops can be altered by no more than one plausibility class and provided that such an adjustment enjoys expert consensus.

4.3 Impact

In DES, 12 separate damage indicators are used to assess the effects and extent of damage of the 'major intensity' scenarios. The timeframe for assessing the damage of the event is defined for each scenario separately.

The damage indicators are allocated to the following four damage areas: *individuals*, *environment*, *economy* and *society*. Each indicator is defined by eight damage extent classes (A 1 to A 8) with the corresponding reference values (see Table 3 and Section 4.3.4, p. 19). The extent of damage is expressed in monetary terms and the damage aggregated by assigning marginal costs to each indicator (see Table 4 and Section 4.3.3, p. 18).

In DES, a multi-criteria approach is used to analyse the risks that are relevant for Switzerland. The use of multiple damage indicators means that the event-related damage can be better captured across the wide-ranging hazards under investigation. It also makes it possible to draw up detailed impact profiles, which can then be used for contingency planning.

4.3.1 Damage timeframe

Depending on the event or development and the damage indicator under investigation, the damage timeframe may vary widely from one hazard to the next. For instance, a

⁶ Since such an overall workshop on all maliciously induced scenarios assessed in DES has proven its worth, it should be examined

for the next revision of DES whether an overall workshop should also be conducted for all non-maliciously induced scenarios.

rockslide may cause direct damage to property within seconds or minutes. But it may continue to cause more damage over several weeks (e.g. a drop in tourism revenue for the affected valley). For development-induced hazards (e.g. spread of invasive species), their effects may accumulate over years and even decades. The expert team determines the damage assessment timeframe for each scenario separately.

4.3.2 Damage indicators

The effects of hazard scenarios are measured by means of the 12 damage indicators for the four damage areas *Individuals, Environment, Economy* and *Society*. One of the bases for the indicator selection was the Federal Constitution (FC) and the subjects of protection it specifies (see Table 3). Each damage indicator is described in Section 4.3.4 (p. 19 onwards).

For each indicator that can be measured in quantitative terms, a unit is defined to express the extent of the damage. For instance, the indicator ‘asset losses’ is

expressed in Swiss francs (CHF). For indicators that cannot be quantified, the effects are correlated with an extent class that is expressed in qualitative terms (see, for instance, S3 – *Impairment of territorial integrity*).

The values given for the extent of damage per indicator amount to a marginal analysis that counts all effects which the event may cause and which would not otherwise occur. For many indicators, there is a ‘base rate’ of effects arising from everyday events. For example, every year, people die in Switzerland due to dehydration or in traffic accidents. A scenario therefore must only count those event- or development-specific effects that exceed the ‘base rate’. For heatwaves, for instance, one would count all heat-related deaths minus those that would have occurred due to dehydration even in the absence of a severe heatwave.

Table 3 provides an overview of the damage indicators used in DES 2020 as well as the articles in the Swiss Federal Constitution which pertain to the given object of protection.

Table 3: Overview of damage indicators used in DES 2020 as well as the applicable articles in the Federal Constitution

Damage area	Damage indicator	Federal Constitution articles
Individuals	I1 Fatalities	Art. 10, 57, 58, 61, 118
	I2 Injured / sick people	Art. 10, 57, 58, 61, 118
	I3 People in need of assistance	Art. 12, 115
Environment	En1 Damaged ecosystems	Art. 74, 76, 77, 78, 104
Economy	Ec1 Asset losses and cost of coping	Art. 61
	Ec2 Reduction of economic performance	Art. 100
Society	S1 Supply shortfalls and disruptions	Art. 102
	S2 Diminished public order and domestic security	Art. 52, 185
	S3 Impairment of territorial integrity	Art. 58
	S4 Damage to and loss of cultural property	Art. 2, 69, 78
	S5 Damage to the reputation of Switzerland	Art. 54
	S6 Loss of confidence in state / institutions	Preamble, Art. 2, 5

4.3.3 Damage monetisation and aggregation

To map the effects captured by the 12 damage indicators in a risk diagram, the total damage is expressed in monetary terms, i.e. monetised.

To this end, marginal costs are determined for each indicator (see Table 4). These correspond to the amount of money that society is willing to pay in order to reduce by one unit the extent of damage of an indicator. (FOCP, 2003; Ecoplan, 2016)

To facilitate aggregation of non-quantitatively defined indicators, an average value of the respective damage extent class of the indicator *Ec1 – Asset losses and cost of coping* is used (see footnote 7, p. 19 and Indicator *Ec1*, p. 23).

The monetary value of the damage for each damage indicator are added together, i.e. aggregated. The aggregated damage of a scenario thus represents a measure of the impact across all damage indicators. As well as corresponding to the direct costs generated by the event, it also expresses the total damage potential that a particular hazard has in relation to all damage indicators examined.

The aggregated damage covers both material damage (e.g. damage to property) and non-material damage. The monetisation of the damage makes it possible to compare the extent of damage across multiple scenarios.

Table 4: Overview of the marginal costs used to monetise damage in DES 2020

Damage indicator	Unit	Marginal costs per unit
I1 Fatalities	Number of people	CHF 6 million*
I2 Injured / sick people	Number of people	CHF 500 000
I3 People in need of assistance	Person days (number of people multiplied by days)	CHF 250
En1 Damaged ecosystems	Affected area multiplied by number of years of adverse effects (km ² multiplied by years)	CHF 330 000
Ec1 Asset losses and cost of coping	CHF	1
Ec2 Reduction of economic performance	CHF	1
S1 Supply shortfalls and disruptions	Person days (number of people multiplied by days)	CHF 500
S2 Diminished public order and domestic security	Person days (number of people multiplied by days)	CHF 500
S3 Impairment of territorial integrity	Qualitative according to intensity and duration, 5 classes	Average value of the respective class Ec1 in CHF
S4 Damage to and loss of cultural property	Qualitative according to significance and number, 6 classes	Average value of the respective class Ec1 in CHF
S5 Damage to the reputation of Switzerland	Qualitative according to significance and duration, 8 classes	Average value of the respective class Ec1 in CHF
S6 Loss of confidence in state / institutions	Qualitative according to significance and duration, 8 classes	Average value of the respective class Ec1 in CHF

* Of the CHF 6 million, CHF 5 million is allocated to I1 – Individuals, and CHF 1 million to Ec2 – Reduction of economic performance

4.3.4 Description of damage indicators

What follows is a description of each of the 12 damage indicators for the four damage areas.

