TRAFFIC INFRASTRUCTURE IN THE FUNCTION OF PROTECTION OF SOFT METS

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Summary: In recent years, terrorists have repeatedly used vehicles to attack large gatherings, resulting in a significant number of human casualties. Unlike explosives or weapons, vehicles are easily accessible to terrorists, requiring minimal training, skills and minimal preparation time to manage them. The purpose of this paper is to analyze the role of transport infrastructure in the function of protecting soft targets from terrorist attacks, based on an analysis of terrorist attacks by vehicles so far. A degree of protection can be achieved by interventions on existing roads by various physical barriers that force the driver to slow down the movement of the vehicle or prevent him from entering the gathering area for more people. On the other hand, controlling vehicles using digital technology can prevent or hinder terrorist attacks by vehicles. The aim of this paper is to propose effective systems for the protection of soft targets against terrorist attacks by vehicles, which it is advisable to install in transport infrastructure.

Keywords: transport infrastructure, terrorism, protection of soft targets, terrorist attacks by vehicles

1. INTRODUCTION

In recent years, the threat posed by terrorism has increased rapidly. Terrorists use readily available means to carry out an attack. A new approach to the fight against terrorism is needed. Public spaces that gather large numbers of people, such as streets with shops, city squares, transportation systems, sports and concert events, either indoors or outdoors, are particularly at risk. Building an environment that is more resilient to terrorist attacks through the architecture and infrastructure of urban systems, in an acceptable and effective way, improves citizens' security.

The question of how to increase cities 'resilience to terrorist attacks through physical interventions and traffic management measures is a challenge for urban planners, builders, transport and security professionals - how to plan cities' resilience to terrorist attacks?

Since the start of 2016, vehicles have been used to carry out more than a dozen terrorist attacks worldwide. Tunisian Mohamed Lahouaiej-Bouhlel hit a massive truck on July 14, 2016 in a mass of people celebrating Bastille Day on the Promenade des Anglais promenade in Nice, killing 86 people and injuring more than 430 people. Two days later, ISIL claimed responsibility for the attack. The Nice terrorist attack, though not the first of its kind, was the most modern modern terrorist attack on a vehicle in Europe that triggered a wave of terrorist attacks on vehicles around the world.

Following the Nice attack, major incidents involving vehicles in Vienna, the USA (Ohio State University), Berlin, London, Antwerp, Stockholm, Paris, Barcelona, Edmonton and New York occurred.

In September 2016, an attacker ran into a car in Vienna Favoriten with a vehicle shouting "Allahu Akbar", fortunately without injuries. In November 2016, Somali Abdul Razak Ali Artan carried out

a car and knife attack at Ohio State University, injuring 11 people. In December 2016, Tunisian Anis Amri crashed into a stolen truck at a Christmas fair in Berlin, killing 12 and injuring 56 in an attack under the responsibility of ISIL.
Attacks on the vehicle continued in 2017, with at least 32 dead and more than 240 injured. On January 8, 2017, a truck driver rammed into a group of Israeli soldiers at a popular tourist destination in Jerusalem, killing four people. On March 22, 2017, terrorist Khalid Masood killed five people and injured more than 50 during a vehicle and knife attack in London. A similar attack was prevented the next day in Antwerp, Belgium. On April 7, 2017, another attacker carried out a terrorist attack in Sweden, hijacking a truck and crashing into pedestrians on a shopping street in downtown Stockholm, killing four and injuring more than 15 people.
On the evening of June 3, 2017, three assailants, with a rented van at full speed, crashed into a crowd of people on the London Bridge, exited the vehicle and attacked a pedestrian with a pedestrian in nearby Borough Market. The attack, which has been claimed by ISIL, has resulted in at least seven killed and 48 injured. The attack followed ISIL's call on May 17, 2017 to carry out terrorist attacks in the United States, United Kingdom and the European Union using knives and trucks. The attacker crashed into a crowd of believers near a mosque in north London on June 19, 2017, injuring at least eight people. Later that day, an armed gunman rammed a Renault Megan into a police car at the Champs-Elysees in Paris, severely wounding himself, with no other casualties. The car contained explosives and weapons.
On 17 August 2017, the attacker intentionally rammed into a crowd of tourists on the Las Ramblas promenade in central Barcelona on August 17, 2017. The attack killed 16 people and wounded 120 people. On September 30, 2017, the second attacker carried out two terrorist attacks on vehicles in Edmonton, Canada, injuring five people in total. In the first attack, the perpetrator used a car to stab a police officer before exiting the vehicle and stabbing him with a knife. The attacker later used the truck and rammed into the pedestrians, injuring four people.
Vehicle attacks turn ordinary everyday objects into killing machines, creating an element of surprise as well as a constant threat. Due to the readily available means of attack, ease of execution, and inability to detect it early, ISIL and similar terrorist groups will most likely continue to use this tactic in their future attacks.

