

CBRE COLLECTIVE PROTECTION IN BUILDINGS

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ABSTRACT

With the aim of an integrated approach, Spiez Laboratory developed fundamentals to mitigate Chemical, Biological, Radiological and Explosive threats. The guidelines concerning the CBRE Collective Protection in Buildings address protection measures for people who stay in aboveground buildings. The integrated risk management allows the evaluation of appropriate measures to improve security for people in buildings, which are based on relevant risks as well as the cost/benefit effects of the measures.

The risk-orientated planning guidelines deal with hazards of incidents with chemical or radiological agents and in particular terrorist attacks with explosives, firearms, chemical, biological or radiological substances. Based on corresponding CBRE reference scenarios data for hazard and risk analyses were provided. With the guidance tool the probability respectively plausibility of a scenario and the vulnerability of built infrastructure, the number of casualties/injuries, the amount of damage and the loss of functionality and services can be estimated. Operational and technical safety and security measures, constructive protection and measures for building services are evaluated due to the risk assessment.

The presented methodology was successfully validated in practice. For four greatly varying sites - an office building, a bus depot, a data center and a main railway station - hazard and risk analyses have been executed. Based on the results, cost-effective safety precautions were recommended.

SCOPE

Underground protective structures offer good protection against the effects of weapons. When needed, they will be occupied as a precautionary measure. Incidents as well as attacks by terrorists or extremists however most of the time take place with no or only short advance warning. In such cases, moving into emergency shelters is often not possible. As a complement to the classical shelter construction there is a need for appropriate and practical concepts for collective protection of persons in aboveground buildings. Spiez Laboratory therefore prepared guidelines describing the principles of the CBRE collective protection in buildings [1], [2].

In Switzerland the National Risk Analysis of the Federal Office for Civil Protection (FOCP) covers the hazards and risks caused by NBC disasters as well as natural hazards at the national level [3], [4]. With regard to CBRE collective protection in buildings, the focus is on the specific analysis and evaluation of protective measures for particular buildings.

HAZARD AND RISK ANALYSIS

To undertake hazard and risk analyses, reference scenarios are used that describe the possible CBRE hazards for persons in buildings. These scenarios are based on the Hazard Catalog [5] and the Reference Scenarios CBRN [6] issued by the Federal Office of Civil Protection.

The hazards and risks for persons in buildings are determined on the basis of these reference scenarios. The approach taken for the development of such object-specific and situational hazard and risk analyses is shown in figure 1.

The relevance of the reference scenarios is assessed using the object-specific *hazard analysis*. In case of scenarios valuated as not being relevant, no further analysis is required. Reference scenarios that have been assessed as relevant can be adapted with regard to the CBRE substances and their amounts considered. The plausibility and magnitude of the reference scenarios are assessed using object-specific *risk analysis*. Scenarios that lack plausibility can be discarded. The risks of possible incidents are situationally adjusted by taking account of the structural characteristics, utilization and operation of the building and the actual hazard potential present.