For each damage indicator, there are eight damage extent classes, along with the ranges of their respective measurement units (see p. 19 onwards).

We also show the average value for each damage indicator and class.⁷ These averages are then used for the calculation of the aggregated extent of damage.

Individuals

The indicators for the *Individuals* damage area record the effects of a hazard on the lives (I1), physical integrity and mental health (I2) of the general public. I3 captures those individuals requiring assistance as a result of the event.

I1 – Fatalities

The damage indicator I1 relates to all people whose deaths can be directly attributed to the event.

I1 – Fatalities: number of people							
A 1	A 2	A 3	A 4	A 5	A 6	A 7	A 8
≤ 10	11 – 30	31 – 100	> 100 – 300	> 300 – 1000	> 1000 – 3000	> 3000 – 10 000	> 10 000
(5.5)	(17)	(55)	(170)	(550)	(1700)	(5500)	(17 000)

⁷ The average value (Av) associated with a min–max range for a particular class is defined approximately as follows:

$$Av = 10^{\frac{\log(\text{Min}) + \log(\text{Max})}{2}}$$

I2 – Injured / sick people

The *I2* indicator includes the number of people affected by injuries or diseases that can be directly attributed to the event.

The indicator takes into account physical and mental illnesses or injuries connected to the hazard. Three levels are distinguished.

The basic units for this indicator are all people who suffer an injury or illness as a result of the event. The three levels of severity outlined below should be assessed accordingly.

Individuals who succumb to their injuries or illness are counted not under this indicator, but under *I1 – Fatalities*.

Individuals requiring one-time emergency psychological care but who do not suffer from an underlying psychological illness are covered by indicator *I3 – People in need of assistance*.

Differing degrees of injury severity are aggregated using weighting factors.⁸

I2 – Injured / sick people: number of people in consideration of their injury or illness

A 1	A 2	A 3	A 4	A 5	A 6	A 7	A 8
≤ 100	> 100 – 300	> 300 – 1000	> 1000 – 3000	> 300 – 10 000	> 10 000 – 30 000	> 30 000 – 100 000	> 100 000
(55)	(170)	(550)	(1700)	(5500)	(17 000)	(55 000)	(170 000)

Injury and illness weighted according to their degree of severity

Level	Injury	Illness	Weighting factor
Severe	Hospital stay of at least 7 days	Chronic illness requiring medical treatment	1
Moderate	Hospital stay of 1–6 days	Severe, persistent illness requiring medical treatment; full recovery	0.1
Minor	No permanent physical harm; medical attention, but no hospital stay	Minor illness requiring medical treatment; full recovery	0.003

⁸ The factors were derived from Bickel and Friedrich (2005).

I3 – People in need of assistance

Indicator *I3* covers people who must be evacuated, temporarily housed, and/or otherwise cared for before, during, and after an event. This may involve, for instance, housing in emergency shelters; supplying food to people in locations cut off from the outside world; or giving emergency psychological assistance to people who are not, however, affected by actual mental illnesses. The duration of assistance required by the directly affected persons is registered. Effects such as supply shortfalls and disruptions for large parts of the population are counted not under *I3*, but under the indicator *S1 – Supply shortfalls and disruptions*.

The unit to quantify the need for assistance is the person day. This is determined by multiplying the number of

people requiring assistance with the duration of impairment in days. The effective duration of assistance required by all individuals is added up. The minimum unit per person is one day. The duration of the requirement for assistance is counted, rather than the period in which assistance services are provided. For instance, one would count the number of days during which the total number of traumatised individuals require emergency psychological assistance, rather than the duration for which the members of care-providing organisations have been deployed.

The cost of providing support services is accounted for in the indicator *Ec1 – Loss of assets and cost of coping*.

I3 – People in need of assistance: person days (number of people multiplied by days)

A 1	A 2	A 3	A 4	A 5	A 6	A 7	A 8
≤ 200 000	> 200 000 – 600 000	> 600 000 – 2 million	> 2 – 6 million	> 6 – 20 million	> 20 – 60 million	> 60 – 200 million	> 200 million
(110 000)	(350 000)	(1.1 million)	(3.5 million)	(11 million)	(35 million)	(110 million)	(350 million)

Environment

The indicator for the damage area 'environment' express the effects of a hazard on the environment. The main effects include water pollution, ground pollution, and changes to the genetic material of organisms or biological diversity.

En1 – Damaged ecosystems

Indicator *En1* measures the size and the duration of an adverse event on ecosystems (woodlands, agro ecosystems, watercourses, lakes, wetlands etc.), which are seriously damaged as a result and which will recover very slowly, if ever. Effects may be caused, for instance, through chemical or radiological pollution, through biological or non-biological contamination, e.g. due to alien invasive species, or through physical damage, such as erosion.

Impacts are understood as damage to ecosystems and/or adverse effects on ecosystem services.

An ecosystem is damaged if, for example, the natural balance is upset considerably or the soil fertility is significantly compromised. For example, heavy chemical pollution of surface waters is measured with the indicator *En1*. If the water level of a lake significantly drops as a result of drought, but without damaging the flora and the fauna in the medium to long term, this is not considered as an adverse impact on the ecosystem.

The impairment of ecosystem services should be only considered if the restriction is not covered by other

indicators (e.g. their use for leisure and recreation). If drought leads to restrictions on the supply of drinking water from surface water among sections of the population, this is recorded by the indicator *S1 – Supply shortfalls and disruptions*. The economic impact of ecosystem damage is not covered by the indicator *En1* but by the economic indicators *Ec1* and *Ec2*.

The unit for measuring adverse effects is the area x year (km² x year). It is calculated by multiplying the affected area with the number of years that the adverse effect lasts. If an area is under the influence of multiple effects, it is only counted once.

The duration of the impairment is the length of time during which the ecosystem persists or the restrictions on its use (e.g. restrictions of cultivation on agricultural land) remain in place. The cycle of different stages of an ecosystem, e.g. succession stages in managed forests, should be taken into account. An ecosystem is regarded as damaged until its condition returns to 'normal'. For instance, in the case of a forest damaged by an extensive fire, the duration is the time until the re-establishment of the early succession stages.

