Threat Assessment for Sensitive Buildings against Terrorism in urban environments*

by Tiziano Li Piani**

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Abstract

The built heritage of European cities is exposed to various hazards of different nature - natural events such as floods or earthquakes but also man-made threats. The escalation of terrorist attacks conducted in urban environments against soft targets necessitates the development of guidelines for the antiterrorism design of buildings and public spaces. Counter-terrorism engineering design is challenged by the lack of definite knowledge and quantitative assessment concerning terrorist risks, including the behavior of terrorists prior and during an attack. The results of a pilot project that aimed at comprehensively addressing terrorist attack scenarios against Churches in urban settings are summarized in this chapter. The threat assessment was based on the statistical inference of patterns extracted from a sizeable database of such attacks. The statistical incidence of certain behavioral patterns enabled the quantitative elaboration of ten threat scenarios, addressing also timing and placement patterns of the attackers based on their modus operandi. This paper summarizes and interprets the main results and findings of the project.

Keywords: Terrorism, input, target, threat encoding algorithm

*****Tiziano Li Piani**, structural engineer and PhD in computational mechanics from the Delft University of Technology in the Netherlands, works as an impact and blast scientist innovator at the national agency TNO-Defense, Safety and Security in The Hague. Furthermore, he is fellow and visiting researcher at several international institutions including at the Joint Research Centre of the European Commission (2020-2021). His projects deal mainly with the experimental testing, computational modelling and engineering design of structures and equipment's exposed to catastrophic man-made threats expected during military operations or terrorist attacks. Furthermore, Tiziano has developed several counter-terrorism projects for the terrorist threat assessment and soft target vulnerability mapping for terrorist attacks in highly urbanized environments. Tiziano's research has been internationally awarded, including winning European Commission (JRC)'s public calls and awards for best research in defense technology. He is author of book chapters and journal papers in the field of computational mechanics, material sciences and counter-terrorism. He joined ITSTIME in 2020.*

Introduction

Over the last years, European countries have been exposed to an aggravation of the level of asymmetry of the international terrorism threat, which implies the progression of terrorist attacks inside or in the surrounding of buildings for civilian use and public spaces inserted in highly urbanized environments. [1] This drift requires the urgent and massive strengthening of the national intelligence services and their coordination at an European and global levels as a preventive measure condensed in counter terrorism laws and codes.[2] However, a society founded on risk assessment [3] must not overlook the terrorist attack as an inescapable occurrence and its mitigation as a necessary mission.[4] The frequency of attacks against soft targets [5] and the observation of their effects in terms of human losses and built heritage disruptions including in some of the European capitals, urge to rethink the approach and to update the tools society is equipped with to protect civilians from urban terrorism. [6] Starting from a plan of reforms of the technical norms for buildings and constructions. [7] A change in perspective implies that buildings for civilian use and public spaces are designed to withstand the effects of intentional attacks commonly addressed in warfare environments.[8] However, protection and security guidelines applied in battle fields against man-made attacks must not be simply transferred to the contexts of buildings for civilian use in urban environments. Nevertheless, this is often what it happens in the design of embassies and firehouses of contemporary cities.[9] Due to the nature of the hosted functions, these are some of the very few buildings in the Western cities designed to withstand the effects of explosions and impacts possibly deriving from intentional attacks, according to a plethora of norms differently developed around the world. [10] Inherent design approaches e.g. of target strengthening and stand-off distances [11] are simply not consistent with the principles of freedom and

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[1] F. Bekkers, R. Meessen, and D. Lassche, *Hybrid Conflicts: The New Normal?*, 2018.

[2] S. Colaiocco, 'Prime Osservazioni Sulle Nuove Fattispecie Antiterrorismo Introdotte Dal Decreto Legge 7 Del 2015 (First Observations on the New Antiterrorism Circumnstances Introduced by Decree Law #7, 2015)', 2015, p. 11.Lorenzo Vidino and James Brandon, 'Europe's Experience in Countering Radicalisation: Approaches and Challenges', *Journal of Policing, Intelligence and Counter Terrorism*, 7.2 (2012), 163–79 <https://doi.org/10.1080/18335330.2012.719097>.

[3] T Bjorgo, *Root Causes of Terrorism: Myths, Reality and Ways Forward*, Routledge, 2005 <https://doi.org/10.4324/9780203337653>.

[4] U. Beck, *Risk Society: Towards a New Modernity*, 2nd edn (Sage, 1986).

[5] For a definition for soft target, the reader is referred to Z. Kalvach and et al., *Basics of Soft Target Protection-Guidelines* (Prague: Soft Target Protection Institute, 2016).

[6] G. Witte and L. Morris, 'Failure to Stop Paris Attacks Reveals Fatal Flaws at Heart of European Security', *The Washington Post* (Paris (France), 28 November 2015).

[7] *FEMA 452: A How-To Guide to Mitigate Potential Terrorist Attacks Against Buildings (2005)*, 2005, p. 248 <https://www.fema.gov/media-library-data/20130726-1456-20490-0832/fema429_ch4.pdf>.

[8] Steven Harre-Young and others, 'The Implications of the UK's Counter-Terrorism Strategy on the Construction Sector', *Association of Researchers in Construction Management, ARCOM 2009 - Proceedings of the 25th Annual Conference*, April 2014, 2009, 1285–94.

[9] O. Wainwright, 'Fortress London: The New US Embassy and the Rise of Counter-Terror Urbanism', *Harvard Design Magazine*, 2019.

[10] Reader is referred to specialist literature as in Donald O. Dusenberry, *Handbook for Blast-Resistant Design of Buildings*, *Assessment* (John Wiley & sons,Inc., 2010). Or Theodor Krauthammer, *Modern Protective Structures* (CRC Press, 2008) <https://doi.org/10.1201/9781420015423>.

