Terrorist and Built Environment

Subjects: Others

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Terrorist impacts have been increasing over time in many countries, being one of the most significant threats for the Built Environment (BE), intended as a network of open spaces (streets, squares) and facing buildings, and their users. Due to the relevance of the perpetrator “will” and the quickness of actions, Terrorism is assimilable to Sudden Onset Disasters (SUOD). BE and its morpho-technological features can be inherently prone or resilient to terrorism risk. The analysis of Risk Mitigation and Reduction Strategies (RMRSs) can support the safety of BE from a sustainable point of view, above all when they transform the existing urban environments.

Terrorist | Built Environment | Risk-Mitigation and Reduction Strategies

1. Introduction

Terrorist impacts have been increasing over time in many countries, being one of the most significant threats for the Built Environment (BE) and its users [1][2]. Emergency conditions due to a terrorist act occur quickly and unexpectedly and are moved by the “will” of the attackers “to hurt innocent people, kill or injure them, or inflict significant damage on essential infrastructure at a single instant or over time, or plan to do so, to bring about political, religious or ideological aims” [3]. Thus, they can be categorized as man-made destructive actions [4][5]. Due to their unpredictable occurrences, they are assimilable to Sudden Onset Disasters (SUOD) [6][7].

The more frequent environments where terrorists perform attacks seem to be urban BEs, especially if highly populated [2][8][9][10]. According to consolidated approaches [11][12][13], targets are defined in terms of: (1) quantity, such as the number and typologies of BE users, tourist presence, the economic values of a BE and hosted activities; (2) quality, by preferring strategic buildings and symbolic targets, such as cultural, religious and institutional places and their occupants. Large cities seem to be more potentially affected by terrorist acts, since here the effects can be maximized [8][10][14]. The BE for terrorist act targets should be considered as the system of indoor (the building) and outdoor areas (the open spaces in the BE) because of their complexity in case of an attack [8]. As for other SUODs, in fact, the outdoor area (the open spaces in the BE, e.g., streets, squares) and each facing building are characterized by layout, facilities, use, occupants’ presence and management strategies that interact in case of an emergency and so also alter the risk levels for their users [15][16][17].

2. The analysis of Risk Mitigation and Reduction Strategies (RMRSs) to understand the terrorism threat in the Built Environment

International classifications of terrorist targets, by including the ones of the European Commission definitions, recognize “hard” and “soft” targets in relation to the protection strategies and risk management that are applied to them [10][13][18][19]. Government buildings, military institutions and additional strategic buildings are “hard targets”, characterized by codified and significant control levels (including restricted access to the public) and protection (including armed guards) measures [18][20]. On the contrary, urban BEs (including open spaces) are ideally “soft targets” for terrorist acts, being characterized by a “high concentration of people, low or no security against violent attacks and attraction for the attacker” due to the exposure contents [19]. They “may be selected by terrorists […] thus inflicting fear to the population and attaining media coverage” [13]. Sights are an example of a significant BE at risk. In fact, such outdoor pedestrian areas (e.g., public spaces, squares, avenues) and the symbolic (historic or religious) buildings facing them could lead to a critical crowding level [13][14][19][21]. Moreover, such places can also temporarily host mass gathering events (e.g., concerts, festivals), becoming very attractive for attackers “for their insufficient or minimal security measures” [10]. In this sense, human-centred factors have a significant role in the overall risk and effects of a terrorist act, as well as of possible risk management strategies, as for other SUODs [22][23][24][25][26]. Finally, further specific buildings could catch the attention of terrorists. For example, public facilities devoted to educational and health

purposes (e.g., schools, hospitals) usually host sensible and exposed people to risks [10][13]. Additionally, the same buildings can be drastically affected by potential crowding conditions.

To increase the safety of the BE, Risk Mitigation and Reduction Strategies (RMRSs) can operate in two different manners and times [8][9][13][27]. Before the event, they are aimed at deterring, detecting and delaying emergency conditions through preventive measures or management procedures implemented by stakeholders and Law Enforcement Agencies (LEAs). During the attack, they are applied to reduce the number of victims and manage the evacuation with the LEAs' support and the BE layout defensive organization, which can lead to people adopting safe behaviours during the emergency phases. In addition to this general classification, strategies applied at the single building scale are generally well codified, especially for "hard targets". Here, RMRSs follow codified standards for counter-terrorism actions provided by governments and intelligence forces [8][9][20][28][29][30][31]. When considering the hosted users, they also relate to common evacuation safety regulations, which are applied to both hard and soft targets [22][27][32]. However, the coordination of RMRSs in BE application, the inclusion of human-centred issues in RMRSs definition, and the presence of holistic-based methodologies for BE stakeholders' decision support seem to be generally poor if compared to other kinds of SUODs, such as fires or earthquakes [33][34].

