ABSTRACT

Nuclear power plants (NPPs) have long been recognized as potential targets for terrorist attacks. A successful attack could have widespread consequences on both public health and the environment. Following the September 11 events and more recent Fukushima accident, the adequacy of the protection measures to defend NPPs against terrorist attacks have been questioned. In order to develop optimal protection strategies it is important to understand what, how and why terrorists attack. However, while the number of studies on the causes of terrorism is vast, not too many studies explore the subject of terrorist targeting preferences.

This research investigates the factors which determine whether a terrorist organization will make a decision to attack nuclear power plant. In general, the attractiveness of potential target depends on two parameters: (1) the motivation of the terrorist organization and (2) its capabilities. In the first step of the research the factors which determine the level of motivation and capabilities were identified and analyzed. Such factors include terrorist organization's characteristics (ideology, organizational structure, resources, etc.), perceived target's characteristics (function, profile, inherent hardness, level of protection, potential damage, location, etc.) and other factors (security environment, presence of armed conflict, historical context, etc.). As the second step of the research a set of hypotheses have been developed to help with assessing the attractiveness of various terrorist attack modes against NPPs. In the final, third step the hypotheses were tested by examining historical data on terrorist attacks against NPPs. In this step the data from the Global Terrorism Database (GTD) and the RAND Database of Worldwide Terrorism Incidents (RDWTI) were used, as well as the data from the Global Chronology of Incidents of Chemical, Biological, Radioactive and Nuclear Attacks compiled by Mothadi et al.

1 INTRODUCTION

Nuclear power plants (NPPs) have long been recognized as potential targets for terrorist attacks [1]. The consequences of an attack on NPP would depend on a wide range of variables, such as the type and status of the facility, the nature of the attack, extent of the damage, weather conditions and the efficiency of countermeasures. Worst case scenarios could have widespread consequences on both public health and the environment.

As NPPs have not been designed to withstand a deliberate crash by large passenger aircraft, in the period after September 11 the attention was focused on such attack mode. However, Fukushima accident clearly demonstrated that it is not necessary to penetrate the containment to cause large releases of the radioactivity into the environment [1]. NPPs contain significant quantities of radioactive material in spent fuel pools, which may be
positioned in buildings more vulnerable to attack than the reactors themselves. Moreover, large releases could be caused by putting reactor cooling or control systems out of operation. And even if the attack fails to cause the release of radioactive material, it can still provoke widespread fear and cause significant economic and socio-political damage. Obviously, when risks of terrorist attacks are analyzed, modes of attack other than crashing a passenger aircraft into NPP should also be taken into consideration.

Following the September 11 events and more recent Fukushima accident, the adequacy of the protection measures to defend NPPs against terrorist attacks have been questioned. It is clear that all NPPs cannot be fully protected from all possible attack modes at all times. In order to develop optimal protection strategies it is important to understand what, how and why terrorists attack. However, while the number of studies on the causes of terrorism is vast, not too many studies explore the subject of terrorist targeting preferences [2].

This research investigates the factors which determine whether a terrorist organization will make a decision to attack nuclear power plant. In the first step of the research the factors which determine the level of attractiveness of potential targets were identified and analyzed. This step is described in Section 2 of the paper. Section 3 relates to the second step of the research, where a set of hypotheses has been developed to help with assessing the attractiveness of various terrorist attack modes against NPPs. In the final, third step the hypotheses were tested by examining historical data on terrorist attacks against NPPs. This step of the research is covered in the Section 4 of the paper. The conclusions are given in Section 5, while Section 6 provides the list of references.

### 2 FACTORS DETERMINING THE ATTRACTIVENESS

In general, the attractiveness of potential target (and by that also the probability that the target will be selected for the attack) can be described as a function of two parameters: (1) the motivation of the terrorist organization and (2) the capabilities. The factors considered influential in determining the level of the motivation and the capabilities can be structured into 3 groups:

1) factors related to the nature of the group: ideology, organizational structure, organizational dynamics, organizational lifecycle status, demographics, resources and operational capabilities,

2) factors external to the group: target characteristics, historical context, events and precedents, relations with external actors and the security environment and

3) decision making factors: general planning characteristics, perceptual filter, operational objectives and attack modalities.

Listed factors influence target selection to a different extent. The ones considered to be particularly important when analyzing the risks for the NPPs are the ideology, target characteristics and the relations with external actors.