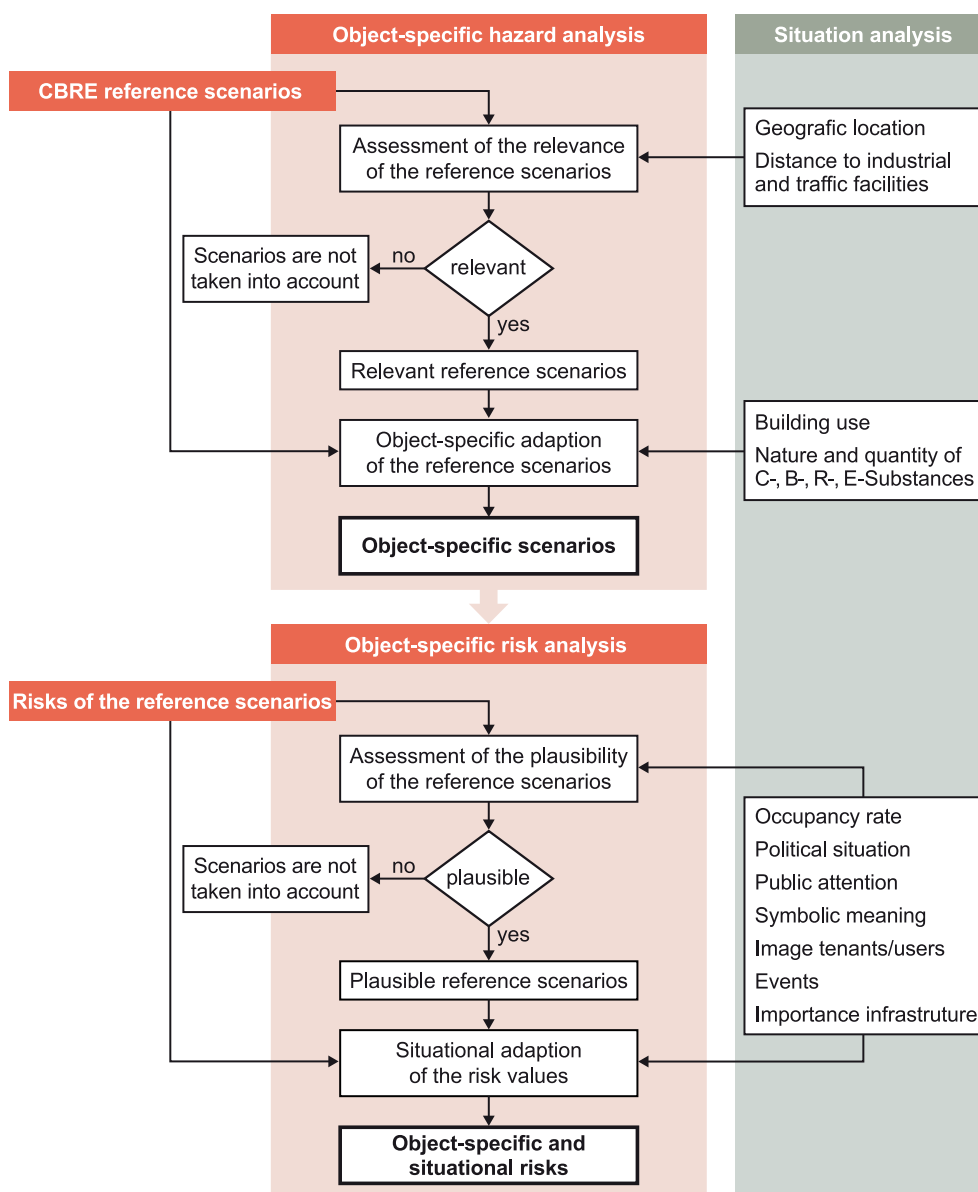


Figure 1: Approach for the object specific hazard and risk analysis

RISKS OF THE REFERENCE SCENARIOS

The risks considered in the reference scenarios are set out in the conceptual principles [2]. They have been developed using the methodology that was developed by the Federal Office for Civil Protection in the framework of the National Risk Analysis. Because these CBRE risks are individual risks related to single buildings, they are much smaller for most scenarios than those associated with disasters and emergencies in Switzerland.

In contrast to statistically recorded incidents, scenarios with a terroristic or extremist background can be described hardly using a frequentist interpretation of the probability. Therefore, for such scenarios subjective probabilities and the related frequencies are estimated. Derived therefrom the plausibility of the occurrence of the scenario is estimated. For the qualitative risk analysis, six classes with regard to both plausibility and damage are defined, as shown in table 1 below:

As a semi-quantitative support for the estimation of the *plausibility* of the scenarios, the probabilities are given for the occurrence of a scenario related to a building over a period of 20 years, as well as the corresponding return period of the scenario.

The estimation of the *damage* is done primarily based on the expected personal and financial damage. The estimation of the financial losses takes into account the damage to property as well as consequential losses and reputational damage, and also losses due to business interruptions.

