RISK MANAGEMENT AT TECHNICAL FACILITIES DECOMMISSIONING AND SITE REVITALISATION

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CONTENT

LIST OF ABBREVIATIONS

Abbreviation	Title
CBA	Cost Benefit Analysis
ČVUT	Czech Technical University
DC process	Process for Decommissioning and Clean-up of the Released Territory
DSS	Decision Support System
ESRA	European Safety and Reliability Association
ESREL	European Safety and Reliability Conference
EU	European Union
FEMA	Federal Emergency Management Agency
IAEA	International Atomic Energy Agency
ISO	International Organization for Standardization
IT	Information technologies
OECD	Organisation for Economic Co-operation and Development
SMS	Safety Management System
SoS	System of Systems
TQM	Total Quality Management
UN	United Nations
WB	World Bank

ABSTRACT

Present book "Risk management at technical facilities decommissioning and site revitalisation" is dedicated to the risk management of the process that includes: putting out the technical facilities from the operation; carrying out the dismantlement of fittings, constructions and buildings; transport of usable fittings, materials and waste, and in need case after their decontamination in the site; cleaning up the released territory, and in need case to perform its decontamination; and passing the released territory in the next civil use. This process is very important to ensure the long-term security and development of humans.

The problems associated with the existence of environmental burdens and brownfields indicate that the humans have not yet been given sufficient attention to this process. Therefore, the publication summarizes the current knowledge about the relevant process, collected in the professional literature. By methods of risk engineering disciplines, they are processed the data on followed processes failures, which has been obtained by systematic analysis of professional sources.

Because the followed process needs to be managed by the public administration, so on the basis of the results of the data processing by referred methods and procedures used in the risk engineering, they are proposed for the public administration two tools for improvement the territory safety management within the public interest. It is a decision support system that will allow the improvement of public administration decision-making, and a risk management plan that will enable the public administration to be prepared for the possible risks and to be capable to ensure their timely qualified mastery. The way of problems solving is based on at the simultaneously preferred risk management concept, i.e., the risk management targeted to the territory safety, and in particular operations, the safety is put above to the reliability.

The present publication “***Risk management at technical facilities decommissioning and site revitalisation***“ summarizes problems and shows methods and procedures for their solution based on system concept and present findings and experiences from practice obtained by special research. It summarizes results of specific research performed in project “***Řízení rizik a bezpečnost složitých technologických objektů (RIRIZIBE)“ CZ.02.2.69/0.0/0.0/16 _018/0002649***”. At the request of the CTU Rectorate and the Ministry of Education, Youth and Sports, the submitted version of the book was supplemented in 2022 with data related to the RIRIZIBE project and the format was modified to keep the original pagination.

Key words: technical facility; decommissioning; decontamination; site revitalisation; risk; safety; risk sources; risk management; integral risk; risk acceptability.

1. INTRODUCTION

The monograph, dealing with the risk management associated with the termination of a technical facility and handing over the released area for further use, focuses on a problem, the solution of which is only on the beginning, namely in both, the professional field and the practice. Its neglection and failure caused many problems in the territory. In many places we find highly contaminated areas that cannot be used for civilian purposes due to dangerous contaminants, and brownfields, i.e. unmanaged areas that are the source of allergens. Both categories of affected areas damage the landscape, reduce the usefulness of the area and more or less endanger the health and well-being of humans around them [1].

Therefore, the problem solved in the book is understood comprehensively, i.e. the territory and each of its entities are represented by a set of open and interdependent systems that dynamically evolve over time, while the development direction of each system is diverse, i.e. not necessarily to be always the same. Therefore, based on current knowledge, the problem solving requires the use of multi-criteria approaches and methods [2,3].

Technical facilities, whatever in the form of products or in the form of large technical complexes, are the result of the technical skill of generations of people. Major technical facilities include:

- power plants,
- industrial buildings,
- dams,
- airports,
- railway stations,
- warehouses,
- hospitals,
- large shopping centres,
- large cultural or sports centres, etc.

These technical facilities belong to administration of various sectors and have aim to ensure a quality life for humans during their lifetimes. They include physical, cyber, organizational and social systems, i.e. individual devices, machines, components, personnel, systems or entire production or service units, which have different life-times [4,5].

All technical facilities, however, have only a certain life time, and then they become unnecessary items and objects that no longer fulfil the mission for which they were created. They become waste or environmental burdens. It is clear from this fact that the safety of technical facilities, assessed from the perspective of ensuring the long-term existence of mankind, does not only concern the operation of technical facilities, but also their proper disposal at the end of their service life. The aim is to prevent the origination of damaged or non-endurable contaminated territories that humans would not further use for their life and development. This is particularly important when we consider that the population of the Earth planet is growing and that it is necessary to provide for humans the livelihood and space. Therefore:

- to be aware of the risks associated with the process of technical facilities decommissioning and clearing up the occupied area in such a way as to allow further land use,
- to select such processes for the decommissioning and clean-up of the released area (*hereafter only DC process*) that are effective, economically and environmentally acceptable.

This means that it is not possible to meet the pious wishes of academics representing the best solution, often from the perspective of one discipline only, but it is necessary to choose a procedure that is feasible and has clear rules and responsibilities.

Based on current knowledge, it is clear that the process of decommissioning and its disposal and vacant territory cleaning belongs to the process of ensuring the integral safety of the human system [6,7]. Therefore, we need to specify the risks and manage them so that the human system, which is a model of the world in which we live, may be safe [2,3,8,9]. According to the data in works [1-5,8-11], when selecting the optimal variant of the DC process in a given case, the following items play a role:

- the achieved safety level of the released area and the surroundings of the technical facility put out of operation,
- technical feasibility of measures to ensure the DC process, which includes:
  - technical facility decommissioning,
  - disassembly of equipment, structures and structures,
  - removal of usable equipment, materials and waste and, if necessary, after their decontamination on site,
  - cleaning up the released area and, if necessary, decontamination of the area,
  - handover of the released area for further civilian use,
- material, energy, knowledge, personnel and financial demands of the DC process,
- speed of implementation of the DC process,
- demands on the management / organization of DC process activities in a specific territory and under the specific conditions and capabilities of the DC process implementer and the relevant public administration.

The aim of the publication is to identify:

- the causes of the risks that have already led or may lead to failure of the DC process and to unacceptable impacts on the human society and environment,
- the appropriate instruments from the toolkit that use the risk-based disciplines to ensure the quality work with the risks associated with the DC process targeting a safe area.

As the publication is intended for engineers, the administrative processes of the actual transfer of the released area from the ownership of one entity to the ownership of the other are only marginally addressed.

It should be noted that the scientific literature of the DC process has not received much attention yet, except in the field of nuclear installations with a high environmental hazard [1,4,5].

The content and concept follow the publications [1-5,8-11], which in a single concept closely monitor the issue of risks and safety of humans, territories and technical facilities. Publication uses the problem concept, terms and data from publications associated with the ESREL worldwide conferences organized by ESRA (European Safety and Reliability Agency) [12-22]; a list of terms that coincides professionally with the concepts of the UN, OECD, IAEA, WB and others [2-5,9] is in [2,3].

The concept used can be briefly summarized as follows - each technical facility is located in an area where there are a number of sources of risk, the implementation of which may damage both, the technical facility and its surroundings. Risk is a measure of losses, damages and harms to protected assets. Its size depends on the real disaster (i.e. the phenomenon that has the potential to damage tracked assets [2,8,9]), which is a source of risk and the vulnerability of local tracked assets. These assets include both, the public and the private assets. In strategic management, they are defined:

- hazard as the probable size of a disaster that occurs once in a given time interval (a so-called project or design disaster) [2,4,9],
- and risk, such as the probable size of losses, damages and harms to the assets under review during a design disaster, calculated for unit of time (typically 1 year) and unit of territory [2,4,9].

Human's goal is the security and development of humans, and for both they are important the safe environment and the safe technical facilities that humans place in the environment. The safety is understood to be a system-level characteristic that humans shape through their measures and actions [1-5,8-11]; and a system is safe when not under its critical conditions does not endanger itself or its surroundings. The safety of the environment in the context described above is specifically monitored in the work [8]. The safety of the technical facility is closely monitored in the works [4,5,23].

In all considerations, it is important to consider that risk and safety variables are generally not supplementary variables, because the safety of the environment and of each technical facility can be improved by organizational measures such as the introduction of warning systems and backup solutions without reducing the size of risk; A supplementary term to safety is the criticality [2,3,8,9].

Current knowledge shows that the world in which people live, i.e. the human system, needs to be in a state that the interconnected systems that are the environment, the social system and the technological system coexist, i.e. their coexistence is ensured. Coexistence generally means common existence. The problem of coexistence is analysed in detail [11].

In the case under review, it is a matter of ensuring such conditions in the human system during the decommissioning the technical facility and the renewal of a territory that ensures the coexistence of interconnected systems, i.e. social, environmental and technological ones. The need and importance of coexistence is considered in many technical fields as it is shown in [1,12-22]. These works in question show that technical facilities cannot be considered as closed systems, but their surroundings need always to be considered, which confirms the requirements gathered in the works [5,6,11].

Figure 1 shows the basic idea of problem understanding, the target of which is the human security and development during the process of the technical facility life cycle.

