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Technological Crises Management and Resilience

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Abstract: Technological crises are ordinary presences in the general context of the human society's development. Their forms of manifestations may be different, ranging from various accidents to destructions of works of art, crashing of travel platforms or facilities, dismantling of various sizes. The efforts directions regarding the crisis management will be aimed at protecting the personnel affected, the target groups in the proximity and the related environment, at the same time with reducing the direct effects generated and the negative consequences that came up. As a general rule, the crisis management is short lasting, and the consequences' management is long lasting. The intervention structures established, immediate and subsequent, will be composed as such according to the type of crisis. The unitary command/control will be provided in synergy at the central level, with a large autonomy for the factors in charge, deployed in the crisis hotbeds. In certain situations, the teams of personnel with certain capabilities will be provided as structures.

Keywords: technological crisis; technological events; technological crisis management; intervention structures; subsequent intervention structures

1. General Statements

Technological crises are particularly large-scale events with far-reaching effects. The effects activate a different range of influence, depending on the nature and disruptive factors of the event. Relevant are the events at the Chernobyl (26 April 1986) and Fukushima (11 March 2011) nuclear power plants. The events were generated by the qualities of the fissile material and affected huge areas over a long period of time. Technological events are spectacular and can lead to disastrous effects and consequences.

For preventive purposes, it is important that operators servicing critical facilities strictly follow the procedures in the job descriptions for technological operation. Critical infrastructures take into account the extreme potential for damage factors. Even the involvement of low probability of occurrence of damage factors (high magnitude earthquakes, heavy rainfall, unpredictable fluctuations in pressure or power supply, landslides, operating accidents) must be considered under aggravating conditions. The calculation of cumulative effects will be assessed on higher variants, with notification of the intervention in matrix format (Mihalcea, Sîrbu & Bogdan, 2021, p. 154).

In the general picture of crisis induction, nuclear, chemical and biological accidents, may occur explosion of ammunition, explosive mixtures, accidents on communication routes, massive fires, collapse or sinking of platforms, damage to hydro-technical or nuclear power constructions, underground accidents, fires, damage to public facilities of major interest, collapse of buildings or installations (Administration, 2020). etc. The occurrence of technological accidents is the responsibility

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of the competent authorities. Beyond the above table, other types of catastrophic events may occur. They depend on technological developments, advances in science, technological security efforts, the vulnerabilities produced and the factors (natural or social) that may be triggered.

Resilience is a term that defines a person's ability to bounce back from an illness, accident, trauma, misfortune or major change in one's physical condition, well-being or comfort. The requirement for the level of deterioration refers to the fact that the effects of the current state should not be exaggeratedly great, and should not exceed a threshold considered as a limit. In addition, as a dynamic triggering factor, one's own energy potential must be at a high level in the situation of the disturbance. Thus, when generating problems that affect the individual's life in a major way, vital energy is stored, in other words it is accumulated in the individual's ego. The stored energy will constitute a power resource, which will then generate the resilience phenomenon. Resilience means the emergence of a sustainable capacity to successfully counteract stress and opposing factors. The body's defensive potential will be preserved by generating inner strength that allows self-protection against future stress (Sîrbu, Mihalcea & Bogdan, 2021, pp. 23-26).

Individual resilience will work by bouncing back from setbacks, keep energy under constant pressure and face life's challenges, welcoming disturbing phenomena (in itself) with a positive attitude, serenity and a smile. The subject's assumption of responsibility will provide the necessary strength to change the unpleasant situation for the better (Essex, 2017, pp. 57-58; 250-251).

2. Intervention Procedures Triggered

For technological crisis interventions, the basic procedures can be: *direct effort*, *sequential effort* and *vertical flooding*. There may also be preparatory procedures such as: monitoring, disconnection of utilities, spatial isolation (in relation to nearby facilities).

The direct effort includes human and technical efforts of the Task Force, produced in the outbreak of technological crisis, activated in one or more directions, using logistical support and specialized equipment, to eliminate the causes and mitigate the effects.