Table 1: Plausibility and damage classes of CBRE scenarios

Plausibility		Likelihood of the scenario within 20 years		Return period of the scenario
P5	Relatively plausible	likely	$\geq 10\%$	< 200 years
P4	Rather implausible	relatively likely	$\approx 5\%$	200 - 1'000 years
P3	Implausible	rather unlikely	$\approx 1\%$	1'000 - 5'000 years
P2	Very implausible	unlikely	$\approx 0.2\%$	5'000 - 20'000 years
P1	Extremely implausible	highly unlikely	$\approx 0.05\%$	20'000 - 100'000 years
P0	Hardly imaginable	extremely unlikely	< 0.01%	> 100'000 years

Damage		Personal damage	Monetary damages incl. consequential and reputational damages
D0	Very low	No personal damage	< 100'000 CHF
D1	Low	1 - 20 Injured	100'000 - 750'000 CHF
D2	Medium	1 Fatality / 10 - 50 Injured	750'000 - 5 Mio CHF
D3	High	2 - 9 Fatalities / ≈ 100 Injured	5 Mio - 50 Mio CHF
D4	Very high	10 - 50 Fatalities / ≈ 500 Injured	50 Mio - 500 Mio CHF
D5	Disastrous	> 50 Fatalities / > 500 Injured	> 500 Mio CHF

The representation of the risks in a matrix format with plausibility and damage enables a visualized comparison of different risks. The risks of the CBRN reference scenarios displayed in such a chart is shown in figure 2. Regarding the levels of the risks, the amplified perception and subjective strong emphasis of incidents with serious consequences - the so-called risk aversion - has been taken into account accordingly.