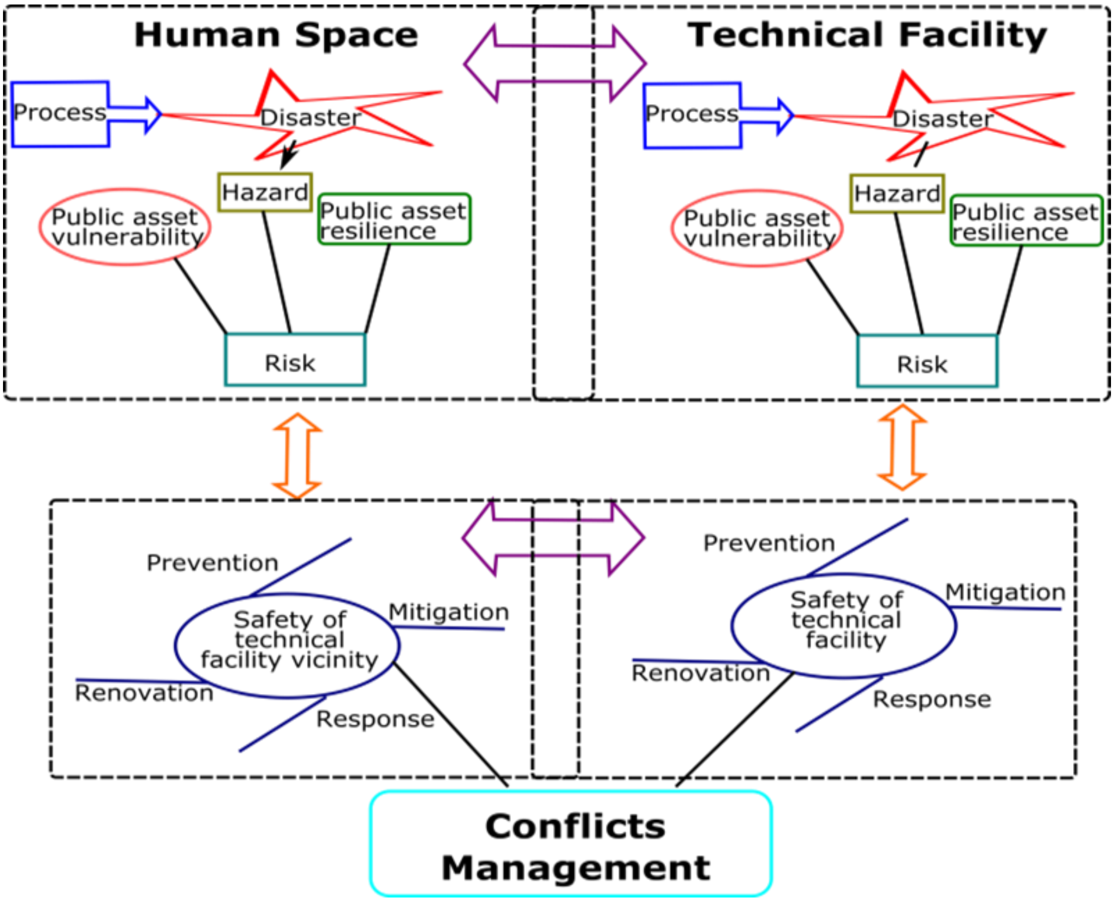

Figure 1. Idea of risk management that needs to be considered during the technical facility life cycle.

As the process of technical facility termination, cleaning up the territory and handing over the released territory for further use, are usually codified by the Building Act and closely related legislation, which is described for example in the work [11,13], so this publication does not deal with technical details of procedures:

- technical facility decommissioning,
- dismantling of equipment, structures and constructions,
- removal of usable equipment,
- methods of demolition of buildings,
- waste removal,
- and administration of the transfer of the territory in question to the administration of public administration, or third parties.

The main reason for this is that the technical implementation depends significantly on the type of technical facility being shut down and on the technical and financial possibilities of both, the relevant legal person responsible and the public administration in enforcing the best solution. More broadly, the publication deals with the process of decontamination, i.e. clean-up of the area in question, because the issue is still not monitored and codified.

Since it is true that without standards and legislation, we would be doomed to repeat mistakes from the past, but without embedding safety in their improvements and the ability to sustainably respond to unexpected events, we would not be ready to address future problems, so we focus on the risks of involved process and we are looking for a way of their quality management and settlement in favour of the human system, i.e. humankind.

It should be noted that working with risks to the public interest requires an understanding the problem, clear rules, motivation, and assigned responsibilities [5]. The publication comes out from publication [1], which emphasize that working with risks to the safety of the technical facility and the surrounding area requires all parties involved to understand the problem, clear rules, skill, motivation, and assigned responsibilities.

The way of solving the problem, which is used further, is based on the currently preferred concept, which is explained in [5], in which safety is superior to reliability. Based on this concept, a safe process is a process that is reliable and functional and which, even under its critical conditions, does not destroy its base and its surroundings. Although in many cases it can be a costly and technically expensive way of solving, it is in the public interest that even the process of ending the existence of a technical facility should not damage the territory, and thus the human society that inhabits the territory.

The monograph is the result of project „Řízení rizik a bezpečnost složitých technologických objektů (Management of risks and safety of complex technological facilities - RIRIZIBE)“ CZ.02.2.69/0.0/0.0/16 _018/0002649”. For recommendations and comments authors thank to reviewers Assoc. Prof., Ing. Petr Šrytr, PhD. For working condition creating the authors thank to the Czech Technical University in Prague, the Faculty of Mechanical Engineering and Department of Energy.

2. FINDINGS ON TECHNICAL FACILITIES DECOMMISSIONING AND SITE REVITALISATION

As mentioned above, the DC process has five main parts (sub-processes) that are interconnected. For the first four subprocesses, technical focus is essential, and for the fifth one, administrative and economic focus is prevailing. In order to ensure the coexistence and safety of the three basic systems of human system, there are important: decommissioning a technical product or a technical facility; dismantling; removal of reusable parts; disposal of waste; and decontamination process if contamination of parts of the technical facility and the territory has occurred.

It is necessary to consider that frequent notion that some technical facilities as fine engineering, food industry, etc. are not a source of contamination, is false, because everywhere there are used e.g. at equipment maintenance the oils, cleaning agents etc., which belong to dangerous substances, and therefore, they are a source of contamination. The failure of the fifth sub-process also means damage to the public interest, i.e. the disturbance of the public welfare and financial loss to the participants, i.e. it also means harms on coexistence, but by its administrative and economic nature it falls within the legal rather than the engineering domain; and it is therefore not followed in detail in the further text.

Findings obtained from the practice show the unacceptable impact of the failure of the first four parts of the DC process [1]. It is demonstrated by many contaminated sites (groundwaters, soils, landfills, building structures, etc.) from which hazardous substances permanently escape or can escape into the environment, namely permanently, periodically or occasionally. The result is often unacceptable affection of health, physical, psychological , social, genetic, aesthetic, or environmental conditions. Since the quality of the environment is necessary for the health and development of the human population, the process under review should be managed in such a way that the risks associated with the decommissioning process allow further exploitation of the released area for the benefit of human society development.

For the humans´ safety and development it is necessary:

- contaminated sites rid of contamination,
- managing the risks of the decommissioning process of technical products and technical facilities, ensure that contaminated sites either would not origin or were under control.

From a real perspective, it is necessary to find conditions for how to do it, how to pay it, and how to enforce it on the manufacturers of technical products and operators of technical facilities. Research shows that:

- in the EU and developed countries, the product-related issue is already being addressed in a number of cases,
- however, solution of the second case is still very rare.

Book [1] shows examples of the rests of the past, so we call as brownfields or old burdens. Because in many cases they represent danger and risk for humans and environment, the EU and developed countries have been today developed effort and spent huge finance for their removing, and led in force the legislation of effective this risk management.

2.1. Technical facilities´ life cycle types

Each technical facility has its own life cycle. It represents the time period by that it goes through. Its beginning is the very idea of realization. This is followed by the transformation of the idea into an investment plan, planning, designing, implementation, use of the technical facility, its maintenance and repair or reconstruction, and finally the technical facility liquidation. The cycle can be divided into its individual phases, which are of different length and are defined by specific activities that are in progress at that stage and define the current state of the project of the technical facility. According to [24] these are the phases:

- pre-investment,
- investment,
- operational,
- liquidation.

The costs associated with each phase depend on the specific technical facility; for cases monitored at work [24], see Figure 2.

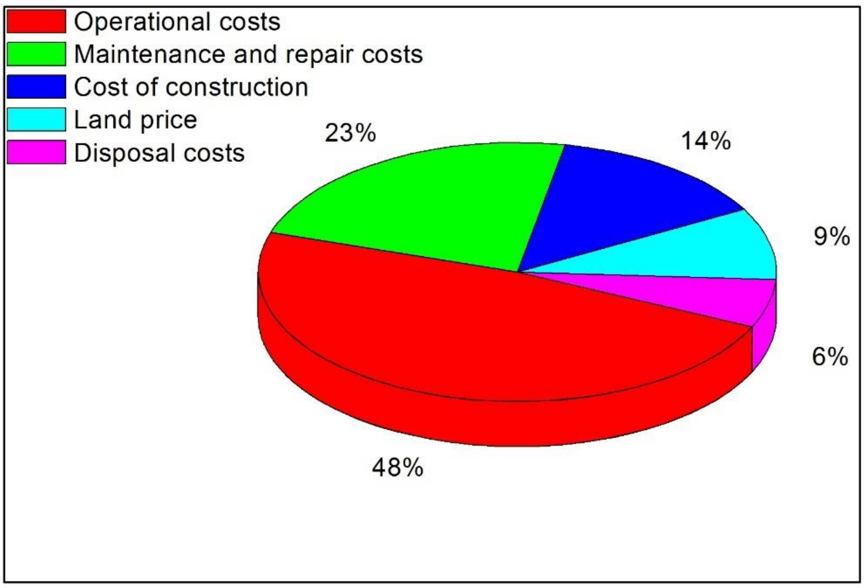

Figure 2. Life cycle costs of technical facilities; processed according to [24].

The life cycle length belongs to the technical-economic characteristics of the technical facility. The advantage of technical facility functional parts is that it is possible to assign a lifetime to each specific functional part and, in addition, to monitor the development of lifetime changes over time. Generally, the lifetime can be divided into two basic groups:

- technical lifetime,
- and economic lifetime.

The technical lifetime is usually considered to be the time from the creation of the technical facility until its deterioration, respectively, until its complete technical termination.

Economic lifetime is the time from the creation of a technical facility to the moment of loss of its economic usefulness. For it, it is important the useful life of the building. As a moment of economic demise of a technical facility, we can consider a situation when it is more advantageous to liquidate an existing technical facility at a given location and build a new one, which will bring higher returns. The criterion may also be the amount of the cost of routine maintenance compared to the property income.

Moral lifetime is the time that we calculate from the beginning of the technical facility to the moment of the construction's obsolescence - layout, style, standards and technology, market changes, development of the territory, etc.

The legal lifetime is the period from the final technical facility approval to the moment of the decision, resp. permission to remove the technical facility.

2.2. Decommissioning

The technical facility decommissioning, in addition to a significant destruction of the technical facility by external natural or other disaster, is preceded by a decision as to whether it is better to innovate the technical facility or to put it out of service and put an end to its existence. Decommissioning is a general term for the formal termination of the active operation of a technical facility. It is a whole process, and in the literature, it is mainly mentioned in connection with the decommissioning of nuclear installations.

The analysis of the literature carried out in [1] shows unsorted opinions on the whole process. The work [25] shows that the standards for the process of shutdown and termination of the existence of a technical facility have not yet been elaborated.

According to work [25], the process in question has eight basic steps:

- approval of the technical facility shutdown plan,
- drawing up a shutdown plan of individual components and fittings,
- decommissioning,
- demotion of components and fittings,
- interruption of the connections,
- termination of activities,
- complete liquidation,
- data archiving.