En1 – Damaged ecosystems: affected area multiplied by number of years of adverse effects (km² multiplied by years)

A 1	A 2	A 3	A 4	A 5	A 6	A 7	A 8
≤ 150	> 150 – 450	> 450 – 1500	> 1500 – 4500	> 4500 – 15 000	> 15 000 – 45 000	> 45 000 – 150 000	> 150 000
(82)	(260)	(820)	(2600)	(8200)	(26 000)	(82 000)	(260 000)

Economy

Economic effects and damages are counted as asset losses and cost of coping (*Ec1*), and the reduction of economic performance (*Ec2*).

Ec1 – Asset losses and cost of coping

Damage indicator *Ec1* measures losses to existing assets and the cost of coping.

Assets include both tangible assets⁹ and financial assets.¹⁰ This indicator counts all damage to assets even if, for example, insurance companies or the State settle the costs.

Cost of coping includes the cost of emergency services, emergency shelters, and provision of care for people in need of assistance.

The example used to illustrate this indicator is flooding. Such an event causes damage to multiple buildings and a

factory. This runs up costs for pumping out basements and removing rubble and driftwood (cost of coping). The physical damage leads to financial losses as the value of the buildings and equipment is now diminished.

Depending on the effects of the hazard, various perspectives can be adopted regarding the financial losses:

- macroeconomic: nationwide cost of coping and damage to national wealth.¹¹
- individual or small-scale: cost of coping and financial losses for individuals or within a spatially limited unit.¹²

Ec1 – Asset losses and cost of coping: CHF

A 1	A 2	A 3	A 4	A 5	A 6	A 7	A 8
≤ 50 million	> 50 – 150 million	> 150 – 500 million	> 0.5 – 1.5 billion	> 1.5 – 5 billion	> 5 – 15 billion	> 15 – 50 billion	> 50 billion
(27 million)	(87 million)	(270 million)	(870 million)	(2.7 billion)	(8.7 billion)	(27 billion)	(87 billion)

⁹ Capital assets are also referred to as 'real capital', e.g. real estate, manufacturing facilities, household effects, or farm animals. In Switzerland, capital assets include buildings and civil engineering works, machines and equipment, farm animals and crops, and computer programs (cf. FSO indicator T10 'Non-financial net capital stock').

¹⁰ Financial assets may include cash, shares, or pension entitlements. Financial assets consist of the balance between assets and liabilities, cf. SNB 'Net financial assets'.

¹¹ Including Switzerland's net assets abroad. This is mainly relevant for hazards that apply uniformly across the country, e.g. rising cost of healthcare due to diseases of affluence.

¹² This is mainly relevant in the case of spatially limited events, e.g. landslides or accidents involving hazardous material.

Ec2 – Reduction of economic performance

Damage indicator *Ec2* includes indirect economic effects that reduce value creation in Switzerland. While *Ec1 – Financial losses and cost of coping* relates to the cost of coping and damage to existing assets, *Ec2* takes into account the consequences for future value creation.

The example used to illustrate this indicator is flooding (cf. example in *Ec1*). Due to the damage caused by such an event, the affected company has zero output for several weeks and therefore suffers a loss of income.

Depending on the effects of the hazard, various perspectives can be adopted regarding financial losses:

- macroeconomic: the sum of domestic value creation is used as an indicator of total economic performance. It is quantified in terms of Gross Domestic Product (GDP). Thus, a reduction of economic performance corresponds to a decline in GDP.¹³
- individual or small-scale: reduction of economic performance for individuals or within a spatially limited unit.¹⁴

Ec2 – Reduction of economic performance: CHF

A 1	A 2	A 3	A 4	A 5	A 6	A 7	A 8
≤ 50 million	> 50 – 150 million	> 150 – 500 million	> 0.5 – 1.5 billion	> 1.5 – 5 billion	> 5 – 15 billion	> 15 – 50 billion	> 50 billion
(27 million)	(87 million)	(270 million)	(870 million)	(2.7 billion)	(8.7 billion)	(27 billion)	(87 billion)

¹³ For instance, in the event of a severe earthquake causing longer-term disruption to most economic activities.

¹⁴ For instance, interruptions to product supply due to transport route disruptions are quantified in terms of the loss of value creation.

Society

The damage area relating to society measures significant disruptions caused by the hazard under investigation. On the one hand, these may include the effects on the Swiss population, e.g. through supply shortfalls and disruptions (S7) or diminished public order and domestic security (S2). On the other hand, it captures the effects on the state: impairment of territorial integrity (S3), damage to or loss of

cultural property (S4), a damage to the reputation of Switzerland abroad (S5) and a loss of Swiss public confidence in the State and its institutions (S6).

To monetarise the indicators that have not been quantitatively defined, e.g. damage to or loss of cultural property, the averaged values of the corresponding extent class of the damage indicator *Ec1 – Asset losses and cost of coping* are applied.

S1 – Supply shortfalls and disruptions

This indicator measures breakdowns or severe disruptions to the supply of critical goods and services to the entire population or parts of it. They are grouped into three sets according to their importance.¹⁵

Supply shortfalls are calculated by multiplying the number of persons affected with the duration of disruption in days. The effective duration of the supply disruption for those

affected is added together. Thus, what is calculated is the duration of the actual disruption. For instance, the total time of a power blackout might be calculated, i.e. the total duration of the outage rather than the number of days on which power was disrupted for a few hours each day.

Economic consequences are covered by the indicators *Ec1 – Asset losses and cost of coping* and *Ec2 – Reduction of economic performance*.

S1 – Supply shortfalls and disruptions: person days (number of people multiplied by days)

A 1	A 2	A 3	A 4	A 5	A 6	A 7	A 8
≤ 100 000	> 100 000 – 300 000	> 300 000 – 1 million	1 – 3 million	> 3 – 10 million	> 10 – 30 million	> 30 – 100 million	> 100 million
(55 000)	(170 000)	(550 000)	(1.7 million)	(5.5 million)	(17 million)	(55 million)	(170 million)

Goods and services weighted by degree of importance

Importance	Goods	Services	Weighting factor
Vital	Potable water, basic foodstuffs, medicine	Medical emergency services, communication first responders	1
Very important	Electricity, heating, natural gas, clothing, shelter	Out- and in-patient medical treatment (excluding emergency services), out-patient nursing care	0.1
Important	Other foodstuffs, fuel	Telephone, IT, TV, transport/traffic (roads, rail, shipping, etc.)	0.001

¹⁵ For weighting, we currently have no rigorous bases. The factors are therefore validated and adjusted throughout the application of the methodology.