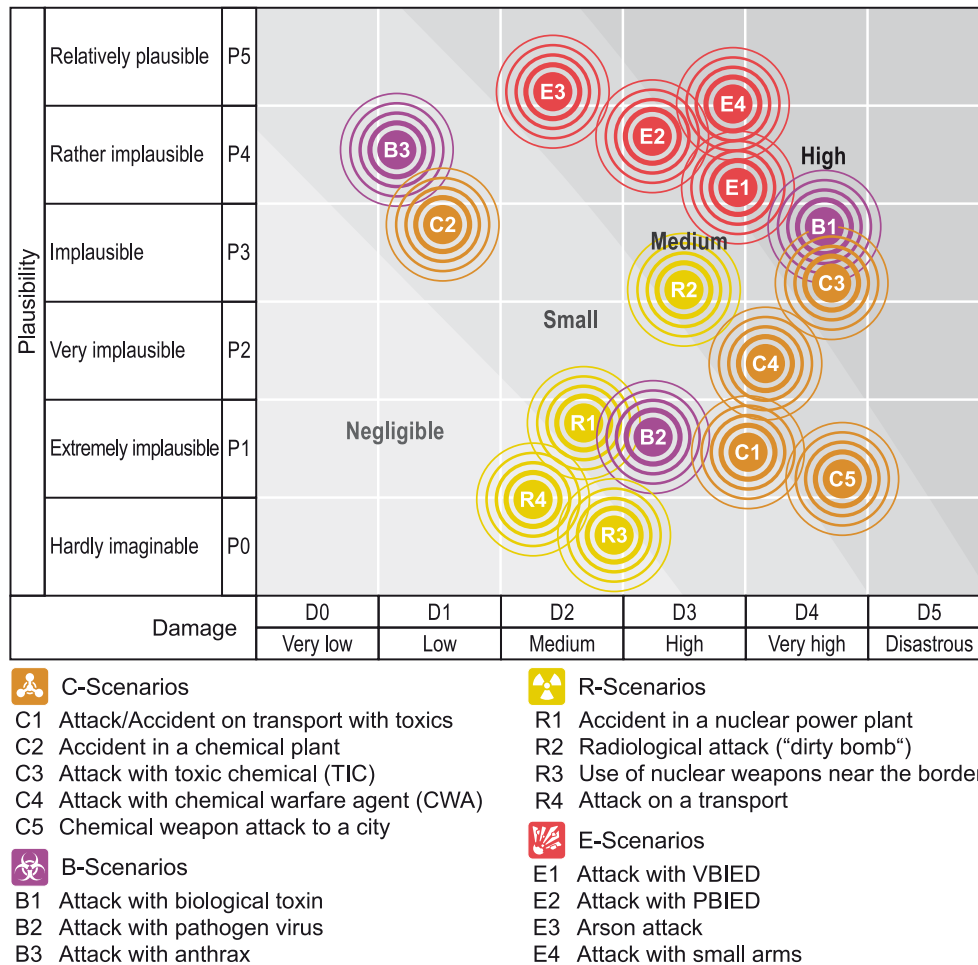


Figure 2: Risks of the CBRE reference scenarios

PROTECTIVE MEASURES

Figure 3 provides a comprehensive overview of the protective measures that can be adopted for CBRE collective protection in buildings. Active measures that may prevent an incident are illustrated on the left. So-called passive measures, which repel or at least reduce the effects of a scenario, are listed on the right. Some measures - for example a perimeter protection, which provides an appropriate stand-off distance - affect as active as well as passive measures. When for an aggressor the success potential and therefore the target attractiveness is small the plausibility of an attack is diminished. In case of an incident an adequate stand-off reduces the effects and thus the damage.

The *design and arrangement* of buildings relates to the most advantageous array of sensitive building elements such as ventilation openings, the creation of stand-off distances or the construction of shelters.

With regard to the *building services*, hazards caused by toxic gases, aerosols and ionizing radiation are relevant. Important in this context are the detection of hazardous substances, the processing of the detector signals and the use of filtering systems.

Security measures are technical/organizational measures such as controls, surveillance and guarding which prevent an incident. *Safety* measures include measures that reduce the impact of an incident. They include alert systems, evacuation as well as fire protection.

Construction measures include amongst others perimeter protection. By limiting access to a building, incidents can be prevented. With a sufficient distance between perimeter and building, the effects of an incident (e.g. the impact of explosions) can be reduced. Construction measures and hardening that improve the robustness of buildings or structural building elements are typical examples for construction measures that reduce the consequences of incidents.