According to the work [26], the decommissioning of a technical facility is part of the life cycle of the technical facility, which needs to be considered from the very beginning of its creation. It has an administrative and technical part and requires financial resources. Therefore, it is necessary to follow a certain strategy to make the whole process safe. The planning and implementation of the decommissioning of a technical facility is a complex and multidisciplinary process that has both, the technical and the non-technical aspects and requires the effective management. In this document, the IAEA states the requirements of the safety standard:

- choice of putting out of operation strategy,
- preparation of the decommissioning plan,
- projects for processes implementing the decommissioning,
- management of objects, components, equipment and materials connected with the decommissioning,
- supervision of the State on the process.

Therefore, the IAEA supports the appropriate research and dissemination of education in this field [27-30]. The US NRC [31] has processed a nuclear decommissioning program. It can always be said that this is a unique problem that has many specifics and takes a long time.

The termination of operation of a technical facility includes the process of decommissioning of the technical facility discussed in the previous paragraphs, as well as the process of its physical liquidation, which includes the removal of further usable components, equipment and materials and demolition of unusable objects, equipment and materials. The demolition process generates a huge amount of waste. To ensure a safe area, it is firstly necessary to separate hazardous waste from waste that can be used as a raw material for the reclamation of the area and from municipal waste that can be managed under the Waste Act in force in a given country. Thereafter, it is necessary to clean up the vacant area and dispose of the waste properly.

2.3. Process of decontamination of equipment and territory and its risks

The word contamination is used to indicate the pollution of a material, environment or system in specific cases by a non-originating or improper substance. In the event of pollution, the functionality of the affected system or material is generally reduced. Contamination is understood in a stronger sense than pollution, because it creates a danger to the environment of the system surrounding due to the action of a non-original substance (contaminant).

The risk associated with contamination is understood in relation to protected interests (assets), mostly the lives and health of living organisms, especially humans. Direct exposure to a contaminated object or indirect, such as water contamination, may constitute a hazard. Contamination can then be divided according to the nature of the impacts on:

- chemical,
- radioactive,

- biological.

The term decontamination generally means the elimination of contamination. In the field of civil protection since the mid-1950s, issues of human decontamination have been addressed. As technical equipment is expensive, great attention has recently been paid to the decontamination of technical equipment, fittings and entire technological objects. The decontamination associated with the DC process has two parts, namely:

- decontamination of parts of the decommissioned technical facility,
- decontamination of the released area.

Decontamination in the field of technical equipment [32] is defined as the removal of contamination from sites or surfaces of equipment or apparatus by:

- washing,
- heating,
- chemical or electrochemical activities,
- mechanical cleaning
- or other means.

Experiences show that in general, some form of decontamination to a greater or lesser extent is almost always required when decommissioning a technical facility. Some decontamination techniques are applicable inside technical facilities and some only outside [32].

The decontamination of buildings, structures and equipment has been systematically developed in the developed world since the late 1970s. In the case of aggressive hazardous substances, it is part of the response to emergency situations accompanied by the dispersion of hazardous substances and contamination not only of persons, but also of buildings, machines and other techniques. At first, simple techniques were used, such as hot-pressurized steam cleaning, and over time, a number of techniques have evolved, now that the techniques are categorized into several types, and each type is suitable in terms of efficiency for certain contaminations, while decontamination costs also play a role, and therefore, the Cost-Benefit-Analysis (CBA) is included in practical applications.

In the early 1990s, more than 8 million chemicals were known, of which approximately 70,000 were used annually. Today, over 20 million chemicals are already known, and about 100,000 chemicals are in use. Every year, 500-1000 new chemicals are added and 30,000 substances are produced in quantities above 1 tonne.

It is a fact that decontamination of technical facilities needs to be done after accidents involving the dangerous substances, examples of which are in the works [4,5,15], but also during the operation of technical facilities where hazardous substances such as sulfuric acid, asbestos, mercury, etc. are used.

In principle, decontamination technologies rely on physical, chemical and biological bases; according to some sources, their segmentation is limited to chemical and physical (mechanical) technologies. Decontamination methods are classified in four categories [32,33], i.e.:

- physical,

- chemical,
- enzymatic,
- energy.

Obviously, before transfer a released area that had been occupied by a decommissioned technical facility for further use, it is necessary to decontaminate the area if it has been contaminated. In the case of soil and surface water decontamination, the approaches outlined in the Waste Management Act are used, some examples are in case studies in [1,34]. The problem that is still open is groundwater decontamination. According to sparse information in the available scientific literature, it can be stated that successful solutions are site specific and that often the solution is to ban the use of polluted water for civilian use; e.g. in village Kozlov since 2004, water from wells contaminated with dangerous substances cannot be used after a traffic accident involving the dangerous substances on D1 [34].

2.4. Plan for decommissioning the technical facility and transfer of territory to further use

As it is apparent from the preceding paragraphs, the transfer of the territory occupied by a technical facility to further use for the benefit of human society is not a matter of twinkling time, but it goes on a long-term process. Therefore, a plan needs to be prepared for this process in accordance with the works [26-31,35]. It needs to include:

- transporting the reusable components, equipment and materials to new places of use,
- categorizing the unusable objects, equipment components and materials into waste categories:
    - dangerous,
    - further usable as raw material,
    - unusable waste,
- remove of hazardous waste,
- demolition and rehabilitation of vacant land,
- decontamination of the released area,
- restoration and landscaping of the cleared area,
- legal transfer of the vacated territory to a new administrator or owner.

3. RISK ENGINEERING METHODS

Both logical methods, i.e. analysis, synthesis, deduction, evaluation and assessment, as well as the specific heuristic methods described in [2,3,36] are used to obtain the results of the presented monograph. At this point we will give only the methods on which the following results are based. These are: fishbone graph; case study; decision support system; and risk management plan.

3.1. What, If

The What, If method is the most general method for detecting the impacts of a disaster by which the risk of a disaster can be determined. We use it in the form of filling the table; Table 1 [2,3,36] using the data from experts obtained by brainstorming or panel discussion.

Table 1. Standard model for applying the What, If method.

Asset		**The potential impact of a disaster on an asset**
Human lives and health		
Human security		
Property		
Welfare		
Environment		
Infrastructures and technologies		
	Energy supply sector	
	Water supply sector	
	Sewerage sector	
	Transport sector	
	Communication and information sector	
	Bank and finance sector	
	Emergency services	
	Basic territory services (industry, agriculture, supply service, health service, waste	

	management, social services, funereal services)	
	Public administration	
Technical facility: - critical fittings - critical components - critical links - critical infrastructures - critical couplings - critical stocks - critical personnel - critical processes management - ………..		

3.2. Checklist

The checklist is an engineering discipline tool that allows a multi-criteria assessment of the nature of the problem being observed [2,3,36]. Checklists are aimed at risk or safety of a technical facility and they are an essential tool for managers because they clearly identify risks in areas that are well-known and for which the development of knowledge and experience are defined by the limits of individual activities, actions, behaviours, etc. To ensure safety and development, it is necessary to eliminate the immediate, evident and recognizable risks. For their identification, the checklist serves very well. Then, it is necessary to reveal and to cope with the risks that are hidden in the chains of possible events, delayed in time using the specific methods and specific and qualified data.

3.3. Ishikawa (Fishbone) diagram

Fishbone diagram (Ishikawa diagram) is a tool used at causal analysis of the observed problem [2,3,36]. The cause-and-consequences analysis helps to thoroughly understand the nature of the problem by forcing us to address all possible disaster causes. The procedure for its application is:

- identification of the problem (it means to answers to the questions:
  - where does the problem occur?
  - what is the nature of the problem?
  - when did it occur?
  - how often did it occur?

- enumeration of significant problem factors (factors are fish bones),
- identification of possible causes (small lines on 'fish' bones),
- diagram analysis.

To create a diagram, it is necessary to collect and organize data about the causes that cause the problem and their impacts. This means that the processes associated with the problem to be solved needs to be described in detail by data, while the random and knowledge uncertainties [5-7] need to be clarified. Collecting the data is a first step and is time and knowledge consuming, as many resources need to be used to make the data files representative, i.e.: complete; containing the correct data; have sufficient data number; the data must be spread homogeneously throughout the observed interval and was validated [2,3].

The tool under review supports the analysis of the causes and consequences of a particular process, phenomenon or state and facilitates the search for solutions to the problems that have arisen. The aim of the method is to identify all possible causes or sources of the problem (or areas that affect the problem) and to structure them graphically.

The problem-solving organizer draws a "fish skeleton". In a group discussion, the consequences are placed on the respective skeleton sites according to their kinship and then causal chains of causes and consequences are searched for on the basis of discussion (brainstorming). The method can be used, for example, in the creation of departmental concepts, in identifying the starting state and in defining the starting points. Data that can be detected with considerable effort by routine data collection or measurement can also be quickly obtained. However, the knowledge and experience (i.e. qualifications) of the discussers is a drawback of the method [36].

3.4. Case study

A case study that relates to a specific decision, is associated with certain work models or simulations of processes that take place over time and territory or in an entity [36]. The case study describes and justifies the real experience gained from life in the subject area, thus broadening the knowledge of the problem and its aspects. The quality of the case study, i.e. the quality of the results presented in the case study, is based on the knowledge and life experience of the case study processor [36].

The case studies are based on both qualitative and quantitative data. Their result is a qualified locally and time-specific solution to a particular problem / case, and therefore, they are a suitable tool to support decision-making and management at the site. They are used when the knowledge of the problem in the system conception is unstructured, i.e. in connection with the problem in which for a number of elements, links and flows of the assessed system there are not only uncertainties that can be assessed by mathematical statistics, but also vagueness (epistemic / knowledge uncertainties), the estimation of which requires highly qualified data sets and demanding theoretical procedures. In other words, the problem and context data in the system in question do not meet the requirements for a generally valid solution. Therefore, either expert methods or case studies are used in these cases.

The case study methodology is, according to the knowledge gathered in [2,3,36], a tool to obtain a set of knowledge about the problem. It combines theory with practice while requiring the practical skills: identifying and recognizing the problem; understanding and interpreting the data and information; distinguishing the facts from the assumptions; analytical and critical thinking; understanding the random and epistemic uncertainties (data is never complete); improving the judgment; ability to communicate issues with experts with a different opinion. It is a problem-solving technique under various conditions (therefore, multi-criteria analysis of the system and its surroundings is important). It allows to solve unstructured problems, which are almost all failures and all complex systems accidents. It does not assume random distribution of solution variants.

It is de facto a historical scenario of a process, i.e. a model of the course of a certain process that takes place under specific conditions, i.e. at a certain place and at a certain time. From a methodological point of view, it is a process model that is compiled on the basis of real data. It is used in project and process management, if the knowledge of the problem in the system conception is unstructured, i.e. in connection with a problem in which many elements, links and flows of the assessed system are not only random uncertainties that can be assessed by mathematical apparatus. statistics, but also knowledge uncertainties, which require highly qualified data sets and demanding theoretical procedures. In other words, the problem and context data in the system in question do not meet the requirements for a generally valid solution.