In such contests of application, RMRSs can be properly classified according to the macro-classifications outlined in Table 1. Main differences depend on their purpose or aimed to implement BE performances.

Table 1. Summary of classification of RMRSs in the terrorism-prone BEs, by outlining main classification options, differences to classify the RMRSs depending on their purpose or implementation-related features, the main references and the interactions among the classification criteria.

General classification criteria	Main classification options	Differences in RMRSs	References
Target-oriented			
	Hard/soft target	based or not on restricted access control, invasive surveillance and strongly-protected BE border limits	[10][11][18]
	Level of (in)visibility	perception by the BE users due to the level of implementation in the BE	[8]
	BE main intended use	differences of operational procedures in BE use and in BE configuration due to the normal use by occupants and stakeholders	[13][35][36]

	Safety/security	limiting failures and protecting the public versus limiting intentional damages and protecting the public order	[7][37]
Attack-oriented	Threat type	where/from where the attack is performed by the terrorists	[36]
	Typology of attack	facing the effects of weapons used by the assaulters	[10][19][35][38]
Time-dependent	Before/during	effectiveness before the attack (e.g. to deter it) or during it (e.g. to manage the consequences)	[38]
Space-dependent	Different zones (layer of defense) of the BE	area/line of application of the strategy in the BE layout in respect to the surrounding and internal elements	[37][39][40]
Physical versus Management	physical/management	implemented into physical elements of the BE or by using operational procedures (based on staff actions)	[13][32][35]

All the RMRSs can influence the perception, shape and management of BE and thus they require to be adequately studied according to their efficacy and perception by urban designers [13][32][35][36][40].

In that sense, near the purpose or performance-based classifications, RMRSs are classified according to the elements of sub-parts of BE that belongs or encompass to. In detail, Table 2 summarizes RMRSs focusing on the relations between strategies and BE elements and highlighting the performances and/or efficacy goals.

Table 2. Systems of RMRSs organized for BE element involved in the Strategy, details of BE parts or elements (including users) and relative performance or efficacy to control/determine.

Strategy related to BE element	BE-related element/part RMRSs and aim	Performance or efficacy to determine
Design of the physical elements in the BE		
	Safe perimeter Implement specific obstacles along the frontier of the BE with the paramount aim to avoid the vehicles access into the target [32][37][40]	• Resistance to impacts that usually depend on vehicle typology and speed • Geometric efficacy when solutions are a system of independent elements • Emergency compatibility to guarantee the possibility of moving out of the BE site
	Building shape Reduce the risk of building occupant, placing unoccupied or low occupancy areas in proximity of the entrances and of the perimeter in a specific "buffer zone" [40]	• facing blast loads effects, taking into account buildings geometry, size and façade continuum. The immediate building surroundings can ensure a positive effect, by using safe perimeter-based solutions • preventing possible assaults of terrorists inside the buildings or in the immediate surroundings, by ensuring the possibility to block views of the inside assets to perpetrators, or improving the building control. The buffer zones could support such strategies while being combined to building orientation, vegetation use, building components and external areas planning elements

		Considering the façades as weaker elements of buildings *structures*	
	Façade protection limit threat and damages propagation from the outside into the buildings [35][36][38][40]	• use laminated glass with an inner layer of polyvinyl butyral well secured into the frames is preferred. For what concerns their positions, windows are placed low down, reducing the distance of flying glass into the room • Use security doors provide enhanced protection against forced entry and overall resilience of the outer shield of the building Moreover, doors should be bomb-resistant, bullet-resistant and extreme-intrusion-attempts resistant	
BE layout			
	standoff-oriented Increase the distance between bombing source and specific target. [40]	• Control the minimum distances with physical elements or specific area to maintain away vehicles from the entrance of buildings or from their more vulnerable parts, by means of *safe perimeter* solutions	
	Sheltering protect the BE occupants in safe areas placed as close as possible to their position before the attack [35][41][42]	• Implement proper “*emergency layout*” and “*emergency plan*” measures as well as on “structure”-oriented measures to contrast the attack-related damages, by combining “*design of physical elements in the BE*”, adopting “*Façade protection*” and “*access control and surveillance*”	