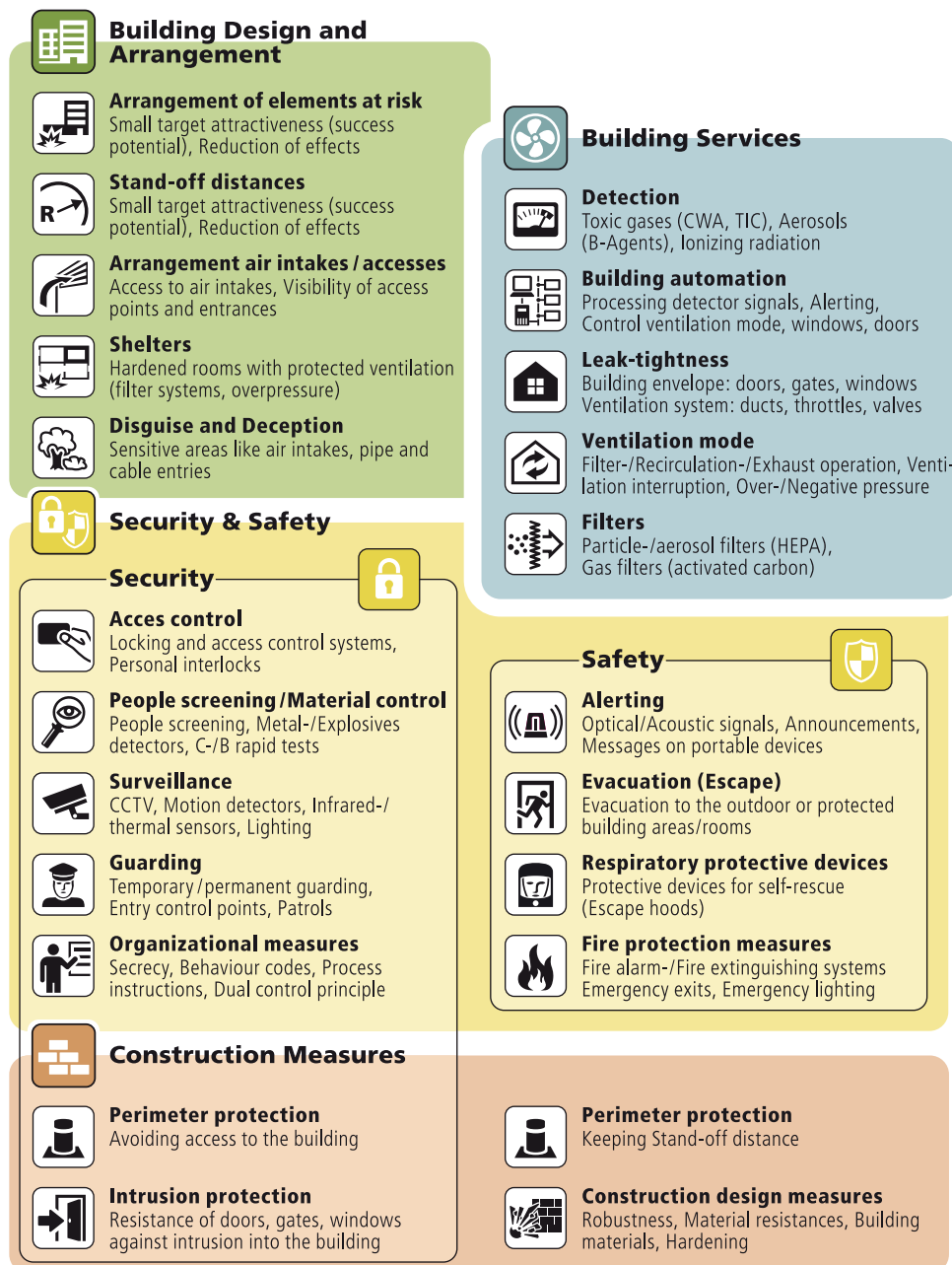


Figure 3: Technical areas and protective measures

EVALUATION OF COST EFFECTIVE AND OPTIMAL MEASURES

The conceptual principles of CBRE collective protection in buildings describe a risk-oriented approach for the assessment of protective measures that is based on marginal costs. In this approach, the expenses required for the measures are contrasted with their effectiveness. Their efficiency is quantified by the relation between costs of the measures and achievable risk reduction. For cost effective measures the expenses for the protective measures are less than the costs incurred by the risks.

Appropriate protective measures reducing the risks which is usually associated with decreasing damages and thus risk costs. Increasing expenditures for protective measures on the other hand also result in higher safety costs. Expenses for protective measures are at an optimum when the total of the safety and the risk costs is minimal. Determining the most cost effective measure, it is important to know that there is only one optimum. To illustrate this approach, an example with an explosive hazard caused by a VBIED and a perimeter protection ensuring stand-off distance is shown in figure 4 below.