2. VEHICLES THAT terrorists use in their attacks

Getting a vehicle to carry out a terrorist attack is easy. The vehicle can be bought, rented, stolen or hijacked on the way to the destination. However, the type of vehicle and its structural and technical characteristics are extremely important factors that affect the success of an attack. Analyzing the previous attacks on vehicles, we can conclude that the attack with smaller vehicles and even smaller vans and ATVs does not result in a large number of casualties. Smaller vehicles do not have the required weight and a large enough wheel range to extinguish a large number of victims. The vehicle most suited to such a terrorist operation is a large cargo truck because of the ease with which it can pass protective obstacles and the great damage it can do to people and infrastructure. Trucks and buses on the roads are busy and do not cause any doubt about the access they usually have to certain areas.
Terrorists are the ideal vehicle (Vehicular Terrorism: The Threat Behind the Wheel, 2017) a heavy duty truck that can be controlled, relatively fast or as fast as possible, heavy, allowing it to destroy anything it hits, with twin wheels, so victims have less chance of escaping than the wheels of a vehicle, have a slightly

elevated suspension and bumper, which allow the truck to climb onto the pavement and pass all obstacles if necessary. Heavy duty vans, some special vehicles such as towing vehicles, etc. and buses are also considered.

Vehicles that terrorists usually avoid are (Vehicular Terrorism: The Threat Behind the Wheel, 2017):

- "Small cars, including larger SUVs,
- Slower vehicles not exceeding 90 km / h,
- Cargo vehicles with trailers that are not part of the cab and can lead to loss of control and jams, especially when cornering,
- Freight vehicles with extended trailers which may cause the driver problems when maneuvering the vehicle. "

Driving characteristics and vehicle dynamics vary with the type and weight of the vehicle. The center of balance is linked to the loading capacity of each vehicle and determines the speed and maneuverability of the vehicle. These are some of the weaknesses that can be exploited in preventing an active vehicle attack. Trucks and buses have a greater turning radius than passenger and utility vehicles. Vehicles with a larger turning radius circle around corners and obstacles. In order to be able to swerve and not lose control of the vehicle and topple over, they must reduce their speed.

3. PROTECTION OF CITIZENS FROM TERRORIST ATTACKS TO VEHICLES

What can we do to protect citizens from terrorist attacks by vehicles? This question is harder to answer when it comes to the overall protection of big cities. When securing a specific event, security officers can take measures to block vehicle access to crowded areas. One possible solution is to set up barriers that temporarily or permanently prevent vehicles from accessing a specific area or prevent vehicles from either achieving high speeds or driving over longer distances. Protective barriers can be extremely visible, such as, for example, metal-coated concrete blocks in front of the Houses of Parliament in London - or concealed, such as heavy concrete flower and sculpture containers located on city streets.

Likewise, streets and access roads can be redone to prevent vehicles from reaching the target of the attack or to prevent the vehicle from accelerating during the attack. Only specific locations can be protected in this way, and multiple, sharp turns and narrow streets can prevent large vehicles from reaching high speeds before reaching an obstacle.

4. CONSTRUCTION MATERIALS AND TYPES OF PROTECTIVE BARRIERS

Common barrier materials are:

- Metal: cast iron; carbonitriated iron; stainless steel; aluminum, bronze or other alloys.
- Reinforced concrete: either cast in place or precast into a mold with embedded steel bars or steel mesh.
- Other materials: large natural stone, wood or trees, dense industrial plastics.

The advantages of metal barriers are great strength; light weight and relatively narrow shape and easy handling. Some of the disadvantages of metals are the complexity of maintenance, the need for routine anti-corrosion paint / coating and less architectural compatibility with the surrounding building materials (color, shape, texture). Compared to metal barrier protections, concrete elements are made of barrier material that has greater

compatibility of appearance (color, shape, texture) with the urban environment, high corrosion resistance, greater durability, less maintenance and usually lower costs. Other protective barrier materials include natural stone, wood or trees and industrial plastics. Stone and plastic materials usually do not have the high strength that metal or concrete has and therefore have to be of large overall dimensions or specific structural combinations to effectively stop vehicles in a collision. Protective barriers can also be made from a combination of materials for a better appearance or complementary properties, or to have the advantage of architecturally enhancing or complementing the environment in urban areas. There are two basic categories of vehicle anti-vehicle barrier (AVB) systems: stationary and operable (Vehicular Terrorism: The Treath Behind the Wheel, 2017).