S2 – Diminished public order and domestic security

This indicator measures how many people living in Switzerland have experienced diminished public order and domestic security, and for how long. This refers to

adverse effects from domestic disturbances, such as unrest, impinging upon or unduly restricting the daily life of the general public. Such adverse effects are measured in person days. The minimum duration per person is one day.

S2 – Diminished public order and domestic security: person days (number of people multiplied by days)

A 1	A 2	A 3	A 4	A 5	A 6	A 7	A 8
≤ 100 000	> 100 000 – 300 000	> 300 000 – 1 million	1 – 3 million	> 3 – 10 million	> 10 – 30 million	> 30 – 100 million	> 100 million
(55 000)	(170 000)	(550 000)	(1.7 million)	(5.5 million)	(17 million)	(55 million)	(170 million)

S3 – Impairment of territorial integrity

This indicator qualitatively describes the intensity of a violation of Swiss territory. The focus is on violations of Swiss airspace and soil.

The indicator comprises various forms of violations of Swiss territory by another state. It takes into account the intensity and duration of this violation.

The extent of damage is determined starting at extent class 4, as the only violations captured are those that may lead to a noticeable impairment territorial integrity or to marked inter-state tensions.

S3 – Impairment of territorial integrity: qualitative according to intensity and duration

A 1	A 2	A 3	A 4	A 5	A 6	A 7	A 8
-	-	-	Short-term, intentional violation of territorial integrity (e.g. civilian or military operations of foreign security forces on Swiss soil)	Short-term, severe violation of territorial integrity (e.g. repeated civilian or military operations of foreign security forces on Swiss soil)	Temporary, severe violation of territorial integrity (e.g. temporary occupation of a limited area of Swiss soil)	Temporary, very severe violation of territorial integrity (e.g. temporary occupation of a considerable area of Switzerland)	Long-lasting, very severe violation of territorial integrity (e.g. occupation of a significant part of Switzerland)
-	-	-	(870 million)	(2.7 billion)	(8.7 billion)	(27 billion)	(87 billion)

S4 – Damage to and loss of cultural property

This indicator describes the damage to or loss of Switzerland's cultural property.

Cultural property worthy of protection may include movable or immovable goods of considerable importance to the cultural heritage of nations. Examples include buildings, artwork, monuments, archaeological sites, books, manuscripts, scientific collections, archival material, and reproductions of cultural assets. They also include buildings such as museums, libraries, archives, monasteries, and places that may be used to safeguard movable cultural property.¹⁶

A distinction is made between cultural property of local, regional (B-class objects), and national (A-class objects) significance as well as property under 'enhanced protection' (cf. Federal Commission for the Protection of Cultural Goods, as per the Second Protocol to the Hague Convention).

The term 'damage' applies to severe detrimental effects that destroy the cultural property or necessitate considerable time or financial investments to restore the latter.

'Loss' encompasses misappropriation (theft, robbery) and irreversible destruction (e.g. through fire, explosion, or water damage).

S4 – Damage to and loss of cultural property: qualitative according to significance and number

A 1	A 2	A 3	A 4	A 5	A 6	A 7	A 8
Damage to or loss of individual cultural property of local significance	Damage to or loss of several cultural property of local significance or individual cultural property of regional significance	Damage to or loss of several cultural property of regional significance or individual cultural property of national significance	Damage to or loss of many cultural property of regional significance and individual cultural property of national significance	Damage to or loss of several cultural property of national significance	Damage to or loss of several cultural property of national significance and few cultural property of international significance (under 'enhanced protection')	-	-
(27 million)	(87 million)	(270 million)	(870 million)	(2.7 billion)	(8.7 billion)	-	-

¹⁶ cf. also Art. 1. of 1954 Hague Convention (SR 0.520.3)

S5 – Damage to the reputation of Switzerland

This indicator comprises the significance and duration of a reputational loss for Switzerland abroad. Damage to Switzerland's reputation could, for example, lead to a situation where other countries refuse to enter into bilateral, multilateral and international agreements with it,

or where its status as a business/tourism destination is severely compromised.

This indicator qualitatively takes into account the significance of the reputational loss and its duration.

S5 – Damage to the reputation of Switzerland: qualitative according to significance and duration

A 1	A 2	A 3	A 4	A 5	A 6	A 7	A 8
Damage to reputation lasting only a few days and related to issues of medium importance (e.g. negative coverage in foreign media)	Damage to reputation lasting from one up to a few weeks and related to issues of medium importance (e.g. negative coverage in foreign media)	Damage to reputation lasting from one up to a few weeks and related to important issues (e.g. negative coverage in foreign media)	Damage to reputation lasting several weeks and related to important issues, but with minor impact on Switzerland's standing and international cooperation	Damage to reputation lasting several weeks and related to important issues, with impact on Switzerland's standing and international cooperation (e.g. termination of agreements with Switzerland, temporary expulsion of Swiss ambassador)	Considerable damage to reputation lasting several weeks, with impact on Switzerland's standing and international cooperation (e.g. termination of significant agreements with Switzerland, expulsion of Swiss ambassador)	Considerable damage to reputation lasting up to several months with visible impact on Switzerland's standing and international cooperation (e.g. political isolation, boycotts)	Lasting, severe and even irreversible loss of reputation with far-reaching impact on Switzerland's standing and international cooperation (e.g. political isolation, boycotts)
(27 million)	(87 million)	(270 million)	(870 million)	(2.7 billion)	(8.7 billion)	(27 billion)	(87 billion)

S6 – Loss of confidence in the state / institutions

Indicator S5 measures the significance of a loss of confidence in the state in general and its institutions, as well as the share of the population that is losing confidence. Such institutions may include the executive, legislative, or legal branches of government as well as state and cantonal organisations such as public administrations, the armed forces, the police as well as state and semi-state bodies.

The significance of such loss of confidence is described qualitatively and includes, for instance, the question of whether the loss of confidence extends to individual cantonal administrative units or to the federal administration in general.

