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NUCLEAR INCIDENT (MALFUNCTION, BOMBARDMENT OR TERROR) AROUND THE WORLD, LEVEL OF PREPAREDNESS AND CHALLENGING ACCEPTED REFERENCE SCENARIOS

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Abstract
The rate of construction of nuclear reactors in the world that supply energy, the geopolitical situation such as with North Korea, Iran, and the rising tensions between the world powers raise the question of whether and when a large nuclear incident will occur. However, after examining several references scenarios for dealing with civil nuclear events and compering them to data obtained from interviews, a careful analysis of previous events, and investigating accidents, it is clear that the current models cannot deal properly with those events. The current plans for coping with nuclear accidents address only partial aspects of disaster management, do not offer accurate description of unfolding events, ignore newly obtain scientific data, and ignore the human factor in decision making level. The current paper will review why Reference Scenario to nuclear incidents accepted currently in various countries around the world are not up to date and shed light on the most critical aspect in proper nuclear disaster management - rational thinking pattern. The suggested model presented at this article, ONDM, is an innovative new mechanism and a more effective preparedness mechanism for

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nuclear disaster, as it takes under consideration past mistakes and provides tools for leaders to make informed decisions under conditions of uncertainty

Keywords: Disaster Preparedness, ONDM, Nuclear Event, Risk analysis assessment, Civil defense.

1. Introduction

Nuclear disaster preparedness is an aspect that caught the attention of the world after the Fukushima disaster in 2011, when it was discovered that despite the design of reactors, the country's preparedness against tsunamis, and countless promises to the public about the safety of the country's many reactors and disaster preparedness. This article offers a professional and insightful perspective to understand and mitigate the failure of Fukushima disaster management and previous nuclear events, which focus on the crucial role of decision-makers in managing a successful disaster and/or worsening it to more serious dimensions than could have been.

2. The Nuclear Threat

Nuclear dangers emanate from both the military and civilian sectors. Although the perception today is that we are far away from a nuclear war, there is an increasing interest in nuclear weaponry. Possessing and developing nuclear arms is now a goal for many countries around the world, some of them for guarantying peace but some of them are more prone to use it than others, as religious and fundamental ones around the world.[1] Nuclear military abilities and knowledge is at different stages in the hands of countries such as Iran and Libya, many times illegally and secretly, and nuclear materials pass under international supervision using seemingly civilians or energy company.[2] In addition, many accidents

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[1] Sergei V. Jargin «Nuclear facilities and nuclear weapons as a guarantee of peace» in *Journal of Defense Management* vol. 6, no. 2, 2016, pp. 147-148.

[2] David Albright, Corey Hinderstein «Unraveling the AQ Khan and future proliferation networks» in *Washington Quarterly* vol. 28, no. 2, 2005, pp. 111-114.

involved nuclear weapons have occurred over the years - including the crash of an American B-52 plane carrying two nuclear bombs in North on 1961; Russian nuclear submarine K-19 that had a serious undisclosed nuclear incident on 1961; Russian nuclear K-8 submarine sunk on 1970 together with its nuclear weapons; and on.[3]

Though it seems we live on peaceful times, countries still possess nuclear weapons, and we cannot predict future changes in international systems that will perhaps lead these countries to employ this power. In addition, there is always a growing threat from terror organizations who have exploited weaknesses in countries that hold nuclear weapons and will acquire a nuclear bomb or fissionable material for a dirty bomb.

At the civilian sector, a previous study,[4] speculated that the likelihood of a nuclear event as a result of a failure in a civilian installation in the near future is certain, and it is not a question of "whether" nuclear disaster will occur, but "when". Despite the progress in the technology of reactor design, many of the operating reactors in the world are still second-generation reactors, similar to the failed reactors in Chernobyl and Fukushima, and there is now an increase in the consumption of nuclear energy in the world and especially in countries such as the United Arab Emirates, Pakistan and India, which plans 19 new reactors to be built in the future.[5] Naturally, the proliferation of nuclear facilities leads to increased probability of accidents and even more serious problems. More and more civilian nuclear facilities are being built such as power stations and/or nuclear research centres and there are more nuclear incidents worldwide, located relatively close to population centres and can constitute a real threat.[6] At many cases those facilities are not as safe as we would like to think. In Fukushima, for example, there were accusations of corruption

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[3] For a review about known military accidents that involves military nuclear material see Kenneth Alvin Solomon «Sources of radioactivity in the ocean environment: From low level waste to nuclear powered submarines» in *Journal of hazardous Materials* vol. 18, no. 3, 1988, 255-262.

[4] A previous study conducted by the author about coping with past nuclear accidents, see Ori Levi-Nissim «Failure of the superpowers (U.S.A, Russia, Japan) to handle large nuclear events» in *Modelling the New Europe* vol. 25, 2018, pp. 122-141.