	Areas division & emergency layout Divide the BE into sectors able to host a definite number of occupants [32][37][43][44]	• circumscribe emergency facilities, access and exit points by means of well-delineated borders by controlling the crowd flows
Access control and surveillance in the BE	*Access control* deterrent character for terrorist attacks [9][29][32][40]	• combine safe perimeter solutions with safety personnel to manage the controls (i.e. video surveillance CCTV systems). The effectiveness is strictly influenced by the application of reliable *coordination actions* as well as by the robustness of the infrastructure which collect and disseminate the information
	Illumination Deterrent observing character for perpetrators [40]	• increase illuminance conditions • combine lighting systems with emergency lighting to support users in attack-affected conditions • combine lighting with CCTV systems to increase the level of coordination pre-emergency and during the emergency
Safety and security management of the BE	*Security personnel* Perform all the actions related to security issues, as deterrent and detection of attackers before the event, and support the First Responders during the event [7][32][35][37][45]	• include all the surveillance bodies involved for the coordination actions pre and during the event • when "*first aid*" solutions are included, they support the immediate aftermath

Emergency plan Manage the attack effect on users during the threat and to estimate damages caused by the attack [40]		• efficacy for action in all the phases of threat during the emergency, combining all the *security personnel*, *first aid* and *emergency layout* strategies • When specific strategies of *users' involvement* are tested or disseminated, emergency plans have to be prepared according to users' preparedness
Coordination, First aid Managing the actions of all the strategies involved during the emergency, aiming at the preparedness of actions [37][43][46][47]		• efficacy in the coordination of all the RMRSs strategies involved for pre and during the emergency. • Promptness in required actions before/after any un-controlled reactions
Users' involvement Improve awareness, preparedness and correct response of citizens to the threat [48][49][50]		• Promoting "educative" initiative by means of special communication actions and through APP for devices • Any performance to control or verify

3. Classification of RMRs to support sustainable Built Environments to fight the Terrorism threat

The brought classifications of existing RMRSs is not enough to determine which RMRS is more convenient to be applied in relation to a specific case study. Therefore, the main challenges for risk-mitigation and management solutions have to be assessed from a sustainable point of view as well. RMRSs should be hence oriented towards the following main sustainability criteria here summarized [8][10][22][24][29][37][43][46][51][52][53]:

- Moving towards redundancy criteria of the resilient BE by combing different strategies to ensure that each of them could support the risk-reduction process (according to different operational procedures) in all the phases of the disaster;
- Selecting solutions to be effective for more than one terroristic threat/attack typology;
- Adopting a human-centred approach to include the behavioural reaction of the exposed individuals (especially in crowds) and of the terrorists, also in respect to the human–BE interactions (i.e., for the promotion of correct emergency behaviours);
- Including mass gathering conditions during strategy planning to ensure the safety and security aspects of different BE use situations;
- Considering the possibilities of connecting different BEs (at a local scale, e.g., indoor-outdoor; at a global/urban scale) to face the disaster;
- Promoting a psychological function of the strategies to ensure they are perceived as reliable by the citizen, to deter the terrorists but also to guarantee the liveability of the BE under normal use conditions.

Due to that, Table 3 and Table 4 summarize the general criteria, following the previous classification in Table 2 and highlighting the general level of applicability, adaptability, cost and redundancy criteria.

Table 3. Sustainability of RMRSs by the applicability, adaptability and costs approach (Design of the physical elements of the BE; BE layout).

RMRS	Redundancy about Attack Typology and Source (External/Internal)	Applicability to Indoor, Outdoor, Both	Coordination with Other RMRSs	Adaptable for Existing BE	Main Application Context (Intended Use; Overcrowding)	Costs
Design of the physical elements of the BE						
Safe perimeter	2/10—external	Outdoor: around buildings and specific targets, or to circumscribe areas in a wider open space	4/16	Adaptable, through punctual installations	For hard targets, because of its complexity level	Depending on adopted technologies and BE perimeter length
Building shape	4/10—external/internal	Principally outdoor but specific measures (i.e., escape routes, shelters) are adaptable in	3/16	Not adaptable	Specific for public buildings with a high number of visitors	Sustainable for new BEs or full BE elements renewal

RMRS	Redundancy about Attack Typology and Source (External/Internal)	Applicability to Indoor, Outdoor, Both	Coordination with Other RMRSs	Adaptable for Existing BE	Main Application Context (Intended Use; Overcrowding)	Costs
		indoors as well				
Façade protection	2/10	Protecting single buildings	4/16	Generally, solutions are related to new facades (which can alter the aspects of the original elements). Interventions on existing openings have a lower impact.	Specific for public buildings with a high number of visitors	New reinforced facades can be put in place with limited costs (depending on the building typology). Interventions on existing openings are encouraged due to their lower costs with respect to the protection increase advantages.
Structure	1/10	Indoor: relative to building's structural system	2/16	Preservation of historic buildings could be affected, unless there are focused interventions	Encouraged only for institutional public buildings with many visitors	Depending on intervention type, structural typology and building dimensions
			BE layout			
Standoff	2/10	Distances applied to the outdoors can be adapted for some indoor conditions	5/16	Possible massive impact, if applied together with Safe Perimeter. Otherwise, adaptable to the historical layout using management actions.	Specific for strategic buildings but extendable to soft targets with visitors and temporary mass gatherings	Depending on land use issues to guarantee the distances in case of new constructions. In existing BEs, costs concern the space use management
Sheltering	6/10	Shelters can be placed inside buildings or constitute a safe area in the outdoor BE	4/16	Adaptable if limited to the definition of shelter areas and their accessibility (management issues); incompatible considering interventions on building	Considering attacks to single and strategic buildings with something/someone to protect	Low costs if limited to existing shelter areas; elevated cost otherwise

