"Babeş-Bolyai" University of Cluj Napoca

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SUMMARY OF THE DOCTORAL THESIS

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CONSOLIDATED POLICY TO MANAGE NUCLEAR RISKS: PREPLANNING, COPING WITH AN EVENT AN AND REHABILITATION OF A STATE

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INTRODUCTION

Nuclear weapons and civil and other nuclear facilities exist and are frequently present in the modern world, and although awareness of nuclear dangers has been reduced with the end of the Cold War, the threat of a civil/military accident or deliberate nuclear attack still exists. Even today, nuclear incidents are a risk that must be addressed, and the nuclear event in Fukushima in 2011 is the most up-to-date example of the continuous need for preparedness for this. The reality is that countries that have dealt with nuclear events in the past failed to cope and decision-makers repeated the same mistakes that those before them had made over and over again; an analysis of information shows that today the situation is no different with regard to future events. Current preparedness is lacking, and it appears that existing models provide a partial answer, overoptimistic assessments of coping capabilities and the probability that an event will occur, lack of preparedness for a low-probability radical event such as the tsunami in Fukushima, absence of accurate instructions for decision-makers, populations and intermediate ranks, and a lack of understanding of how to manage a crisis event in the most effective way possible.

The current research seeks to learn from the past and overcome the failures that led to defective management, so that when the next nuclear event occurs, the same past mistake will not be repeated – through a model – the Operational Nuclear Defense Model (ONDM). The model is the product of in-depth qualitative research, combined with the researcher's experience resulting from his role in the IDF, formal and informal field studies and a comprehensive theoretical review, which have led to the creation of a comprehensive model addressing appropriate management of a disaster at all levels – from the level of decision-makers to that of civilians and evacuation forces – which can improve a county's preparedness and save the lives of many people when required.

Research Aim

The research is applied through multiple methods, mainly combining the researcher's experience, interviews with experts, field research and case studies, so as to build an applied model to deal with nuclear disasters around the world for policy-making echelons – the

ONDM model, which will be able to cope with civilian nuclear accidents, military accidents, a nuclear attack or a terrorist attack with a dirty bomb.

The real need to investigate the nuclear threat and build a model to successfully cope with it is evident because nuclear events have a destruction ability of enormous proportions. The number of casualties can be extreme, destruction widespread, and the effects of an event continue for decades through ground contamination and long-term medical effects. This is irrespective of whether it is a deliberate bombing, an incident of stolen radioactive materials or a terrorist attack, nuclear weapon accident or accidents at civilian facilities[1]. The level of existing risk regarding the nuclear issue, together with past flawed management and lack of sufficient preparedness for the future, lead to the conclusion that in order to prevent a large disaster resulting from a nuclear event in the future, one must cope directly with the nuclear issue, a topic that despite daily newsworthy information around the world is generally pushed back to the margins of the political and public agenda from the point of view of defense and preparedness.

The research aim becomes clearer because of the unwillingness of bodies and executives to deal with the nuclear issue, which can be attributed to a number of reasons – the assumption that little can be done in case of a nuclear event, unwillingness to create public panic through discussions about the issue or information for civilians, decision-makers' lack of knowledge regarding how to cope properly, the high classification of the nuclear topic and coping with it in almost every country, lack of accurate knowledge about the long-term implications and damage from nuclear events, the assumption that there is such a low probability of an event occurring, and the fact that efforts are not invested in broadening knowledge on the issue. Unwillingness to deal with the matter have led to the fact that there is almost no real discussion of the topic at any level, and as it was discovered at the Fukushima event, a lack of understanding led to the inability to cope with the disaster. Moreover, these events require handling and preparedness at an international level, because of their effects on many countries, and it is of paramount importance to understand the events, learn from

[1] One must emphasize that there are significant differences in the scope of damage and its focus in each of these events; in other words, in the case of a nuclear bomb, fallout constitutes a less severe problem than the direct damage, whereas in civilian events, generally a considerable amount of radioactive material is emitted, and contamination is the focus of the problem.

management faults and apply the lesson learned in the future in this field as well. The increasing use of civilian nuclear facilities and world geo-political changes such as the rise of radical Islam and Iran's nuclear ambitions lead to the conclusion that the time has come to bring this issue out of the shadows, to explore past events in depth, examine how and whether conclusions are applied in various countries and update countries' nuclear risk policies so that they are relevant and effective at present.

Accordingly, the development of a model containing defined treatment plans and readiness at every stage of a nuclear event is the only way it is possible to successfully cope with the destructive results of a nuclear event, and thus the proposed research has three defined aims:

1. To **investigate** how Japan, the United States and the U.S.S.R. dealt with five past nuclear events – Hiroshima, Nagasaki, Three Mile Island, Fukushima and Chernobyl. Analyses attempted to understand how these countries conducted themselves before, during and after the events, and focused mainly on elements requiring care and correction.
2. To **investigate** how the U.S.A., Switzerland, Israel and Finland work in preparation for major nuclear incidents.
3. To **develop a nuclear risk management model** (**ONDM**) that can guide, at state level, how to prepare, deal with and rehabilitate after a nuclear event, which will have possibilities for European or universal adaptation.

The ONDM seeks to provide answers to handling and managing widespread nuclear events at levels 6-7 on the INES[2] scale.

- ✓ **Mishaps in civilian nuclear structures caused by technical failure or malfunction**, such as negligence or deliberate failure, improper handling of a nuclear facility, an event resulting from faulty construction etc. similar to the Chernobyl or Three Mile Island nuclear event.

[2] The INES scale is used to determine the level of nuclear disaster, was constructed in 1990 in the light of the Chernobyl disaster, and the worst disasters such as Chernobyl and Fukushima are found at the top of the scale, i.e. level 7.

- ✓ **Faults in civilian nuclear structures resulting from unexpected and destructive natural disasters**, similar to the one in Fukushima.
- ✓ **Nuclear events and crises as a result of military attacks on civilian areas**, as they occurred in Hiroshima and Nagasaki.

I. LITERATURE REVIEW

I.1 Theoretical approaches

The basic theoretical approach used to analyze this research is **the realist approach to international relations**. In effect, this approach cuts off countries' foreign policies and the relations between them from general moral and ethical principles and bases them on national interest. The assumption is that every country is driven by its own national interest and countries are not interested in moral issues such as human rights or historical obligations. According to this view, a country's sovereignty gives it the freedom and responsibility to do everything needed to safeguard itself, to survive and promote its interests. The international setting is a constant state of a battle of interests, and the desire to realize a country's interests begets arrangements whereby each party to an agreement is only concerned about its own interests (Morgenthau, 1978).

In fact, the political system is made up of diverse and numerous interests and each country tries to achieve its interests through power. International relations are fundamentally and unchangingly a struggle for power, states are the most important players in international relations, and there is no higher political authority to which countries are accountable (Walker, 1993). Under the realist approach, each country's conduct as a 'lone wolf' according to its interests makes it difficult for more of them to cooperate, and especially, as it will be presented later, in situations in which their interests or citizens are endangered. This situation hampers cooperation between countries on issues such as managing nuclear crises, especially in European countries, where there are many countries in a small area that have to set their national interests aside in favor of comprehensively dealing with a serious nuclear disaster.