- Stationary barriers are equivalent to, but not exactly equivalent to, the "fixed barriers" defined in FEMA 430 (2007), fixed to the ground or the base diaphragms and used to block the entry of vehicles into a specific area.
- Operable barriers are not attached and can be moved as needed to allow access to authorized vehicles. Operable barriers are ramps or wedges. Usually, hydraulic or electrical power is required to set them up. Their overall fabrication and design is more complicated than stationary barriers.

4.1. STATIONARY PROTECTION BARRIERS

Common stationary barriers are:

- Columns or columns - common barriers to vehicles, and their advantage is that they take up little space and are easy to install,
- Sculptures and other heavy objects,
- Metal fences,
- Concrete or stone protective barriers (fixed or anchored concrete barriers, road barriers called Jersey barriers, protective concrete walls, concrete flower containers).

In recent years, barriers or short guard posts have increasingly been used as barriers. Metal poles that prevent a vehicle from being parked cannot be considered a safeguard against terrorist attacks by vehicles, as they cannot successfully stop even a personal vehicle, let alone a truck. In addition, the piers must be deeply anchored to the ground, which means that they would probably not be erected on the bridges, given that two recent attacks in London have taken place on bridges.

Thick metal short poles are typically intended to stop vehicles weighing up to 7 tons at speeds up to 70 km / h (Krishna-Prasad, 2006; Kinney et al., 2014). Such technical characteristics of these columns would not be sufficient to stop a truck weighing 20 tons. The disadvantage of such poles is that in places where a lot of people move, they can injure pedestrians when pedestrians fall on a pole.

A large heavy cannon is placed in front of Emirates Stadium in London, which is the Arsenal club's logo, but also serves as a barrier.

Jersey concrete barriers are common and widespread vehicle barriers designed to permanently or temporarily maintain safety and direct traffic. They were created by the New Jersey State Highway Bureau to separate lanes on the freeway. The Jersey concrete barrier is 80 to 100 cm high and was originally designed to minimize damage and the likelihood of a vehicle collision in highway lanes. There are variations of the original shape such as tapered concrete barriers, F-shaped barriers and California K-rail barriers.

The simple construction, mobility and efficiency of the Jersey obstacles make them applicable to prevent vehicle attacks. The advantages of Jersey obstacles are their ability to quickly stop a vehicle using a large mass of concrete, eliminate collision with a vehicle at an angle, dissipate kinetic energy by lifting the front of the vehicle and planting it on obstacles. They are easily stacked in continuous arrays or combined with other types of obstacles such as steel railings. They are easily placed in various flexible specimens for temporary or permanent protection.

The disadvantages of Jersey obstacles are mainly related to the purpose for which they were initially made, which is to remove the vehicle and not to completely damage or stop the vehicle in motion. They minimize damage to the vehicle in the event of minor contact and prevent the vehicle from crossing and frontal collision and are designed to divert, slow or prevent severe vehicle collisions. In defense against terrorist attacks, Jersey obstacles cannot usually be fully effective if attacked by lorries due to insufficient height of the obstacle, relatively weak anchorage on the ground, and sloping front of the obstacle causing the truck to be lifted.

Newer versions of barriers are made of polyethylene. They are lightweight for transport and suitable for short-term use. These plastic barriers are usually filled with water after installation, and may be filled with earth, sand or concrete.
Multiple Jersey obstacles can be positioned in such a way that the vehicle passing the path between the obstacles must wind, which automatically slows it down.

The drawback of Jersey obstacles located near city facilities is their appearance, especially in areas with high pedestrian traffic where visual attractiveness of the space is expected.

Short concrete firewalls as well as high freestanding walls are made of cast concrete elements, road barriers or other road barrier materials and are usually reinforced with iron. The walls can be perforated or non-continuous to give a better appearance or to allow pedestrian passageways while meeting safety requirements. Firewalls must be either installed in the ground or anchored to the base in order to withstand the impact of the vehicle.