[11] The safe *stand off distance* is the minimum distance between a building and an hypothesized source of explosion. Its perimeter is protected through the insertion of structural deterrence systems and target strengthening approaches. Its assessment is based on standard measures of the amount of energy released in an explosion, e.g. *equivalent TNT*. In T. Li Piani, 'Structural Design and the Social Function of Space as Vulnerability Factor and Solution to the Progression of the Terrorist Threat in Urban Environments (Italian)', *Security, Terrorism, Society (STS)*, 8.2 (2018), 7–17.

democracy,[12] aesthetic standard,[13] and economic constraints [14] European cities are spatial reflection of. [15] Moreover, buildings for civilian use are commonly designed only against natural dynamic loadings, such as wind and earthquakes. Wind, earthquakes, impact and blasts are all different dynamic phenomena, which are prone to determine different modes of response on the same structure. [16] Abundantly simplifying the technical dissertation, the high deformation rates with respect to the natural period of the structure [17] caused by the abrupt release of large amounts of energy [18] inherent to close in explosions or ballistic impacts, [19] cause severe local damages on the single structural elements, before the structure itself is dynamically excited as during a seismic excitation.[20] After decades of relative quiescence, the study of the dynamic behaviour of building materials [21] has recently gained renovated attention and important advancements on the mechanical assessment of highly dynamic loadings have been accomplished in the latest years in the top research centres in the world.[22] However, there is still a significant chasm with respect to the

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[12] Alberti, *De Re Aedificatoria*, 1443.

[13] C. Sitte, *City Planning According to Artistic Principles* (A Random House Book: Columbia University Studies, 1889).

[14] Cost-benefit analyses are included in the design approach of the current earthquake technical codes *EN 1998-1 (2004): Eurocode 8: Design of Structuresfor Earthquake Resistance – Part 1: General Rules, Seismicactions and Rules for Buildings [Authority: The EuropeanUnion Per Regulation 305/2011, Directive 98/34/EC, Directive2004/18/EC]*, 2004. For instance, structural design nowadays is normed to allow the production of damage on the structure during an earthquake, also in a way which obliges subsequent demolition, provided that minimum safety, operational and functional requirements are ensured during the event.

[15] J. Coaffee, P. O'Hare, and M. Hawkesworth, 'The Visibility of (In)Security: The Aesthetics of Planning Urban Defences Against Terrorism', *Security Dialogue*, 40.4–5 (2009), 489–511 <https://doi.org/10.1177/0967010609343299>.

[16] Li Piani, 'Structural Design and the Social Function of Space as Vulnerability Factor and Solution to the Progression of the Terrorist Threat in Urban Environments (Italian)'. And J. Weerheijm, J. Mediavilla, and J. C.A.M. Van Doormaal, 'Explosive Loading of Multi Storey RC Buildings: Dynamic Response and Progressive Collapse', *Structural Engineering and Mechanics*, 32.2 (2009), 193–212 <https://doi.org/10.12989/sem.2009.32.2.193>.

[17] All buildings have a natural period, which is the time required for one complete oscillation of the body.

[18] Pressures also of the order of billions of Pascal within durations of milliseconds. Li Piani, 'Structural Design and the Social Function of Space as Vulnerability Factor and Solution to the Progression of the Terrorist Threat in Urban Environments (Italian)'.

[19] Explosions are also not at all all the same. For instance, these can be categorized on the basis of their nature as physical, chemical and nuclear. For further information, the reader is referred to scientific works as in T. Ngo and others, 'Blast Loading and Blast Effects on Structures - An Overview', *Electronic Journal of Structural Engineering*, 7 (2007), 76–91 <https://doi.org/no DOI>. Or

[20] Luis Pereira, 'New Computational Approach towards the Simulation of Concrete Structures under Impulsive Loading' (Delft University of Technology (TU Delft), 2018).

[21] J. Weerheijm and P. Forquin, *Response Mechanisms of Concrete under Impulsive Tensile Loading*, *Understanding the Tensile Properties of Concrete* (Woodhead Publishing Limited, 2013) <https://doi.org/10.1533/9780857097538.2.181>.

[22] Finite element numerical models as in T. Li Piani, J. Weerheijm, and L. J. Sluys, 'Dynamic Simulations of Traditional Masonry Materials at Different Loading Rates Using an Enriched Damage Delay: Theory and Practical Applications', *Engineering Fracture Mechanics*, 218.May (2019) <https://doi.org/10.1016/j.engfracmech.2019.106576>. are developed to accurately simulate the behavior of materials subjected to shock waves. Phenomenological ballistic models as in T. Li Piani, J. Weerheijm, and L. J. Sluys, 'Ballistic Model for the Prediction of Penetration Depth and Residual Velocity in Adobe: A New Interpretation of the Ballistic Resistance of Earthen Masonry', *Defence Technology*, 14.5 (2018), 4–8 <https://doi.org/10.1016/j.dt.2018.07.017>.are used to derive quick estimation of fundamental ballistic parameters during operations in the field. A comprehensive list of works and approaches used within the characterization of materials at high strain rates is available in T. Li Piani, 'Experimental-Numerical Material Characterization of Adobe Masonry: Tests and Simulations

knowledge currently available on the seismic behaviour of buildings and corresponding design approaches.[23] The level of sophistication reflected in codes is such that numerical simulations of three-dimensional non-linear models of the building subjected to artificial [24] or synthetic [25] representations of real seismograms can be developed today to design structures against earthquakes.[26] The effective definition of mathematical models for the simulation of the physical reality and inherent interactions [27] implies the consistent target [28] properties approximation and the quantitative input [29] encoding assessment.[30] Under these premises, the phenomenological challenge inherent the design of soft targets against terrorist attacks arises. In fact, with respect to earthquakes or wind, a terrorist attack is not completely addressed solely by its mechanical input, that is by the result of a series of mechanical principles e.g. based on Newtonian physics.[31] Instead, a terrorist attack starts with the carrier of its mechanical input, namely the attacker, who constitutes a physical entity, a psychological unit and a social atom capable or reflecting, understanding and adapting according to the nature of a human being way before hitting the structure.[32] Precisely this human connotation contributes the perception of aleatory and uncertainty attributed nowadays to a possible quantitative threat assessment of the terrorist hazard, preventing its proper modelling and design in the fields of civil engineering and urban planning.[33] However, the design and planning of built heritage of the city has been homo-centric for millennia and instead the compartmentalization of competences and functions which characterizes a post-modernist society has largely contributed to the disposal of the human behaviour and nature from the design equations of spaces and buildings.[34] Instead, few pioneering works in the field of Architecture have recently restored the importance of the assessment of the social practices within the spatial planning of urban environments. Similar works proved the necessity to integrate formal technical rules of design with

on Various Types of Earthen Bricks and Mortar in Statics and Dynamics' (Delft University of Technology - TU Delft, 2019).

[23] R K Reitherman, 'Five Major Themes in the History of Earthquake Engineering', *15th World Conference on Earthquake Engineering (15WCEE)*, 2012.

[24] Based on stochastic algorithm which lay foundation on the theory of casual vibrations and wavelets Luis E. Suárez and Luis A. Montejo, 'Generation of Artificial Earthquakes via the Wavelet Transform', *International Journal of Solids and Structures*, 42.21–22 (2005), 5905–19 <https://doi.org/10.1016/j.ijsolstr.2005.03.025>.