[5] WNA, *Plans for new reactors worldwide*, 2018a, [http://www.world-nuclear.org/information-library/current-and-future-generation/plans-for-new-reactors-worldwide.aspx] [Accessed 18/05/2018]

[6] Ori Levi-Nissim, *op.cit*, pp. 123-124.

such as falsifying safety data and connections between political people and the company that ran the nuclear reactors, TEPCO, which led to a low level of pre-disaster preparedness and inadequate plans and compensations of post-disaster coping and rehabilitation.[7]

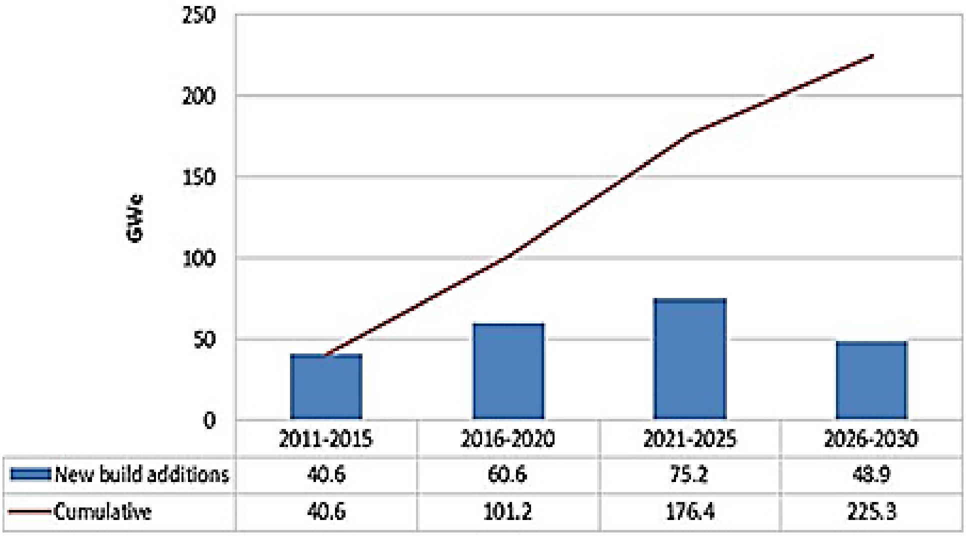

Fig. 1. *Projected increase in world's nuclear generating capacity*.[8]

There are now several nuclear disaster treatment programs that have emerged after the Fukushima event, which are supposed to provide a coping mechanism that will prevent and/or successfully deal with a serious nuclear event. Detailed plans reviewed for the purpose of this article are of the United States,[9] Canada,[10] France,[11] Germany,[12] and Finland.[13] It is

[7] Many accusations of corruptions rose in the media and at reports from NGOs reports as Greenpeace, see Antony Froggatt «Fukushima two years later: Lives still in limbo» in Brian Blomme, Steve Erwood, Nina Schulz, Rianne Teule, *Fukushima fallout*, Amsterdam: Greenpeace international, 2013, pp. 10-21; as an example of the media accusations see CBS News «Fukushima meltdown apology: "It was a cover-up"» 21 June 2016, [https://www.cbsnews.com/news/fukushima-tepco-power-japan-nuclear-meltdown-apologizes-cover-up/] [Accessed 12 June 2018].

[8] WNA, *Reactor database*, 2018b, [http://www.world-nuclear.org/information-library/facts-and-figures/reactor-database.aspx] [Accessed 21 May 2018].

[9] USNRC, *State-of-the-Art reactor consequence analyses project*, Vol. 1-2. Washington: US Nuclear Regulatory Commission, NUREG/CR-7110, 2012.

important to understand that disaster preparedness is a comprehensive aspect that is primarily relevant to decision-makers and not necessarily to appropriate professional equipment - that is, if a country trains emergency teams, buys suitable equipment and presents it to the public, a protocol on how to act at certain stages in a nuclear scenario does not mean that it is ready for a nuclear disaster. The most important and influential elements in the successful management of a nuclear disaster are the ones in which the existing models are irrelevant. First and foremost, the need to build a rational thinking pattern at the time of the disaster, examining existing programs in light of material and knowledge gained from interviews, document analysis, analysis previous events and personal experience three main points can be identified that make these models ineffective in the larger picture of nuclear disaster management:

3. Insufficient Professional Coping

Theoretically, the reviewed models present a comprehensive picture of disaster management, but an in-depth examination reveals that reality is different, and that these models suffer from many professional flaws. First it is important to note that at the level of emergency teams or those operating civilian power stations routinely as engineers or safety inspectors, there is a high level of preparedness and professional procedures that have been built on the basis of past events, but it not enough to prevent the next disaster. The insufficient professional aspect derives from other aspects as wrong coping models that are based on inaccurate and overly optimistic information.[14]

Taking the US and Canadian models for dealing with a nuclear disaster, for example, they are built based on Probabilistic Safety Analysis (PSA), a measure that has already been criticized for its disadvantages that

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[10] CNSC, *Study of consequences of a hypothetical severe nuclear accident and effectiveness of mitigation measures*, Ontario: Canada Nuclear Regulator, 2015.

[11] SGDSN, *National response plan: major nuclear or radiological accidents*, Paris: Prime minister office republic of France, 2014.

[12] SSK, *Planning areas for emergency response near nuclear power plants*, Berlin: German Commission on Radiological Protection, 2014.