Short firewalls are usually well reinforced and at least 90 cm high. Reinforced reinforcement of short concrete walls provides resistance to high impact force and maintains stability due to the mass of passive soil pressure. High firewalls are designed to block heavy vehicles (eg trucks) and vehicles that achieve high speeds on impact. Higher-height walls have a larger contact area with the front of the truck and can cause the vehicle to overturn. Higher firewalls also need a wider foundation. To reduce the cost and time of construction, prefabricated concrete wall panels are typically used to be installed on site, and precast units are easily integrated into other perimeter protection systems.

The advantages of using concrete walls as a barrier are the high stopping power of the vehicle from all angles, high walls can destroy the vehicle and block most of the catapulted objects, and high walls serve as a vehicle crash protection and explosion protection.

The major drawbacks of concrete walls are the imposing large overall dimensions for walls with adequate anti-collision effect, higher costs and longer construction time required for large walls in relation to smaller obstacles, unattractive appearance and difficulty of erection in urban areas.

Another, more aesthetically pleasing option is the strategic placement of heavy flower

pots, metal lighting poles and sculptures around the area to be protected. Although it is possible to protect certain places, it is unlikely that just about any area in the city can be protected.

Fixed or anchored flower containers are either poured on site or pre-cast into the mold and delivered to the site. They can also be constructed of concrete blocks. Previously molded flower pots usually serve as urban architectural elements or so-called molds. street furniture. Filled with soil and plants, they are good absorbers of vehicle impact energy. In order to completely prevent the vehicle from entering a specific area at full speed, flower containers must be anchored to the ground.

Concrete flower containers, either ground-mounted or ground-anchored, can stop a 6.8 ton truck at speeds greater than 50 km / h, even when the tanks are individually mounted. Concrete flower containers are usually taller and wider than one meter.

The advantages of these popular barriers are that they effectively stop the vehicle at high speed, destroying the vehicle and prevent any potential further movement, dissipate kinetic energy with a combined mass of concrete and soil, enhance the urban environment and complement the appearance of the environment.

Some of the drawbacks of fixed flower containers are intrusive and large dimensions for the purpose of stopping vehicles, higher costs and longer construction time than road obstacles (Jersey obstacles) and difficulty setting up in urban areas with limited space.

4.2. OPERATIONAL SAFETY OBSTACLES

Operable barriers require significant construction time, are expensive and require special maintenance. It is because of these characteristics that operable barriers are not suitable for protection during occasional events or for placing on parades. Nevertheless, they can be used integrated with moving and stationary obstacles, as well as for blocking vehicles.

The two most effective operable barriers for vehicles are wedges and guard posts. There may be different sizes, lengths and combinations of specimens for optimal protection of a particular area. They are best suited for traffic control, defense of facilities and fixed areas of permanent pedestrian zones and gathering places for large numbers of people, such as stadiums, parks and city squares commonly used for large public events.

Due to the increasing need to prevent terrorist attacks by vehicles, scientists and innovators are working to find new and innovative solutions. Last year, three new, easy-to-handle barriers were introduced, no special training is required to install them, they are portable and can be easily transported in standard vehicles (New Measures to Counter Vehicle-Ramming Attacks Exposed, 2017). They are made of solid but resilient materials that absorb the energy of the vehicle's impact, allowing the transfer from kinetic to potential energy, shifting the momentum of the vehicle to the ground to stop the vehicle. Portable barriers do not require infrastructure preparation, are quick to set up and easily adapt to the area to be protected.

FBM Flat Crossing Barrier is a multi-purpose, portable, fast, effective vehicle barrier. The modular system can stop vehicles weighing up to 2.5 tons, including cars, trucks, tractors, motorcycles and quad vehicles. The barrier is ideal for use in urban areas. Individual units can be arranged to suit different vehicles and road widths (New Measures to Counter Vehicle-Ramming Attacks Exposed, 2017).

The pyramidal folding barrier for heavy vehicles is a unique, two-way barrier that simultaneously blocks the entry and exit of vehicles. The modular barrier system for vehicles completely stops vehicles weighing up to 7 tons. It does not need concrete foundations, can be hydraulically or manually activated, can serve as a temporary or permanent obstacle even during low probability of attack, can be used to slow down traffic (New Measures to Counter Vehicle-Ramming Attacks Exposed, 2017).

The RMB barrier stops heavy trucks and semi-trailers weighing up to 40 tons. The obstacle causes the vehicle to lift up during the stopping process, thus reducing the damage caused by the impact (New Measures to Counter Vehicle-Ramming Attacks Exposed, 2017).