Another theoretical approach in this study, and the model to be presented, refers to leaders' decision-making models, an aspect on which the ONDM model focuses, and to which many other models do not relate. Decision-making varies from one leader to another, and there are numerous decision-making models in international relations, which also affect countries' coping with regard to cooperation with other countries in disasters and crises (Ömer, 2008). This study focuses on the following key approaches:

- ✓ **Individual approach** - People make decisions differently, according to their subjective perceptions and experiences in life and the political world, and certain leaders can take decisions in various ways – there are leaders who tend to make decisions by themselves and those who tend to listen to the opinions of others when making decisions, others who tend to decide on the basis of a rational analysis of the situation, and there are those who are inclined to make moral/emotional decisions. There are leaders with long-term vision and those with defined political aims, and the like (Calin & Prins, 2015; Redd & Mintz, 2013).
- ✓ **Cybernetic Approach** - The assumption in this approach is that decision-makers are limited by their cognitive abilities, and therefore cannot carry out genuine rational judgement. Like all people, decision-makers are limited in memory and abilities to understand complex situations, especially in the field of international relations, which are complicated by a great many variables and possibilities, and therefore there is certainly no possibility of rational choice because all choices necessarily include a high level of uncertainty (Calin & Prins, 2015; Redd & Mintz, 2013).
- ✓ **Rational choice** - this is a model that describes decision-making as a rational procedure in which decision-makers are aware of possible alternatives to a situation, make decisions based on practical and logical judgments and opt for the most appropriate decisions to deal with a situation (Redd & Mintz, 2013).

I.2 Nuclear Danger and the Need for an Appropriate Coping Model

Nuclear dangers emanate from both the military and civilian sectors. Although the perception today is that we are far away from a nuclear war, it must be clarified that since World War II there has been an increasing occurrence of nuclear weaponry and possessing

and developing nuclear arms has spread to many countries – from democratic and liberal regimes to religious and fundamental ones around the world (Ahmed, 1999). Nuclear weapons were located in countries that were under Soviet rule during the Cold War and some were never returned to Russia even after the breakup of the Soviet Union, and military abilities and knowledge about the nuclear issue is, at different stages, in the hands of countries such as Iran and Libya as well (Albrighta & Hindrestein, 2005). Countries still possess nuclear weapons, and we cannot predict future changes in international systems that will perhaps prompt these countries to employ this power. In addition, there is always a growing threat from terrorist organizations which have exploited weaknesses in countries that hold nuclear weapons and which will acquire a nuclear bomb or fissionable material for a dirty bomb.

However, even if we accept the idea that a nuclear attack is highly unlikely, because there has been no nuclear event linked to a nuclear weapon attack since World War II, this does not mean that damage has not been caused by accidents that have involved nuclear weapons. Many accidents have indeed occurred over the years - including the crash of an American B-52 plane carrying two nuclear bombs in Goldsborough, North Carolina, in the U.S.A. on 24 January 1961; the Russian nuclear submarine K-19 carrying ballistic missiles with nuclear warheads, which on the 3-4 July 1961 was involved in a serious nuclear incident; the Russian nuclear submarine K-8 from the Northern Fleet of the Soviet Navy that sunk on 12 April 1970 in the Bay of Biscay together with its nuclear weapons; the Russian submarine K-431 that had a nuclear accident on 10 August, 1985 (Solomon, 1988).

These events illustrate the fact that large amounts of nuclear weapons can increase the probability of a nuclear accident. Nuclear weapons are still a threat to populations and can cause a multi-casualty event in one way or another, and one must acknowledge this and cope with the possible results instead of ignoring the problem.

The central threat this research addresses is coping with a civilian nuclear disaster. Since the discovery of nuclear energy, there has been not only a nuclear weapons race, but more and more civilian nuclear facilities have been built such as power stations and/or nuclear research centers, located relatively close to population centers, which can constitute a real threat – as

it has occurred in a number of events in history, including the disasters examined in this research, which are Three Mile Island, Chernobyl and Fukushima (Ansolbehere et al., 2003).

These events are not isolated, but part of a sequence of nuclear events at various levels of severity over the years. Past accidents in nuclear facilities have shown how extensive the damage can be, where comprehensive research has found that there have been 174 civil nuclear incidents of various levels between 1946-2014. The research examined these events by categories and how facilities that were meant to be damage-proof could suffer great damage for various reasons. Nuclear **event frequency** has declined constantly since the 1970s, and in 2015, the data shows that every nuclear facility has 0.002-0.003 safety incidents per annum. Regarding **event severity**, it was found that whilst indeed there had been a decline in the number of nuclear incidents - the decline was only in low and medium incidents, but no decline was registered in the number of catastrophic accidents. In other words, these researchers have found that although there are fewer events, there is still no decrease in the probability of severe events, so if an accident occurs, it will probably be at a high level and with severe environmental effects. Over the years, many safety procedures have been created that have led to a reduction in moderate nuclear events, but it is still impossible to prevent serious unpredictable accidents, such as a natural disaster or a human error that no model has tackled (Wheatley, Sovacool & Sornette, 2016).

In effect, many countries are likely to be exposed to a nuclear incident, because civil nuclear facilities exist in almost every country around the world. Even modern facilities, designed to be as safe as possible, can have mishaps, because of human error, faulty design or the occurrence or a powerful, unexpected natural disaster. Wheatley, Sovacool and Sornette (2016) have emphasized that there is a 50% probability that one of the following catastrophic events will occur – a severe strike against a nuclear facility as a consequence of a natural disaster will take place in the next 50 years; a fault at a nuclear facility as a result of an accident or faulty design will occur in the next 27 years; an accident resulting from human error will take place in the next 10 years.

These figures emphasize the fact that it is not a question of "whether" but "when" another nuclear disaster will occur. Hence, there is a significant need to prepare for the next major

nuclear event, because adherence to familiar and proven procedures can save lives and prevent significant damage.

I.3 Failures Coping with Past Events

One of the key points of the current research that highlight the need for a new applied model is the fact that time after time, coping with past nuclear events was flawed. Examination of three civilian nuclear disasters has yielded the following results:

- ✓ **The accident at Three Mile Island** occurred on 28 March 1979 and caused the core of the nuclear reactor in Pennsylvania, U.S.A. to melt. As a result, the reactor dome exploded, and radioactive elements were released into the system. An analysis of how the Three Mile Island disaster was managed yielded a picture of lack of preparedness, and although the direct events that led to this disaster were technical failures, the IAEA report (2013) that analyzed the event revealed failures in operating, preventing and containing the disaster, as a result of a lack of knowledge and absence of preparedness among the facility's designers, workers and decision-makers. Workers were not trained to cope with the mishap that occurred because decision-makers did not think an event of such proportions was possible. Therefore, there were no procedures or disaster management center at the site itself, nor was there any civilian preparedness on the outside.
- ✓ **The reactor disaster at Chernobyl** occurred on the night between 25 and 26 April 1986, after two years of operation, when penetration of oxygen and air into the reactor started a huge fire and a series of explosions. However, the disaster at Chernobyl occurred in the Soviet Union during the Cold War and, t herefore, it is difficult to acquire information about it. With regard to this disaster too, it has become clear that building and safety standards were very low, evacuation plans were unsuitable and carried out in panic, and management of the event itself was defective and improvised.
- ✓ **The disaster in Fukushima** occurred after a severe earthquake and tsunami in Japan, in September 2011, where the tsunami caused the flowing of the power station and destroyed the generators that provided electricity to the cooling system, which led to a chain reaction, resulting in the overheating and complete meltdown of the three reactors.