[13] STUK, *Finnish report on nuclear safety: Finnish 7th national report as referred to in Article 5 of the Convention on Nuclear Safety*, STUK-B 205, Helsinki: Radiation and Nuclear Safety Authority, 2017.

[14] Spencer Wheatley, Benjamin Sovacool, Didier Sornette «Of disasters and dragon kings: a statistical analysis of nuclear power incidents and accidents» in *Risk analysis* no. 37, vol. 1, 2017, pp. 100-101.

outweigh its advantages, resulting a failure to predict and deal with nuclear disasters, and based on optimistic and unrealistic assessments.[15] In today's reference scenarios and preparedness plans for nuclear disaster, those unrealistic assessments are evident in the US coping plan that assume that 90% of the population within a 16 km radius of the site must be evacuated beyond 36 km radius.[16] This is despite the fact that at the Fukushima incident the evacuation the massive evacuation took months and caused many casualties, both as a result of the hesitation of the decision-makers and due to the nature of the evacuation itself.[17]

Also, even if these models do provide an accurate narrative of events, the US and Canadian reference scenario is based on PSA, as noted, and they are not designed to create overall readiness but those are specific coping frames that was built for each nuclear site separately.[18] The problem is that only two such models have been built on only two power plants in the US,[19] and the information generated from these models is placed on other power stations without precise description, thus creating non-realistic overall preparedness. This means that though those are similar nuclear power plants, each plant requires different operating procedures due to different landscape, populated areas, output, and many other factors. When an event occurs in the US at one of the many nuclear power stations,

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[15] *Ibid*. p. 99-100.

[16] The recommendation of the report is that response organization emergency plans are required to include detailed evacuation plans for the 10-mile emergency planning zone, and in some scenarios the evacuation radius can be up to 20 miles in selected areas, see USNRC, *op.cit*, pp. 55-56.

[17] There were 2,202 disaster-related deaths in Fukushima, according to the government's Reconstruction Agency, from evacuation stress, interruption to medical care and suicide, see Robin Harding «Fukushima nuclear disaster: did the evacuation raise the death toll?» in *Financial Times*, 11 March 2018, [https://www.ft.com/content/000f864e-22ba-11e8-add1-0e8958b189ea] [Accessed 12 October 2018]; yet, there were only seven deaths of workers form the nuclear plant itself - disaster-related deaths (two cases), heart attack (three cases), sepsis (one case) and only one case of radiation-induced leukemia, see WHO, *Health risk assessment from the nuclear accident after the 2011 Great East Japan Earthquake and Tsunami based on a preliminary dose estimation*, Geneva: World Health Organization, WN-665, 2013, p. 93.

[18] For elaborate explanation of PSA modeling see Olivier Nusbaumer, *Introduction to Probabilistic Safety Assessments (PSA)*. Leibstadt: Nuclear Power Plant Leibstadt AG, 2012.

[19] Those are model for two common nuclear reactors in USA: Peach Bottom boiling-water reactor (BWR) power station in Pennsylvania, and Surry pressurized-water reactor (PWR) power station in Virginia, see USNRC, *op.cit*, p. xi.

there will be no specific reference description, but only these general data. This will make it difficult for the decision-makers and increase their level of uncertainty and cause discretion which will develop with the event and is based on assumptions and beliefs. As stated, do not provide a comprehensive picture, not policy for decision-makers, relate to essential and significant elements such as laconic evacuation, and in fact encompass only a very small part of the disaster.

The reference scenario of France does include a real reference to the level of decision-makers, but this, too, is not enough for the researcher's opinion. The decision-making process is too broad, the chain of actions presented is described in general points and disconnected from the rescue forces, but the main problem is a too cumbersome mechanism of operation that includes too many entities dealing with the disaster.[20] Another faulty example is the Finnish coping model report, that has only a general statement that the human factor must be taken under consideration.[21]

4 New Scientific Knowledge is Not Embedded in Models

A significant point that arose from comparing the reference programs to the information accumulated in the study is the incorrect scientific knowledge on which these programs are based. Science is a body of knowledge that progresses and evolves over time, and we currently know more accurately about the dangers of radiation and long-term effects. The nuclear knowledge is constantly updating, and new knowledge is constantly implemented in many fields as medical devices, new and more efficient energy generation techniques, and theoretical academic knowledge.[22] But from examining the references scenarios, it seems that in nuclear preparedness and coping models no new knowledge is implemented.

In fact, interview with several nuclear experts conducted as a part of a comprehensive research revealed that only recently expert has realized that models for evacuation and treatment of the population are based on misinformation, and the long-term impact of a nuclear accident in terms of exposure to low levels of radiation is lower than science assumed only 15 years ago. Existing coping programs do not rely on new knowledge but

[20] SGDSN, *op.cit*, see for example response strategies (pp. 25-49) and the quick response sheets (pp. 56-101) that do not provide elaborate information for decision makers;

[21] STUK, *op.cit*, pp. 42-45.