[25] Obtained from complex deterministic and stochastic simulations of the seismological problem of earthquake generation A. Sinvhal and H. Sinvhal, 'Simulation of Synthetic Seismograms', *Seismic Modelling and Pattern Recognition in Oil Exploration*, 1992, 63–90 <https://doi.org/https://doi.org/10.1007/978-94-011-2570-3_4>.

[26] Rui Pinho, 'Nonlinear Dynamic Analysis of Structures Subjected to Seismic Action', in *Advanced Earthquake Engineering Analysis*, ed. by Alain Pecker (Vienna: Springer Vienna, 2007), pp. 63–89 <https://doi.org/10.1007/978-3-211-74214-3_5>.

[27] Which is at the basis of the structural design against natural hazards.

[28] The building

[29] The hazard

[30] Christian Hennig, 'Mathematical Models and Reality: A Constructivist Perspective', *Foundations of Science*, 15.1 (2010), 29–48 <https://doi.org/10.1007/s10699-009-9167-x>.

[31] The analytical study of the motion of projectiles in fluids begins in the XVIII century, with the second book of Newton's Principia, entitled *The motion of bodies,* as explained in Jose Gaite, 'Penetration of Fast Projectiles into Resistant Media: From Macroscopic to Subatomic Projectiles', 2017 <http://arxiv.org/abs/1705.02337>..

[32] C. Song and others, 'Limits of Predictability in Human Mobility', *Science*, 327.November (2010).

[33] National Capital Planning Commission, 'The National Capital Urban Design and Security Plan', October 2002, 2004, 26.

[34] Ana Rosa C. Cavalcanti and T. Li Piani, 'Housing by People and Their Work: Design Principles for Favelas Residents', *The Plan Journal*, 2 (2019), 30.

notions deriving from ethnography, geography, economy and anthropology in order to better design spaces for people.[35]

This research starts from the premises resumed so far. It combines hard sciences tools with soft sciences theories in order to fully encode the terrorist threat for soft targets in highly urbanized environments of European cities. This integrated approach results in the hypothesis that the human behaviour can be encoded with the same rigor with which math frames earthquakes and wind or any other natural phenomena. Within a Galileian empirical approach, [36] a pilot project was started in 2015.[37] This was aimed at developing a full encoding paradigm of the terrorist threat of Islamic matrix for Christian Churches in Europe. The rapid escalation of IS in the Middle East and its progressive influence in the African continent were suspected to degenerate into international terrorism in the core of Europe.[38] In this regards, Churches were recognized to represent a particularly attractive target for terrorists of religious inspiration [39], as unfortunately confirmed at the end of the project. [40]. Actually, the reasoning behind the choice of Churches as targets of this counter terrorism analysis is twofold. In fact, Churches are buildings which also embody features typical of public spaces. Churches are intended for Christian prayers but are open to anyone wishing to approach it, welcoming the poor and the rich, the tourist and the prayer, at any time and independently from race and religion and social condition.[41] Their intrinsic vulnerability is the result of their features of openness, inclusiveness and democracy [42] which result in the spatial relationships physically established with the public space exterior to the building perimeters.[43] The encoding paradigm of the terrorist threat for Christian Churches in the project pilot developed in 2015 was based on the study of the most significant patterns emerged from the statistical elaboration of a database created to contain quali-quantitative information regarding terrorist attacks already perpetrated against Christian Churches in the world. In the following paragraphs, the pilot experiment is extensively explained. Section 2 explains the database organization and the implemented information. Section 3 translates the main patterns statistically derived into abstract generalizations of the possible types of terrorist attacks prone to be performed against Christian Churches. Section 4 interprets the emerging scenarios and validates the approach against real incidents lately

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[35] Ana Rosa C. Cavalcanti, *Housing Shaped by Labour: The Architecture of Scarcity in Informal Settlements* (Berlin: Jovis Press, 2018).

[36] Observation, hypothesis, experiment, validation or confutation. Philip P. Wiener, 'The Tradition behind Galileo's Methodology', *The University of Chicago Press*, 1 (1936), 733–46.

[37] T. Li Piani, *Operative Guidelines for Protection of Places of Worship: A New Approach toward Security Design of Sensitive Buildings* (Milan: Institute for Advanced Strategic and Political Studies, ISBN:97888940373-2-6, 2017).

[38] Homeland Security Committee, 'Terror Gone Viral: An Overview of the 75 Isis Linked Plots against the West (2014-2016)', March, 2016.

[39] Ideology plays a decisive role in '*targets selection under strategic constraints*' in Austin I. Wright, *Terrorism, Ideology and Target Selection* (Princeton).

[40] In 2016, the first attack on a Christian Church in Europe was conducted by ISIS affiliates A. Hussey, 'France Church Attack: Even If You Are Not a Catholic, This Feels like a New and Deeper Wound', *The Guardian* (France, 2016). In 2019, anti-Islamist attacks targeted also a mosque in New Zealand.P. Billy, 'The New Zealand Attack Exposed How White Supremacy Has Long Flourished Online', *TIME*, 2019. Muslims still constitutes the most widely targeted by terrorist attacks in the world *National Consortium for the Study of Terrorism and Responses to Terrorism (START), Maryland University.*

[41] in Alberto Maggi, *Versetti Pericolosi. Gesù e Lo Scandalo Della Misericordia (Jesus and the Scandal of Mercy)*, Fazi (Collana Campo dei Fiori, 2011).

[42] Intrinsic public spaces.

[43] K. Peinhardt and N. Storring, 'Inclusive by Design: Laying a Foundation for Diversity in Public Space' (Project for Public Spaces, 2019).

happened in Europe. The extended version of this research will be published in the paper version of the journal.

The Database of the Terrorist Attacks on Places of Worship in the World (I.T.A.W.)