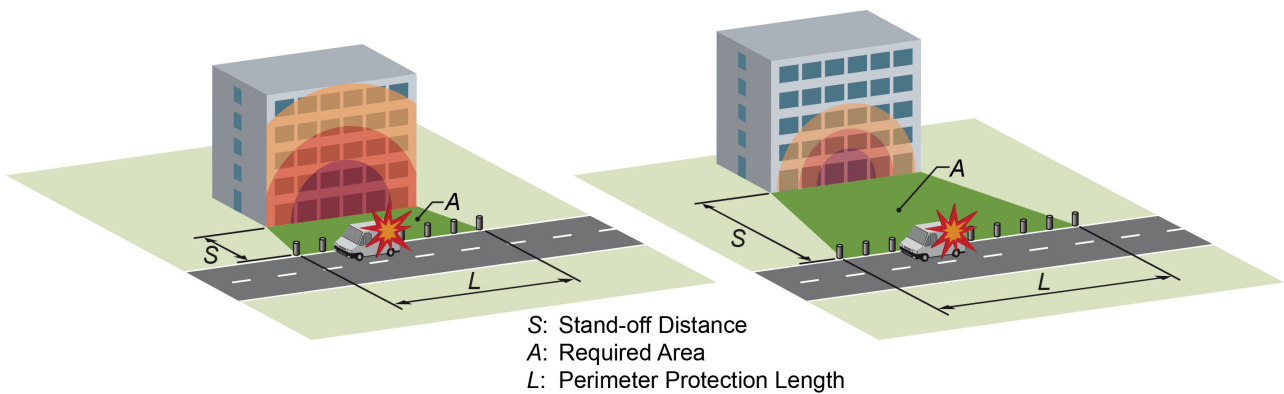


Figure 4: Perimeter protection ensuring stand-off distance and thus reducing explosion damage

For the example pictured above, the following figure 5 shows the risk costs and the safety costs as a function of the stand-off distance. In order to compare to costs properly, it is important that risk costs as well as the safety costs are converted in annual costs.

With increasing stand-off the building damages are becoming less severe due to the decreasing overpressure and impulse of the blast. Therefore, also the annual risk costs decrease strongly. On the other hand the area needed to achieve the stand-off must also taken into account. For this reason the costs for the protective measure increase with the stand-off distance. Summing the annual risk and safety costs the result typically is a bathtub curve with a minimum. The optimal measure respectively the optimal stand-off distance in the example, is at the total costs minimum.

It is recalled that this example describes the principle for the evaluation of optimal protective measures. It is obvious that in practice - especially in urban areas - the available space is limited wherefore often also the arrangement of perimeter protection is given.

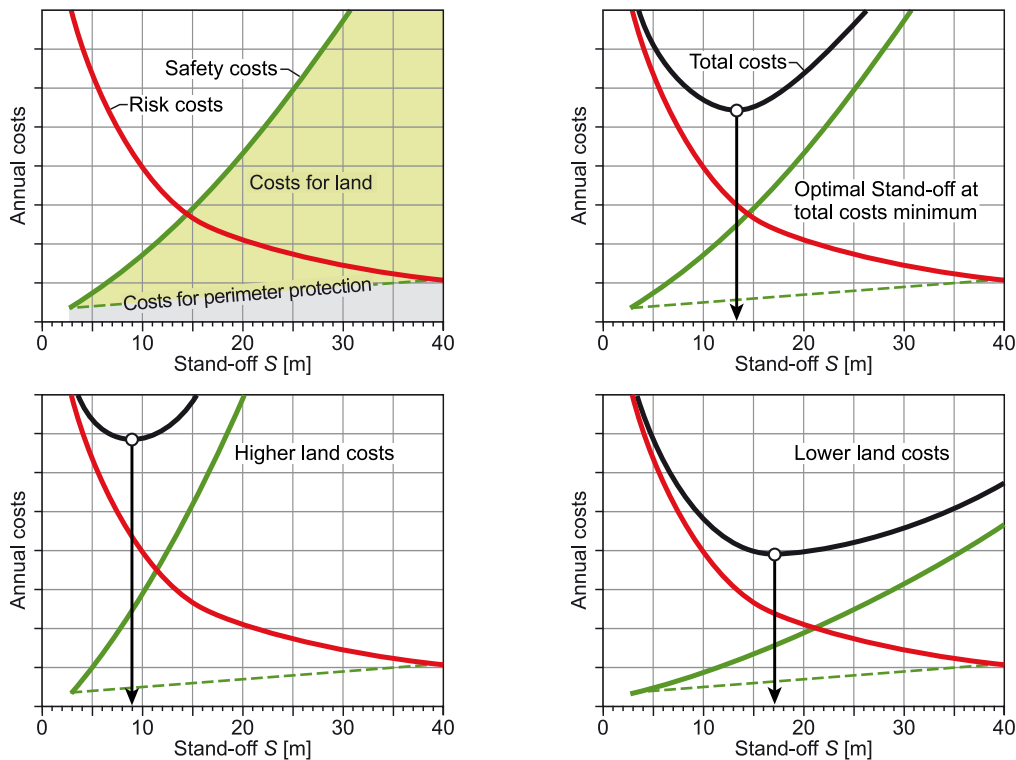


Figure 5: Example for the determination of the most cost effective (optimal) stand-off distance