[22] Stacey M. Weston, *Nuclear Reactor Physics*, 3rd Edition, Weinheim: Wiley-VCH, 2018, p. xxiv.

rather on traditional knowledge that has been fixed by decision-makers, and this body of knowledge has not yet been assimilated into the nuclear policy systems. The most prominent of them is a vast and unnecessary evacuation radius, as it was in Fukushima. The US reference scenario for nuclear accident describes an evacuation radius similar to that of Fukushima, up to 36 km,[23] and the Canadian plan is slightly more recent and sets a radius of evacuation of up to 12 km at worst. However, this reference scenario also states that in a serious accident, people must remain under cover of a 50 km radius from the event, which is not necessary and can cause unnecessary harm.[24] The German reference scenario describes that only 5 km around the power plan is to be considered for evacuation, there are cases in which people that are up to 100 km from the point will be forced to remain under cover and/or to consume iodine tablets.[25] In fact, from the professional knowledge aspect it is clearly stated that one can rely on existing knowledge and there is no change in the body of scientific knowledge on the subject, in complete contrast to nuclear researchers who have examined every aspect of nuclear accidents in the last half century.

Interviewed scientists say that fixation of evacuation areas larger than necessary is based on political considerations and taking as much safety as possible, and they are not prepared to take the risk and assimilate new knowledge that reduces the dimensions of the evacuation. But in order to effectively address the problem and be able to make rational decisions based on actual data, it is necessary to overcome the political concerns of the decision-makers and to act in accordance with the data obtained from the analysis of past nuclear events.

5. The Human Weakness in Decision-makers

These two elements emphasized that inadequate scientific knowledge and inadequate professional preparedness impair disaster preparedness,

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[23] The US coping models refers to 20 miles radius evacuation according to needs and the severity of the disaster, see USNRC, *op.cit*, pp. 55-59.

[24] CNSC, *op.cit*, pp. 47-48.

[25] The German coping recommendations divides land around the nuclear plant to three zones: central zone of 5 km radius, middle zone extending 20 km of the plan, and the outer zone that extends for about 100 km of the nuclear plan. The report suggests recommendations as staying indoors, distribution of iodine tablets and prohibition on food consumption; SSK, *op.cit*, pp. 4-6.

but they also affect the way decisions are made at the cognitive level. The models for dealing with a nuclear disaster describe the event in a dry and technical way, which is in fact all that they offer - dealing technically with the problem. The psychological coping of decision-makers does not take place despite its central importance, and models do not deal with elements in decision-making approaches and do not relate to the human weak point, especially at this level. This is the main drawback of programs dealing with nuclear events, and this is a central element in the ONDM (Operational Nuclear Defense Model) and hardly receives reference in existing reference scenarios.

The existing models were created in response to the Fukushima event, and the action plans that were examined did indeed assume that the human factor represents a key aspect. Therefore, these and many other action plans try to reduce the human factor by means of actions that must be carried out automatically in order to mitigate the disaster and deal with it. A similar understanding exists in the design of nuclear reactors from third and fourth generations. Today nuclear reactors are built and designed with automatic or passive coping systems that almost completely exclude the person from the picture at disaster time by automated mechanisms to contain the damage.[26]

But in decision-makers level, the human is a primary part of the equation and there is still no reference scenario nor action plan for dealing with nuclear accident that describes how to reduce the human factor at this level of disaster treatment - except the ONDM. Each and every model examined for the current study places its emphasis on the actions of emergency forces and professional teams and there is little or no reference for appropriate actions by decision-makers. In contrast to general opinion, the interviews with experts and the researcher's experience show to what extent erroneous decisions made by decision-makers affect the management of a disaster. That is primarily due to the fact that catastrophic events are almost always unknown events that existing plans overlooked or thought they have a faint chance of occurring, therefor no plans for them was created.[27] At times there is an event but none of the emergency scenarios

[26] WNA, 2018a, *op.cit*.

[27] Maaike van Tuyll, « Dealing with future risks in the Netherlands » in *Biosecurity and bioterrorism: biodefense strategy, practice, and science* vol. 11, no. S1, 2013, p. s55; Spencer Wheatley, Benjamin Sovacool, Didier Sornette, *op.cit*, pp. 105-106.

address it, there are no more automatic plans of operation and the professional teams turn to the decision-makers for orders - and this was the exact situation in Chernobyl.[28] and Fokushima.[29] At those incidents, as in many large-scale incidents, one wrong decision completely changes preparedness arrangements and harms - sometimes fatally - the ability of emergency teams to treat the phenomenon.[30]

In uncertain situations, humans at any level tend to carry out emotional decisions out of fear, panic, absence of scientific knowledge, not comprehending existing circumstances, inability to cope with unknown situations, extraneous considerations and the like.[31] Existing models and preparedness programs place great emphasis on professional aspects and outline automatic methods of action to mitigate the human factor of the emergency services and engineers when dealing with nuclear disaster, but these methods are only a fraction of what is needed to manage a successful unexpected event. It is true that any appropriate coping with disaster requires a technical plan for recession and damage, professional teams, appropriate equipment and predefined evacuation plans - but this is not enough at all. Past events have shown that the greatest number of casualties is due to poor choices made by decision-makers, and this situation was particularly evident in the management of the Fukushima disaster.[32]

Moreover, the excessive reliance of decision-makers only on professional elements causes them to have a psychological gap between the way they

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[28] See an analysis of Chernobyl accident at Dillwyn Williams « Lessons from Chernobyl: The world needs to improve its handling of international disasters » in *BJM* vol. 323, no. 7314, 2001, pp. 643-644.