After the disaster in Fukushima, it was discovered that preparedness was lacking, and the safety standards of the reactors fell below the required levels in a number of areas such as readiness for a tsunami, preparedness for earthquakes, and faulty ventilation design in case of emergency. It was also found that evacuation plans were unsuitable and were restricted to a 16-kilometer radius, despite the fact that the polluted area spread to a radius of over 80 kilometers from the facility. There was no organized evacuation plan, no information regarding the expected extent of the damage, and the appropriate authorities were neither prepared not trained for a nuclear disaster (Froggatt et al., 2013).

Examination of these events leads to the conclusion that there was no suitable coping in any of the stages; lessons from the past were not learnt, and more importantly, damage could have been smaller with regard to both human life and the economy, had there been an organized plan and an applicable coping model for each of the disaster's stages.

- ✓ **unsuitable advanced civil preparations** expressed by an absence of organized and appropriate evacuation plans for an event of that size, unsuitable treatment of casualties, lack of plans to treat those who were uprooted from their homes, lack of plans to treat psychological aspects and their impact on the population;
- ✓ **faulty professional coping with the event** expressed by a lack of knowledge and operating plans to contain the damage, lack of professional knowledge at political and senior management levels to give appropriate orders, unsuitable forward planning in equipment and human resources, inaccurate estimate of damage and/or probability of a disaster and more;
- ✓ **unsuitable/insufficient plans to treat and rehabilitate after the event,** expressed by lack of reparations and ability to pay for the damage, lack of cooperation between state bodies and various countries to treat and rehabilitate properly, lack of suitable plans to treat radiation in the affected area, lack of long-term policies and solutions for evacuees and more.

The only military nuclear events to have occurred in human history are the events of Hiroshima and Nagasaki, which had a huge effect on the populace and took the lives of between 120 and 200 thousand people, according to various estimates. A report analyzing the disasters explained that there was a significant difficulty understanding what exactly had

killed people and how many had been killed at the time of the bombing. The three causes of death were direct and indirect casualties from the bomb itself, heat and radiation. By addressing how the security forces coped with the event, we are now aware of the devastating power of nuclear bombs, and this knowledge should be applied so that coping with the next military nuclear event will not be similar to how events were dealt with in World War II.

I.4 Failures in Existing Models for Future Coping

It is important to understand that like most social science approaches and theories, the risk management approach proposes a process of simplifying complex systems, with risk management being a central variable in the decision-making process in international relations (Mennen, 2013).

Many countries use the National Risk Assessment (NRA) and coping model regarding aspects of national risks, which shows coping with crises under risk themes. The model presents a list of risks, possible scenarios which are graded and presented alongside one another. In managing a state's risks, several possible scenarios and their effects are considered and measured from various points of view. The scenarios are analyzed, and the model proposes a framework of possible and effective ways of coping with the crisis. These models present to decision-makers the probabilities of certain events happening and their effects, through which decision-makers are supposed to implement policy and define priorities in order to prepare for and perhaps prevent a threat or disaster (Mennen, 2013).

A review of existing models for dealing with nuclear events under the NRA indicates that the main problem in faulty future nuclear coping design is that the countries of the world operate by low attribution scenarios. In other words, various countries such as Holland, Ireland, France, the USA, Canada and more that were examined for the purpose of the research are highly prepared for and can adequately handle events at the level of 0-3 on the INES index[3], but there is no sufficient readiness for events at a higher level on the index, and at a low probability level - that is, the low likelihood of a large-scale nuclear disaster

[3] Levels 0-3 are the low levels defined as "incidents" compared to the higher levels of 4-7 that are defined as "accidents" and are the ones that cause actual damage. The events of Chernobyl and Fukushima were categorized at the highest level in this index, level 7.

leads to faulty future planning. The main example of this is the Fukushima event in Japan, when the country had highly effective models for coping with a tsunami, but there were no plans to deal with a nuclear failure (Froggatt et al., 2013). However, these low-probability events are the main danger, and not events with a higher probability of occurrence. In these models, the method of coping is performed according to the severity of the damage from the event versus the probability that the event will occur, when the model presents detailed coping methods for events that are more likely to occur, but very destructive events that are reasonably low are not within the range of these methods, and a large nuclear accident was also categorized as the least likely to occur (Mennen, 2013).

This is the main weak point of models based on the NRA measure, because the dominant component in risk management models is the probability of an event occurring, and it is not applicable to large nuclear events, whose probability of occurring is low. The events with the greatest impact are usually rare and/or malicious - and these conditions make the use of probabilities, or even rough estimates thereof, irrelevant (Eijffinger, 2012). It seems that although many countries assume that they are addressing a future nuclear disaster, the low likelihood of a large-scale disaster will make these models irrelevant - as it has happened in the past. There is no doubt that various failures have not been assimilated into these models, and we must update the proper manner of coping not only with technical aspects, but also deal with many other dimensions at the decision-making level. It is important to remember that history has proven time after time that malfunctions happen even at modern facilities, designed to be as safe as possible, and the use of nuclear energy by its very nature has inherent risks that may lead to accidents.

The probabilistic safety analysis (PSA) measurement is used in many countries in the world. PSA is used to measure and manage risks in civil nuclear industry. This measurement deals with nuclear risks in a similar way to the general risk management model. It also examines the probability of an accident as the key measurement of coping (Wheatley, Sovacool & Sornette 2016). This model presents a number of possible scenarios structured according to their occurrence probability and the damage they will cause, when it tries to determine numerically and as accurately as possible what are the undesirable

scenarios that could happen, the probability of such events occurring and what the results could be (Nusbaumer, 2012).

This model is built for each nuclear facility separately and does not constitute a general model, or a political outline for dealing with an event on a professional or civil level. It is meant to meet a number of key aims: to provide an estimate regarding the frequency of an accident and damage to a reactor core, and identify the order of events of an accident; to identify the components at a facility that are likely to fail or those whose damage to them could lead to a chain of catastrophic events; to identify which actions or people can cause or contribute to an accident; to provide computerized samples to power stations in favor of safety; to rank, according to level of severity or expected strike, the possible scenarios; to evaluate a facility's operation; to evaluate professional knowledge and knowledge limitations of workers at a power station; to provide information to lead decision-makers and plan desired changes if needed. At the end of the day, this constitutes a detailed and comprehensive model of all aspects of a civil nuclear facility (Nusbaumer, 2012).

Today, there are several plans to deal with a nuclear disaster that are meant to provide coping mechanisms that will successfully prevent and/or deal with a severe nuclear event based on the PSA scale. The detailed plans reviewed in the light on this scale were in the U.S.A., Canada, France and Germany. These are technical models presenting a range of coping scenarios resulting from a nuclear reactor failure and ways of coping with nuclear fallout, civilian damage, evacuation plans, and the like. However, Wheatley, Sovacool and Sornette (2016) presented a position whereby these models too do not respond to the problems, and this scale has been subjected to academic criticism because of its ineffectiveness. Employing this scale in the past has led to failures in predicting and dealing with nuclear disasters, models based on this scale did not correctly assess danger and damage levels caused by various events, the predictions and probabilities of an accident were based on optimistic, unreal assessments and the models greatly underestimated the probability of a serious nuclear accident occurring. In addition, even if these models did indeed provide an accurate narrative of events occurring, models that are not based on the PSA scale are not intended to produce comprehensive preparedness, but are built for every nuclear facility separately – and in the U.S.A., for example, there are only two such models for only two power stations.