VALIDATION OF THE CONCEPTUAL PRINCIPLES

The applicability of the principles for collective CBRE protection in buildings were validated in practice by Spiez Laboratory. To this end, the object-specific CBRE hazards and risks were evaluated for four different buildings and facilities. The buildings selected for this validation project differed profoundly with regard to size, geographical location, utilization and occupancy rate. The methods for hazard and risk analysis as well as the evaluation of the protective measures were applied to an office building of a SME, a bus depot of a public transport enterprise of a city, the data center of a bank, and a large railway station. The analyses were conducted with the help of specialists who contributed their particular competencies to the resolution of the different problems. Stakeholders who were familiar with the building, security experts and facility managers as well as external risk experts and CBRE specialists participated in the expert groups (Delphi survey).

The results of the four risk analyses are shown in figure 6, in a comparative manner. As is common in safety engineering, the risk profiles of the buildings are shown as so-called cumulative curves. A comparison of the risks shows that the highest risks are present at the railway station whilst the lowest ones are found for the office building. The comparatively large risks at the railway station result from the large public exposure as well as the general vulnerabilities related to the operation of a railway station. For all buildings, the E scenarios (attacks with explosives or small arms) contribute the largest share of the overall risk whilst the risk contribution of C scenarios is generally small. The risks associated with an attack using a radiological bomb (“dirty bomb”) are significant for the railway station as well as the bus depot. The analysis of the data center yielded small risks because security and safety measures are already implemented and because the bank operates a redundant data center.

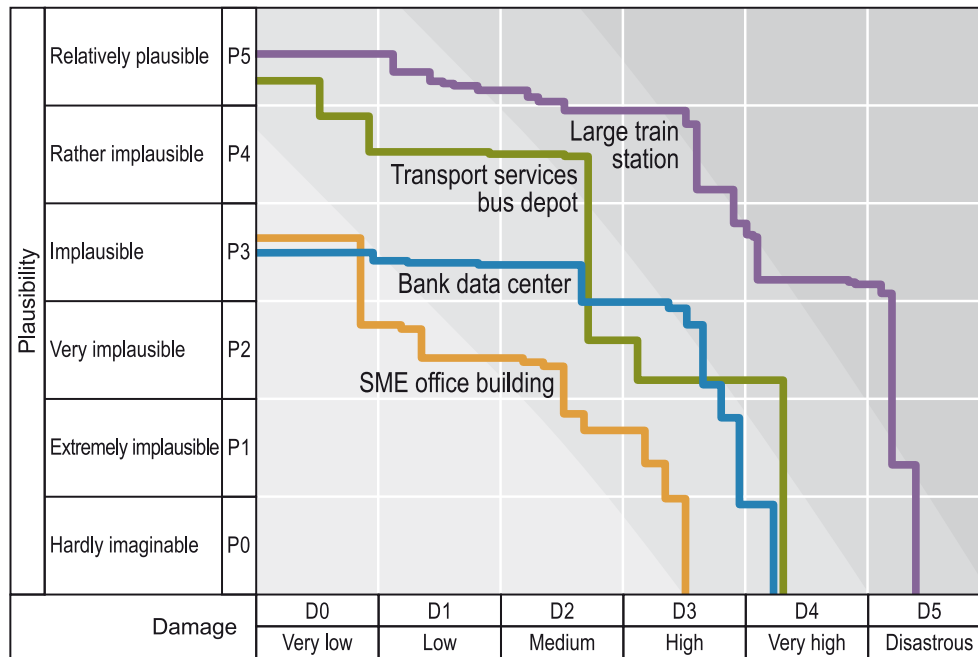


Figure 6: Risk profiles (cumulative curves) of the objects studied in the validation project

The validation of the conceptual principles for the CBRE collective protection in buildings was able to demonstrate that the methodology for the conduct of hazard and risk analyses can be used for very different objects and, consequently, that the evaluation of cost effective protection measures is possible.

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