[29] See impact of the accident on preparedness at Pablo Figueroa, « Nuclear Risk Governance in Japan and the Fukushima Triple Disaster: Lessons Unlearned » in Michelle Ann, Miller Mike Douglass, *Disaster Governance in Urbanising Asia*, Singapore: Springer, 2016, pp. 263-282.

[30] Ali Farazmand « Learning from the Katrina crisis: A global and international perspective with implications for future crisis management » in *Public Administration Review* vol. 67, no. s1, 2007 pp. 149-151.

[31] Theoretical elements of decision taking in uncertain situations can be learned from: *Ibid*; Costel Calin, Brandon Prins « The sources of presidential foreign policy decision making: Executive experience and militarized interstate conflicts » in *International Journal of Peace Studies* vol. 20, no. 1, 2015, pp. 17-34; Steven B. Redd, Alex Mintz « Policy perspectives on national security and foreign policy decision making » in *Policy Studies Journal* vol.41, 2013, pp. S11-S37.

[32] For a report about the Fukushima disaster and casualties see WHO, *op.cit*.

perceive the preparedness for disaster and the reality they face in times of disaster. They develop dependence and a sense of unrealistic security based on partial and unrealistic plans, mainly lack of knowledge and misunderstanding of a nuclear event, and when an event arrives, decision-makers encounter the realistic situation in which professional teams are inadequate, lack knowledge, the gap between expectations and reality creates panic and pressure from other parties and the public, leading in critical hours after the disaster to making irrational decisions, mismanagement of the event and greater damage.

From an analysis of nuclear events and as a result of extensive research on this issue, it was found that leaders' decision-making in dealing with nuclear events could best be described under two familiar academic approaches - the Individual Approach and the Cybernetic Theory. These two approaches describe the fact that the person in his/her decision-making is imperfect and is limited in his/her mind, his/her knowledge, prevents emotions and character traits, finds it difficult to understand complex situations, and in fact these approaches describe the main drawback to making informed decisions – The person himself.[33]

The ongoing research shows that the management of past events was flawed at the highest level, the level of decision-makers, even if we assume that there were no ulterior motives in the considerations of leaders linked to political interests or hiding corruption and unpreparedness. The decision-making was plagued by panic, lack of professional and scientific knowledge, lack of understanding of the situation, difficulties in communication between various bodies, poor communication with the public, and a lack of belief that the state is currently in the midst of a nuclear event at level 6-7.

This is a central point that has a huge impact on nuclear event management. This point, which is at the top of the management of the event and affects all the levels below it, is not in the existing preparedness programs and does not deal with it. Well-equipped emergency teams are an important point - but they cannot prevent damage and problems caused by mismanagement,

[33] See Costel Calin, Brandon Prins, *op.cit*, that emphasize the central role of the leader, and all its imperfections, about decision making process during a military conflict; also Steven B. Redd, Alex Mintz, *op.cit*, that describe theoretical decision making models of policy-makers and conclude that due to the human factor it is impossible to use a rational and analytic theory to human behavior. the Cybernetic Theory assumes that humans have cognitive limitations, and the Individual Approach focus on the human traits and character as a dominant factor.

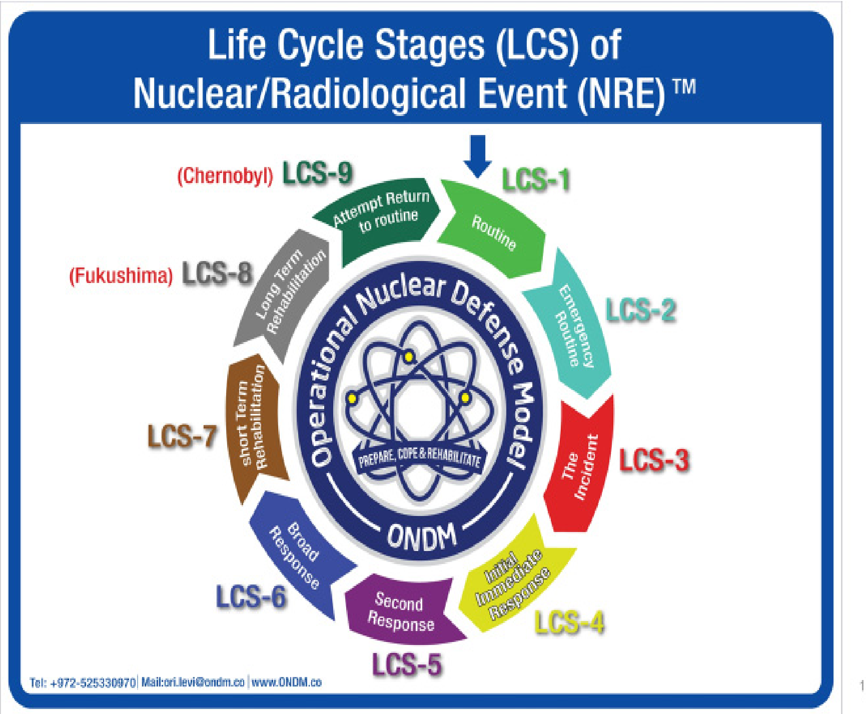
such as inadequate evacuation or damage of long-term effects. In the Fukushima event, the mismanagement of the event claimed many lives and today hundreds of thousands of people displaced from their homes and a large-scale damage to Japan as a country trying to recover from the event to this day. In Chernobyl the situation is similar, as a series of poorly made decisions, due to misperception of the event, led to the known disaster.