The processing of a case study, as well as the processing of an expert opinion, requires both, the multidisciplinary and the interdisciplinary theoretical and practical knowledge, at least in the field of management and systems safety management, as well as considerable practical experience. In addition, it teaches justifying decisions to solve a problem.

In original monograph [1], they are used two forms, evaluation case study and prognostic case study. The evaluation study evaluates the potential risks and their impacts on the safety of the technical facility being prepared in a specific territory. When compiling it, the following questions are used:

1. What is the problem of the proposed technical facility and its surroundings?
2. What are the aspects and impacts of the problem on the conditions and development of the proposed technical work and its surroundings?
3. What is the root cause of the safety damage the proposed technical facility and its surroundings?
4. How could be averted the accident or failure of proposed technical facility and its surroundings?
5. What should be done to prevent a proposed technical facility and its surroundings from occurring safety the damage of during the lifetime?

Process of case study compilation is in Figure 3.

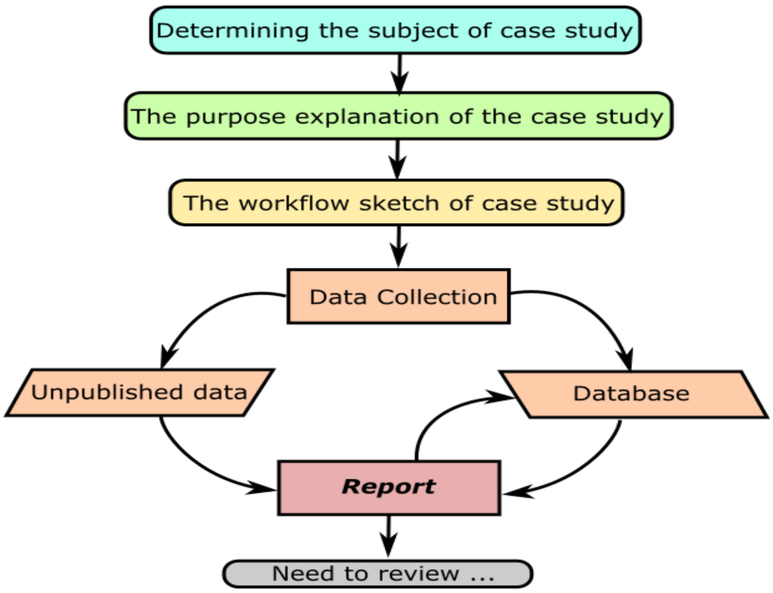

Figure 3. Process of case study compilation.

3.5. Decision Support System

The Decision Support System (DSS) [2,3,36] is a special technique for obtaining data for deciding the complex problems. It generally consists of the following components:

- data management module,
- model of management modules (model library),
- module for management of dialogue with user,
- and knowledge core (Knowledge engine).

There are different DSSs, or they have different conceptual starting points:

- model-based DSS (it using statistical simulations),
- communication DSS (it is for cooperation on a number of decisions),
- document DSS (it uses different types of documents to support decisions),
- knowledge DSS (it contains defined rules).

The decision support system (DSS) helps to solve the problem by supporting an analytical style of decision making against heuristic decision making. This means that:

- it organizes information for decision-making situations,
- it interacts with the decision-maker at various stages of decision-making,
- it extends the information horizon of the decision-making body,
- it facilitates multi-criteria evaluation, because it has built-in multi-criteria methods without the user knowing their mathematical structure.

Decision support systems use a general model for the certain case, reflecting the real situation. When specific parameter variables are substituted, they provide results for the given problem. The aim is to ensure that the result corresponds to the optimal solution. In their creation and application are used:

- knowledge and data from experts who know the technical parameters, limits and conditions of the technical facility and the local vulnerabilities,
- the principle of maximum utility theory [37], i.e. "the greater, the better" or "the greater, the worse".

DSSs are divided into special ones that provide support for solving the specific problems; and general, which are based on adaptive and flexible decision-making models. Obviously, the use of a specific DSS is only possible when verification establishes that the conditions for technology transfer are met [38]. Otherwise, the method needs to be adapted to local conditions. It should be noted that the adaptation of the method to specific conditions cannot be done by IT specialists, but by technical experts, who know the technical parameters, limits and conditions of the technical facility and local vulnerabilities.

Applications of sophisticated DSS based on multi-criteria evaluation give good solutions. In our case, we will compile a DSS in the form of a checklist [36] supplemented by a rule for evaluating questions and assigning a logical value scale.

DSS application aims are:

- identifying, managing, eliminating or minimizing unforeseen events that have adverse impacts on critical elements, critical components, critical processes, critical functions, critical infrastructure and critical technologies in the technical facility,
- the process of comparing the estimated risks against the benefit and / or cost of possible countermeasures and establishing an implementation strategy in the context of integral (systemic, overall) safety,
- determining which disasters (harmful phenomena) the technical facility is exposed to, what are the risks from individual harmful phenomena, what damage may arise, which measures will eliminate or minimize the occurrence of harmful events,
- the procedure consists of:
    - the assets are defined and their safety requirements are defined,
    - identification of vulnerabilities, potential impacts and risks,
    - estimated:
        - the amount of potentially caused damage,
        - and the cost of appropriate safety measures,
    - adequate safety measures are selected.

For critical items, limit values (limits) shall be established to ensure acceptable security. This means that the task of their managing is to ensure compliance with the limits, and therefore, the basis is thorough monitoring and qualified DSS.

3.6. Scoring the variables using the decision matrix

The method of scoring the variables according to [36] makes it possible to classify the problem described by two mutually incommensurable variables into several categories according to established preferences. The method itself does not set or recommend classification criteria. In practice, it is very often used to classify risks into acceptable, conditionally acceptable and unacceptable risk [2,3,36] or to categorize objects according to their criticality [3,23]. The method will be further used to assess the benefits and risks of the proposed technical facility.

3.7. Risk management plan

The risk management plan is based on the TQM facility management method [39], i.e. in the monitored facility they are considered priority risks that could not be settled and that have the potential to significantly damage a technical facility at their realization. The plan itself is drawn up in the form of a table [2,3] that considers the risks of:

- technical facility itself (connected with its technology),
- internal sources of risk of the technical facility related to its construction, construction, equipment and operation,
- technical facility personnel,
- external sources of risk of technical facility associated with natural disasters,
- external sources of technical facility risks related to public administration behaviour, competition, market, etc.,
- attacks on technical facility,
- cybernetic risk sources associated with networks,
- war.

For each risk area, the table shall indicate:

- domains of causes of risk,
- the probability of risk realization occurrence and the expected magnitude of the impacts of the risk on the protected assets (basic public assets should also be considered based on legislative requirements),
- risk management measures, or at least for risk mitigation, which are clearly identified, and at each of them it is given responsible person for their implementation.

The risk management plan is also recommended by ISO 31000 [40].

To develop a risk management plan that meets the management requirements required by the TQM, it is necessary to know in detail:

- disasters, i.e. sources of risks,
- local vulnerabilities that determine the severity (criticality, relevance) of critical situations,
- and possibilities of response in critical situations.

As is has been shown, that the risks are associated with itself work with the risks, a checklist (Table 2) for assessing the criticality of the risk management plan [23] has been developed and tested in practice; the scale of which was used to assess each item:

0 point - fulfilment of the criterion has negligible shortcomings in the monitored area (less than 5%), i.e. it has negligible criticality,

1 point - fulfilment of the criterion has low deficiencies in the monitored area (5-25%), i.e. it has low criticality,

2 points - fulfilment of the criterion has medium deficiencies in the monitored area (25-45%), i.e. it has medium criticality,

3 points - fulfilment of the criterion has high shortcomings in the monitored area (45-70%), i.e. it has a high criticality,

4 points - fulfilment of the criterion has very high deficiencies in the monitored area (70-95%), i.e. it has a very high criticality,

5 points - fulfilment of the criterion has extremely high deficiencies in the monitored area (higher than 95%), i.e. it has extremely high criticality.

Table 2. Checklist for judgement of quality of risk management plan.

Question	**Rating**
Is the risk management plan guided by a clear vision and the objectives pursued?	
Does the risk management plan apply the principle of integrity (i.e. consideration of the welfare of the social, ecological and economic subsystem; expression of costs and benefits; impacts and benefits of economic activity using the both, the monetary and the non-monetary values)?	
Are substantial elements considered in the risk management plan (e.g. fair distribution of resource use between present and future generations; over-consumption and poverty; human rights; environmental conditions conditional on life; prosperity permitted by economic development and off-market activities)?	
Is the risk management plan adequate in scope (e.g. appropriate time and space measure)?	
Is the risk management plan practically focused (e.g. explicitly defined categories that link the idea with indicators and criteria; a limited number of key objectives; a limited number of indicators; a standardized way of measuring and benchmarking; benchmark values, thresholds, development trends)?	
Is the risk management plan open (e.g. generally accepted methods and databases; explicit plausibility, elimination of uncertainty)?	
Is effective risk management communication included in the risk management plan?	

Is the general public involved in the risk management plan?	
Does the risk management plan provide for a follow-up assessment (e.g. specifying the progressive targets due to system development)?	
Are the institutions' capacities ensured in the risk management plan (e.g. identification of responsibility for meeting the decision-making process objectives, data collection and storage, documentation)?	
TOTAL	

The scale for overall criticality of the risk management plan is determined in analogy to the principles used since the 1980s in CSN standards. The resulting criticality rate, assuming all criteria have the same weight, can range from 0 to 50; the thresholds for the criticality level of the risk management plan corresponding to the scale used are given in Table 3.

Table 3. Value scale to determine the level of criticality of the risk management plan.

Criticality rate of the risk management plan	**Values in %**	**Number of points for all criteria**
Extremely high– 5	Over 95 %	Over 47.5
Very high – 4	70 - 95 %	35 – 47.5
High – 3	45 - 70 %	22.5 – 35
Medium – 2	25 – 45 %	12.5 – 22.5
Low – 1	5 – 25 %	2.5 – 12.5
Negligible – 0	Less than 5 %	Less than 2.5

4. RISK SOURCES

Some examples of failure of decommissioning of a technical facility shown in [1] show that these failures result in old environmental burdens and brownfields, i.e. areas that cannot be used for civilian purposes, and are moreover usually contaminated and have less or more potential to damage public assets. According to the work [1] the causes of the old ecological burdens are:

- releases of hazardous substances from technologies in factories,
- negligent disposal of hazardous waste in unsecured landfills in old quarries and carriages,
- inappropriate storage of raw materials, wastes and various products of production,
- operator negligence,
- living the old abandoned technical facilities without proper cleaning and indemnity.