S6 – Loss of confidence in the state / institutions: qualitative according to significance and duration

A 1	A 2	A 3	A 4	A 5	A 6	A 7	A 8
Impairment of confidence lasting only a few days and related to issues of medium significance (e.g. very critical coverage in Swiss media)	Damage to confidence lasting for one up to a few weeks and related to issues of medium significance (e.g. very critical coverage in Swiss media; occasional demonstrations)	Damage to confidence lasting for one up to a few weeks and related to significant issues (e.g. extremely critical coverage in Swiss media; occasional demonstrations)	Damage to confidence lasting for a few up to several weeks and related to significant issues (e.g. strikes, larger demonstrations)	Damage to confidence lasting several weeks and related to significant issues weeks (e.g. multiple strikes, occasional mass demonstrations)	Considerable damage to general confidence lasting several weeks (e.g. extended strikes in many areas, mass demonstrations across Switzerland)	Considerable damage to general confidence lasting up to several months (e.g. general strikes)	Lasting, severe or even irreversible loss of general confidence (formation of local or regional groups for self-organisation of public life, up to the point of vigilante group formation)
(27 million)	(87 million)	(270 million)	(870 million)	(2.7 billion)	(8.7 million)	(27 million)	(87 million)

4.4 Likelihood of occurrence

Two factors are used to identify risk: the extent of damage and the likelihood of occurrence. In DES the likelihood of occurrence is determined only for non-maliciously induced events. However, for maliciously induced events, the plausibility is determined instead of the likelihood of occurrence (see Section 4.5, p. 32).

In DES the method for estimating the likelihood of occurrence is mainly based on expert elicitation conducted in hazard specific workshops; the results are thereby determined by consensus. The estimation process may also take into account or include results from frequentist or probabilistic models.

In DES, the likelihood of occurrence is expressed as the 'return period', or 'frequency'.

The assessment is based on eight likelihood classes.

4.4.1 Likelihood of occurrence, return period and frequency

Risk analyses may use the return period or frequency (annuality) instead of the likelihood of occurrence. All these measures are essentially equivalent; they just use different scales.¹⁷ The most important factors are the return and observation periods.

Swiss civil protection tends to use the return period, or 'frequency'.

Likelihood refers to the possibility of an event happening. It determines the probability of a given event occurring at least once during a certain period of time (e.g. in the next five or 10 years) when the necessary conditions are in place for it to occur. Likelihood always takes a value of between 0 and 1. This is equivalent to a value of between 0 and 100%.

The return period refers to the time span expressed in years during which statistical computations or estimates expect a given event to occur at least once on average. It is expressed as (1 time in x years).

The frequency (or annuality) describes the expected number of events per year. It is expressed as x times per year. Frequency is the reciprocal of the return period. These values are shown in Figure 5 (see p. 32).

4.4.2 Likelihood classes

It is possible to estimate with a high degree of precision the likelihood of occurrence (return period or frequency) for natural and technological hazard scenarios (as well as for certain societal hazard scenarios). This work is based on statistics or – where the data are lacking – on expert elicitation. If point estimates are not possible, the likelihood of occurrence (or frequency) can be attributed to a likelihood class (L-class). For L-class estimates, the mean value of the given class is used to represent the risk in the risk diagram (see footnote 7, p. 19).

DES applies eight likelihood classes (L1 to L8) (Fig. 5). The likelihood of occurrence is expressed as the return period with the corresponding description.

The likelihood classes and their descriptions are helpful for subjective expert estimations if no or few objective estimations are available. In addition, the likelihood classes can be used for more detailed risk assessments.

¹⁷ e. g. using Poisson distribution. This is mainly used for discrete events with very low probabilities ('Distribution of rare events'). The only relevant variables for the calculation are the return period/frequency and the forecast period. From this, it is possible to calculate

the likelihood of occurrence for a pre-defined forecast period:

$$\text{Likelihood of occurrence } P = 1 - e^{-\frac{\text{Forecast period}}{\text{Return period (once in x years)}}}$$

Table 5: Likelihood classes (L-classes)

L-class	Description	Frequency* (once in x years)	Annuality (1/frequency)	Likelihood** for 10 years (%)
L8	On average, few events in Switzerland during a human lifespan.	≤ 30	≥ 0.03	≥ 28
L7	On average, one event in Switzerland during a human lifespan	> 30 – 100	< 0.03 – 0.01	< 28 – 9.5
L6	Has occurred in Switzerland before, but possibly several generations ago	> 100 – 300	< 0.01 – 0.003	< 9.5 – 3.3
L5	May have never occurred in Switzerland, but is known to have happened in other countries	> 300 – 1000	< 0.003 – 0.001	< 3.3 – 1.0
L4	Several known events worldwide	> 1000 – 3000	< 0.001 – 0.0003	< 1.0 – 0.33
L3	Only few events worldwide	> 3000 – 10 000	< 0.0003 – 0.0001	< 0.33 – 0.1
L2	Only individual known events worldwide, but also conceivable in Switzerland.	> 10 000 – 30 000	< 0.0001 – 0.00003	< 0.1 – 0.033
L1	Only individual, if any, known events worldwide. Such an occurrence is regarded as very rare even on a global scale, but cannot be fully ruled out for Switzerland either.	> 30 000	< 0.00003	< 0.033

* In Switzerland the term 'return period' is also used for the common term 'frequency'

** For at least one occurrence within the given time period.

4.5 Plausibility

For deliberate events, DES assesses their plausibility, not their likelihood of occurrence.

There are several factors which make it impossible to reach a definitive conclusion on the likelihood of occurrence (frequency) of maliciously induced events (e.g. terrorist attacks, political events and armed conflicts). They include the unpredictability of the actors; the fluctuating willingness to act and react to evolving security situations and the resulting fast-changing threat landscapes, as well as the lack of statistically useful case numbers. (Brown, 2011)

To assess plausibility, DES 2020 adopts an indicator-based approach, which replaces the qualitative method used previously in Switzerland.

Several expert groups were involved in the development of the new method; they also tested it in a workshop setting. Switzerland took a number of elements from the

indicator-based methods already adopted by the UK and Singapore for their national risk analyses, and developed these further for Switzerland's specific context.

4.5.1 Indicator-based plausibility assessment

Plausibility is assessed by two qualitative leading indicators: 'Intent and ability' of the perpetrator and 'Scenario feasibility'.