In my professional opinion, past events were escalated out of control due to inappropriate and exaggerated decisions based on the panic, lack of knowledge and wrong advice given to the leaders - the decision-makers. Therefore, the main goal of the presented ONDM is to build high readiness at the professional level, but mainly to provide tools for decision-makers to eliminate the elements that lead to irrational choices and to create a decision-making model based on the rational choice approach. This model describes decision-making as a rational process in which decision-makers are aware of possible alternatives to the situation, make decisions based on reasonable and logical judgment, and make the most appropriate decision to deal with the situation. By shifting the center of gravity in managing an event to rational rather than emotional choices, we can best mitigate the destructive effects of mismanaging an event.

6. ONDM - Operational Nuclear Defence Model

The main premise of the model is that the core failures in managing nuclear events, time after time, were at the level of decision-makers - and therefore ONDM emphasizes decision-makers' levels of coping with nuclear events. This is the key point of the ONDM, which provides decision-makers with professional tools and knowledge to carry out appropriate judgments at uncertainty situations. The key objective is to construct a hierarchical and comprehensive arrangement that will manage a disaster in a manner of collective thinking in which emergency teams, operational teams, security and rescue forces, decision-makers at every level, as well as the public itself, will provide information under a hierarchical, organized and complete arrangement.

ONDM contains 9 sequential stages called Life Cycle Stages (LCS) that together constitute the complete incident life cycle. That creates an overall and comprehensive nuclear preparedness, coping and rehabilitation plans for every stage of the incident. It is aimed to create a flowing and simple structure that can contain the information, use it to envelope operational procedures and new knowledge that will not replace decision-makers but guide them by specific measures to make more accurate and efficient decisions using a specific pattern, based on knowledge and understanding the situation.



This is a visual presentation of the nine stages of the model, arranged according to the colors attributed to them and moving in a clockwise direction. These stages are LCS-1: routine (portrayed in green), a day-to-day routine stage when there is neither information nor signs of a nuclear event; LCS-2: emergency routine (portrayed in turquoise), when there is information or potential circumstances of a nuclear incident are created; LCS-3: the moment of an incident (portrayed in red), describing a specific moment or a date or time when it is known for certain that a nuclear incident has occurred; LCS-4: initial, immediate reaction (portrayed in yellow), which is the immediate point in time when various immediate, mainly spontaneous, actions occur; LCS-5: second response (portrayed in purple), when the ambition is to mitigate the event and turn initial reactions into organized arrangements whereby everyone acts according to existing instructions; LCS-6: broad response (portrayed in blue), the stage dealing with a large nuclear event in which all intended enveloping systems cope with and treat an emergency situation; LCS-7: short-term rehabilitation (portrayed in brown), when the focus of action is returning life to routine with immediate management, when there is a transition from a holding situation to consolidation; LCS-8: long-term rehabilitation (portrayed in grey), when there is rehabilitation and rebuilding with people returning to damaged areas and moving from crisis to consolidation and growth. Correct to September 2018, this is the stage reached in Fukushima; LCS-9: attempt return to routine (portrayed in bottle green), when an event is remembered, learned from, and growing from it to improved preparedness in the routine stage. Correct to September 2018, this is the stage reached following the incident in Chernobyl.

ONDM is constructed and based on comprehensive research conducted over a number of years, and it suggests a much more effective frame model than existing preparedness models examined in this article. The model addresses deficiencies in existing models, assimilated elements of uncertainty, focused on decision-making, and is created in the form of an interactive presentation that contains a huge amount of clear and accessible information. ONDM is a frame model, and any country, region, city or defined territory that strives for nuclear preparedness can build unique and detailed readiness arrangements according to their needs.

7. Conclusions

The nuclear threat, though hidden from public attention, still very much exist today. Fukushima was the waking call for many countries around the world that created and updated their nuclear preparedness plans, but the current preparedness condition of the examined reference scenarios is not adequate, and a new approach is needed that a real and appropriate action will be taken when the time is needed. Current plans are built on optimistic and unrealistic assessments, they do not address many important issues, they do not contain new scientific data and do not take under real consideration the human factor. To overcome those flaws, the ONDM was presented as a new and innovative method for successful manging large-scale nuclear event at any stage.