The problem of decommissioning a technical facility (particularly the complex one) and ensuring the continued civilian use of the area occupied by the technical facility is far more complex than the examples given. Technologies used in technical facilities are becoming obsolete, the technical facilities´ operations become challenging to energy, cooling, personnel, finance etc., and so it is necessary either the technical facility to modernize or to rebuilt, or to shut down the operation and the occupied territory released for further civilian use. The very followed problem is today the last alternative, i.e. the process consisting of the termination of the operation of the technical facility, the clean-up of the territory and the handover of the territory for civil use.

It is a process that consists of solving a number of administrative and technical tasks. As mentioned in the introduction, the professional sphere is only beginning to solve this problem, which means that there is little data on the process and its failure. Because it was not found a comprehensive publication on the problem sought, the database of failures in this technical facility life cycle [34] was constructed by help of Google [41], using the keywords: decommissioning; plant decommissioning; factory decommissioning; failures / errors / errors at decommissioning; removal plant from operation. It was found 124 cases, which enable to obtain results given in [1], which are hereafter described.

Performed critical analysis of the data from the available expert papers on the exclusion process, in which there were found not only descriptions and regulations of the process, but also the mentions on critical points, phases that may be the cause of possible process failures, some real particulars were obtained.

Based on a critical analysis of data in the literature summarized in [1,34], e.g. sources [42-62], the causes of failure of the followed process were identified from the following areas:

- legislative,
- technical,
- organizational on the side of public administration,
- organizational on the side of the solver

- domain associated with the processing of the project for the process of decommissioning the technical facility and cleaning up the occupied territory so that it is worthy of other civilian purposes,
- domain related to the supervision and control powers of the public administration,
- domain linked to the lack of law enforcement,
- the omission of economic, environmental and social factors,
- other.

Specifically identified causes of DC process failure:

1. Legislative causes:
   - lack of legislation requiring the owner or operator of a technical facility which, when it terminates to operate, ensure:
     - the removal of technical equipment, buildings and waste,
     - adequate waste disposal,
     - appropriate decontamination and remediation of the occupied territory, i.e. the State does not impose the responsibility of the owner or operator of the technical facility for the DC process,
   - inadequate legislation requiring the owner or operator of a technical facility that, when it terminates to operate, ensure:
     - the removal of technical equipment, structures and waste,
     - adequate waste disposal,
     - appropriate decontamination and remediation of the occupied territory, i.e. the State insufficiently imposes the responsibility of the owner or operator of the technical facility for the DC process,
   - lack of legislation or insufficient legislation requiring the owner or operator of the technical facility to collect funds and resources to carry out the DC process, i.e. the State does not impose an obligation on the owner or operator to collect funds to carry out the DC process (it means that the DC process needs to be paid by the State / public authorities),
   - the legislation does not oblige the owner or operator of a technical facility to draw up a plan for the implementation of the DC process and to present the feasibility certificate for expert judgment,
   - the legislation does not contain tools to enforce the proper implementation of the DC process by the owner or operator,
   - the legislation does not contain requirements for a safety culture that the owner or operator must follow when implementing the DC process.
2. Technical
   - lack of technical means to implement the DC process,
   - use of a wrong procedure for dismantling equipment facilities,
   - the use of faulty technologies in the removal of waste from the territory,
   - use of faulty technologies in waste disposal,

- the use of defective technologies in decontamination and rehabilitation of the released area,
- personnel carrying out the removal of technical installations and structures did not have the required knowledge, technology and equipment,
- personnel carrying out the disposal of waste from the territory do not have the required knowledge, technology and equipment,
- personnel carrying out the disposal of waste from the territory do not have the required knowledge, technology waste disposal do not have the required knowledge, technology and equipment,
- personnel carrying out the decontamination and remediation of the cleared area do not have the required knowledge, technology and equipment.

3. Organizational causes on the side of public administration:
    - the government and the public administration do not pay any attention to the problems associated with the DC process, i.e. they neglect supervision in terms of public interest,
    - the government and the public administration do not pay sufficient attention to the problems associated with the DC process, i.e. they do not sufficiently supervision the public interest,
    - the government and public administration do not have the tools to enforce the proper implementation of the DC process,
    - there is no system of communication between the public administration and the DC project implementer on the course of the DC process,
    - public administration has not procedures for solving the problems related to the implementation of DC process - for example in the case of insufficient funding for technical works.
4. Organizational reasons on the part of the DC process implementer:
    - there is a lack of knowledge on how to carry out the DC process,
    - lack of quality documentation for the implementation of the DC project,
    - lack of staff capable of performing the DC process well,
    - there is no risk monitoring associated with the implementation of the DC process,
    - there is no safety management system in place to implement the DC process,
    - there is no system of communication with the public administration on the course of the DC process.
5. Causes associated with the project processing for the process of decommissioning the technical facility and cleaning up the vacated area so that it is worthy of other civilian purposes:
    - the owner or operator of the technical facility has not drawn up a DC process plan,
    - not all sources of risk (All-Hazard-Approach in the form described in the paper [8]) have been considered when drawing up the DC process plan,

- no risk analysis and prioritization of risks in terms of public interest were carried out when drawing up the DC process plan,
- the DC process plan does not contain risk management measures in favour of the security of the territory and human society,
- the owner or operator of the technical facility has not assessed all the claims required by the implementation of the DC process, e.g. noise during demolition works, contamination of environmental compartments during decontamination of buildings, structures and equipment, etc.

6. Causes related to supervision and control powers of public administration:
   - the government and public administration do not have a system of supervision for oversee the DC processes, and therefore, the supervision is of poor quality,
   - the government and public administration do not have criteria to assess the correctness of DC processes,
   - the owner or operator of the technical facility does not cooperate with the public administration in the preparation and implementation of the DC process.
7. Causes connected with omission of economic, environmental and social factors:
   - the operator or owner of the technical facility does not have sufficient funds to implement a quality DC process,
   - the operator or owner of the technical facility does not consider local social and environmental needs when implementing the DC process.
8. Other:
   - the State does not have a professional institution able to provide advice to the owners and operators of technical facilities in the field of DC process implementation,
   - the public administration does not have at its disposal an expert institution which is able to expertly assess the correctness of the DC process, the proposal of which is submitted by a real own or operator of the technical facility.

The causes of the coexistence disruption caused by the incorrect implementation of the process of decommissioning a technical facility and the handover of the released area for further civilian use (DC process) are illustrated in Figure 4.

Figure 4 shows that the main causes of the coexistence disruption caused by the erroneous implementation of the DC process are mainly related to the knowledge and behaviour of the entities managing the territory, permit and supervise the technical facilities in the territory, confirming the conclusions in the works [1,5]. It means that safety culture of all participated subject is insufficient.

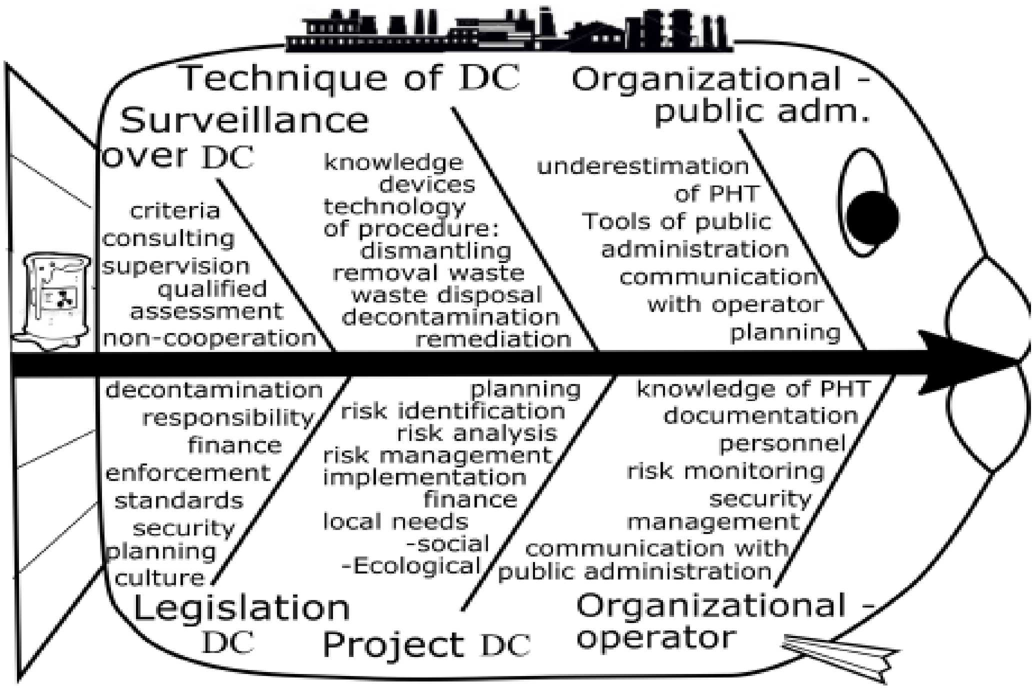

Figure 4. Causes of failures of coexistence of technical facility and its surroundings due to incorrect execution of DC process = process of decommissioning of technical facility, clean- up of territory and disposal of waste and subsequent transfer of released area for further civil use.

6. TOOL - DECISION SUPPORT SYSTEM FOR ENSURING THE COEXISTENCE AT TECHNICAL FACILITY DECOMMISSIONING AND SITE REVITALIZATION

In order to avoid the failure of the decommissioning process and the transfer of the land occupied by the decommissioned technical facility to the next civilian use (DC process), all sources of risk need to be considered in the technical facility design process and in the technical facility operation process. It is necessary to pay attention to avoiding the sources of unacceptable new risks in the released area. They could complicate the transfer of the released area for further civilian use. It is very important that during the process of decommissioning the technical facility itself and subsequent decontamination of contaminated fittings, buildings and territories, there would not select the inappropriate procedures that would damage the released area in the long term.

It should be noted that the diversity of technical facilities is large, and therefore, the diversity of DC processes is great. For this reason, technical details are not addressed in this publication.

As it has been stressed on several occasions, none of DC process is simple and one-off, it contains a number of administrative and technical sub-processes. Therefore, the implementation plan contains a number of subtasks that need to be elaborated in detail in the form of plans. It is about:

- a plan for dismantling the machinery,
- plan for the removal of machinery,
- a plan for the collection and removal of dangerous substances,
- a plan for the collection and removal of particularly hazardous waste,
- a plan for the demolition of buildings,
- a construction waste disposal plan,
- contaminated site clean-up plan (cleaning and appropriate decontamination),
- landscaping plan,
- a plan for the administrative operations connected with the transfer of the vacated area to the public administration or to a third party

Based on the knowledge gathered [1,4,5,9,12-22,63,64], a checklist to assess the risks associated with the proposed technical facility was draw up [23], Table 4 with philosophy, the higher the risk, the lower the safety of the technical facility, which means low coexistence of the technical facility with its surroundings.