The information produced by these models is projected onto other power stations, without accurate explanations, and when a future event takes place in the U.S.A. at one of its many nuclear power stations, there will not be a specifically addressed description, but only general data, which will make it difficult for decision-makers to act, increase their levels of uncertainly and lead to considerations that will develop with the event and be based on hypotheses, assumptions and beliefs. These models do not provide an overall picture, do not present real policies to decision-makers; they refer laconically to critical and significant elements such as evacuation, and in fact, they include a very small part of an overall disaster.

In addition, a key point of failure in the PSA model on which many countries around the world rely is that it does not provide an answer to decision-makers, nor guides them on how to act. The research findings show that leaders' decision-making when coping with nuclear events can be described at best under the **individualistic and cybernetic approaches**, which emphasize that people, when making their decisions, are not perfect and are limited by their intelligence, knowledge, motivated by feelings and personal characteristics and struggle to understand situations that are too complex. In fact, it can be said that these approaches describe the key disadvantage that prevents making rational decisions – people themselves. Management of past events was flawed at the highest level, at the decision-making level, and decision-making was infected by panic, absence of professional and scientific knowledge, not understanding the situation, communication difficulties between various bodies, deficient communication with the public and lack of belief that the country was actually facing a 6-7 scale nuclear event. Therefore, the central purpose of the model is to construct high preparedness at a professional level, but mainly to provide tools to decision-makers so as to remove those elements that lead to irrational choices, and create a decision-making model according to the **rational choice approach** in which decision-makers are aware of possible alternative choices for a circumstance, execute decisions on the basis of rational and practical judgments and make the most suitable decisions to cope with the situation.

An additional model that was examined is the EU's model for coping with nuclear incidents, which predominantly deals with cooperation among member states. The current coping model in Europe written in 2014 by WENRA (Western Europe Nuclear

Regulators' Association) and HERCA (Heads of the European Radiological Protection Competent Authorities) emphasizes that the key manner in which Europe will address a nuclear event is a model based on successful cooperation. The core obstacle with which European countries have to cope when dealing with a nuclear disaster, according to the plan, is cooperation among a large number of countries and authorities existing in every country to handle a disaster. The plan addresses the fact that various countries' plans to handle a disaster are neither identical nor coordinated, and there are real gaps in the levels at which countries have internalized and acted according to European safety instructions. The plan presents principles for cooperation between countries in a disaster, including a nuclear one, encompassing mainly principles of cooperation and fast and proper information sharing between the sides - before a disaster, in the critical hours during the disaster, and after one (HERCA, 2014).

However, the key aspect affecting cooperation and constituting a barrier to successful cooperation is conflict of interests. According to the realist approach, countries are key players and act to attain their interests alone in the chaotic international arena. In practice, during periods of crisis that involve many countries, only seldom are the interests of all participants parallel, and only seldom are common action procedures applicable (Saurugger, 2014). In Europe, conflicts of interests between states are highlighted because of the EU member states' sovereignty in the nuclear field, which determines their nuclear policy that prepares them for a nuclear crisis according to their own interests.

There are attempts to maintain a unified policy agreed upon by all EU countries in dealing with crises, because Europe is composed of a large number of countries with a relatively small territory. A crisis nuclear event affects many countries, therefore the main need for a successful resolution of the crisis is cooperation. Cooperation can occur mainly when interests coincide or when they meet the needs of both sides (Donnely, 2000). Furthermore, Saurugger (2014) clarified that cooperation among many countries constitutes an enormous obstacle because of the multitude of opinions of political entities with diverse interests. Even in the European Union, despite the fact that it includes countries with a common culture, common interests and without ethnic, religious or territorial conflicts – still in dealing with

crises, it has to cope with different opinions through negotiations to reach an agreement on cooperation.

In fact, from the point of view of Europe's coping with previous crises, first and foremost the 2008 economic crisis and the refugee crisis, it appears that the relations within the EU are no different from those between countries in the international arena - strong states use their power to try to impose solutions that are appropriate to their interests, and other countries, strong or weak, choose to act in crisis situations according to their interests even contrary to the directives of EU institutions (Crespy & Saurugger, 2014; Kamel, 2014; Winslow, 2016).

On the surface, it seems that these models provide a proper response, but a careful analysis shows that the models relate primarily to the professional aspect; they mainly refer to local issues, and do not relate to full disaster preparedness at the decision-making level. The professional aspects constitute a mere fraction of the proper management of a disaster, and the most significant and influential elements in successful nuclear disaster management are those to which the existing models are irrelevant. Accordingly, the current research is a comprehensive study that ultimately led to the ONDM model, which is designed for better management of nuclear events, overcoming past failures and future preparedness programs, and creating a comprehensive, applicable, realistic and coherent framework that can provide a response to all ranks for properly coping with a disaster.

II. RESEARCH DESIGN AND METHODOLOGY

The current research was carried out using the qualitative research method and used in many stages various methods including case studies, interviews and action research. The qualitative research paradigm seeks to explain examined phenomena in a comprehensive manner, with a certain extent of simplification and looking above specific details (Guba & Lincoln, 1994). This research method constitutes interpretive research, focusing mainly on interpreting information gathered from research participants, and these are people’s actions, statements or patterns of thought. The research is meant to refer to all possible aspects so as to carry out an in-depth examination of the research field and isolate within it relevant data so as to understand how chains of events, players and feelings were produced, why they are

what they are, and how they operate in the examined environment (Marshall & Rossman, 2010).

The current research employed a multi-stage method, which includes a variety of methods collecting information from a number of different sources. The ability to combine data acquired from multiple sources (data triangulation) is one of the central characteristics of qualitative research, as is combining research methods to examine a single problem (methodological triangulation). This is due to an understanding that every method can discover elements and data that another had failed to bring to the surface, and as such find a more comprehensive solution to an examined problem (Patton, 2002). The current research was carried out by combining data sources and methods using interviews with key informants so as to understand the level of existing knowledge and readiness on nuclear matters and conduct in past events; case studies including document analysis and field work in the places themselves so as to understand future preparedness and what went wrong in past accidents; and action research that combines, in the findings, the researcher's personal experience and actions as part of his role in the field of preparedness for nuclear dangers and disasters.

Three integrated tools were used to reach the research aims:

- ✓ **Semi-Structured In-Depth Interviews** - In the current research, in-depth interviews were carried out with 15 people from professional and political frameworks, and the knowledge obtained constituted a central layer in collecting relevant knowledge to investigate past nuclear events, as part of comprehending how countries deal with and prepare for future events, as well as an attempt to understand what perceptions exist with regard to risk management and feasibility of nuclear events at the level of decision-makers. The choice of this research tool derived from the wish to understand what interviewees relied on in making their decisions: what are the factors that drive and/or drove them, what their limitations are in the way they manage risks or perceive the situation, and, particularly, how it is possible to improve mistakes in thought processes under a future model. The core contribution of these interviews to the current research is the accumulation of new knowledge regarding possible ways of coping, especially by turning latent knowledge into overt knowledge

- ✓ **Document Research** - Another aspect of qualitative research is gathering information from various documents, which also constitutes a significant knowledge source. Documents can be any material object, they do not have to be written in comprehensible text and can take the form of pictures or even other artifacts that can illuminate an examined subject (Patton, 2002). Most documents in the current research are written documents such as official reports, archived memoranda acquired from visiting studied areas and relevant museums, public and confidential (as much as possible) information describing future preparedness plans, or reports analyzing past events, and any document relevant to the research aims. These documents are meant to provide much information to qualitative researchers, depending on the nature of the document.
- ✓ **Participatory Action Research** - Action research is research that structures new knowledge through reflection regarding researchers' personal experiences, so as to improve their action in the field as a rational process, and to understand the personal and social circumstances in which their experiences occur. Action research integrates academic knowledge with applied, daily experience, in a manner in which analytical models taken from the academic research field are implemented in projects in which researchers are involved so as to create a new conceptual knowledge framework. In other words, a researcher's own past constitutes an academic case study in itself. This is a colorful research method, and the current research will use experiential methodology, that is examine past professional experience at personal and collective levels from the professional world of the researcher and learn from this for future application (Fals-Borda & Rahman, 1991).