Ideology strongly influences the motivation of terrorists to attack. It provides the essential rationale for the targeting and identifies what the permissible range of targets is. This is achieved by identifying clearly who the enemy is and why it is legitimate for members of the group to attack that enemy. According to the ideology, terrorist groups can be divided into (1) nationalist-separatists, (2) secular utopians, (3) political-religious groups and (4) single-issue groups. Nationalist–separatists aim to create an independent homeland based on ethnic criteria, thus ending what they see as political dominance by a domestic/foreign ethnic group. For nationalist–separatists the likely recipients of the terrorist message, or so-called primary
audiences, are government decision makers of opposing ethnic groups, allied foreign
governments of the regime, etc. Secular utopians seek to change the existing state ideology.
The classical primary audience of secular–utopian left-wing groups is capitalist political–
economic elites, while right-wing groups would try to influence the entire political
establishment that pursues the "wrong policies". Political–religious groups seek to pave the
way for a theocracy, usually by replacing a secular government. Political decision-makers, a
secular political system and their allies are the primary target audience of those groups.
Finally, single-issue groups focus obsessively on specific themes such as animal rights,
environmental issues or abortion. For such groups primary audiences are typically groups,
associations and persons who advocate the "wrong policies" [2][3].

Target characteristics influence both the motivation and the capabilities. The most
important characteristics that tend to affect terrorist targeting are (1) the intimidation effect,
(2) the symbolism and (3) the attack feasibility. As terrorists seek to profoundly intimidate
their target audiences in order to force them to make concessions and to attract supporters,
their attacks must be perceived as incurring high costs. Usually, the loss of human life is
considered as very costly while purely material losses would be less intimidating. It is
important to note that terrorist targets typically tend to be chosen for their symbolic value
rather than for the absolute value or utility. According to the attack feasibility, targets can be
classified as soft (low protection) or hard targets (heavy protection) and also as complex
(strong prior knowledge about the target is required) or simple to attack (minimal prior
knowledge is sufficient). The terrorists are likely to seek a balance between the difficulties of
attacking the target in light of its other features (intimidation value, symbolic value) and then
opt for those targets that offer "the most bang for the buck" [2][3].

Having identified a range of permissible, intimidating, symbolic and feasible targets,
terrorists usually also pay attention to how an attack might affect the relations with external
actors whose reactions and interests they value (sympathizers and supporters, the mass media,
the general public, other extremist and criminal groups and the state apparatus). Such
considerations may significantly influence the motivation, i.e. may lead terrorists to refrain
from attacking certain targets [2][3].

3 HYPOTHESES FORMULATION

After having identified the factors which influence the attractiveness of potential
targets, relative attractiveness of NPPs as the targets for terrorist attacks can be estimated. In
this effort it is important to distinguish between (1) attacking the NPPs without the intent to
cause the release of the radioactivity into the environment and (2) attacking with clear
objective to cause such release. The first case refers mainly to the attacks against NPPs in
construction (still no radioactive material on-site), although the attacks without the intent to
cause the release could be launched also against the facilities in operation. The second case
refers exclusively to the attacks against NPPs in operation.

When the most influential factors are taken into consideration, the following can be
concluded:

- Ideological and symbolic value - NPPs could possess significant symbolic
  meaning for various terrorist ideologies. Their value for anti-nuclear groups is
  obvious. Nationalist-separatists and religious-political terrorists are likely
  inclined towards attacking the targets linked to the state and its authority
  symbols. Left-wing groups might also attach some symbolism to NPPs,
  especially in cases where a capitalist government relies heavily on energy
  revenues. For the right-wing groups, as well as for the single-issue groups which
are not focused on nuclear themes, the symbolic value of the NPPs should be much lower.

- **Intimidation effect** - There is no doubt that the attacks against NPPs can be costly. Direct and indirect costs of certain attacks against the facilities in construction have reached billions of Euros\(^1\), while the attacks causing major releases could produce even higher costs and also high casualties.

- **Attack feasibility** - NPPs in operation are probably among the potential targets with the highest level of protection. Only the groups with the highest capabilities could attack such hard targets successfully. On the other hand, NPPs in construction should be considered much softer targets.

- **Relations with external actors** - Anti-nuclear groups should have no difficulties with external actors if NPPs in construction are targeted. Nationalist-separatists and secular utopians would have to carefully analyze potential negative effects of such kind of attack. It is believed that very few terrorist groups, primarily the ones of the political-religious ideology, would get "green light" from outside stakeholders to the attack NPP in operation in order to cause large release. Obviously, such attacks would have to be carried out outside of the terrorist group's country or region of origin, which put focus on the groups involved in the international terrorism.