The main indicators are each assigned two sub-indicators with pre-defined evaluation criteria; these are set for each scenario in an expert workshop. The indicators are used to determine a plausibility index with values from 1 to 5 (in 0.5-point increments). These are ranked according to one of five plausibility classes (P-classes).

A rating system is used to rank the sub-indicators. Their combined ratings are then used to determine the two main indices ('Intent and ability'; 'Scenario feasibility') – with values from P1 to P5 – for each of the two main indicators. The mean of both these indices provides the indicator-based P-index for a given scenario.

First, in hazard-specific workshops, experts assess the plausibility of the various scenarios for the given hazard. The results are then subjected to an overall evaluation and validation in a second workshop, and consolidated. This makes it possible to identify and correct any distortions that may arise, e.g. due to the composition of the hazard-specific workshops.

Figure 2 provides an overview of the plausibility assessment method.



* In the Unrest scenario, the Police information indicator replaces the Intelligence information indicator.

Figure 2: Overview of the indicator-based method used in DES 2020 to assess the plausibility of deliberate events

Main indicator: 'Intent and ability'

The main indicator 'Intent and ability' captures indications of the intent of one or more potential perpetrators and their ability to attack Switzerland either with the means stipulated in the given scenario or with other comparable means.

'Intent and ability' is divided into two sub-indicators 'Intelligence/police information' and 'Past events'.

Sub-indicator 'Intelligence / police information'

The 'Intelligence information' sub-indicator deals with terrorist, cyber and other attack scenarios. It captures signs of activities, attempts or other indications of the intent of one or more potential perpetrators to carry out the described or a comparable scenario.

The 'Police information' sub-indicator deals with the *Unrest* scenario. It captures police information on the pre-conditions, i.e. the 'shared intent and ability' (or 'collective intentionality', within the population to carry out the described or a comparable scenario.

Sub-indicator 'Past events'

The 'Past events' sub-indicator captures events which have occurred previously in Switzerland or in other countries, which are identical or comparable to the given event, as well as successful efforts to thwart such an attack, irrespective of the actual or suspected existence of one or more potential perpetrators (applies by analogy to the *Unrest* scenario).

Main indicator: 'Scenario feasibility'

The main indicator 'Scenario feasibility' captures the technical and operational viability of an event which is identical or comparable to the one described in the given scenario, irrespective of the existence of potential perpetrators.

'Scenario feasibility' is divided into two sub-indicators 'Technical feasibility' and 'Operational feasibility'.

Sub-indicator 'Technical feasibility'

The 'Technical feasibility' sub-indicator captures the technical viability of a scenario for Switzerland, i.e. general technical requirements and specific prerequisites in terms of specialist equipment, procurement, groundwork and knowledge, as well as the hazards involved in handling the equipment required to induce such an event.

Sub-indicator 'Operational feasibility'

The 'Operational feasibility' indicator captures the operational viability of a scenario for Switzerland, i.e. requirements such as organisational effort, communication structures, funding and training.

4.5.2 Plausibility index and plausibility classes

The indicator-based method is used to determine the plausibility indices for each scenario (index values from P1 to P5, in 0.5-point increments). These are then assigned to one of five plausibility classes (P-classes P1 to P5) on an ordinal scale. Here, the P1–P4 classes are each assigned two possible index values; P5 is assigned one. The plausibility measure of each P-class ranges from 'hardly plausible' to 'highly plausible'.

The following table sets out the metrics for the P-indices and P-classes, as well as definitions and descriptions.

Table 6: P-classes and P-indices. The information in the descriptions with regard to indications of the intent of potential perpetrators and scenario feasibility is derived from the main indicators and main indices. Only an approximate definition can be provided for indications of intent and scenario feasibility in P-classes P4, P3 and P2.

P-class	P-index	Plausibility	Description
P5	5.0	highly plausible	The possibility of the event occurring in Switzerland is very well conceivable in comparison to other scenarios. There are undeniable indications of the potential perpetrator's intent. The feasibility of the scenario is easy overall.
P4	4.5	plausible	The possibility of the event occurring in Switzerland is well conceivable in comparison to other scenarios. There are undeniable to clear indications of the potential perpetrator's intent. The feasibility of the scenario ranges from easy to challenging overall.
	4.0		
P3	3.5	quite plausible	The possibility of the event occurring in Switzerland is conceivable in comparison to other scenarios. There are clear to non-existent or indiscernible, respectively indications of the potential perpetrator's intent. The feasibility of the scenario ranges from easy to complex overall.
	3.0		
P2	2.5	somewhat plausible	The possibility of the event occurring in Switzerland is little conceivable in comparison to other scenarios. There are clear to non-existent or indiscernible, respectively indications of the potential perpetrator's intent. The feasibility of the scenario ranges from challenging to complex overall.
	2.0		
P1	1.5	hardly plausible	The possibility of the event occurring in Switzerland is hardly conceivable in comparison to other scenarios, but cannot be fully ruled out. There are no indications of the potential perpetrator's intent. The feasibility of the scenario is complex overall.
	1.0		

4.5.3 Plausibility assessment method

The plausibility assessments are performed as part of expert workshops. They largely apply the indicator-based method and are supplemented by a final overall assessment and validation by the experts.

Sub-indicators are assessed separately and usually in a workshop setting by a team of experts using the Delphi method. The assessment of the 'Intelligence information' sub-indicator for terrorist, cyber and other attacks is performed exclusively by the Federal Intelligence Service (FIS). The *Unrest* scenario is assessed in expert workshops; here, the police assessment carries the most weight.

Indicators are used to determine the P-indices of each scenario. These indices are then subjected to a final overall assessment and validation by experts in a special, standalone workshop. This makes it possible to compare the scenario assessments generated by the different workshops. In certain cases, the plausibility

assessment can be changed, but by no more than one class. The reasons for these adjustments are logged.

4.6 Risk presentation

One of the key results of DES is a comparison of the impact and risks of selected hazards and scenarios. Impact diagrams and risk diagrams are created for this purpose. The risks of non-maliciously induced and of maliciously induced events are presented in separate risk diagrams.

The comparison serves as a basis for risk dialogue and discussions on the acceptance of risks (risk assessment). It is also used to prioritise risks and measures to mitigate them.

4.6.1 Impact diagrams

Impact diagrams (see hazard files, FOCP 2020a) map the effects of the analysed scenarios.