For practical application, two scales are assigned to the checklist:

- one in Table 5 for assessing the selected criteria using the grading scale (0-5) and the concept of “the higher the value, the higher the risk [37], i.e. the lower coexistence of technical facility with surroundings”,

- and the second scale for the evaluation of the entire checklist based on the principle that was introduced into ČSN standards in the 1980s, Table 6.

The assessment of Table 4, hereafter given, assumes that all criteria have the same weight. Practical examples [34] show that in many cases some criteria are more important than others, and therefore, it is necessary to assign them higher weight, and to change data in Table 6 by appurtenant way.

Table 4. Checklist for assessing the risk connected with coexistence in implementing the DC process; Y – YES, N - NO. Number of criteria n = 42.

Criterion	**Assessment**.	
	Y	**N**
The level of quality of legislation, i.e. the level rules for the implementation of the DC process, which set the responsibilities, limits and conditions imposed on the course and outcome of the process.		
The level of quality of the criteria for assessing the correctness and feasibility of the DC process design.		
The level of quality of the public administration surveillance system over the implementation of the DC process.		
The level of quality of the tools by which public administration can force the correct implementation of the DC.		
The level of possibilities and sources of public administration to complete the DC process in the event that the DC implementer declares bankruptcy, or the finances handed over to the owner or operator of the technical work to the implementer of the DC project, are insufficient.		
The level in which the DC process considers the impacts of disasters under the All-Hazard-Approach in the form described in the work [8] that are possible in the territory, and at risk determining uses methods that respect the knowledge set out in [64].		
The extent to which the DC process is considering the impacts on the population in the surroundings.		
The extent to which the DC process is considering the impacts on environment		
The extent to which the DC process contains security analyses in which they are considered cross-cutting risks, which are carried out by interconnection of components and systems of technical facility and territory only under certain conditions (e.g. in the event of disasters) and may cause cascading failure in the implementation of the DC process.		
The extent to which the DC process contains countermeasures (preventive, mitigation, reactive and renewing) to cope with expected emergencies and possible critical situations; has		

operational regulations for normal, abnormal and critical conditions, emergency plans and an entrenched obligation to transmit information to the public administration in accidents, the impacts of which go beyond the liquidate technical facility fence; i.e. it considers all basic public assets.		
The extent to which the DC process has documentation that considers all possible conditions and which contains clearly defined functions which must be respected, as they are important for the management of the territory safety.		
The extent to which the DC process has documentation in which it is: clearly assessed the vulnerability of the area's critical assets and proposed their protection; and evidence of the management of possible accidents in the DC process so that the impacts of accidents are acceptable to public assets.		
The extent to which the DC process has documentation in which it is clearly defined: the safe implementation of the DC process and tools for ensuring the safety; a procedure for building a safety culture during the implementation of the DC process; programme to maintain and increase the required safety.		
The extent to which the DC process includes in the documentation an assessment of whether the whole process or some part of it may belong to the interest of insiders or terrorists. In case yes, whether if they are given the appropriate technical and cyber resources, human resources and financial costs for the protection of public assets.		
The extent to which the DC process contains in the documentation procedures for cooperation with public administration in the implementation of the process.		
The extent to which the DC process includes in the documentation procedures for cooperation with the public and the acquisition of its support in the implementation of the process.		
The extent to which the DC process contains in the documentation all the essentials required by the legislation.		
The extent to which the DC process contains in the documentation a verified timetable for the implementation of the process.		
The extent to which the DC process contains in the documentation a realistic division of the investment unit into stages.		
The extent to which the DC process contains in the documentation realistically set the parameters of performance of works and operating mode.		
The extent to which the DC process contains in the documentation clearly defined responsibilities for processes connected with the DC implementation.		

The extent to which the DC process demonstrates in the documentation the ensuring the necessary technology and material for the quality implementation of the process.		
The extent to which the DC process demonstrates in the documentation of the provision of qualified staff.		
The extent to which the DC process demonstrates in the documentation the necessary material and protective equipment for personnel in the event of hazardous works and specific decontamination-related works.		
The extent to which the DC process includes in the documentation working regimes at process implementation that respects the social needs of workers and ensures their security.		
The extent to which the DC process contains in the documentation verified financial requirements for the implementation of the process.		
The extent to which the DC process contains in the documentation budgets in the dossier for all important sub-tasks in which they are reserves to cover the multi-costs incurred e.g. by: increase the tax burden; by changing public government support; the occurrence of a natural or other disaster, etc.).		
The extent to which the DC process uses technology that does not have obvious defects.		
The extent to which the DC process contains in the documentation a proof that the process is feasible by available resources (knowledge; material for production; raw materials for operation; technical elements, equipment and components; finance; management method; or operator skill in construction operation).		
The extent to which the DC process contains complete technical documentation, i.e. an accurate description of the shutdown and disassembly of all-important components and equipment.		
The extent to which the DC process contains in the documentation a list of stocks and reserves for problems associated with the dismantling of critical components and fittings.		
The extent to which the DC process contains in the documentation energy performance data and an assessment of whether the surrounding territory has a free relevant capacity.		
The extent to which the DC process contains in the documentation data on transport claims and an assessment of whether the surrounding area has a free relevant capacity.		
The extent to which the DC process contains in the documentation data on material claims and an assessment of available potential suppliers.		
The extent to which the DC process includes measures to cope with organisational accidents.		

The extent to which the DC process includes the introduction of reliable monitoring of all critical processes associated with the implementation of the process.		
The extent to which the DC process contains a clear concept of works progress and clear individual progress regimes focused on safety.		
The extent to which the DC process contains clear limits and conditions that must be respected during the implementation and their verification.		
The extent to which the DC process includes an assessment of the impacts of process failures on the social area (according to auxiliary Table 5).		
The extent to which the DC process includes an assessment of the impacts of process failures on the technical and economic area (according to auxiliary Table 5).		
The extent to which the DC process includes assessment of impacts on environment (according to auxiliary Table 5).		
The extent to which the DC process includes the valuation of the costs of restoring the territory damaged by the failure of the process and the assessment of the capacity to restore the released territory.		

Table 5. Scale for determination of rate of risk that planned technical facility means for its surroundings (rate of coexistence disruption); by analogy to scales in [65]; p – annual insurance, ABT-the annual budget of territory governance.

Domain	**Risk rate**	**Classification criterion**
Social	*By accident or failure of technical facility, it is affected:*	
	0	less than 50 humans
	1	50 - 500 humans
	2	500 - 5000 humans
	3	5 000 – 50 000 humans
	4	50 000 – 500 000 humans
	5	more than 500 000 humans
Technical and Economic	*Accident or failure of technical facility causes damages:*	
	0	less than 0.05 p
	1	equal to p
	2	between p and 0.05 ABT
	3	between 0.05 ABT and 0.075 ABT

	4	between 0.75 ABT and 0.1 ABT.
	5	higher than 0.1 ABT.
Environment	*Accident or failure of technical facility causes:*	
	0	very low damages of environment
	1	damages of environment with which the nature cope during the acceptable time
	2	moderate damages of unrenewable resources of nature and natural reservations.
	3	medium damages of unrenewable resources of nature and natural reservations
	4	unreturnable damages of unrenewable resources of nature and natural reservations
	5	devastation of landscape, unrenewable resources of nature and natural reservations

Table 6. Value scale for determining the rate of the coexistence at DC process implementation; N = five times the number of criteria in Table 4; N = 210.

The level of coexistence disruption (risk) between technical facility and surrounding	**Values in % N**
Extremely high – 5	More than 95 %
Very high – 4	70 - 95 %
High – 3	45 - 70 %
Medium – 2	25 – 45 %
Negligible – 0	Low than 5 %

The assessment of a particular case according to Table 4 needs to be carried out independently by a team of specialists from different departments; a team, which has proved its worth in practice [65], is consisting of:

- a public administration officer in charge of spatial / land-use planning,
- a public administration official responsible for territorial development,
- technical facility representative,
- a representative of an expert institution for assessing the safety of technical facility – e.g. from technical inspection,

- and a representative of the Integrated Rescue System.

The resulting value for each criterion is median, and if there is a large dispersion of values for any one criterion, the public administration responsible for land-use planning needs to provide a further survey where each evaluator gives reasons for his / her evaluation in the case and based on panel discussion or brainstorming the resulting evaluation is determined.

The appreciation of the benefits of the DC process for the territory is done again using a checklist. On the basis of the knowledge gathered above, a checklist is drawn up to assess the contribution of the DC process to the territory [1], Table 7. For application in practice, two scales are assigned to the checklist: one in Table 8 for assessing selected criteria when applying the classification scale (0-5) and the concept 'the higher the value, the higher the contribution of the technical work to the territory"; and the scale for the evaluation of the whole principle-based checklist introduced into Czech Technical Standard, Table 9.

Table 7. Checklist for assessment of the DC process return for territory. A- result of assessment (YES or NOT).

Planned technical facility	**Criterion**	**A**	**Note**
	It increases education of the population in the territory		
	It increases the possibility of employment of the population in the territory		
	It increases the level of services in the territory		
	It increases welfare in territory		
	It contributes to the development of basic infrastructure in the territory.		
	It raises the prestige of the territory		
	It contributes to the cultural development of the territory		
	It improves the situation in the social sphere in the territory – Table 8		
	It improves situation in technical and economic spheres in territory - Table 8		
	It improves the situation in environment protection and welfares in territory - Table 8		

Table 8. Value scale for determining the rate of benefits that the technical facility means for the territory; it is designed by analogy to the scales set out in the work [23], ABT – the annual budget of the territory.

Domain	**Benefit rate classification**	**Criterion**
	Rate	*Technical facility benefits:*
Social	0	less than 50 humans
	1	50 - 500 humans
	2	500 - 5000 humans
	3	5 000 – 50 000 humans
	4	50 000 – 500 000 humans
	5	more than 500 000 humans
	Rate	*Technical facility gives to territory budget:*
Technical and eco-nomic	0	less than 0.005 ABT
	1	0.005-0.01 ABT
	2	0.01-0.025 ABT
	3	0.026-0.05 ABT
	4	0.05-0.075 ABT
	5	higher than 0.075 ABT
	Rate	Technical facility contributes to environ-ment protection and welfare increase per year by sum of money:
Environment	0	less than 50 EUR
	1	50 – 500 EUR
	2	500 – 5 000 EUR
	3	5 000 – 50 000 EUR
	4	50 000 – 500 000 EUR
	5	more than 500 000 EUR

Table 9. Value scale for determining the rate of return of the technical facility for its surroundings; N is quintuple of criteria in Table 7 (N=42).