The researcher's experience also constitutes an important layer of the current research, mainly because of the researcher's role and experience in the field of emergency and its various aspects, in the civil defense of Israel and around the world, and in the nuclear area. The researcher's key professional experience is a result of many years spent as a commander and officer in the field of civil defense in the Israeli Defense Forces, including at present (in the reserve forces). Because of his roles in the past and present, total responsibility falls on the shoulders of the researcher to deal with every possible scenario that includes multiple injuries on the Israeli Home Front – war, terror strikes, earthquakes, tsunamis, chemical,

biological, conventional, non-conventional, nuclear or any other disaster caused by man or nature.

It must be emphasized that the researcher's experience is not limited to drills and preparedness, but he also commanded Home Front areas during military operations that included missiles falling on urban areas. In addition to the researcher's operational experience due to his role in the Israeli Defense Forces, he also conducted numerous meetings, guidance encounters and field studies in various places around the world, in areas that are relevant to preparedness and nuclear issues.

In order to solve the complex problem facing this study, it is not possible to point to one of the methods and/or approaches of qualitative research separately as one that is precisely suited to the problems addressed in this research, but it is appropriate to use as many methods and information sources as possible, at different research stages. Furthermore, the use of multi-stage and multi-method research is central to the reliability, validity, triangulation, and generalizability of research. The field of the current study, i.e. the nuclear one, entails inherent limitations that make it difficult to study the subject in depth. The nuclear field requires a high level of confidentiality, and even regarding the analysis of nuclear accidents, there is a chance that published information is not entirely accurate or that it is incomplete due to the great sensitivity of the subject. Therefore, the research was carried out in the most appropriate way, through a combination of research methods and tools, and each approach can discover elements in the field that have been overlooked by the researcher through another method or other tools. The purpose of the methodology in the current research was to combine three research tools that would yield reliable and solid findings, which would form solid grounds for a model that will be presented later on.

III. MAIN FINDINGS

Findings emerging from the interviews were analyzed and then divided into categories, in accordance with the qualitative research approach.

✓ **Considerations in Decision-Making**

This category focused on the considerations facing leaders and decision-makers when coping with a nuclear or crisis event in general. This category is divided into three sub-categories

examining different aspects of these considerations – dilemmas facing decision-makers, the place of public opinion in decision-making, and extraneous considerations in decision-making. An analysis of the findings in this category clearly shows that leaders' decision-making when coping with crises or nuclear events in the past was not founded on professional considerations, but mainly on public opinion, whether mistaken or not, economic considerations and sometimes even on political benefit considerations for decision-makers, and not on the best outcome in a professional sense. It is clear that the decision-making procedure, as reflected in the findings, is unprofessional and sometimes even inappropriate.

✓ **Importance of Information and Its Effect on Managing a Nuclear Disaster**

The role of information in managing the disaster is a category that refers to one of the most significant aspects of preparedness for and management of a nuclear disaster, or any other multiple casualty event. This category encompasses three sub-categories – absence of professional knowledge about the effects of a disaster, applying learned knowledge when dealing with nuclear events, and the aspect of hiding and sharing information between bodies and its influence. An analysis of the findings in this category clearly shows that there is a lack of knowledge regarding the effect of nuclear disasters, especially among decision-makers, but also in the scientific world. However, the fundamental problem revealed was that it is not only difficult to accumulate scientific knowledge, but knowledge that has already been gathered from past events such as Chernobyl or Three Mile Island was not applied in decision-making procedures in later events, notably Fukushima. During these disasters, information was not passed on to decision-makers, there was no appropriate transfer of knowledge between bodies and countries, and the absence of knowledge among decision-makers led in the past to wrong choices and decisions, which in some cases even made the situation worse and turned what could have been a relatively small nuclear event into a disaster. Lack of knowledge led to actions based on assumptions, and sometimes decisions relied on worst-case scenarios, even though in practice, the situation was completely different. An analysis of the findings in this category illustrated how important a future model would be, one that will provide leaders and decision-makers with enough scientific knowledge with regard to the nuclear file and its effects, and especially knowledge

accumulated from past events and the importance of sharing it when correctly managing a disaster.

✓ **Psychological Aspects in Managing a Disaster**

This category focuses on the role of mass psychology in dealing with a nuclear disaster and analyzes the psychological variables influencing decision-making. This category is divided into four sub-categories, which are: general effect of mass psychology on decision-making, the central role of fear and panic in both the public and decision-makers, the psychological effect of routine public information and the effect of public information whilst managing a disaster. The findings in this category emphasize psychological aspects as very significant in decision-making by public figures, professionals and the public in general, especially the aspects of fear and panic. Lack of knowledge and misleading knowledge about the effects of nuclear power lead to fear and panic among the public, which affects leaders' decision-making, and in fact, most decisions are made based on psychological considerations, whether conscious or not, and not necessarily on professional ones. Decisions such as widespread evacuation and keeping the public in the dark are based on the desire to prevent panic, even though these decisions are professionally incorrect, thus leaving the public and population in the dark in times of both emergency and routine, in contrast to the logic and recommendations of professionals. It is clear from the findings in this category that psychological aspects not only influence decision-makers, but also prompt them to act in inefficient and unprofessional ways, a situation that an appropriate model should successfully deal with.

✓ **Estimates of Future Disasters Occurring and Their Extent**

This category focused on how interviewees regarded the chances of a future nuclear disaster, military or civil, and what, in their opinion, the extent of a future disaster could be. This category was divided into two sub-categories: assessments of the probability of a nuclear disaster occurring and the damage from such a disaster. The findings here were mixed – some interviewees assumed it is very reasonable that a disaster would occur soon, whereas others assumed the chances of this were low, and these were also divided with regard to the expected damage. It is clear from an analysis of the interviews that consensus needs to be established among decision-makers that even though the probabilities of a disaster are small,

one must be prepared for it, because nuclear disasters derive mainly from unexpected events or chains of events, and one must correctly understand the expected damage in every event and case.

✓ **Knowledge from Past Events that Can Contribute to Future Coping**

This category focused on knowledge accumulated from past events from different points of view, so as to understand what the failures were, and the developments in safety and functioning aspects that can be learned with regard to managing future events. This category is divided into three sub-categories – one examines how emergency services and decision-makers in the emergency services coped when they had to directly tackle the problem, the second refers to the safety of civil nuclear reactors and developments in this field and the third is knowledge accumulated from past military nuclear events. The findings in this category reveal that past management and preparedness was lacking with regard to coping with almost every large nuclear event, and very little was learned from past events to manage the latest one, in Fukushima. However, the findings show that in fact, from the standpoint of civil safety, there has been real progress and learning from past events in the way reactors are built and human resources trained, so that today, the level of safety is much higher than in the past, as a direct result of lessons learned from accidents. Still, the findings show that a nuclear event cannot be prevented for the simple reason that those events that cannot be foreseen are precisely the causes of a disaster, and despite the advanced planning of civil reactors, this assumption will not change.