The damage determined for the 12 damage indicators (see Section 4.3.4, p.19 onwards.) is not expressed as an exact value. Rather, it is assigned to one of several extent classes. Here, account is taken of the damage assessment (use of extent classes) and the concomitant fuzziness (see Section 5.1, p. 37).

4.6.2 Risk diagrams

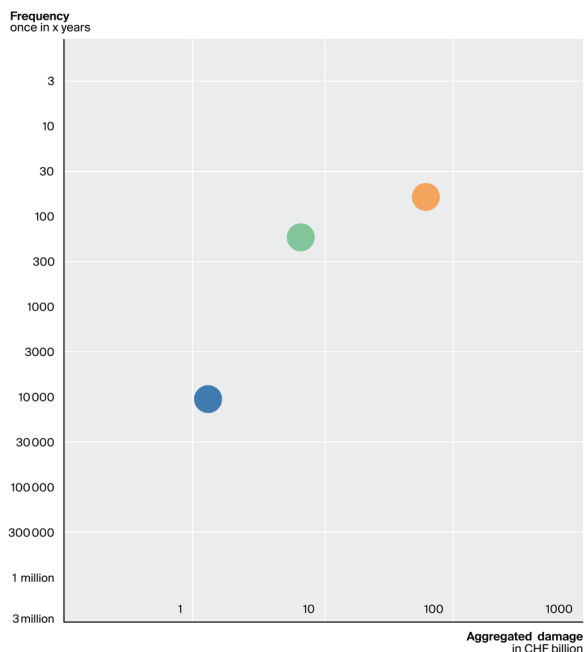
Risk diagrams allow a (visual) comparison of the risks posed by a range of hazards.

Two separate risk diagrams are created due to the fact that DES assesses the plausibility of maliciously induced events rather than their likelihood of occurrence.

Figure 3 shows the DES 2020 risk diagrams in exemplary form.

Risk diagram for non-deliberate events

In DES the risk diagram for non-deliberate events is designed in such a way that the calculated impact is expressed as monetised and aggregated damage (in CHF) on the x-axis; the likelihood of occurrence is expressed as frequency (once in x years) on the y-axis (on a reverse scale). The scales of both axes are logarithmic because this makes it possible to capture the wide range of values in a single diagram.



Since Switzerland applies frequency intervals ranging from up to 30 years to 100–300 years, particularly when dealing with natural hazards, these and the corresponding intervals are highlighted in the diagram.

Concrete values for the aggregated damage and frequency are used to decide where each hazard is placed on the diagram. These can be concrete estimated values or mean values of an estimated class. The size of the dots on the diagram does not capture any fuzziness in the hazard risk analyses.

Risk diagram for deliberate events

The risk diagram for deliberate events is designed in such a way that the calculated impact is also expressed as monetised and aggregated damage (in CHF) on the logarithmic x-axis. Plausibility is shown as an index value on the y-axis and assigned to one of five plausibility classes.

The risk diagram for non-deliberate events therefore makes it possible to directly compare the aggregated damage with the hazards shown in the risk diagram for maliciously induced events. However, it is not possible to directly compare plausibility and frequency, and therefore the respective risks.

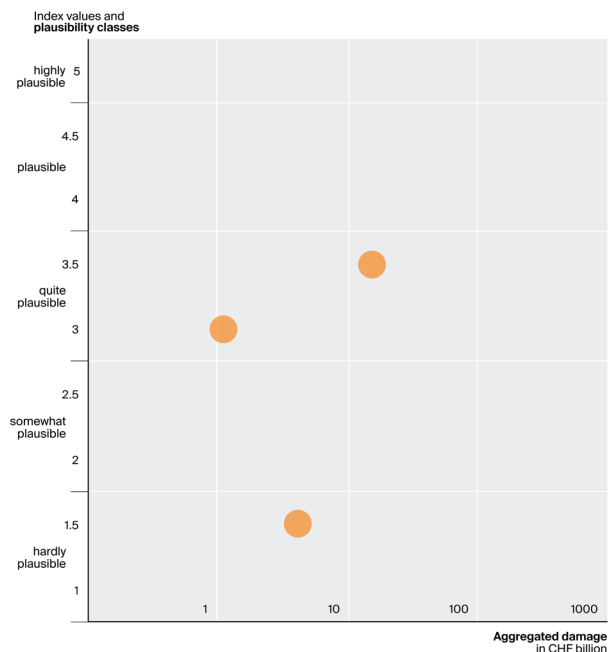


Figure 3: Examples of risk diagrams in DES 2020 for non-deliberate and deliberate events.

5 Interpretation of the results

One of the major advantages of ‘Disasters and Emergencies in Switzerland’ (DES) is that risks can be presented in a transparent way and compared in a risk diagram. This is an indispensable foundation for risk dialogue and, by extension, risk assessments by the relevant agencies. Assessing risks from a political or social point of view in particular is not part of DES. However, there are various aspects inherent in the method that have to be considered. They are briefly explained below:

5.1 Fuzziness

The (semi-)quantitative risk analysis method used in DES 2020 enables the calculation of precise risk values by visualising risks in the corresponding risk diagrams. It should be noted that these diagrams model risks not reality. They also expose some fuzziness in the collection of data and model scenarios. This fuzziness needs to be taken into account when interpreting the results of the risk analysis.

Fuzziness in data collection

DES compares well-known hazards like flooding with rather intangible hazards like terrorist attacks involving NBC agents. For certain hazards, empirical values and a statistical basis are available for establishing the frequency and the extent of damage for each hazard scenario. This is not the case for more obscure hazards. Here, the risk analysis relies more heavily on assumptions and expert appraisals. Even with well-known hazards, expert appraisals are unavoidable, e.g. when determining the extent of certain damage indicators.

To a large extent, careful data collection and awareness of the respective collection methods can help to preclude distortions, resulting in good data quality

Fuzziness in modelling

The choice of scenario and the marginal costs used to express damage in monetary terms may lead to model uncertainty.

Comparisons are always made between the risks of the representative scenarios for events related to a given hazard. There is a certain degree of freedom when designing the progression of the scenario and its classification according to a comparable level of intensity (major), which in turn influences the impact and likelihood of occurrence that the scenario has.

The monetising of damage based on marginal costs reflect societal preferences. The marginal cost rates and risk aversion factors used here may have a crucial effect on the aggregated damage and must therefore be validated periodically.

