

Primer on Impact Protection for Critical Transportation Infrastructure



December 2018

FHWA-HIF-18-054



U.S. Department
of Transportation
**Federal Highway
Administration**

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TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. FHWA-HIF-18-054	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Primer on Impact Protection for Critical Transportation Infrastructure		5. Report Date December 2018	
		6. Performing Organization Code: V-335	
7. Author(s) John Wojtowicz, CPP; Nathan B. Grace*		8. Performing Organization Report No. DOT-VNTSC-FHWA-18-17	
9. Performing Organization Name and Address U.S. Department of Transportation John A. Volpe National Transportation Systems Center 55 Broadway Cambridge, MA 02142-1093		10. Work Unit No.	
		11. Contract or Grant No. HW22A1	
12. Sponsoring Agency Name and Address Federal Highway Administration Office of Infrastructure 1200 New Jersey Avenue, SE Washington, DC 20590		13. Type of Report and Period: Technical Report September 2018	
		14. Sponsoring Agency Code FHWA-HIF-18-054	
15. Supplementary Notes *SGT, Inc., 7701 Greenbelt Road, Suite 400, Greenbelt, MD 20770			
16. Abstract This document provides FHWA, AASHTO members, and State/local/Tribal highway officials with a consolidated synthesis on vehicle security barrier (VSB) options to protect highway critical infrastructure from high-speed impact of medium- and heavy-duty trucks, transportation facility vehicle access points, and their perimeters. This document is a synthesis of publicly available documents and standards in the United States and United Kingdom. The information is beneficial to all transportation modes (aviation, rail, pipeline, mass transit) owners and operators as physical security reviews are conducted for critical infrastructure within the realm of their responsibility. This primer, though not specifically developed to address vehicle-as-weapon (VAW) threats by terrorists, will be beneficial to emergency management and law enforcement officials responsible for developing protective measures for large crowds, as well as community planners focused on improving pedestrian/bicycle safety in congested vehicle locations. Information about explosive protection from VSBs is not presented in this primer.			
17. Key Words Vehicle security barriers, intrusion protection, transportation critical infrastructure protection, physical security, perimeter security, facility protection, bollards, active barrier, passive barrier, vehicle-as-weapon, resilience, risk management, risk mitigation.		18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161. http://www.ntis.gov	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 71	22. Price

Form DOT F 1700.7 (8-72)

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in ²	square inches	645.2	square millimeters	mm ²
ft ²	square feet	0.093	square meters	m ²
yd ²	square yard	0.836	square meters	m ²
ac	acres	0.405	hectares	ha
mi ²	square miles	2.59	square kilometers	km ²
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft ³	cubic feet	0.028	cubic meters	m ³
yd ³	cubic yards	0.765	cubic meters	m ³
NOTE: volumes greater than 1000 L shall be shown in m ³				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m ²	cd/m ²
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in ²	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm ²	square millimeters	0.0016	square inches	in ²
m ²	square meters	10.764	square feet	ft ²
m ²	square meters	1.195	square yards	yd ²
ha	hectares	2.47	acres	ac
km ²	square kilometers	0.386	square miles	mi ²
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m ³	cubic meters	35.314	cubic feet	ft ³
m ³	cubic meters	1.307	cubic yards	yd ³
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact degrees)				
°C	Celsius	1.8C+32	Fahrenheit	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m ²	candela/m ²	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in ²

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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List of Abbreviations

Abbreviation	Term
AASHTO	American Association of State Highway and Traffic Officials
ASTM	ASTM International (International Standards Organization)
AVB	Active Vehicle Barrier
CPNI	Centre for the Protection of National Infrastructure (UK)
CTTSO/TSWG	Combatting Terrorism Technical Support Office/Technical Support Working Group (U.S.)
DHS	Department of Homeland Security (U.S.)
DoD	Department of Defense (U.S.)
DOS	Department of State (U.S.)
DOT	Department of Transportation (U.S.)
FHWA	Federal Highway Administration
IED	Improvised Explosive Device
LRFD	Load and Resistance Factor Design (FHWA)
MASH	Manual for Assessing Safety Hardware
NCHRP	National Cooperative Highway Research Program
PAS	Public Available Standard (UK)
PBIED	Personal Borne Improvised Explosive Device
PDC	Protective Design Center (USACE)
RDG	Roadside Design Guidelines
SDDC/TEA	Surface Deployment and Distribution Command's Transportation Engineering Agency (U.S. DoD, Transportation Command)
TL	Test Level (AASHTO MASH Standard)
TSA	Transportation Security Administration (DHS)
UFC	Unified Facilities Criteria (U.S. DoD)
UK	United Kingdom
U.S.	United States
USACE/PDC	United States Army Corps of Engineers/Protective Design Center
VAW	Vehicle-as-Weapon
VBIED	Vehicle-Borne Improvised Explosive Device
Volpe Center	USDOT John A. Volpe National Transportation Systems Center
VSB	Vehicle Security Barriers

Executive Summary

The Federal Highway Administration (FHWA) Office of Infrastructure is committed to assessing potential risks to U.S. highways, roadways, tunnels, bridges, and other infrastructure and providing solutions to protect these assets and the general public. In 2017, FHWA asked the John A. Volpe National Transportation Systems Center (Volpe Center) to evaluate current information and practices of United States (U.S.) and United Kingdom (UK) counterterrorism, security, and transportation government agencies, industry, and academia on vehicle security barrier (VSB) technology, standards, and implementation. Volpe Center security engineering experts carefully reviewed and synthesized available information on VSBs and systems to help inform FHWA Field Offices, State, local, and Tribal highway departments in their decisionmaking process.