Sequential (sequential) effort involves local or particular actions on parts of the critical target, produced from inside or outside the outbreak. In technological crises sequential interventions may be mandatory (sequential).

Vertical flooding contains major or decisive actions, carried out vertically, particularly downwards (from aircraft or ships) (Bogdan & Bogdan, 2017, pp. 97-104).

The effort to mitigate and then eliminate the consequences of the technological crisis is articulated. The crisis focus will be secured from a remote location, isolating the technological crisis area from the natural and social environment. Between the security circle and the outbreak, the elements of the intervention group will be placed. Hypothetical courses of action (from the plans) will be set up and updated according to the decision of the specialists, carefully based on the spot. Once the technological operational device is in place, it will be possible to start the intervention action in the outbreak. Priority will be given to rescuing personnel, mitigating destructive effects and protecting key unaffected or critical parts of the target (Mihalcea, Sîrbu & Bogdan, 2021, pp. 135-136). People with medical problems will be transported to hospitals, those affected to nearby camps. Shelter, water, food, heating, medical and psychological assistance will be provided. The technological outbreak that has been extinguished will be monitored, preserved and guarded for further investigation by the competent bodies, technological or investigative in nature[1].

In all cases, measures and actions will be carried out on the basis of the analyses and views of specialists in the areas of crisis, in conjunction with the existing plans of the responsible parties[2].

3. Case Studies

For the relevance of technological crises and impact assessment, we will use the events at the Teleajen Petrochemical Platform, the Chernobyl Nuclear Power Plant accident, the shipment of ammonium nitrate from Mihailesti, the Sayano-Shushenskaya Hydropower Plant failure and the Fukushima Nuclear Power Plant accident (Bogdan, 2014, pp. 69-132).

3.1. Teleajen Petrochemical Platform, Romania, 1983

The technological crisis occurred on the night of 06/07 December 1983, 01.30 hours at the Pyrolysis Section. The event consisted of a strong explosive ignition of the ethylene-ethane hydrocarbon mixture.

Due to changes in the working regime of a pressure compressor, technical construction vulnerabilities and uneven expansion of the support to pressure pipelines, approximately 9 tonnes of hydrocarbons were released into the atmosphere. The plant was immediately shut down from the control panel. The instantaneous ignition of the fuel produced a huge detonation which destroyed the pyrolysis plant almost completely. The neighbouring installations containing combustible substances were also set on fire. 27 operators died and 39 people were injured. The event is the biggest catastrophe in the history of Romanian petrochemicals (Rizea, Enăchescu & Neamțu-Rizea, 2010, pp. 268-340).

A security cordon was quickly installed in the critical facility to prevent access by uninvolved persons. Entry was possible for fire and military crews (all participants wore gas masks ready for use). Civil security structures evacuated the affected persons, provided emergency medical aid. The fire was brought under control, the deceased were evacuated, the traces of the petrochemical disaster were preserved to facilitate further technological analysis and criminal investigation[3]. Due to communist censorship, not all the details of the technological crisis are known (Mihalcea, Sîrbu & Bogdan, 2021, pp. 138-139).

3.2. Chernobyl Nuclear Power Plant, Ukraine, 1986

The Chernobyl disaster occurred on 26 April 1986 at 23.40. The nuclear accident resulted from the start of the cooling test of reactor 4 at 23.00. At 23.40 a state of emergency is declared due to the impossibility of shutting down the reactor. At 23.44 hours reactor no. 4 escapes from control and explodes, killing 30 operators. As a result of the deflagration, approximately 50 tons of radioactive material is blown into the air. Following the decision of the Soviet political leadership, by about 1800 sorties/helicopter, an

[1] According to the Emergency Ordinance no. 1/January 29, 2014 (updated) regarding the National Emergency Management System.