RMRS	Redundancy about Attack Typology and Source (External/Internal)	Applicability to Indoor, Outdoor, Both	Coordination with Other RMRSs	Adaptable for Existing BE	Main Application Context (Intended Use; Overcrowding)	Costs
				facades and structures.		
Area division	5/10	Both	6/16	The adaptability is related to the area configuration and dimension	Specific for mass gathering events in open spaces	Low costs associated with physical solutions (e.g., open space perimeter), but management and operational issues should be evaluated (e.g., organizing activities in the spaces and their relation; access controls)
Emergency layout	5/10	Outdoor or within strategic buildings and hard targets	8/16	Adaptable for each situation	Adaptable in each event typology	Depending on the extension of the emergency area in relation to the BE activities

Table 4. Sustainability of RMRSs by the applicability, adaptability and costs approach (Access control and surveillance in the BE; Safety and security management of the BE).

RMRS	Redundancy about Attack Typology and Source (External/Internal)	Applicability to Indoor, Outdoor, Both	Coordination with Other RMRSs	Adaptable for Existing BE	Main Application Context (Intended Use; Overcrowding)	Costs
Access control and surveillance in the BE						
Access control	7/10	Applicable to circumscribed areas in open spaces/inside abuilding	7/16	Adaptable for existing BE because of the possibility to circumscribe areas (i.e., outdoor perimeter)	Adaptable for events with considerable crowding conditions (mass gathering events)	Depending on the number of access/control points and to the employed technologies/personnel
Security service	6/10	Employable in indoor and outdoor conditions	6/16	Adaptable for existing (including historical) BEs through not invasive installations	Adaptable to private and public buildings, and also in open spaces and mass gatherings	Depending on the BE dimension to monitor and on the adopted technologies

RMRS	Redundancy about Attack Typology and Source (External/Internal)	Applicability to Indoor, Outdoor, Both	Coordination with Other RMRSs	Adaptable for Existing BE	Main Application Context (Intended Use; Overcrowding)	Costs
Illumination	4/10	For outdoor spaces; in indoor, mainly for scarce luminance condition of buildings	3/16	Adaptable for existing (including historical) BEs with possible restrictions at technological level (e.g., systems integration/installation)	Adaptable both to private and public buildings, both in open spaces and mass gatherings	Depending on the number of installed devices, and their operational and maintenance issues
Safety and security management in the BE						
Security personnel	7/10	Employable in indoor and outdoor conditions	8/16	Adaptable in each condition	Personnel could support an emergency in whatever building. It is strongly recommended in mass gathering events, especially outdoors	Depending on building dimension and floors. In mass gatherings, depending on event area extension and number of participants
Coordination	10/10	Always recommended	7/16	Not dependent on the BE typology	Necessary in each case; it requires special consideration for some hard targets or mass gathering events	Low-cost improvement of performances is possible, but costs could be related to the employed technology
First aid	9/10	Always needed; support from external rescuers' actions	7/16	Adaptable in each condition	Mandatory for mass gathering and in hard targets of the BE	Low costs by considering the direct possibility to save lives
Emergency plan	10/10	Always needed	11/16	Adaptable in each condition	Recommended in any cases, especially in mass gathering events and in hard targets of the BE	Depending on management and operational phases; they could be elevated considering case by case (e.g., cost of personnel considering their number)
Users' involvement	10/10	Users should be involved in the same manner for both indoor and outdoor scenarios. However, the provided data will be different	7/16	Not dependent on the BE typology	Users should be formed to face disaster both in BE normal use and in case of events with overcrowding conditions	Financing informative campaign can be considered as an investment on citizen safety; costs for users' involvement are also related to evacuation guiding tools for mobile devices (e.g., apps)

This Entry is part of the results of the Project BE S2ECURe—(make) Built Environment Safer in Slow and Emergency Conditions through behavioural assessed/designed Resilient solutions (Grant number: 2017LR75XK). https://www.bes2ecure.net/

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