The development of engineering coding of natural hazards for structures is based on the analysis and simulation of historical recurrences. [44] This approach can be declined to the comprehensive encoding of man-made hazards for structures and human beings. To this end, a database was created in 2015. The *Islamist Terrorist Attacks on places of Worship Database (I.T.A.W.)* was ideated and organized to contain relevant information regarding terrorist attacks perpetrated by religious terrorism of Islamist matrix against Christian Churches in the world between 11th September 2001 and 1st January 2016. Several dataset of attacks already exist around the world and are used by services of national governments or international organizations for different purposes.[45] The large majority of tools currently available focusses attention on the outcome of the terrorist attacks in terms of human casualties and structural damage. Instead, in the *I.T.A.W.* database, the entire dynamics of the terrorist attack was meant to be parametrized, including the behavioral patterns exhibited by terrorists before and during the execution of the attack. For each attack, implemented information was derived from data elaboration of open sources.[46] Police reports, witnesses records, media press, footages and videos were among the consulted sources used to reconstruct the entire dynamic of the event and for each case, the derived information was validated crossing different sources at the same time. As a result, the database currently elaborates 102 attacks [47] and is meant as a constantly updatable tool. Not all the attacks perpetrated in Churches around the world were included in the database. Some exclusion criteria were adopted in order to define a solid and consistent dataset. The following exclusion criteria were set:

- Attacks happened within the implicit submissiveness or connivance of the public authority, that in a democratic society is aimed at protecting citizen's freedom and property were excluded; [48]
- Attacks targeting centers of religious aggregations different than Churches were excluded; [49]
- Attacks suspected of being the direct consequence of personal revenges toward individuals were excluded; [50]
- Attacks that did not produce any damages to the building or any human victims were excluded; [51]

[44] Joseph Ha, 'Recurrence Relations for Computing Complete P and SV Seismograms', *Geophysical Journal of the Royal Astronomical Society*, 79.3 (1984), 863–73 <https://doi.org/10.1111/j.1365-246X.1984.tb02873.x>.

[45] W.R.Johnston, 'Worst Terrorist Strikes Worldwide' <www.jonhnstonesarchive.net>. Another source in Jewish Virtualibrary.org, 'Terrorism against Israel: Comprehensive Listing of Fatalities from 1993'. Or Homeland Security Committee.

[46] OSINT analysis is at the basis of the research. B Schuurman and Q. Eijkman, 'Moving Terrorism Research Forward: The Crucial Role of Primary Sources', *International Center for Counter Terrorism-The Hague*, 2013.

[47] The database has been implemented using Microsoft Excel software.

[48] E.g. some storming attacks involving a large portion of the local population in Nigerian villages were excluded.

[49] E.g. community centers or underground Churches.

[50] In order to differentiate between criminality and terrorism.

[51] E.g. only planned attacks or failed attacks.

· Attacks poorly reported by public sources of information were excluded.

The database is organized into five sections and twenty-eight columns. Each column contains data or data elaborations in form of dates, numbers, initials, acronyms or entire sentences.

The first section is called '*General Information*' and contains seven columns. It resumes general information regarding the spatial and temporal domain of the perpetrated attack, in terms of geographic location where the event took place and day and daytime in which the attack took place.

The second section, named '*Target Information*', contains five columns which provide information details regarding the building targeted by the assailants. The first column refers the Church's name and its possible religious confession. If more than one Church was targeted within a coordinated plan of multiple attacks, the complete list of names is correspondingly reported. The presence of mitigation and deterrence defensive systems for building protection was registered in the next two columns. The first one refers the presence of whatever constructive element apt to obstacle or distance the attacker from the direct access to the building.[52] This information is accompanied by the indication on the presence of guards at protection of Church's entrances. [53] The following column indicates the religious or civil festivity in which the attack took place, if any coincided with the date of attack. The last column specifies the liturgical moment when the attack took place, including if no Mass was ongoing at the moment of the incident.

The '*Input Information*' section contains nine columns. The type of threat provided by terrorists and their operative strategy were meant to be parametrized within this section as an input for the aimed target. The first three columns are devoted at assessing some general features of the terrorists who perpetrated the attacks, in terms of numbers, genre composition and possible affiliation to terrorist groups. Next, the typology of attack is classified according to the main means of offence used by the involved terrorists to explicate their aim. In the first column, the type of weapon is specified. [54] A list is provided if multiple combinations of weapons were adopted.[55] In the next column, additional information on the detail of the input, including possible weapon model and brand is registered.[56] The following three columns are meant to parametrize the final purpose of the terrorist mission and the corresponding strategy meant to achieve it. The first column implements ad hoc formulae to categorize the final scope of the attack with respect to the targeted building.[57] Next, the planned strategy operatively adopted by the terrorists to reach the place of worship and conduct the attack is summarized in one sentence.[58] Details on the assailants' behavior, including clothing and appearance features showed in the premises of the attack were reported in the following column. The last one indicates if the attack was

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[52] Also the presence of outdoor steps was conceived as a deterrent.

[53] Soldiers, policemen, private security but also civilian citizen and worshipper volunteers are included in the same category.

[54] E.g. belt bombs, firearms or grenades

[55] These attacks were defined as 'hybrid'.

[56] E.g. AK47.

[57] Most of the attacks shared well defined categories of purposes, ranging from the production of the maximum level of human casualties to the execution of specific figures of the religious organization (e.g. the priest, the guards) or simply to desecrate religious symbols.

[58] E.g. terrorists might have walked along the main street of the town or taken a bus to reach the Church.

meant to be part of a broader terrorist plan aimed at targeting the same or multiple targets.[59]

The fourth section, named '*Input-Target Interaction*' contains five columns of information assessing the outcome of the terrorist attack. First, the exact position where the attack took place with respect to the targeted place of worship is registered. The next column reports the possible structural damages observed on the targeted building as well as for the nearby ones. The two following columns refer respectively the number of casualties and injured people reported as a consequence of the attack. Finally, the last column categorizes the victims according to their functions in the religious celebration. [60] The last two columns of the database indicate if the terrorist attack was lately claimed by any specific terrorist firm, including extra notes and peculiar details emphasized by mass media.

Threat Assessment for Terrorist Attacks on Places of Worship

General inference

General inference on database information can be promptly derived using statistical analysis. In average, seven attacks per years are represented in the database. These attacks are not homogeneously distributed along the last fifteen years, with a significant increase after 2009. In fact, the number of attacks quintuples in the last luster, shifting from three incidents per year in average between 2001 and 2008 to fifteen attacks per year in between 2009 and 2016 (Figure 1). [61]
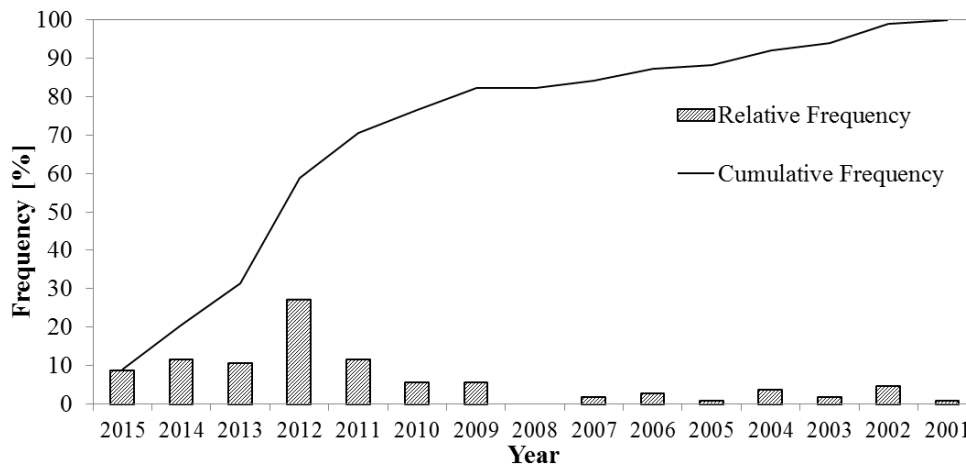