[2] Government Emergency Ordinance no. 20/25 April 2007 regarding the organization and operation of the Ministry of Internal Affairs, art. 2-5.

[3] According to the Emergency Ordinance no. 1/January 29, 2014 (updated) regarding the National Emergency Management System.

attempt is made to throw over the damaged reactor the quantity of 5,000 tons of sand and lead to locate and extinguish the fire.

The centre of gravity (and danger) of the accident was the risk of chain reaction. at the level of fuel in reactor no.4. The lack of efficient cooling, the failure to operate technological systems properly, the high level of radiation in the plant area can be added as critical points.

The next day, 27 April, some 135,000 inhabitants were evacuated within a 40 km radius. It was only on 28 April, at 9 p.m., that the Soviet leadership, through USSR President Mikhail Gorbachev, officially announced the catastrophe (Rizea, Enăchescu & Neamțu-Rizea, 2010, pp. 341-342).” Between 15 and 16 May, the release of radioactive and contaminated material into the atmosphere increased. The damaged reactor was covered with a lead sarcophagus. Subsequently, another 100,000 people were evacuated from Ukraine, Belarus and Russia. In 1989, the construction of reactors 5 and 6 was halted and in 1991 reactor 2 was shut down due to a fire. On 12 December 2000, the Chernobyl nuclear reactor complex was permanently shut down.

The accident was due to a number of technical errors in the operation of the reactor. As reactor 4 was scheduled for a routine shutdown for maintenance operations, the plant management decided (by its own decision) to carry out an additional test to verify the use of the available electrical energy for the operation of the emergency installations and the reactor core cooling pumps until the diesel pumps came on line. When the procedure was carried out for the first time, the energy distributor refused to lower the power. The reactor's emergency cooling system was switched off, yet the reactor was operating at 50% of its own power. The operators' interventions to stabilise the reactor were risky and improvised, the reactor's technical operating protocol being outdated and unusable. The pumps provided insufficient coolant, with the pressure increasing more than 100 times in a very short time. The sudden rise in temperature induced a meltdown in the nuclear fuel mass, with nuclear fuel particles interacting violently with water. There were two explosions about 2 minutes apart, with about 5% of the radioactive material in the reactor being released into the atmosphere *(there was no chain reaction)* (Rizea, Enăchescu & Neamțu-Rizea, 2010, pp. 342-346).

The number of deaths and illnesses is conflicting, with no official reports. Various sources put the death toll in the dozens and the number of illnesses in the thousands. Thyroid cancers, leukaemia, genetic mutations and multiple tumours have increased enormously in the area. The aerial (helicopters) and armoured equipment used in the intervention (highly radioactive, which has become a source of radioactivity in turn) is rusting in a huge graveyard. The area around Chernobyl is deserted by the inhabitants, who have left or evacuated to other areas.

It is planned to build another external concrete sarcophagus, about 100 meters high, for protection. It is estimated that the financial effort will be around $2 billion. Even under these conditions, the possibility of radioactive contamination of the environment is maintained in the future, as the effort is aimed at the effects rather than the cause of the nuclear event affecting (Mihalcea, Sîrbu & Bogdan, 2021, pp. 139-141).

3.3. Nitrate Transport, Mihăilesti, 2004

The explosion took place on 24 May 2004, 05.50 hours, about 150 meters south of the southern exit of Mihăilesti in Buzău County. The cause of the deflagration was the failure to comply with the operational requirements of ammonium nitrate (NH_4NO_3) concerning explosion, well known in the field of pyrotechnics.

1. The diesel and nitrous mixture detonates when it reaches a critical temperature. If fires, glowing tubes, electric lightning etc. intervene, it will react in a chain reaction..

2. Initiated by another explosive (pyrotechnic cap or trotil, dynamite, astralite), the nitrate will explode. For which it is used in land reclamation, road construction, underground tunnel production, being cheap, safe and easy to handle.