5.2 Risk aversion

It has been observed empirically in many situations, and also explained theoretically that events that have the potential to cause severe damage are weighted more heavily than would be warranted by their extent of damage. This is known as ‘risk aversion to major events’, or simply ‘risk aversion’. (FOCP, 2008)

As this phenomenon is a societal norm, it must be factored in when interpreting risks.

In addition, the calculation of risk (risk as the mathematical product of the extent of damage and the likelihood of occurrence) must factor in that information is lost on whether the given scenario is associated with major damage and a low likelihood of occurrence or with little damage and a high likelihood of occurrence.

5.3 Sensitivity analyses

Hazmat road accident, windstorm and flooding are subjected to sensitivity analyses. These check whether the expert appraisals are consistent with the model values derived from the modelling of historical data. The results for these three hazards demonstrate a high degree of consistency between the risk estimates and the risk models. (Spada, 2018)

Appendix

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A4 Scales of damage indicators

Damage area		Indicator	Unit	A 1	A 2	A 3
Individuals	I1	Fatalities	Number	≤ 10	11 – 30	31 – 100
	I2	Injured / sick people	Number	≤ 100	> 100 – 300	> 300 – 1000
	I3	People in need of assistance	Person days	≤ 200 000	> 200 000 – 600 000	> 600 000 – 2 million
Environment	En1	Damaged ecosystems	km² x year	≤ 150	> 150 – 450	> 450 – 1500
Economy	Ec1	Asset losses and cost of coping	CHF	≤ 50 million	> 50 – 150 million	> 150 – 500 million
	Ec2	Reduction of economic performance	CHF	≤ 50 million	> 50 – 150 million	> 150 – 500 million
Society	S1	Supply shortfalls and disruptions	Person days	≤ 100 000	> 100 000 – 300 000	> 300 000 – 1 million
	S2	Diminished public order and domestic security	Person days	≤ 100 000	> 100 000 – 300 000	> 300 000 – 1 million
	S3	Impairment of territorial integrity	Qualitative by intensity and duration	–	–	–
	S4	Damage to and loss of cultural property	Qualitative by significance and number	Damage to or loss of individual cultural property of local significance	Damage to or loss of several cultural property of local significance or individual cultural property of regional significance	Damage to or loss of several cultural property of regional significance or individual cultural property of national significance
	S5	Damage to the reputation of Switzerland	Qualitative by significance and duration	Damage to reputation lasting only a few days and related to issues of medium importance (e.g. negative coverage in foreign media)	Damage to reputation lasting from one up to a few weeks and related to issues of medium importance (e.g. negative coverage in foreign media)	Damage to reputation lasting from one up to a few weeks and related to important issues (e.g. negative coverage in foreign media)
	S6	Loss of confidence in state/institutions	Qualitative by significance and duration	Impairment of confidence lasting only a few days and related to issues of medium significance (e.g. very critical coverage in Swiss media)	Damage to confidence lasting for one up to a few weeks and related to issues of medium significance (e.g. very critical coverage in Swiss media; occasional demonstrations)	Damage to confidence lasting for one up to a few weeks and related to significant issues (e.g. extremely critical coverage in Swiss media; occasional demonstrations)

	A 4	A 5	A 6	A 7	A 8
I1	> 100 – 300	> 300 – 1000	> 1000 – 3000	> 3000 – 10 000	> 10 000
I2	> 1000 – 3000	> 3000 – 10 000	> 10 000 – 30 000	> 30 000 – 100 000	> 100 000
I3	> 2 – 6 million	> 6 – 20 million	> 20 – 60 million	> 60 – 200 million	> 200 million
En1	> 1500 – 4500	> 4500 – 15 000	> 15 000 – 45 000	> 45 000 – 150 000	> 150 000
Ec1	> 0.5 – 1.5 billion	> 1.5 – 5 billion	> 5 – 15 billion	> 15 – 50 billion	> 50 billion
Ec2	> 0.5 – 1.5 billion	> 1.5 – 5 billion	> 5 – 15 billion	> 15 – 50 billion	> 50 billion
S1	> 1 – 3 million	> 3–10 million	> 10 – 30 million	> 30 –100 million	> 100 million
S2	> 1 – 3 million	> 3 – 10 million	> 10 – 30 million	> 30 – 100 million	> 100 million
S3	Short-term, intentional violation of territorial integrity (e.g. civilian or military operations of foreign security forces on Swiss soil)	Short-term, severe violation of territorial integrity (e.g. repeated civilian or military operations of foreign security forces on Swiss soil)	Temporary, severe violation of territorial integrity (e.g. temporary occupation of a limited area of Swiss soil)	Temporary, very severe violation of territorial integrity (e.g. temporary occupation of a considerable area of Switzerland)	Long-lasting, very severe violation of territorial integrity (e.g. occupation of a significant part of Switzerland)
S4	Damage to or loss of many cultural property of regional significance and individual cultural property of national significance	Damage to or loss of several cultural property of national significance	Damage to or loss of several cultural property of national significance and few cultural property of international significance (under 'enhanced protection')	–	–
S5	Damage to reputation lasting several weeks and related to important issues, but with minor impact on Switzerland's standing and international cooperation	Damage to reputation lasting several weeks and related to important issues, with impact on Switzerland's standing and international cooperation (e.g. termination of agreements with Switzerland, temporary expulsion of Swiss ambassador)	Considerable damage to reputation lasting several weeks, with impact on Switzerland's standing and international cooperation (e.g. termination of significant agreements with Switzerland, expulsion of Swiss ambassador)	Considerable damage to reputation lasting up to several months with visible impact on Switzerland's standing and international cooperation (e.g. political isolation, boycotts)	Lasting, severe and even irreversible loss of reputation with far-reaching impact on Switzerland's standing and international cooperation (e.g. political isolation, boycotts)
S6	Damage to confidence lasting for a few up to several weeks and related to significant issues (e.g. strikes, larger demonstrations)	Damage to confidence lasting several weeks and related to significant issues weeks (e.g. multiple strikes, occasional mass demonstrations)	Considerable damage to general confidence lasting several weeks (e.g. extended strikes in many areas, mass demonstrations across Switzerland)	Considerable damage to general confidence lasting up to several months (e.g. general strikes)	Lasting, severe or even irreversible loss of general confidence (formation of local or regional groups for self-organisation of public life, up to the point of vigilante group formation)

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