Level of technical facility benefits for territory	**Values in % N**
Extremely high – 5	More than 95 %
Very high – 4	70 - 95 %
High – 3	45 - 70 %
Medium – 2	25 – 45 %

Low – 1	5 – 25 %
Negligible – 0	Less than 5 %

At the DC developer risk management based on data in Table 4 we consider the responsibility principle that is general in Europe [66]. It means that in the followed DC process both, the developer and the public administration are responsible for the DC process safety.

Considering:

- the ALARP principle as in works [67-69],
- the integrated approach as in works [70,71],
- and the assumption that all risk sources have the same occurrence probability, we obtain the requirement for tolerable risk measured by the DC process maximum annual losses *RZTD*

$$\boldsymbol{RZTD < 0.1 \sum_{i=1}^{n} \frac{k_i\, REZ}{5\, T}} \qquad (1)$$

where *REZ* is the total DC process utility value (planned budget for DC realization), k_i are result evaluations of risk sources in Table 4, *n* is the number of risk sources (in our case 42) and *T* is the DC lifetime in years. When this condition is not fulfilled, so the proposed DC process may not be accepted for realisation because the coexistence will be violated. It means that either a new option or other risk reduction measures should be requested, followed by a further assessment of the proposal. In other case the evaluation process continues.

In order that the losses caused by the DC at its operation might be also acceptable for the territory, it is calculated the benefit that the DC process gives rise to territory. Using the data in Tables 7 – 9 and the principles for expected return [72] and the same assumptions on data processing as in the previous case, the expected annual DC process return caused by the DC process operation *PRZTD* is

$$\boldsymbol{PRZTD = 0.7 \sum_{i=1}^{n} \frac{k_i\, CPTD}{5\, T}} \qquad (2)$$

where *CPTD* is the total DC process utility return during the lifetime *T,* k_i are result evaluations of return sources in Table 7 (assessed by experts with help of data in Tables 8 and 9) and *n* is the number of benefit sources (in our case 10). The expected pure annual DC process return *RPTD* is given by

$$\boldsymbol{RPTD = PRZTD - A - RPNTD} \qquad (3)$$

Where *A* is annuity and *RPNTD* is operating costs. Difference *R* of allowed maximum annual DC process losses *RZTD,* Eq. (1), and of expected pure annual DC process return *RPTD,* Eq. (3)

$$\boldsymbol{R = RZTD - RPTD} \tag{4}$$

is used as the quantitative property for decision-making. They are used the boundaries of acceptability of risk that used the UN and the Swiss Re [8], namely:

- amount of annual premium for protected assets in territory (*PRTD),*
- one-tenth of annual territory budget (*ABT*).

On the basis of results of scoring, they are determined the categories to which in a given case, the risk associated with technical facility belongs:

R is less than PRTD, risk is acceptable,

R is between PRTD and 0.1 ABT, risk is conditionally acceptable,

R is higher than 0.1 ABT, risk is unacceptable.

In the first case, the DC process benefits will outweigh the DC process disadvantages, it means the expected losses are acceptable and the coexistence of the DC process with its vicinity is ensured. It can be done permit for the DC process realization.

In the second case, the effective DC process safety management is required; it means to include additional preventive measures in the DC process design and to ensure the mitigation, reaction and renovation measures for coping with risk realization.

In the latter case, unacceptable risk, it should be thorough reflection on conclusion – either to reject the proposed DC process variant, or to ask for further measures associated with an increase of DC process safety (it is necessary to require application of: higher knowledge; a better technical equipment; the higher costs for protective systems; ensuring the greater human resources readiness, etc.) and after this new coexistence judgement.

The tool was tested in five real cases with success. The tests showed that it is pernickety on expert knowledge and moral, however, it ensures the coexistence the DC process with its vicinity during the DC process lifetime.

6. TOOL - RISK MANAGEMENT PLAN FOR ENSURING THE COEXISTENCE AT TECHNICAL FACILITY DECOMMISSIONING AND SITE REVITALIZATION

Problems related to the termination of the technical facility operation and other activities contained in the DC process can only be solved by targeted management of priority risks, which are not yet described in national regulations and standards. However, this does not prevent the application of this recommended tool today. A very effective plan for rapid problem management is priority risk management plan [5].

The risk management plan is based on identified sources of the causes of accidents or failures of objects or processes in buildings or territories, the results of which were losses of human lives, financial and other damage, and therefore, they can be considered as priorities, which would be monitored. And mainly in the interest of safety, they might be ensured timely response and recovery [5]. It helps to resolve conflicts because, in the event of an expected conflict of interest, the objectives of addressing the problem caused by the realization of the risk can be agreed in advance, the respective responsibilities can be determined and the procedures for responding to the problem can be codified. The risk management plan contains four basic items, namely:

- risk causes (technical, organizational, internal, external, cyber),
- description of the causes of the risk,
- probability of occurrence and evaluation of risk impacts,
- risk mitigation measures and responsibilities.

In complex world, the technical facility management represents the hierarchical interconnected system. According to [66], the responsibility principle paid in Europe means that for risk management are responsible both, the technical facility management and the public administration that gives permit and supervise the provision of public interest.

In work [5], which summarized the principles for managing the risks of complex technical facilities, it is shown that the possibilities that exist at the level of management in question should be considered when dealing with tasks allocation and determination of responsibilities. The possibilities are determined by both, the powers and the accessibility and amount of disposition resources, forces and means needed to address:

- well-structured problems can be successfully solved at the operational level of technical facility management.
- structured and poorly structured problems that are not associated with high risks for the technical facility can be successfully solved at the middle level of technical facility management,
- at the top level of technical facility management, both the complex and the unstructured problems that have risks that can be controlled using the tools available only to the top management of the technical facility can be successfully solved,

- only by the mutual cooperation of the public administration and the top management of the technical facility can be solved complex and unstructured large-scale problems with high risks.

The model risk management plan in question is drawn up by analogy to the situation in the legislation in the Federal Republic of Germany, the Republic of Austria, Switzerland and other Western states [8]. In managing the DC process, responsibilities are considered for the following functions:

- municipality mayor,
- chairman of the building authority,
- a public servant responsible for the safety of the territory,
- the official responsible for the development of the territory,
- the responsible representative of the investor of the DC process,
- responsible representative of the future user of the vacant territory (public administration or third party),
- responsible representative of the relevant professional institution responsible for safety related to technical facilities (Technical Inspection, Environmental Inspection, Nuclear and Radiation Inspection, State Office for Occupational Safety, etc.),
- responsible representative of civil protection (e.g. Integrated Rescue System in the Czech Republic),
- President of Parliament.

For the purpose of the DC safety management, i.e. the process of decommissioning of a technical facility, subsequent decontamination of the facility, equipment, territory and transfer of the released area for further civilian use, at considering of above identified sources of failure of coexistence, is given derived risk management plan for public administration in Table 10. There is no distinction between the risk management plan for a technical facility of local to regional significance and for a technical facility of national to transnational importance, since building documents are issued by office in site.

Table 10. Risk management plan to ensure safety in the DC process implementation; investor means implementer.

Risk domain	**Risk description**	**Occurrence probability** **Impacts**	**Measures for risk mitigation**
Public administration	Incorrect supervision under the DC process	Probability: medium Impacts: great	***Measures:*** Ask DC process investor for rectification according to building law ***Execute:*** Building office chairman

			Responsibility: municipality mayor
	Incorrect supervision under the demolition or decontamination	Probability: medium Impacts: great	***Measures:*** Ask DC process investor for rectification according to building law ***Execute:*** Building office chairman ***Responsibility:*** municipality mayor
	Missing the off-site emergency plan for case of occurrence of non-demanded situation at demolition or decontamination	Probability: medium Impacts: great	***Measures:*** Ask DC process investor for rectification according to environment protection law ***Execute:*** public administration officer responsible for territory safety and civil protection specialist ***Responsibility:*** municipality mayor
Technical – connected with the DC process implementation	Used DC process technology has evident technical deficits	Probability: low Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman
	The DC process implementation is too exigent on sources available in a given territory (knowledge; material for territory decontamination; finance; management way; or skill of workers).	Probability: medium Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman

	Incomplete technical documentation, e.g. it does not contain description of all activities and way of their execution (it goes above all on works connected with the decontamination and handling with waste).	Probability: medium Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of Technical Inspection
	Document on the DC process technical feasibility is missing.	Probability: great Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of Technical Inspection
	Measures for correction of the DC process implementation impacts on territory are missing.	Probability: great Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of Environment Inspection

	There are missing critical technical fittings for implementation of the DC process.	Probability: great Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of Technical Inspection
	Impacts of the DC process implementation on surrounding territory were not considered.	Probability: great Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** officer of public administration ***Responsibility:*** municipality mayor ***Cooperation:*** specialist of Inspection
	Energy demandingness of the DC process exceeds the capacity gettable in the territory.	Probability: medium Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of Inspection
	The DC process implementation demands on transport exceeds possibilities in the territory.	Probability: medium Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office

			Responsibility: Building office chairman ***Cooperation:*** specialist of Inspection
	Demands of the DC process implementation were not correctly evaluated and would cause to happen outages of services in the territory by basic needs.	Probability: medium Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of Inspection
Financial – connected with the DC process implementation	Costs on the DC process implementation were underestimated.	Probability: great Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of Inspection
	Costs on the territory decontamination were not included in the DC process costs.	Probability: great Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of Inspection
	Costs on disposal and liquidation of waste were not	Probability: great Impacts: great	***Measures:*** ask DC process investor for revision

	included in the DC process costs.		***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of Inspection
	In the DC process budget, they were not considered occurrence of situations that would adjure further costs (e.g. increase of taxes, change of support from public administration, occurrence of natural or other disaster etc.).	Probability: great Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of appurtenant Inspection and specialists of civil protection
Personnel for the DC process implementation	Deficit of personnel	Probability: medium Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** Officer of public administration for territory development ***Responsibility:*** Municipality mayor
	Deficit of qualified personnel (mainly for territory decontamination).	Probability: great Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of public administration ***Responsibility:*** Building office chairman