The findings clearly show that although in the field of safety, knowledge has accumulated and contributed to future coping, nothing has been learned from past events at decision-making and emergency service functioning levels, or from a military point of view.

✓ **Appropriate Preparedness Prior to a Nuclear Event**

This category focused on existing levels of preparedness at the level of emergency teams and decision-makers, and primarily on what appropriate levels of preparedness are revealed in the interviews, so as to deal with a future event. This category is divided into three sub-categories – operational preparedness of decision-makers today, what appropriate preparation is at civil level and what it is at military level. The findings in this category show that existing levels of preparedness to deal with a nuclear disaster are not at all high,

according to the interviewees, as well as document analysis and case studies, with regard to both military and civil incidents. The assumption is that it could happen and there are appropriate preparedness plans in close circles and a small team of emergency forces, but there is no overall preparedness and there are no plans for the population. Regarding appropriate coping, the findings show that experts have a large number of proposals that could be applied and/or developed more effectively in a future model, topped by an emphasis on defending the home front, early civil preparedness, suitable regulations and preparedness of emergency teams, a fixed decision-making model that cannot be deviated from, creating a management/command mechanism suited to dealing with an emergency, and appropriate knowledge for decision-makers. It is clear from an analysis of this part of the findings that much needs to be done to improve existing preparedness for a future nuclear event, as well as the fact that experts have a lot to contribute to the field.

- ✓ **Future Coping Plans to Alleviate and Contain an Event and Rehabilitation Thereafter**

This category sought to examine what suitable coping plans should be carried out, in the opinion of the interviewees, to lessen and contain damage, in other words during the unfolding of an event itself, and what actions are appropriate to be taken immediately afterwards and in the long term, in the light of interviewees' experience and knowledge gained from past events. With reference to military events, interviewees described that one must assume that security forces will not be available to deal with an event and to prepare in advance. Furthermore, it was found that it is essential to stop a civil event through the correct management of an event before it turns into a catastrophe, but one must also consider that containing an event will not successfully deal with its long-term implications. However, one must still act professionally, and the emphasis is placed on evacuation, which does more harm than good, including many fatalities, even more than those caused directly by the disaster. Appropriate evacuation, as stated by many interviewees, must be carried out only according to an existing, specifically built plan and model, and without deviation. So too, rehabilitation and actions after an event must be carried out under the direction of a guiding hand, and by making appropriate decisions, because the management of previous events was inefficient, billions of dollars were wasted, and ineffective actions executed. It is clear from an analysis of information in this category that a fundamental change is needed to existing

preparedness according to experts' recommendations. It is essential to correctly manage an event, including appropriate responses in real time, according to advanced models, along with a free and complete transfer of information in real time and after an event.

III.1 Knowledge Added from the Researcher's Experience

In the light of the researcher's experience, through a re-examination of past events and reflections, a number of relevant impressions emerged in the context of the current research on the emergency response issue:

✓ **Central Role of the Public in Managing and Coping with a Nuclear Disaster**

As part of civil preparedness, the researcher's experience identified the importance of reference to the public during routine times as part of high preparedness, and the central role of the public during disasters as part of handling and managing an event. The researcher's experience reveals that civil strength and public support are dramatic and necessary parameters with a critical effect on the freedom of action given to emergency organizations, the army and government to act in a democratic country. It is possible to use the public as part of the resources available to cope with a multiple casualty disaster. Public knowledge about an event is of great significance, and lack of knowledge harms the proper management of the disaster. Public morale is also extremely important in the current aspect of coping with a nuclear event. It is of utmost importance for the public to know how to conduct itself with emergency services at a tactical level, follow their instructions, understand the arrangements they face, not fear rescue and police services and trust them.

✓ **Decision-Makers' Influence**

Based on the researcher's experience, another vital aspect of the model is decision-makers' influence on the successful management of a disaster in many areas. Despite detailed descriptions in existing coping models, the researcher's experience shows that there is never a single "correct" decision during an event, and decision-makers constantly need to use judgment, experience, professional and/or political advice and consider wide-ranging macro effects on the country and even relationships with other countries. Furthermore, the way in which leaders address the public is important, since the latter is influenced by the former, as commanders and heads of authorities control and understand their actions. How they are perceived influences the public's preparedness and civil resilience.

✓ **A Crisis Event Will Always Cause Disorder and Deviation from Procedures**

Another central aspect emerging from the researcher's experience and constituting a central feature of managing any disaster is the comprehension that reality during crisis events is a chaotic, disorganized one, and not as described in models with an order of actions and a rational sequence of events. Such events are characterized by inbuilt disorder, and the more unexpected an event, the greater the disorder at every level – starting from decision-makers, continuing with emergency teams and ending with civilians themselves. Lack of order is a characteristic of any crisis event, but when the event is larger and unexpected, the disorder characterizing it will be greater, and the gap will broaden between the 'dry' procedures that are logically constructed and the correct way to cope with the chaotic reality of a nuclear event.

✓ **Emergency, Operational and Rescue Services' Professional Preparedness**

A central topic known to the researcher is the necessity of a high level of professionalism among emergency and rescue teams. They must profoundly recognize the nature of the disaster they face, possible ways of action, and they must have the most advanced equipment possible that suits dealing with a specific event and/or crisis events in general. Still, the aspect of equipment and appropriate training is extremely significant in managing a disaster, but it is not alone - suitable equipment is not necessarily the most expensive or sparkling; sometimes simple, efficient and cheap equipment is the best solution to multiple casualty events. Furthermore, the crucial importance of suitable equipment and emergency teams' preparedness is expressed at the stage of dealing, mitigating and containing an event, and at all other stages of coping with an event**,** the professional preparedness of emergency teams is secondary to other aspects such as population morale, correct decision-making, investing in other long-term channels such as shelters or emergency depots, safety measures and more.

✓ **Importance of Cooperation and Rapid Information Sharing between Authorities**

The researcher's experience underlines another vital point, which is also expressed both in theoretical literature and especially in the research findings - the importance of bodies sharing accurate knowledge. The researcher's experience shows that reports acquired from managing bodies and emergency teams by decision-making echelons are overly pessimistic,

and emergency teams and rescue bodies will generally describe the worst possible scenario to decision-makers, mainly for the purpose of allocating resources and getting priority.

✓ **Drill, Drill, Drill**

This issue is central to and well-known in disaster preparedness, and should be emphasized again because of its great importance and contribution to preparedness, as experienced by the researcher during his years as an officer in the Israel Defense Forces. One cannot avoid the obvious – drilling will lead to completeness and the more drills there are, not just for emergency services, but for all levels and echelons of the system, the readier a country will be to cope with unknown crisis events.

IV. CONCLUSIONS AND APPLIED CONTRIBUTION

In the light of an analysis of the findings, expert theoretical literature, case studies and the researcher's experience, important points were distilled that must be integrated into the model to successfully deal with a nuclear disaster. The following are the key points from the research conclusions that make an applied contribution to the ONDM model.