Based on the estimation summarized above, 4 hypotheses were proposed:

1) When all the factors are taken into consideration, attacking the NPPs in construction is attractive to much more terrorist organizations than attacking the NPPs in operation.

2) Attacking the NPPs in construction is not only attractive to the anti-nuclear terrorists but also to the nationalist-separatists, left-wing secular utopians and religious-political groups.

3) Temporal variations of the number of terrorist attacks against NPPs in construction follow the variations of the number of such facilities.

4) Attacking the NPPs in operation in order to cause large release is attractive only to a very limited number of terrorist groups.

## 4 HYPOTHESES TESTING

The explanatory weight of the formulated hypotheses was tested by examining historical data on terrorist attacks against NPPs. The data from 3 databases was taken into consideration. These include (1) the Global Terrorism Database (GTD), (2) the RAND Database of Worldwide Terrorism Incidents (RDWTI) and (3) the Global Chronology of Incidents of Chemical, Biological, Radioactive and Nuclear Attacks compiled by Mothadi et al. The GTD and the RDWTI were chosen because they are among the leading and most comprehensive open data sources on global terrorism. The third database was included because of its focus on CBRN attacks.

The GTD is an open-source database providing the information on terrorist events around the world from 1970 through 2011. The GTD stores systematic data on domestic as well as transnational and international terrorist incidents and presently includes more than

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\(^1\) For example, Lemoniz NPP remained unloaded partly because of terrorist attacks and the costs have been estimated to 3,4 billion Euros [5].
104,000 cases. For each incident the information is available on at least 45 variables. The GTD is maintained by the National Consortium for the Study of Terrorism and Responses to Terrorism (START). The information contained in the database is based on reports from a variety of open media sources. Information is added to the GTD only if the source is considered credible [6].

The RDWTI is a compilation of the data on terrorist attacks from 1968 through 2009. At this moment it contains the data on more than 40,000 incidents. Prior to 1998, the database recorded only international terrorism incidents and afterwards both domestic and international incidents. For each incident the data on 20 parameters is stored. The RDWTI is publically accessible for research and analysis. It is maintained by the RAND Corporation [7].

The Global Chronology of Incidents of Chemical, Biological, Radioactive and Nuclear Attacks is the most comprehensive compilation of CBRN-related terrorist incidents. It covers the period from 1961 to 2005 and contains the data on 448 cases. For each case a general description is provided, along with the details on the type of agent employed and the number of casualties that resulted. The database has been formed by consulting various primary-source materials, internet postings and existing literature [8].

By performing systematic search of the databases, the records on 22 terrorist attacks against NPPs were identified2 (see Table 1). As the databases contain the records on approx. 145,000 attacks, relative contribution of the attacks against NPPs towards total terrorist attacks amounts to less than 0.02%. Identified attacks occurred over the period from 1971 to 1986 and took place in 8 countries. The largest contribution to the total number of attacks comes from Spain (6), France (5), Switzerland (3) and United States (3). It is evident that most of the attacks (16 out of 22) were carried out in Western Europe.

Altogether 16 NPPs have been attacked by terrorists (for 2 attacks the facility is unknown). Lemoniz NPP was targeted 5 times, while the rest of the facilities were attacked only once. At the time of attack 16 NPPs were in construction phase and 4 in operation. The attacks were mostly carried out by the use of explosive devices.

NPPs have been attacked by at least 8 terrorist groups (for 9 attacks the perpetrator is unknown). According to the ideology, 5 groups belong to nationalist-separatists, 4 to single-issue anti-nuclear groups, 1 to single-issue groups focused on other themes and 3 to left-wing secular utopians3. According to the examined data, only 2 groups have carried out more than one attack against NPPs: Basque Fatherland and Freedom (5 attacks) and Gruppe Haw Weg Den Scheiss (2 attacks).

The first proposed hypothesis (see Section 3) posits that, when all the factors are taken into consideration, attacking the NPPs in construction is attractive to much more terrorist organizations than attacking the NPPs in operation. This is mainly because of significant differences in the attack feasibility and in the support of the outside stakeholders. The data provided in Table 1 fits the hypothesis well. The majority of the attacks were indeed directed against the facilities in construction. Moreover, the descriptions of the attacks against the facilities in operation indicate that the goals were actually not to cause the release of the radioactivity into the environment, which probably lessened the concerns of the outside stakeholders.