Figure 1: Relative and cumulative frequency of terrorist attacks per year

The cruelest year is 2012, when 90% of the attacks are localized in Africa (Figure 2). Religious attacks involved only two geographic continents: Africa (fifty-four attacks) or Asia.[62] However, attacks significantly targeted African countries only from 2010.

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[59] Coordinated attacks are recalled if contemporarily happening or if shifted within no more than 24h hours.
[60] E.g. priest, worshipper, guards etc. It is worthy referring that Christians and Muslim passersby were often involved in the effects of the attacks.
[61] Li Piani, *Operative Guidelines for Protection of Places of Worship: A New Approach toward Security Design of Sensitive Buildings*.
[62] Where the Middle East is included in the classification '*South Asia*'
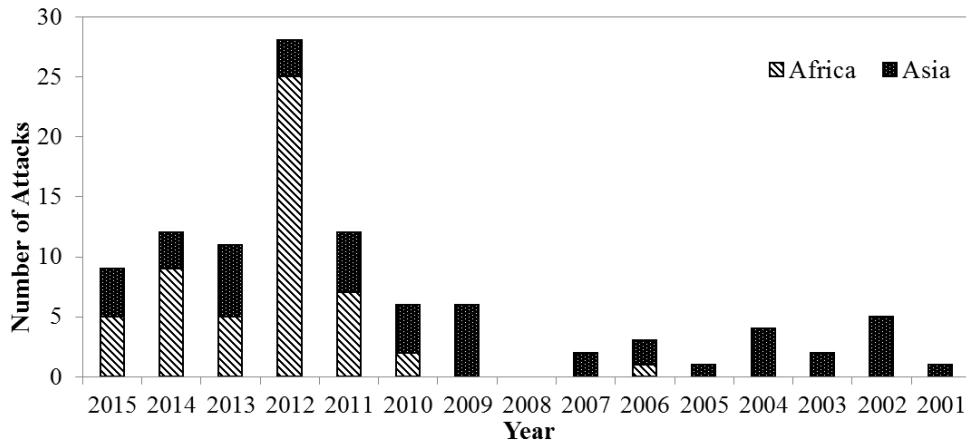
Figure 2: Number of attacks per year in Asian and African countries

The most involved countries in the database are Nigeria, Egypt and Kenya in Africa, Iraq, Pakistan and Philippines in the Asian continent (Figure 3). The most targeted cities in the world are Baghdad, Kaduna, Jos and Mosul (Figure 4).
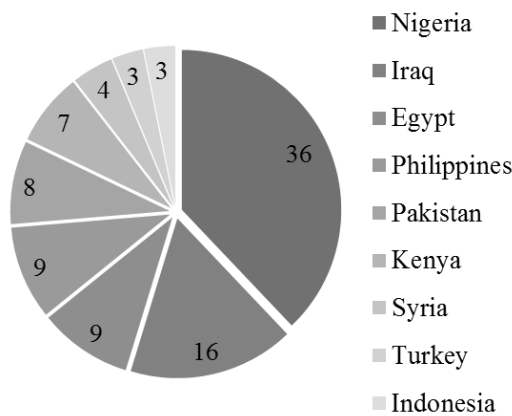

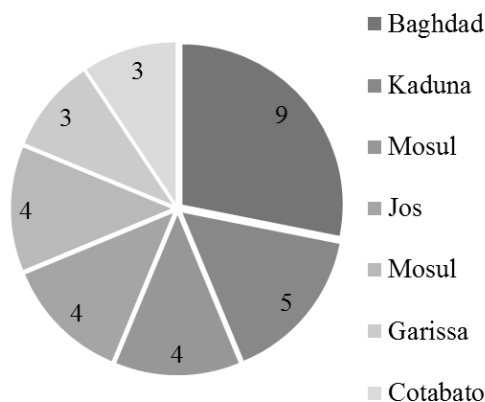Figure 3: Number of attacks in the most targeted countries

Figure 4: Number of attacks in the most targeted cities

Definite terrorist matrices are recognized behind fifty-nine attacks. More than twelve different matrices are accounted in the database, although Boko Haram, al Qaeda and Al Shabaab are the dominant ones in terms of frequency (Figure 5). On the other hand,

in 2015 ISIS is the most accredited terrorist group with two relevant attacks along the same year. All the terrorist groups strike in single continents, with the only exception of Al Qaeda and ISIS, which hit targets located in different Countries.
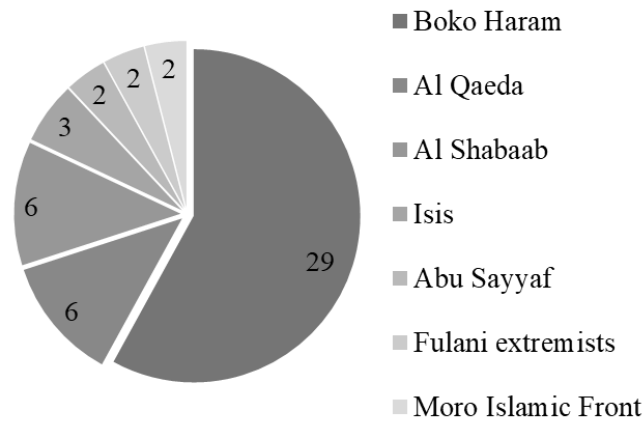

Figure 5: Most frequent terrorist groups

Also analyses results characterized by low statistical incidence are prone to provide fundamental insights on terrorist threat assessment. For instance, some statistical findings suggest that Jihadist attacks on Church are not always specifically meant to maximize human casualties.[63] In fact, temporal density distribution of attacks is more heterogeneous than expected (

Figure **6**).[64] Only half of the attacks in Churches take place on Sunday and the rest is spread along weekdays. Not all the attacks target the Church when Mass is ongoing.[65] Similarly, less than 20% of the attacks happen on festivity days, which are not always religious ones.