	Working regime of the DC process implementation does not include social needs of workers.	Probability: medium Impacts: medium	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of public administration ***Responsibility:*** municipality mayor ***Cooperation:*** specialist of appurtenant Inspection
Management of the DC process implementation	Documentation does not contain all required pertinences requested by legislative.	Probability: medium Impacts: medium	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of appurtenant Inspection
	The DC process implementation timetable is wrong.	Probability: great Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of appurtenant Inspection
	Separation of the DC process capital unit to stages is wrong.	Probability: great Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:***

			specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of appurtenant Inspection
	Working regime of the DC process implementation is wrong.	Probability: great Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of appurtenant Inspection
	There are missing the procedures for the DC process implementation at abnormal and possible critical conditions (flood, hot weather etc.).	Probability: great Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of appurtenant Inspection
	Thera re missing the continuity plans for overcome of critical situations at occurrence of beyond design disasters (e.g. great finance crisis).	Probability: great Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:***

			specialist of appurtenant Inspection
Safety at the DC process implementation	At the preparation of the DC process implementation, they were not considered all possible risks inside and outside of technical facility and their impacts on surroundings.	Probability: great Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of appurtenant Inspection
	There were underestimated the external disasters impacts on the DC process implementation.	Probability: great Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of appurtenant Inspection specialists of Civil protection
	In performed safety analyses, there were not considered the cross-sectional risks that are realised by way of non-demanded interconnections only under certain conditions; i.e. e.g. at occurrence of great external disasters.	Probability: great Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of appurtenant Inspection

	There are missing the safety and emergency plans, or they are not logically tied.	Probability: great Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of Civil protection
	The functions important for the management of safety of the DC process implementation are not clearly defined.	Probability: great Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of appurtenant Inspection
	Vulnerabilities of critical assets connected with the DC process implementation are not correctly judged.	Probability: great Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of appurtenant Inspection
	Evidence on cope with possible accidents at the DC process implementation is insufficient (e.g.	Probability: great Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:***

	critical activities of decontamination).		specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of appurtenant Inspection
	Insufficient mitigation of the DC process implementation on environment.	Probability: great Impacts: medium	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of appurtenant Inspection
	They are unclearly determined: the aim of safety, which would be followed at the DC process realization; and tools for the safety ensuring.	Probability: great Impacts: medium	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of appurtenant Inspection
	In the DC process implementation, the safety culture is not considered.	Probability: great Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:***

			specialist of appurtenant Inspection
	It is not specified program for maintenance of required safety and on its increase at the DC process implementation.	Probability: great Impacts: great	***Measures:*** ask DC process investor for revision ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of appurtenant Inspection
Other risk sources at the DC process implementation	The DC process in in interest of mafia, insiders and terrorists and it does not contain protective measures.	Probability: low Impacts: great	***Measures:*** ask DC process investor for revision - facility safeguard (physical, cyber protection) - support and motivation of employee ***Execute:*** specialist of Building office ***Responsibility:*** Building office chairman ***Cooperation:*** specialist of public administration for territory safety specialist of public administration for territory development specialist of Civil protection municipality mayor
	The DC process implementation is not acceptable for public.	Probability: medium Impacts: great	***Measures:*** ask DC process investor for revision - cooperation with public

			- support of territory development and public actions ***Execute:*** specialist of public administration ***Responsibility:*** Municipality mayor ***Cooperation:*** specialist of public administration for territory safety specialist of public administration for territory development specialist of Civil protection
War	Damage of buildings, territory and all equipment for the DC process implementation.	Probability: low Impacts: great	***Measures:*** - support for peace - negotiation ***Execute:*** Government ***Responsibility:*** Parliament Chairman

In order to the risk management plan may fulfil its role, it needs to be based on quality data processed by experts using the quality methods and be backed by legislation that ensures well-divided competences and enforces responsibilities, thus contributing to building a safety culture in society.

7. CONCLUSION

For its security and development, the humans need to manage risks in favour of safety. Therefore, the basic function of the State is to oversee the coexistence of all major systems that are necessary for the life and development of citizens, i.e. the environment, technical facilities and technologies and the public good, and to properly manage the processes associated with the application of technologies that humans create and use; the obligation in question is enshrined in the Constitution.

With regard to human knowledge, the DC process, which includes:

- decommissioning of technical facilities,
- the dismantling of equipment, constructions and structures,
- the removal of disposable equipment, materials and waste and, if necessary, after their decontamination on site,
- clean up of the vacated area and, if necessary, decontamination of the area,
- handover of the released area for further civilian use

it needs to consider all known data and experience.

In order for the implementation of the DC process to work well and meet the expected objectives needed for the development of human society, it is important firstly to clarify:

- tasks to be undertaken by the implementation of the DC process,
- demands on resources, forces and means needed to implement the DC process,
- risks associated with the implementation of the DC process, under normal, abnormal and critical conditions,
- demands to implement all measures in the implementation of the DC process in order to maintain territory integral safety (i.e. coexistence of basic systems).

Given the complexity of the world and its dynamic evolution, the limited ability of people to anticipate future phenomena and the limited knowledge, resources, forces and means of human society, they need to be applied in the implementation of the DC process lessons learned from past experience.

An analysis of some specific failures in the implementation of the DC process, which had significant and long-term impacts on the territory and on the lives of its residents, showed that the existence of conditions for technology transfer was not considered in the decision-making [38]. In fact, it was not considered that the safe (reliable and functional) implementation of the DC process is determined by both, the parameters of the decommissioned technical facility and the environment parameters in which the activities take place. Examples of the disposal of old burdens [1], which were originated either due to the omission of the DC process or to its poor execution, show that the human society has to incur very high costs for their removal in order to ensure the safety of humans.

The current knowledge implies that the disciplines for creating the safety and the safety management are multidisciplinary and interdisciplinary disciplines, their issues belong to all basic scientific disciplines, i.e. social, environmental and technical. The basic reason is that to ensure safety and its qualified management, it is necessary cooperation of engineers from technical fields, system engineers, IT specialists, economists, personnel officers, public administration officials and politicians, because only in this way the overall goal can be achieved in cooperation with citizens, which these disciplines are pursued in the interest of humans.

In the Europe, the TQM project management is used in Europe. It is consisting of the whole entity's efforts to establish and maintain an environment in which the entity continually improves its ability to provide high quality products and services to customers, i.e. in the public administration for citizens. Rossenau [73] extends the usual general definition of objectives for project management needs by an element that has become the cornerstone of modern project management and which is de facto taken up by all other authors dealing with the topic. A key attribute is the concept of a triple imperative, which illustrates the need to achieve three independent goals - not just one. Successful project management means achieving the required implementation parameters at or before the deadline and within budget costs. For convenience, a schematic diagram in the form of a triangle or an axial map is shown (Figure 5). It shows the true relationship between the triple-imperative parameters

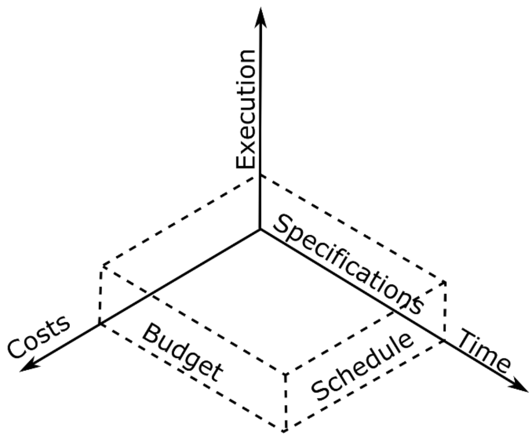

Fig. 5. Three-dimensionality of project objectives (it is necessary to consider: technical implementation, costs and duration to be considered) - processed according to [73].

The way of solving the problems presented above is based on the currently preferred concept, which is explained in the paper [5], in which safety is superior to reliability. On the basis of the concept of safe system is a system that is reliable and functional and even under its critical conditions will not destroy itself and its surroundings. In the public interest of the humans, even the process of termination the existence of a technical facility must not damage the territory and thus the human society that inhabits it. Therefore, the public administration needs to have legal instruments to enforce at least a satisfactory solution, and the responsible legal entity needs to have the financial means to satisfactorily cease the physical existence of the technical facility and clean up the vacated area.

As the experience in this area is poor, it is necessary to amend the laws accordingly - the Building Act needs to be imposed on the responsible public authority:

- incorporate the obligation of the technical facility operator to create a financial fund related to the DC process in each building permit and operation permit, ,

- control the fund in question and do not allow so it might be used for other activities.

Finally, it is possible to say that irrespective of legislation and finance, based on current knowledge, the DC process (including: decommissioning of technical facilities; dismantling of equipment, structures and constructions; removal of usable equipment, materials and waste, and needs to be decontaminated on-site; clean-up of the vacated area and, if necessary, decontamination of the land; and transfer of the land to civilian use), is feasible for the vast majority of technical facilities.

Based on current knowledge, there are serious problems associated with the DC process for nuclear power plants and other nuclear installations. This is mainly a lack of knowledge and unpreparedness for the decommissioning process. This is accompanied by enormous financial costs and a great deal of time for specific works. Analysis of the DC processes following the nuclear accidents at Chernobyl and Fukushima [74] revealed very serious problems related to the dismantling of damaged units and the decontamination of the area.

According to data collected at work [74], for example in the case of Chernobyl, for the implementation of the DC process, it was first necessary to build a dry repository to ensure the safe storage of all fuel assemblies from Chernobyl blocks for a hundred years. By building a new sarcophagus (completed in 2017), contaminated buildings have been preserved so that liquidation works can be carried out safely and in the long term, i.e. mainly the dismantling of the old sarcophagus and the destroyed Unit 4 reactor.

According to the work [75], in the second phase currently underway the reconstruction of the water distribution system for the fire protection system is being carried out. The next one, which is planned to start in 2022, will include the dismantling of pressure pipes as well as control and protective piping. In the subsequent stages, according to current plans between 2028 and 2046, the most contaminated equipment should be removed. Regarding the area, it is assumed in the coming years that at least partially biomass will be collected from the forests and burned in the incinerator. Excessively contaminated areas now have a restricted zone regime and, in the future, once the level of contamination has fallen to an acceptable level, industrial use is expected.

Today, old environmental burdens and brownfields pose major dangers to urbanised areas, endangering the health of people in the surrounding area and harming not only the environment, but also the sustainable development of human society. From the previous attempts to apply the above tools in practice, it shows that due to great diversity of both, the technical facilities and their surroundings in which technical facilities are placed, a simple template cannot be used for the process of decommissioning the technical facility and revitalising the territory. Account should be taken of both the nature of the technical facility and the local specificities of the territory.

Ensuring the correct implementation of the process in question (focused on sustainability) requires not only knowledge, but also system solutions. System solutions require knowledge, correct way of execution and finance. Therefore, the professional procedures of the monitored process should be handled by experts in the public interest and that the financial reserves for the process concerned be made. Appointed basic requirements need to be exhaustively imposed by legislation and the
and public administration needs to have the right to exercise high-quality supervision of their implementation.

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