Shvetsov has designed and patented an ARPD barrier that blocks attack by passenger, off-road and commercial vehicles by means of a pull-out pole, and is positioned at points of possible vehicle entry into pedestrian zones (Shvetsov, A. V., Sharov, V. A., Shvetsova, S. V., 2017). When designing a vehicle anti-assault device, the author took into account the specific characteristics of pedestrian zones.

5. THE ROLE OF TECHNOLOGY IN PREVENTING THE USE OF VEHICLES TO PERFORM TERRORIST ATTACKS

Many companies are exploring ways to improve the Advanced Emergency Braking Systems (AEB), which activate vehicle brakes when on-board sensors detect a possible collision. In accordance with EU Regulation 347/2012, such technology has been mandatory in new transport vehicles since 2014, and upgrading the technology to stop the vehicle instantly and extending its use to all vehicles would certainly prevent numerous vehicle attacks. The initial objective of this Regulation was to avoid vehicle collisions in front of motorways, and the Regulation applies to vehicles over 3.5 tonnes. For the AEB system to detect people and brake, more sophisticated cameras need to be installed on vehicles. Passing rules on AEB systems to passenger cars would also help reduce the number of road fatalities and attacks by smaller vehicles.

Delivery vehicles are increasingly equipped with sensor technology and one option could be an extinguisher switch that would shut off the vehicle and report the location to it immediately after the vehicle is reported missing. One has to be careful about this, as this is a cyber security issue and can cause a bigger security problem to shut down a large and heavy vehicle at high speed. Technical solutions such as remote locks, vehicle activation and other safety mechanisms could help prevent theft of vehicles. Truck manufacturers, however, fear that adding biometric systems such as fingerprint scanners to truck cab doors could endanger drivers. The hijackers could target drivers to gain access to vehicles. Geo-fencing systems are also being developed that could use software to limit speeds or enter specific areas based on GPS location, slow down unauthorized vehicles, and eventually stop them. On the other hand, it should be noted that modern cars with electronic controls are connected to the Internet, can be hacked and used for terrorist attacks, and a resourceful terrorist can use an older vehicle or find a way to disable AEB and other systems.

6. GUIDELINES FOR SELECTION OF SAFEGUARDS

Barriers to vehicles in an urban environment need to meet the unique requirements of functionality and acceptable visual aesthetics. In addition to

a solid defense against vehicle crashes, urban barriers should serve as both an architectural element and functional "street furniture".

The following steps should be followed in selecting the appropriate barriers (Caspe, M., Ji, J., Shen, L., Wang, Q., P. E., and Zhai, Y., 2010):

1. Step: Assessing the risk of a possible attack includes:

a) Field exploration of the site to identify weak points,
b) Conducting traffic analysis to identify possible attack scenarios and access by authorized vehicles,
c) Determination of minimum clearance in the event of an explosion,
d) Determining the level of protection.

2. Step: Selecting and setting the most appropriate obstacles for vehicles includes:

a) Determining the location of obstacles to ensure a minimum safe distance,
b) Exploring location conditions to determine possible foundations,
c) Choosing the right criteria based on your desired level of protection,
d) Choosing an aesthetically appropriate protective barrier that fits into the urban environment.

Critical selection factors are: counter-terrorism functionality; decorative / aesthetic flexibility in urban areas; environmental impact; set up and cost.

7. CONCLUSION

Terrorist organizations advocate the conduct of terrorist attacks by modified or standard vehicles on a crowd of people, buildings and other vehicles. The targets of such attacks may be the locations of various public gatherings, parades and other celebrations, sports and concert events, fairs or shopping areas.

Vehicle attacks are considered unsophisticated attacks because the perpetrator can carry out such an attack with minimal planning and training. Such attacks are difficult to detect in advance, and their successful implementation can result in numerous human casualties. Events that attract large groups of people and are therefore attractive targets for attackers by vehicles, usually announced in advance, which greatly facilitates the planning, preparation and training of an attack. These attacks clearly demonstrate how difficult it can be to stop such an attack once it is launched.

In response to the increasing number of vehicle attacks, the development of protective barriers to vehicles that can withstand a direct vehicle crash has also been successful. Made as lightweight and compact, many vehicle barriers come in modular parts so they can be easily transported, transported, installed and removed. The barriers in place should allow pedestrians, cyclists and authorized emergency vehicles to pass through.

Choosing ready-made protective products as a universal solution is not recommended for all specific sites that want to protect themselves. Before making a final decision on the selection of safeguards, comprehensive analysis, comparisons and evaluations of the various barriers available on the market should be made.

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