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[63] This observation was confirmed by the results of recent reports concerning the assessment of Jihadist terrorist activities in Western countries and terrorists target selection criteria, as in the *AIVD Insight into Targets Fifteen Years of Jihadist Attacks in the West (Algemene Inlichtingen En Veiligheidsienst)*, 2019.

[64] This apparent contradiction is based on the common assumption that terrorism against soft targets is always meant to maximize casualties. Actually, a definite agreement even on the definition for terrorism (and counter terrorism) is still lacking. Significant advancements have been made by notable scholars in the field like in Alex P. Schmid, *The Routledge Handbook of Terrorism Research.*, ed. by Alex P. Schmid (New York and London: Routledge, 2011). Or in Scott N. Romaniuk, *The Palgrave Handbook of Global Counterterrorism Policy (Pag. 20)* (London: Palgrave, 2017).
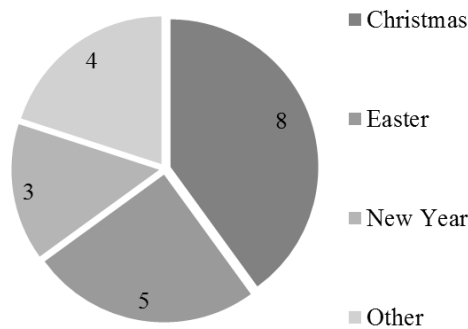
[65] Cases in which Church is empty are also recurrent.
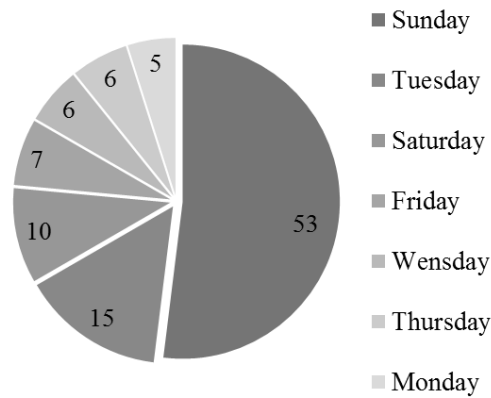
(a)
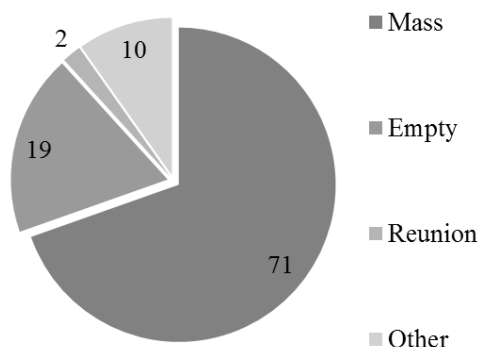
(b)

(c)

Figure 6: Distribution of attacks along the week (a), according to possible ongoing rites (b) and most targeted festivities (c)

In order to interpret all the found patterns and give explanation to new ones possibly emerging from dataset, statistical elaboration can be deepened using multivariate analysis. This operation allowed the emersion of definite trends with high statistical incidence when information is disaggregated according to the type of weapon used to perpetrate the attack. Patterns not only concerned the outcome of the mechanical input but extended to the depiction of the entire dynamics of the attack, including the chosen day and daytime of attack and also the assessment of the actions performed by the attackers during the premises of the attack. The extensive treatment of each category of attacks emerging from dataset analysis will be included in the paper version of this

article. In the following, only the resulting threat scenarios are reported as potential types of terrorist attacks involving places of worship:

Scenario 1 (side arm attack) : During a morning Mass on a weekday, 2-4 terrorists on foot enter the Church in order to kill worshippers or the priest using machetes or knives;

Input 2 (side arm attack): At the end of Mass on a weekday, 1-2 terrorists on foot wait outside the Church in order to kill a worshipper or the priest leaving the building using knives;

Input 3 (shooting attack): During Mass on a whatever day time and day of the week, 3-5 terrorists, arrived by motorbike or city car, enter the Church in order to kill worshippers or the priest using fire guns;

Input 4 (shooting attack): When no Mass is ongoing on a whatever day time on a weekday, 2-4 terrorists, accompanied by lookouts on motorbikes, stop outside the Church in order to execute the guards at building protection using fire guns;

Input 5 (car bomb attack): On a Sunday morning Mass, 1-3 terrorists drive city car or truck - bombs at maximum speed against the Church's entrance or one lateral wall in order to kill randomly humans and to produce damages on the building;

Input 6 (suicide attack): On a Sunday morning Mass, 1-2 terrorists arrived on foot or by city car enter the Church on foot in order to kill worshippers or the priest or the guards activating their belt bombs;

Input 7 (bombing attack): On a whatever day time and day of the week, 1-2 terrorists on foot leave inside or outside the Church an explosive device hidden in a bag or in a box activated to explode to kill randomly or worshippers;

Input 8 (bombing attack): On a whatever day time and day of the week, 1-2 terrorists park a car-bomb or hide a device in a parked car activated to kill randomly and to produce damages on the building;

Input 9 (bombing attack): During Mass on a whatever day time and day of the week, 1-3 terrorists arrived on foot or by car enter the Church in order to kill worshippers or the priest or remain outside to kill worshippers or guards, throwing grenades;

Input 10 (hybrid attack): During a Sunday morning Mass, 4-6 terrorists arrived on foot or by car enter one or more Churches in order to kill randomly worshippers using fire guns and grenades;

Interpreting an encoding algorithm for the human behavior behind terrorist attacks