- ✓ **Human Weakness -** One of the key points that emerged from the research is the fact that at every level we are dealing with human beings, and human beings tend to make mistakes in every aspect – reactor design, decision-making, erroneous preparedness for a disaster, faulty coping during a disaster and more. Human weakness is the reason why it does not matter to what extent models and safety regulations are put together; when people are part of the equation, a system is incomplete and earmarked for potential failures of which we must be aware and to which we must refer in the future model. It is necessary to address ways of making irrational decisions, lack of mental preparedness, relying on erroneous scientific information regarding the influence of nuclear events on the population, and human errors at a professional level. The research emphasizes that when decision-makers hesitate and make flawed decisions because they do not have a comprehensive action plan, even the most professional emergency teams can be revealed as inefficient and have a marginal influence on the overall management of a nuclear event.

- ✓ **Obligation to Learn from Past Mistakes -** Another key aspect that must be integrated into the ONDM model is learning from past mistakes. The research provided an abundance of knowledge from the analysis of nuclear events and interviews, and it is necessary to teach this new knowledge to all ranks involved– both the scientific level of knowledge and the one engendering preparedness for a disaster. Existing models do not teach decision-makers how to behave as a direct result of past events, do not address differences in construction and protection etc. All these must be assimilated into a future model so as to deliver suitable preparedness.
- ✓ **Keeping the Public Informed Routinely and During a Disaster** - The human factor constitutes a significant obstacle that the proposed model seeks to overcome on a number of levels and in a number of areas, where one of the central ones is how information is passed on to the public. This is a key aspect that was emphasized at every stage of the research and the theoretical review, because despite the emergency services', governments' and other bodies' awareness of models – the most important player is completely in the dark, namely the public itself. The key findings that one has to assimilate in any future model is that public knowledge does not necessarily lead to panic. Experts and scientists, as well as people with experience and the public itself, explained that it is desirable for the public to be knowledgeable, perhaps not of every technical detail, but available information does not harm, as it rather contributes to the proper management of a disaster. The understanding from this research is that public knowledge does not constitute an obstacle, but is a tool to better manage a disaster, to create trust between government and the public, to raise public morale, to increase the public's sense of protection, to provide the public with the tools to protect itself, and the like.
- ✓ **Cooperation and Knowledge Transfer between Bodies and Countries -** Another key point that must be integrated into a future model is the need for bodies and countries to cooperate during a disaster and the stages thereafter. Knowledge transfer between bodies and countries was revealed to be very problematic when dealing with past nuclear events, and this absence of cooperation not only damaged handling and easing disasters during their occurrence, but was also harmful to the treatment and rehabilitation of the populace, and even damaged future professional preparedness of other countries for

disasters. Knowledge transfer between bodies and states is critical and should be placed at the top of the list of priorities in future coping with nuclear events. Previous models and management did not understand the state as a player in the international field, and the findings showed that in disaster management is much more noticeable between countries. Yet, one of the failures the proposed model seeks to address where no answers are provided in existing plans to cope with a nuclear disaster is how professional knowledge transfer at the time of a disaster is managed. In a situation where every minute is critical, and decisions have to be made swiftly, decision-makers themselves often do not have the required professional knowledge, as it clearly emerged from the interviews. For example, politicians are not experts on scientific subjects and scientists are not experts on the engineering issues of each reactor, as engineers are, and therefore professional knowledge transfer is essential for correct treatment. This key aspect, which also refers to professional knowledge transfer about disaster management, is one of the most destructive factors in the proper management of a nuclear disaster – and therefore it needs to be fundamentally changed.

- ✓ **Direct and Indirect Damage in a Nuclear Event** - A critical element that must be understood when building a model for future dealing with a nuclear event is the scope of expected injuries to people in a stricken area, which is much lower than expected by existing models. The findings clearly showed that in the case of a military or nuclear event, the number of casualties is a much lower than expected. Moreover, in such events, it appears that indirect damage caused by panic and incorrect management is a many fold greater than direct damage from the event itself. Therefore, it is important to understand that correct management can significantly reduce the number of casualties, both from direct damage, and mainly from indirect damage, and in any case, one must comprehend that a nuclear event does not constitute total destruction or necessarily damages at a radius of tens of kilometers. The main threat is not the outcome of a nuclear event, but that of panic, loss of control, developing mishaps of disproportional dimensions and the inability to deal with them. This aspect and the extent to which flawed management of an event is not only unsuccessful in preventing damage, but actually adds a lot more, are of great significance. On this point, it should be emphasized that a future model must focus on and address in detail population evacuation. This is

an area that has only a small place in existing models for future coping with events, which sometimes simply give provisions of an area or population numbers that need to be evacuated – but no emphasis at all is placed to the accompanying aspects. Any nuclear event includes a huge movement of population because of the scale of the damage, but this leads to many coping and rehabilitation difficulties that are not referred to at all and which emerged in the research findings – including what to do with the population, how to deal with their needs, how to compensate them and handle evacuation on an economic level, and the like.

From everything said, it is clear that there are significant flaws in the past management of nuclear events, and even the situation existing today does not constitute a platform for appropriately coping in the future. Existing models are local, do not address the complex dimension of relationships between countries and between different bodies, but mainly how to professionally cope in the short term. They are based on scientific knowledge that has been found misleading, contain all flaws that existed in past management and anchor??? them. A future model to cope with nuclear events must be uniform and comprehensive, describing not only local management but also the complex interactions between bodies and countries, between government and civilians, and between professional teams and decision-makers. A country that purchased equipment and funds units to treat a disaster must understand that this alone is not suitable preparedness and does not make it ready for a nuclear disaster.

It appears that existing models and the manner in which countries relate to disasters today focus only on the immediate treatment of a disaster, its containment and minimizing damage, but what is clear from this research is that disaster preparedness includes a lot more than this. They do not address sufficiently or in enough depth the coping stages after a disaster – especially aspects of dealing with the populace and decision-making levels. There is no model guiding decision-makers to the bases for deciding whether to evacuate populace or not, whether to request international aid or not and how to be prepared for this, and one cannot expect politicians to know this without detailed and suitable training. When decision-making steps are wrong for any reason, emergency services and the way they cope constitute only a small part of a disaster's results. In fact, it is precisely emergency teams, with all their

deficiencies and mistakes, who acted with courage and professionalism to cope with past disasters, and not so decision-makers. Decisions made were mainly bad and resulted in long-term damage to civilians and the economy. The basis for the successful management of a nuclear event is the need to create a defined and clear operational model for decision-makers, which can neutralize the human manner of decision-making where there is a high probability of irrational judgment. Such a model must be comprehensive, based on existing knowledge, take the public into account, but not surrender to panic and inappropriate pressures; it must give equal weight to professional and home front preparedness, and understand that coping with an event does not end until years after its occurrence. It must educate and guide decision-makers, lead to a sense of public confidence, produce and efficient mechanism to cope with an event, and with the many dimensions that make up the proper management of a nuclear event.

IV.1 ONDM: Operational Nuclear Defense Model Presentation

In the light of the research findings and researcher's experience, the conclusions and findings have been assimilated to create a model to cope with a nuclear event called the Operational Nuclear Defense Model (ONDM). The model's general structure is based on the discovery that it is precisely at the level of professional teams, be it emergency teams or those operating civilian power stations routinely, that there is a high level of preparedness and professional procedures that have been built on the basis of past events. Despite this, the core failures time after time were at the level of decision-makers for reasons described in depth in the analysis of the research findings – and therefore, the ONDM emphasizes decision-making levels' coping with nuclear events. This focus becomes stronger in the light of an examination of existing models to cope with nuclear events today because every model examined for the current research is built in reverse – the core emphasis is on emergency forces and professional teams, a lower emphasis on middle management levels, and little or no focus on appropriate actions by decision-makers. In contrast to general opinion, the research findings and researcher's experience show to what extent erroneous decisions affect the management of a disaster, and sometimes one action of decision-makers completely changes preparedness arrangements and harms – sometimes fatally – the ability of emergency teams to treat the phenomenon.