2 This does not imply that only 22 terrorist attacks against NPPs have been carried out worldwide so far. Ref. [8] clearly indicates that only a fraction of the attacks on nuclear facilities has been recorded in the examined databases.

3 The ideologies of the groups were determined according to the information provided in ref. [9] and [10].
Table 1: Terrorist attacks against NPPs recorded in the examined databases

<table>
<thead>
<tr>
<th>Date (dd/mm/yyyy)</th>
<th>Country</th>
<th>NPP</th>
<th>Status(1)</th>
<th>Group(2)</th>
<th>Ideology(3)</th>
<th>Attack mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/08/1971</td>
<td>United States</td>
<td>Yankee (Verm.)</td>
<td>C</td>
<td>Unknown</td>
<td>U</td>
<td>Armed Assault</td>
</tr>
<tr>
<td>26/03/1973</td>
<td>Argentina</td>
<td>Atucha I</td>
<td>C</td>
<td>ERP</td>
<td>LW</td>
<td>Armed Assault</td>
</tr>
<tr>
<td>03/05/1975</td>
<td>France</td>
<td>Fessenheim</td>
<td>C</td>
<td>MPA</td>
<td>LW</td>
<td>Bombing/Explosion</td>
</tr>
<tr>
<td>15/08/1975</td>
<td>France</td>
<td>Brennilis</td>
<td>O</td>
<td>Unknown</td>
<td>U</td>
<td>Bombing/Explosion</td>
</tr>
<tr>
<td>03/06/1977</td>
<td>Spain</td>
<td>Lemoniz</td>
<td>C</td>
<td>ETA</td>
<td>NS</td>
<td>Bombing/Explosion</td>
</tr>
<tr>
<td>10/10/1977</td>
<td>United States</td>
<td>Trojan</td>
<td>O</td>
<td>NWLF</td>
<td>LW</td>
<td>Bombing/Explosion</td>
</tr>
<tr>
<td>18/12/1977</td>
<td>Spain</td>
<td>Lemoniz</td>
<td>C</td>
<td>ETA</td>
<td>NS</td>
<td>Bombing/Explosion</td>
</tr>
<tr>
<td>08/03/1978</td>
<td>Spain</td>
<td>Lemoniz</td>
<td>C</td>
<td>ETA</td>
<td>NS</td>
<td>Bombing/Explosion</td>
</tr>
<tr>
<td>17/03/1978</td>
<td>Spain</td>
<td>Lemoniz</td>
<td>C</td>
<td>ETA</td>
<td>NS</td>
<td>Bombing/Explosion</td>
</tr>
<tr>
<td>15/02/1979</td>
<td>Switzerland</td>
<td>Kaiseraugst</td>
<td>C</td>
<td>Unknown</td>
<td>U</td>
<td>Bombing/Explosion</td>
</tr>
<tr>
<td>25/02/1979</td>
<td>Switzerland</td>
<td>Leibstadt</td>
<td>C</td>
<td>Unknown</td>
<td>U</td>
<td>Bombing/Explosion</td>
</tr>
<tr>
<td>13/06/1979</td>
<td>Spain</td>
<td>Lemoniz</td>
<td>C</td>
<td>ETA</td>
<td>NS</td>
<td>Bombing/Explosion</td>
</tr>
<tr>
<td>15/06/1979</td>
<td>France</td>
<td>Unknown</td>
<td>U</td>
<td>Unknown</td>
<td>U</td>
<td>Unknown</td>
</tr>
<tr>
<td>05/11/1979</td>
<td>Switzerland</td>
<td>Gosgen</td>
<td>O</td>
<td>Unknown</td>
<td>U</td>
<td>Bombing/Explosion</td>
</tr>
<tr>
<td>18/08/1980</td>
<td>Spain</td>
<td>Asco</td>
<td>C</td>
<td>Unknown</td>
<td>U</td>
<td>Bombing/Explosion</td>
</tr>
<tr>
<td>19/01/1982</td>
<td>France</td>
<td>Superphenix</td>
<td>C</td>
<td>PEC</td>
<td>SI</td>
<td>Armed Assault</td>
</tr>
<tr>
<td>18/08/1982</td>
<td>France</td>
<td>Golfech</td>
<td>C</td>
<td>Unknown</td>
<td>U</td>
<td>Bombing/Explosion</td>
</tr>
<tr>
<td>18/12/1982</td>
<td>South Africa</td>
<td>Koeberg</td>
<td>C</td>
<td>ANC</td>
<td>SI</td>
<td>Bombing/Explosion</td>
</tr>
<tr>
<td>31/10/1984</td>
<td>West Germany</td>
<td>Unknown</td>
<td>U</td>
<td>HWDS</td>
<td>SI</td>
<td>Bombing/Explosion</td>
</tr>
<tr>
<td>25/01/1985</td>
<td>West Germany</td>
<td>Kruemmel</td>
<td>O</td>
<td>HWDS</td>
<td>SI</td>
<td>Bombing/Explosion</td>
</tr>
<tr>
<td>01/07/1985</td>
<td>Philippines</td>
<td>Bataan</td>
<td>C</td>
<td>ANG</td>
<td>SI</td>
<td>Bombing/Explosion</td>
</tr>
<tr>
<td>14/05/1986</td>
<td>United States</td>
<td>Palo Verde</td>
<td>C</td>
<td>Unknown</td>
<td>U</td>
<td>Sabotage</td>
</tr>
</tbody>
</table>