A successful nuclear disaster management depends on establishing rational decision-making capabilities among leaders, as opposed to past events that were based on irrational decision-making. At past events, decision-makers, as any human, based their decisions on elements as primarily panic, public fear, a desire to conceal the magnitude of the catastrophe from the world and the core at the political echelons, a problem in understanding the situation, and even foreign interests. Accordingly, under the terminology of the ONDM (www.ONDM.co), leaders' decision-making was inevitably based on Emotional Thinking Pattern (ETP), a form of decision-making that significantly impairs disaster management. The ONDM is intended to lead decision-makers at all levels by means of preparedness and appropriate knowledge to provide the human factor errors and create a situation in which at the time of the disaster they will not act emotionally but will manage the event through a Rational Thinking Pattern (RTP). This is done by reducing the level of the unrealistic components and creating an equation in which decisions are made based on elements such as knowledge, viable choices, familiarity with the system, decision-making from a sense of control and understanding of the causes and consequences of each action. this can moderate the human weakness in decision-makers in nuclear events and allow to make fateful decisions quickly. Changing human decision-making process is not easy, but under an appropriate model of action and direction it is possible to reduce and even eliminate the human weaknesses in the decision-making mechanism by rationalizing a chaotic event, thereby creating the ability to make rational, rapid and effective decisions in times of disaster.

The practical conclusions are implemented unto the ONDM, that identifies the elements leading to incorrect decision making, eliminates them, and replaces them with elements that create a rational pattern of thought. It uses key principles for that aim - simplicity of use, accessibility and clarity of information; two-directional knowledge transfer; emphasis on decision-makers and not on professional teams; gives greater control for decision-makers instead of an operational model emphasizing the status of mid-level management; improving quality of decisions from emotional decisions based on low certainty levels to rational decisions based on information and feasible action options; flexibility and universal application; improving professional power from efficient to effective teams; and employs an international professional team applying work experience in various places around the world.

In addition, the ONDM is created as a flexible and modifiable model, which is an important feature in managing a disaster. It can be adaptable for every country or region's needs, and can assimilate knowledge for long-term preparedness. The model is aimed to absorb information over time, to develop according to changes in a country over years and/or changes in the existing body of scientific knowledge, new technological or professional abilities, political and social changes, and more. This can be executed quickly, using arrangements that combine new knowledge with existing information. A new and orderly procedure as the suggested ONDM is a critical step for future coping with nuclear disaster, and current countries must understand that though Fukushima showed the world the importance of a plan for dealing with nuclear events - the new plans must be efficient and professional and not just general plans that will fail when disaster strikes.

References

Albright, David; Hinderstein, Corey (2005), «Unraveling the AQ Khan and future proliferation networks» in Washington Quarterly vol. 28, no. 2, 109-128.

Calin, Costel; Prins, Brandon (2015), «The sources of presidential foreign policy decision making: Executive experience and militarized interstate conflicts» in International Journal of Peace Studies vol. 20, no. 1, 17-34.

CBS News (21 june 2016), «Fukushima meltdown apology: "It was a cover-up"» [https://www.cbsnews.com/news/fukushima-tepco-power-japan-nuclear-meltdown-apologizes-cover-up/] [Accessed 12 June 2018].

CNSC (2015), Study of consequences of a hypothetical severe nuclear accident and effectiveness of mitigation measures, Ontario: Canada Nuclear Regulator.

Farazmand, Ali (2007), «Learning from the Katrina crisis: A global and international perspective with implications for future crisis management» in Public Administration Review vol. 67, no. s1, 149-151.

Figueroa, Pablo (2016), « Nuclear Risk Governance in Japan and the Fukushima Triple Disaster: Lessons Unlearned» in Michelle Ann, Miller Mike Douglass, Disaster Governance in Urbanising Asia, Singapore: Springer, 263-282.

Froggatt, Antony (2013), «Fukushima two years later: Lives still in limbo» in Brian Blomme, Steve Erwood, Nina Schulz, Rianne Teule, Fukushima fallout, Amsterdam: Greenpeace international, 10-21.

Harding, Robin (11 March 2018) «Fukushima nuclear disaster: did the evacuation raise the death toll?» in Financial Times, [https://www.ft.com/content/000f864e-22ba-11e8-add1-0e8958b189ea] [Accessed 12 October 2018]

Jargin, Sergei V. (2016), «Nuclear facilities and nuclear weapons as a guarantee of peace» in Journal of Defense Management vol. 6, no. 2, 146-150.

Levi-Nissim, Ori (2018), «Failure of the superpowers (U.S.A, Russia, Japan) to handle large nuclear events» in Modelling the New Europe no.25, 122-141.

Nusbaumer, Olivier (2012), Introduction to Probabilistic Safety Assessments (PSA). Leibstadt: Nuclear Power Plant Leibstadt AG.

Redd, Steven B.; Mintz, Alex (2013), «Policy perspectives on national security and foreign policy decision making» in Policy Studies Journal vol. 41, s11-s37.

SGDSN (2014), National response plan: major nuclear or radiological accidents, Paris: Prime minister office republic of France.

Solomon, Kenneth Alvin (1988), «Sources of radioactivity in the ocean environment: From low level waste to nuclear powered submarines» in Journal of hazardous Materials vol. 18, no. 3, 255-262.

SSK (2014), Planning areas for emergency response near nuclear power plants, Berlin: German Commission on Radiological Protection.