This is the key point of the ONDM, which focuses on decision-makers and provides them with professional tools and knowledge to carry out appropriate and correct judgments. 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. The comprehensive arrangement is meant to create from this information an envelope of operational procedures and knowledge that will not replace decision-makers, but lead them to make correct decisions using a rational thinking pattern based on knowledge and understanding the situation. This comes instead of carrying 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.

The model proposed here is a frame model that constitutes a defined operational framework with a flexible structure that will suit any country employing it for nuclear preparedness. Every country is characterized by different political arrangements and hierarchies, a different emergency services structure, various levels of preparedness, diverse decision-making arrangements, and more. Thus, for example, there are countries with presidents who are responsible and those where prime ministers are the supreme authority. In many countries around the world, the emergency service responsible for treating a nuclear disaster is the fire brigade, in others there is a combined atomic-bio-chemical arrangement, whilst in others there is a dedicated emergency arrangement solely for this purpose. Therefore, the proposed model describes a framework that although rigid, provides flexible room for changes suitable for every country, city or region, its needs, its level of preparedness and its existing hierarchical structure. The ONDM is made up of nine consecutive stages, which together constitute a complete life cycle of an incident. These stages are:

1. Life cycle stage (LCS)-1: routine (portrayed in green), day-to-day routine stage when there is neither information nor signs of a nuclear event.
2. LCS-2: emergency routine (portrayed in turquoise), when there is information, or potential circumstances of a nuclear incident are created.

3. LCS-3: the moment of an incident (portrayed in red), describing a specific moment or a date and time when it is known for certain that a nuclear incident has occurred.
4. LCS-4: initial, immediate reaction (portrayed in yellow), which is the immediate point in time when various immediate, mainly spontaneous, actions occur, in other words, not planned, carried out by anyone who hears about an incident whether it is in the relevant area or at a distance and is unaffected by it, in which the system to manage a nuclear disaster begins its actions to mitigate and ease the event in its initial stages, according to a planned order of action.
5. LCS-5: second reaction (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.
6. LCS-6: broad reaction (portrayed in blue), the stage dealing with a large nuclear event in which all intended enveloping systems cope with and treat an emergency situation, including organized bodies and government.
7. 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.
8. 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, Japan, after the disaster there.
9. LCS-9: ambition to return to normal (portrayed in bottle green), when an event is remembered, learned from, and one has improved preparedness in the routine stage. Correct to September 2018, this is the stage reached following the incident in Chernobyl, Ukraine.

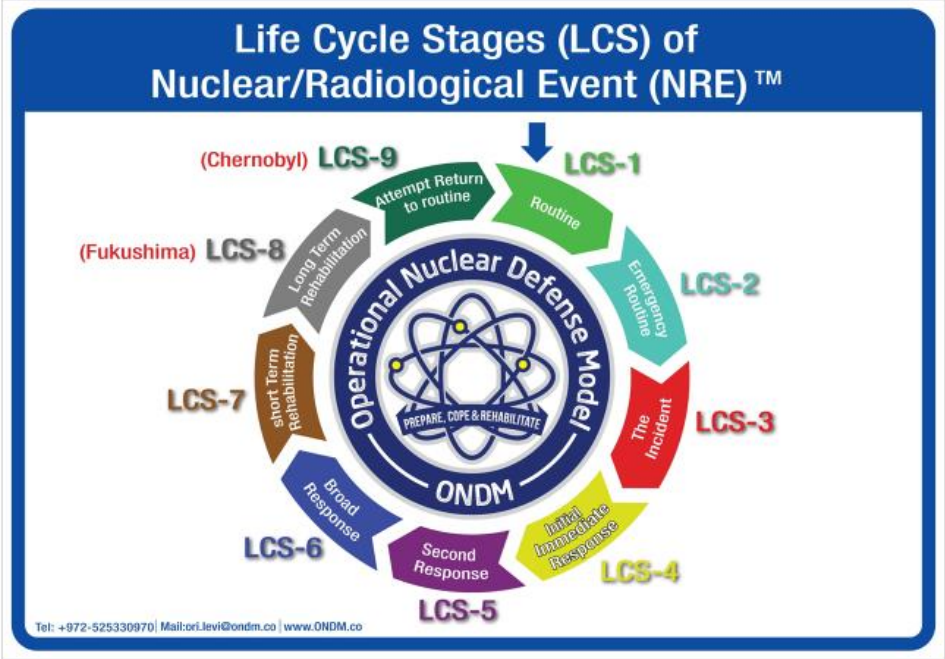

Figure 1: Nine LCS in the model developed by the researcher as a response to nuclear events, from an analysis of past events – ONDM.

The model contains an enormous amount of information that is intended to be accessible and available to all users. Therefore, the model is constructed as an interactive file in which all this information about regulations to cope with a nuclear event are clearly shown using a sunburst representation, where with each hierarchical level the file showing the model presents information relevant to each stage and/or relevant role. This type of visual presentation describes hierarchy as a series of rings spread out for each category – each ring describes a level in the hierarchy, and the central circle represents the focus and the hierarchy moving outside it. As part of the research conclusions about the relevance of accurate information and its transfer between bodies, the model emphasizes the importance of sharing information hierarchically, from those on the front line taking care of a disaster to decision-making levels, as part of the need to create a platform for decision-making that is as rational as possible, based on a vast body of reliable information. Each role-holder at every stage reports to his/her supervisor, who collates relevant information from those under him/her, as described graphically. The information entered into the model is multidimensional and, to be presented statically, uses an interactive file so that as one goes down the hierarchy, more information is spread before a user. In this way, one can enter an enormous amount of information into one format – as it is required to manage a nuclear disaster at all levels – in

a visual and comfortable form for every user, instead of presenting models in complicated and illegible forms such as complicated flowcharts. The principle of the model's simplicity is essential, as the conclusions of the current research show, because in order to reduce uncertainty and build a platform for rational choices, one must show as simple a structure as possible, which will not confuse decision-makers or others covered by the model, who may find it difficult to understand complicated arrangements at times of pressure and crisis.

Furthermore, the model's interactivity makes it flexible and modifiable, which is the most important feature in both managing a disaster and long-term preparedness, as well as making a general operational framework suitable to the unique needs of every country. The model's flexibility allows it to absorb information over time, develop according to changes in a country over years and/or changes in the existing body of knowledge – taken from another significant conclusion in the current research. As stated, existing models do not provide an appropriate response to the problem, in the researcher's opinion, because these fixed models were built on knowledge accumulated decades ago. However, new scientific knowledge about the long-term effects of nuclear matters must be assimilated into a model, not only when it is put together, but also for a long period of time, so as to maintain high levels of preparedness. Accordingly, the model itself presents a framework to manage events that is on the one hand rigid enough to manage an event according to the conclusions of the current research, and on the other hand, the model provides flexibility to assimilate all new knowledge, a new level of preparedness, 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. The general structure of the model is presented visually below:

Figure 2: ONDM Complete model: LCS 1-9

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