3. Large quantities of nitrate (dozens of tons) stored together can generate *critical mass* and produce a chain reaction without pyrotechnic pulses or temperatures above 200 degrees.

In Mihăilesti a truck carrying 20 tonnes of ammonium nitrate overturned and the diesel in the tank caught fire. The vehicle's ignition came into contact with the nitrogen charge. When the fire brigade from Buzău arrived, the fire was immediately extinguished. After about 60-90 seconds the first explosion occurred, and after about 1 minute and 2 seconds the second explosion occurred.

The explosion of the 20 tonnes of nitrate produced a crater 21 metres in diameter and 6.5 metres deep. The fragments of the vehicle were scattered up to 400 metres, affecting the roofs of nearby houses. Eighteen people died (including seven firefighters and two journalists from the Antena 1 TV station) and 13 other witnesses were seriously injured.

The internal security structures have achieved:

- fast and correct actions to inform about the event and to direct traffic on European Route E-85;

- immediate departure to intervention of the firefighters belonging to the Buzău County Dispatch, with two fire engines, correctly generating the device for extinguishing the fire.

During the intervention, the danger of explosion, induced by the ammonium nitrate charge in contact with the burning diesel, was not reported and transmitted (Mihalcea, Sîrbu & Bogdan, 2021, pp. 142-143).

3.4. Sayano-Shushenskaya Hydropower Plant, USSR, 2009

The Sayano-Shusenskaya Yenisey River Hydropower Plant is the largest and most powerful hydropower plant of its kind in the Russian Federation, ranked sixth in the world. The dam was one kilometer long and 245 metres high, had ten hydroelectric generators, and a total capacity of 6.4 million kw (Mihalcea, Sîrbu & Bogdan, 2021, p. 143).

On 17 August 2009, 08.30 hours, an extremely high pressure, known as "water hammer", was generated in the turbine No. 2 area. Possibly a large solid body got into the turbine nozzle and got stuck in the blades or in the narrow portion of the outlet. High water pressure projected the 900-ton turbine into the air, flooding the turbine hall. The water hammer shattered equipment in the engine room, operators on shift, severely damaging power units 7 and 9. The roof over turbines 3, 4 and 5 collapsed. Turbine 6 was damaged, short circuits occurred, the turbine hall flooded and a transformer exploded.

As for the damage, the figure of 75 people affected, 69 dead and 6 missing, is reported. Indirect losses, caused by the non-production of energy and the economic damage in the chain, amounted to $1.2 billion (Rizea, Enăchescu & Neamțu-Rizea, 2010, pp. 365-373).

Domestic internal security structures:

- have been involved in securing the affected perimeters;
- have evacuated deceased persons and searched for missing operators, according to procedures;

- have made efforts to analyse the event and establish the causes of the disaster;
- maintained public order, allowed access to specialists and equipment to restore the state of operation of the hydropower plant (Mihalcea, Sîrbu & Bogdan, 2021, pp. 143-144).

3.5. Fukushima Nuclear Power Plant, Japan, 2011

The nuclear accident on 11 March 2011 was caused by an earthquake measuring 7.1 on the Richter scale, which occurred at 14.46 in north-western Japan. The quake generated a huge tsunami with waves 15.7 metres high. The huge waves (critical vulnerability of the power plant), caused physical damage and disruption of power supply to the nuclear power plant. On 12 April there was a 6.3 earthquake. Due to the power outages, the power was switched to backup electrical batteries. As the backup accumulators and diesel generators had been flooded with water, only a few of these resources could be used. As the capacity and service life of the accumulators were low, electrical failure quickly intervened, resulting in a nuclear accident.