(1) Status: C - in construction  O - in operation  U - unknown
(2) Group: ERP - Ejercito Revolucionaria del Pueblo  MPA - Meinhof-Puig-Antich Group
        ETA - Basque Fatherland and Freedom  NWLF - New World Liberation Front
        PEC - Pacifist and ecological committee  ANC - African National Congress
        HWDS - Gruppe Haw Weg Den Scheiss  ANG - Anti-Nuclear Group
(3) Ideology: LW - left-wing groups  NS - nationalists-separatists  SI - single-issue groups
        U - unknown

The second hypothesis contends that attacking the NPPs in construction is not only attractive to the anti-nuclear terrorists but also to the nationalist-separatists, left-wing secular utopians and religious-political groups. The data given in Table 1 supports the hypothesis in most parts, although the attacks against the facilities in construction carried out by religious-political groups haven’t been recorded so far.

The third hypothesis posits that temporal variations of the number of terrorist attacks against NPPs in construction follow the variations of the number of such facilities. In order to test the explanatory weight of this hypothesis, temporal variations of the number of terrorist attacks against NPPs were presented on the graph together with the variations of the number of construction starts and connections to the grid (see Figure 1). The data on the number of construction starts and connections to the grid was extracted from relevant IAEA publication [11]. It is evident that for the period 1970-1990 the number of terrorist attacks on NPPs correlates well with the number of NPPs being constructed. It seems however that such correlation doesn’t exist for other time periods, especially for the period from 2006 onwards.
In this latest time period the number of the facilities in construction started to increase significantly, however there was no such increase in the number of terrorist attacks.

Finally, the fourth hypothesis presumes that attacking the NPPs in operation in order to cause large release is attractive only to a very limited number of terrorist groups. The data from Table 1 supports the hypothesis to a certain extent because, as already mentioned, no such attacks were carried out so far. Attacking NPPs in order to cause large release could be attractive only to the groups which (1) are ready to use the weapons of mass destruction, (2) have the capabilities to manage large, complex projects and (3) are able to carry out the attacks outside of their country or region of origin.

It should be mentioned that there are at least two candidates which meet all the prerequisites and which have already expressed the interest [1]. These are al-Qaeda and the terrorists from the North Caucasus. Al-Qaeda has repeatedly attempted to purchase stolen nuclear material or nuclear weapons and to recruit nuclear expertise. There is evidence that al-Qaeda’s leadership considered a possibility to attack NPPs prior to September 11 [1]. Terrorists from the North Caucasus have in the past planned to seize a nuclear submarine armed with nuclear weapons, have carried out reconnaissance on nuclear weapon storage sites and have repeatedly threatened to sabotage nuclear facilities or to use radiological “dirty bombs” [1].

5 CONCLUSIONS

This research investigates the attractiveness of nuclear power plants as terrorist attack targets. Within the scope of the research the factors which determine the attractiveness of potential targets in general, as well as the attractiveness of NPPs in particular, were identified and analyzed. In addition, a set of hypotheses related to the various terrorist attack modes against NPPs has been developed. The hypotheses were tested by examining relevant historical data on terrorist attacks. It turned out that historical data supports all the hypotheses being proposed, at least to a certain extent.
It is clear that all NPPs cannot be fully protected from all possible terrorist attack modes at all times. In order to develop optimal protection strategies it is important to understand what, how and why terrorists attack. This research is considered to be a small step in that direction and clearly much more investigation in the area is needed.

REFERENCES