The approach adopted in this research hypothesizes that the human actions which subtend a terrorist attack can be quantified and encoded as a mechanical variable, with the same level of mechanism associated to an earthquake or an impact. This approach neglects the preliminary assessment of the root causes which lead the terrorist(s) to

pursue an attack. Independently from any possible radicalization paths pursued or forced recruitment induced, the human nature of the attacker is employed and conceived only as the series of decisions and actions that the threat carrier makes among binary options given by the boundary conditions of the weapon carried and of the environment surrounding the target. [66] As a result, the full identification assessment between the mechanical input and its carrier is hypothesized along the entire temporal span which starts from the premises of the doorstep of the terrorist attacker up to the final point of the attack. In this approach, the possibility of the attacker to change idea and resign from attacking until the premises of the target is negated and the free will is considered as a suspended feature of 'its' human nature. Despite the mechanism imposed to the human behavior [67] might appear to be a strong limitation when it comes to predict actions made under pressure conditions, empirical evidence seems to corroborate its operative implications.[68] Furthermore, this approach also overcomes the misleading interpretation sometimes found in literature which would associate a less serious threat to attackers which self-radicalize, with respect to Jihadist of first generations.[69] The approach followed in this work parametrizes the political, social or religious nature of the terrorist attackers in terms of the final outcome of the attack and the inherent strategies planned to maximize its effects with respect to the social function of the target aimed to offend.[70] In this setting, also the factual distinctions between urban terrorism and organized criminal modus operandi are operatively smoothed because both evaluated in the series of behaviors and acts determined by the needs that the beliefs which might either come from religious fanaticism or by the belonging to a clan print on man's will. [71] For

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[66] Radicalization results from a combination of educational, cultural, social, economic and psychological factors of difficult interpretation. Alex P. Schmid, *Radicalisation, De-Radicalisation, Counter-Radicalisation: A Conceptual Discussion and Literature Review*, The Hague: International Centre for Counterterrorism, 2013 <http://www.icct.nl/download/file/ICCT-Schmid-Radicalisation-De-Radicalisation-Counter-Radicalisation-March-2013.pdf>. or L. Vidino, 'Radicalization, Linkage, and Diversity - Current Trends in Terrorism in Europe', *RAND Corporation*, 2011 <https://doi.org/10.1214/10-AOAS405>.

[67] Which de facto de humanizes the attacker.

[68] Public opinion was shocked after watching a video recording one of the attackers involved in the last series of attacks against Churches in Sri Lanka (2019) caressing a little girl in the path undertaken to enter the Church and blow up himself. However, in the interpretation of the author, this may happen if the mission is 'programmed' in the human brain of the attacker as a result of a complete alienation process (https://www.youtube.com/watch?v=CfND24XvyYU). In a physiological approach, a caress is interpreted as a human reflex with the same level of mechanism associated to taking off a coat when sun shines.

[69] Recent reports like *AIVD Insight into Targets Fifteen Years of Jihadist Attacks in the West (Algemene Inlichtingen En Veiligheidsienst)*. sharply shed light on the evidence that the proportions of successful attacks has actually increased over the last years. To address differences in the radicalization processes among different generations of Jihadists, the reader is referred to some relevant sources as L. Vidino, *Il Jihadismo Autoctono in Italia: Nascita, Sviluppo e Dinamiche Di Radicalizzazione (Native Jihadism in Italy: Emergence, Development and Radicalization Dynamics)*, ed. by ISPI (ISPI, 2014).

[70] In an unique case study on the radicalization and training of a spontaneous Jihadist cell recently published in Manuel Ricardo Torres-Soriano, 'How Do Terrorists Choose Their Targets for an Attack? The View from inside an Independent Cell', *Terrorism and Political Violence*, 00.00 (2019), 1–15 <https://doi.org/10.1080/09546553.2019.1613983>., Islamist religiously motivated attackers were found to train and plan attacks based also on sources of extreme left and anti-establishment groups.Alex P. Schmid, *Political Terrorism. A Research Guide to Concepts, Theories, Data Bases, and Literature* (Amsterdam: North-Holland Publishing Company, 1984).

[71] Daniel Boduszek and Philip Hyland, 'The Theoretical Model of Criminal Social Identity: Psycho-Social Perspective', *International Journal of Criminology and Sociological Theory*, 4.1 (2011), 604–14; Emma Alleyne and Jane L. Wood, 'Gang-Related Crime: The Social, Psychological and Behavioral

example, the dynamics of the subgroup of shooting attacks (Input 4) category emerging in this paragraph clearly recall some of Camorra's executions.[72] Behind expert curtains of propaganda,[73] criminal modus operandi and urban warfare techniques are trained and operatively applied to accomplish the final aim of preventing individuals or groups from experiencing security and freedom in the everyday life.[74] Operative and practical reasoning can be effectively used also to interpret some specific and definite trends statistically emerging from database elaboration.[75] Furthermore, sophisticated shooting attacks proved to be capable of overcoming imposed constraints and deterrence means. The most complex attacks seem to be the result of a in depth evaluation of the most effective plan and equipment to be adopted in order to exterminate worshippers. In this sense, the incidents reconstructions reveal that the majority of attacks, with different levels of abstractions, were always somehow prepared and organized, also considering possible deterrent factors to be faced. Needs and contingency reasoning might be used to explain also global patterns like the trend clearly emerging in Figure 2 and not interpreted yet. This refers to the peak of intensity in the graph by year 2012, when 90% of the 30 attacks were located in Africa. That year coincided with the peak in rampage of Boko Haram, which was identified behind more than 20 attacks in Churches in Nigeria, whereas Al Shabaab was recognized in other three attacks happening in the same year in Kenya.[76] Before 2010, Boko Haram attacks in Nigeria were mainly focusing military targets or buildings representative of economic interests or political interferences and public opinion was relatively concerned about local terrorism.[77] The group lately started to targeting soft targets, particularly including public spaces of aggregations like Churches, with the ultimate goal of maximizing disruption and producing broader international media impact, regardless of the lives of the civilians of different beliefs possibly involved.[78] Given local dynamics and territorial ambitions, groups like Boko Haram and Al Shaabab share she same Wahhabi global mission as well as the inherent terrorist operative strategies.[79] Both groups become soon affiliated to more notorious organizations operating in the Middle East: Boko Haram has recently pledged alliance to the Islamic State, while A Shaabab is closer to Al Qaeda.[80] The illegal and religiously forbidden financing sources of terrorist groups operating in different countries are also similar and often interconnected, including collaboration

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Correlates', *Psychology, Crime and Law*, 19.7 (2013), 611–27 <https://doi.org/10.1080/1068316X.2012.658050>.

[72] 'Threat Assessment : Italian Organised Crime', *Europol Public Information*, 7.6 (2013), 11–17.

[73] Alex P. Schmid and J. de Graaf, *Violence as Communication. Insurgent Terrorism and the Western News Media* (London: Sage, 1982).

[74] Recent reports confirm sophistications of attacks against soft targets progressively acquired along years: 'CTED Analytical Brief: Responding to Terrorist Threat against Soft Targets', 2019, p. 7 <https://doi.org/10.1017/CBO9781107415324.004>. and *Tony Blair Institute for Global Change : How Islamist Extremists Target Civilians*, 2018.