On 14 March, with temperatures rising to 2,000 degrees, there was a risk of the radioactive core melting and a catastrophic explosion. The radioactivity of the surrounding environment increased, especially on the wind propagation direction (no chain reaction). The cooling effort and contaminated liquid spills increased the radioactivity of the sea water. In successive radii of 2, 3, 10 and then 20 km, more than 100,000 citizens were evacuated from the area. This finally resulted in almost 160,000 people being evacuated. The population was advised not to leave their homes in order not to be irradiated. A fire broke out at Rector 4 (which was being overhauled during the earthquake). In order to avoid a nuclear disaster, 50 specialists remained in the damaged plant to operate critical systems and avoid an unimaginable nuclear catastrophe.

The centre of gravity of the Fukushima nuclear accident was the possibility of a chain reaction. The critical points were the lack of power supply, insufficient cooling of the reactors and high radiation levels in the plant.

The external power supply was restored on 22 March (reactor 3 on 25 March). The dangerous level of radiation in the plant was maintained until March 2015. It was not until mid-December 2011 that the cooling of the reactors was brought under control. More than 1,000 citizens died as a result of the extended evacuation period. It will take about 40 years to fully decontaminate the affected area of about 30,000 km^2..

Japanese internal security structures:

- acted impeccably, ensuring technological discipline and order in the area around the plant, securing critical perimeters in conditions of high radioactivity, with state-of-the-art modern protection equipment;
- structured fluently and coherently all the technological flows, towards the power plant energy supply, water discharge and accident control;
- acted quickly and efficiently, in successive forms, towards the massive evacuation of the population;
- facilitated access for reactor cooling, stabilizing the situation and ensuring control over the radioactive core of the plant;
- for months made a constant effort to maintain public order and technological discipline in the area near the power plant (Mihalcea, Sîrbu & Bogdan, 2021, p. 144).

4. Resilience in Technological Crises

In technological crises, the joint effort of the resilient state-society binomial will be activated, through the manifestation of common interests, objectives, visions, lines of effort, attitudes, intentions and actions. Organisations, communities, numerically small groups and individuals will be able to constitute intervention operators, aspects directed by resilient state institutions The state will support affected social groups through alert, understanding, intervention, monitoring and operational, logistical and medical support capacities (Administration, 2020, p. 23).

Technological crisis may contain specific ways of damage, such as outbreaks of flammable substances, nuclear, biological or chemical contamination, impairment of the setting (environment) or damage to communities, potentially disabling individuals. Aggressions produced by technological factors generate loss of human life and massively induce the phenomenon of fear, fright and dread. Technological events, by the scale of their effects and harsh impact, generate flows of thoughts that dissipate energy, shape the mood of the victimised communities (Essex, 2017, pp. 83-84).

The technological crisis calls for a better understanding of resilience, particularly regarding the possibilities of optimizing processes of this type. We also see the following as important opportunities for increasing resilience:

- diversified social relationships, built up over a long period of time - those with family, friends, relatives, the support of other groups, involvement in action groups must be amplified;
- optimism about the problem-solving process - optimistic thinking will induce positive changes in the course of solving unfavorable situations;
- goal setting in life - strictly positive visioning, through realistically structured goals, vision, objectives and priorities will be extremely beneficial to the resilient process;
- acceptance of change as a way of life - in disagreement with the negative perspective on change, which will perpetuate the disastrous state;
- impetuous action - taking the initiative and making a determined and constructive effort will lead to beneficial and even difficult to explain rationally;
- rediscovering one's own values - thinking to identify past sources for similar situations, appealing to internal springs as triggers for resilience;
- building a positive outlook on oneself - with optimism about instinctual, psychological and coping possibilities;
- realistic view of the future - building long-term perspective, realistically situating disruptive agents in a wider spectrum, realistically quantifying the implications of the unfolding crisis;
- robust soul optimism - expectations of the good, hope, intuition of the solution to the bad;
- concern for self - attention to own needs, priorities and feelings, being spiritual, relaxed, trusting, destined (Berndt, 2014, pp. 183-185).

Technological crises must be considered as an element of learning, helping to increase strength of character. People need to enhance their strengths, stimulate individual creative curiosity, optimism, humor, thoughtfulness, recognition and enthusiasm.

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