STUK (2017), Finnish report on nuclear safety: Finnish 7th national report as referred to in Article 5 of the Convention on Nuclear Safety, STUK-B 205, Helsinki: Radiation and Nuclear Safety Authority.

USNRC (2012), State-of-the-Art reactor consequence analyses project, Vol. 1-2. Washington: US Nuclear Regulatory Commission, NUREG/CR-7110.

van Tuyll, Maaike (2013), «Dealing with future risks in the Netherlands» in Biosecurity and bioterrorism: biodefense strategy, practice, and science vol. 11, no. S1, s55-s63.

Weston, Stacey M. (2018), Nuclear Reactor Physics, 3rd Edition, Weinheim: Wiley-VCH.

WHO (2013), Health risk assessment from the nuclear accident after the 2011 Great East Japan Earthquake and Tsunami based on a preliminary dose estimation, Geneva: World Health Organization, WN-665.

Williams, Dillwyn (2001), «Lessons from Chernobyl: The world needs to improve its handling of international disasters» in BJM vol.323, no.7314, 2001, 643-644.

WNA (2018a), Plans for new reactors worldwide, [http://www.world-nuclear.org/information-library/current-and-future-generation/plans-for-new-reactors-worldwide.aspx] [Accessed 18/05/2018]

WNA (2018b), Reactor database, [http://www.world-nuclear.org/information-library/facts-and-figures/reactor-database.aspx] [Accessed 21 May 2018].

Ahmed, S. (1999) Pakistan’s nuclear weapons program: turning points and nuclear choices. International Security, 23(4), pp. 178-204.

Albright, D. and Hinderstein, C. (2005) Unraveling the AQ Khan and future proliferation networks. Washington Quarterly, 28(2), pp. 109-128.

Baverstock, K., & Williams, D. (2007) The Chernobyl accident 20 years on: an assessment of the health consequences and the international response. Ciência & saúde coletiva, 12(3), pp. 689-698.

Calin, C. and Prins, B. (2015) The sources of presidential foreign policy decision making: executive experience and militarized interstate conflicts. International Journal of Peace Studies, 20(1), pp. 17-34

CNSC (2015) Study of consequences of a hypothetical severe nuclear accident and effectiveness of mitigation measures. Ontario: Canada Nuclear Regulator.

Deutch, J., et al. (2003) The future of nuclear power: an interdisciplinary MIT study. MIT Energy Institute.

Farazmand, A. (2007). Learning from the Katrina crisis: A global and international perspective with implications for future crisis management. Public Administration Review 67(s1), pp. 149-159.

Froggatt, A., et al. (2013). Fukushima fallout. Greenpeace International.

Levi-Nissim, O. (2018) Failure of the superpowers (U.S.A, Russia, Japan) to handle large nuclear events. Modelling the New Europe, 25, pp. 122-141.

Mennen, M. G. and van Tuyll, M. C. (2015) Dealing with future risks in the Netherlands: the national security strategy and the national risk assessment. Journal of Risk Research, 18(7), pp. 860-876.

Nusbaumer, O. (2012) Introduction to Probabilistic Safety Assessments (PSA). Leibstadt NPP.

Redd, S. B. and Mintz, A. (2013) Policy perspectives on national security and foreign policy decision making. Policy Studies Journal, 41(S1), pp. S11-S37.

SGDSN (2014) National response plan: major nuclear or radiological accidents. Paris: Prime minister office republic of France.

Solomon, K. (1988) Sources of radioactivity in the ocean environment: From low level waste to nuclear powered submarines. Journal of hazardous Materials, 18(3), pp. 255-262.

SSK (2014) Planning areas for emergency response near nuclear power plants. Berlin: Recommendation by the German Commission on Radiological Protection.

Stacey, W. M. (2018) Nuclear reactor physics. New York: John Wiley & Sons.

STUK (2017) Finnish report on nuclear safety: Finnish 7th national report as referred to in Article 5 of the Convention on Nuclear Safety. Helsinki: Radiation and Nuclear Safety Authority, STUK-B 205.

USNRC (2012) State-of-the-Art reactor consequence analyses project, Vol. 1-2. Washington: US Nuclear Regulatory Commission, NUREG/CR-7110.

Wheatley, S., Sovacool, B. and Sornette, D. (2017) Of disasters and dragon kings: a statistical analysis of nuclear power incidents and accidents. Risk analysis, 37(1), pp. 99-115.

WHO (2013). Health risk assessment from the nuclear accident after the 2011 Great East Japan Earthquake and Tsunami based on a preliminary dose estimation. Geneva: World Health Organization, WN-665.

Williams, D. (2001). Lessons from Chernobyl: The world needs to improve its handling of international disasters. British Medical Journal, 323(7314), pp. 643-644.

WNA (2018a) Plans for new reactors worldwide. [Online]. Available from: http://www.world-nuclear.org/information-library/current-and-future-generation/plans-for-new-reactors-worldwide.aspx. [Accessed 18/05/2018]

WNA (2018b) Reactor database. [Online]. Available from: http://www.world-nuclear.org/information-library/facts-and-figures/reactor-database.aspx. [Accessed 21/05/2018].