[75] As an example, need for clear visibility in case of suicide car bomb attacks forces morning timings for attacking.

[76] *Global Terrorism Index. Measuring and Understanding the Impact of Terrorism*, 2015.

[77] Adesoji O Adelaja, Abdullahi Labo Late, and Eva Penar, 'Public Opinion on the Root Causes of Terrorism and Objectives of Terrorists : A Boko Haram Case Study', *Perspectives on Terrorism, Leiden University*, 12.3 (2018), 35–49.

[78] T. Li Piani, 'Local Trends and Global Dynamics of Religious Terrorism in Africa', *NATO Defense College Foundation Paper*, 2019, 10.

[79] A. Mbiyozo, 'How Boko Haram Specifically Targets Displaced People' (Institute for Security Studies, 2017).

[80] Jennifer Ogbogu, 'Analysing the Threat of Boko Haram and the ISIS Alliance in Nigeria', *Counter Terrorist Trends and Analyses*, 7.8 (2015), 16–21 <https://doi.org/10.2307/26351381>.

with international criminal organizations.[81] These revenues have been fostered by the introduction and spread of internet in Africa from which Boko Haram particularly benefitted.[82] Internet is used by such organizations for funding, but also for propaganda, recruitment and training. In this regards, internet is becoming the virtual field of training of the terrorist attacks. Social media such as Telegram and Whatsapp have been recently adopted for the training and planning of terrorist attacks, including indoctrination of potential lone wolves abroad. This observation, linked with the definite patterns of actions emerging from statistical elaborations on an dataset heterogeneous in time and geography suggests the possible existence of a global online terrorist network, not only for the radicalization, but including for the preparation, teaching and training of the terrorist candidates.

At the moment of the creation of this database, all the terrorist attacks of Islamist matrix performed against Christian Churches were located outside the European Continent.

On July 22nd 2016, a first terrorist attack religiously motivated was perpetrated in the Church *Saint-Étienne-du-Rouvray* in France by two assailants armed with knives.

This unfortunate episode represents an important source of validation for the algorithm previously defined from the *I.T.A.W.* dataset. In particular, due to the nature of the mean of offence, the dynamics of the event are suitable for comparison with the *Input 1* identified in the previous paragraphs of this Chapter. From media news, on a Tuesday morning, at 9.35 am, two attackers walked entering the 16th century Church of Saint Etienne during the Mass. Consistency with the model in terms of number of attackers, approaching strategy and chosen day and daytime emerges: According to Input 1, '*During a morning Mass on a weekday, 2-4 terrorists on foot enter the Church'.* According to the Rouen incident reconstruction, the assailants specifically targeted the priest on the altar [83] and next randomly stabbed other worshippers. Also in terms of final aim, the ultimate goal emerging from reality finds consistency with the predicted aim of Input 1 of '*to kill worshippers or the priest'*. Furthermore, also the outcome of the attack happened in France, in terms of the killed priest and the four injured worshippers is close to the average values emerging from database elaboration in the side arm category of respectively 1.3 killed and 3.1 injured persons.[84] More evidence on the typical terrorists' behavioral patterns before and after the attack and on the spatial vulnerability maps emerging from database elaboration are discussed in the following section. This unfortunate episode provides also evidence about the existence of an international online recruitment and training network. It is in fact worth noticing that the two young terrorists [85] were recruited via the Telegram channel '*Sabre de Lumiere*'.[86]

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[81] Edwin Bakker, *Jihadi Terrorists in Europe: Their Characteristics and the Circumstances in Which They Joined the Jihad* (Netherlands Institute of international Relations, 2006).

[82] Kate Cox and others, 'Social Media in Africa (A Double-Edged Sword for Security and Development)', *UNDP*, 2018.

[83] The priest was ferociously slaughtered (https://www.telegraph.co.uk/news/2016/07/26/murder-of-a-priest-how-the-horror-unfolded-as-two-islamic-state/). Sympathy of the author goes to the brave priest and to all the innocent victims of any man-made attacks.

[84] It appears that after the attack the two young terrorist tried to use worshippers as shelters against the police which was alerted by a nun escaped during the premises of the attack. Attackers were finally killed by police.

[85] With criminal records.

[86] Sword of the Light, a symbol for the sword of truth, whose shine eliminates falsehood like light wipes away darkness. In Li Piani, 'Local Trends and Global Dynamics of Religious Terrorism in Africa'.

Since 2016, other serious terrorist attacks happened against Churches around the world, which further validated the suitability of the derived series of terrorist attacks idealizations for places of worship presented in this chapter.[87] On 15th March 2019, in Christchurch, New Zealand, a multiple terrorist attack conducted by a radicalized group of Islamophobic white-supremacist was conducted against the *Al Noor* mosque and an Islamic center in Linwood during the Friday prayer.[88] If the encoding algorithm is declined to account for the social function of the Mosque and the inherent timing, Input 3 (fire guns attack) shows consistency with the factual evidence emerged from records on the New Zealand attack.

Conclusions

Society is more and more exposed to threats and hazards which directly or indirectly result from mankind activities on Earth. The escalation of international terrorism in urban environments requires an effective safety design for all the elements of the city, including buildings for civilian use. The difficulty to assess the terrorist hazard for structures of the city is mainly related to the social nature of the attacker and to the antisocial function of the attack. In this research, the human component which subtends terrorist attacks on buildings has been encoded using a methodology and an approach commonly followed in the dynamic assessment of mechanical input like earthquakes. In this setting, the behavior of terrorists which results from the human reasoning over a finite systems of available options at finite temporal discretization is considered to be less aleatory and more easily simulated than an earthquake, because its phenomenology takes roots in the nature of human being which is known to larger extents than many other natural phenomena. The inference of statistical recurrences of terrorist attacks which share the same final target allows the modelling of the human behavior during an attack and encoding algorithms which mechanize the planning strategy, timing and preparation of man-made hazard scenarios as a function of the mechanical input and of the social function of the target can be generalized. These threat scenarios are prone to shed light on the vulnerability of places of worship against terrorist attacks. The vulnerability mapping goes beyond the scope of this concise report and will be extensively treated in the paper version of this article.

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[87] T. Li Piani, 'After Sri Linka: Anatomy of Terrorist Attacks in Churches (Italian)' (ISPI, 2019), p. 10.

[88] The 'Islamic Friday' is the day in which Muslim worshippers are called to go to mosque to profess their public prayers called Jumuʿa (جمعة). These prayers are performed at midday and preceded by a sermon declaimed by the preacher (khuṭba).

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