This document provides an overview of publicly available documents and standards on VSB options for protecting highway infrastructure, buildings, and personnel from the high-speed impact of medium- and heavy-duty trucks and other vehicles, transportation facilities vehicle access points and their perimeters. This document is intended to help transportation agencies understand the issues and options related to VSBs, once they have completed a detailed risk assessment and identified critical transportation infrastructure as part of their overall resiliency risk management process. This primer will benefit all transportation modes (aviation, rail, pipeline, and mass transit) as owners and operators consider the resiliency of their assets and the potential of high-speed truck incidents and vehicle-borne attacks against key infrastructure and property. This document does not specifically address vehicle-as-weapons threats by terrorists or other individuals, but it does provide helpful information and a list of resources for emergency management and law enforcement officials who are responsible for protecting large crowds of people. This information may also benefit community planners and developers who are focused on improving pedestrian and bicycle safety in areas with congested traffic.

This primer offers an overview of VSBs and the risk management process. Risk management methodologies may be similar, but each organization will calculate risk differently by considering threat, consequence, vulnerabilities, countermeasures, and other limitations based on their identified infrastructure. A carefully selected VSB system can help reduce the level of risk to infrastructure and personnel. When conducting the risk assessment, an organization should identify the types of threats being addressed. Vehicle security barriers can help mitigate the risks posed by vehicles, however, the type of barrier and location where it is implemented will vary if the threat is a vehicle impact versus an explosive-laden vehicle. For explosive-laden vehicles, an additional assessment step is required to determine if the proposed solution introduces additional risk from shrapnel and debris caused by barrier location or the type of VSB selected.

1 Introduction

The 2003 Blue Ribbon Panel on Bridge and Tunnel Security convened by the U.S. Department of Transportation (USDOT) and the Federal Highway Administration (FHWA) at the request of the American Association of State Highway and Transportation Officials (AASHTO) Transportation Security Task Force documented recommendations for bridge and tunnel security. The panel offered seven overarching recommendations to reduce bridge and tunnel exposure from potential terrorist attacks. An institutional recommendation was the dissemination of information about bridge and tunnel security and cost-effective countermeasures to decisionmakers, facility owners/operators, designers, and elected officials.¹

In February 2013, the President issued Presidential Policy Directive 21 (PPD-21), *Critical Infrastructure Security and Resilience*, which included an update to the 2009 National Infrastructure Protection Plan (NIPP). This update emphasizes the complementary goals of security and resilience for critical infrastructure. The 2013 NIPPP discusses various risk management activities to reduce identified critical infrastructure exposures by increasing the security and resiliency of those assets. As defined in the Department of Homeland Security (DHS) 2010 Risk Lexicon, risk management is defined as the “process of identifying, analyzing, assessing, and communicating risk and accepting, avoiding, transferring or controlling it to an acceptable level considering associated costs and benefits of any actions taken.”²

Risk management includes measures designed to deter, detect, disrupt, and prepare for threats and hazards; reduce or eliminate a vulnerability to an accident, attack or other disaster; mitigate consequences; enable improved effective response; and enable the restoration of operations/capability as quickly as possible following the event; whether a terrorist attack, natural disaster, accident, or other incident. The risk management approach focuses attention on these prevention, protection, mitigation, response, and recovery activities that bring the greatest return on investment, not simply the vulnerability reduction to be achieved. Risk management activities may also include the means for reducing the consequences of an attack or incident, which in turn increases security and strengthens resilience by identifying and prioritizing actions to ensure continuity of essential functions and services and supports enhanced response and restoration.³

Risks are determined through an assessment process where organizations need to assign metrics to threats. Since September 2001, multiple risk assessment methodologies have been developed by industry and the Federal government to address various pieces of the increasingly complex problem of assessing risk. Risk assessments include the calculation of threats,

¹ The Blue Ribbon Panel on Bridge and Tunnel Security, Recommendations for Bridge and Tunnel Security. 2003, page 13. Available at: <https://www.fhwa.dot.gov/bridge/security/brp.pdf> [Accessed 2/26/2018].

² DHS Risk Lexicon, 2010 Edition. Available at: <https://www.dhs.gov/xlibrary/assets/dhs-risk-lexicon-2010.pdf>. [Accessed 8/27/2018].

³ NIPP 2013: Partnering for Critical Infrastructure Security and Resilience. Available at: https://www.dhs.gov/sites/default/files/publications/NIPP%202013_Partnering%20for%20Critical%20Infrastructure%20Security%20and%20Resilience_508_0.pdf. [Accessed 8/27/2018].

vulnerabilities, and consequences, with the vulnerability assessment component of incorporating mitigation measures (i.e., policies, procedures, and technologies—such as vehicle security barriers (VSBs)).

This primer provides FHWA, AASHTO members, and State/local/Tribal highway officials with a compilation of VSB information to protect critical infrastructure from the high-speed impact of medium- and heavy-duty trucks, measures to prevent these vehicles from gaining access to critical infrastructure, transportation facility vehicle access points and their perimeters. This primer is a synthesis of publicly available reports and standards in the United States (U.S.) and United Kingdom (UK). The information is beneficial to all transportation modes (aviation, rail, pipeline, mass transit) owners and operators as physical security reviews are conducted for critical infrastructure within their realm of responsibility.

This primer, though not specifically developed to address vehicle-as-weapon (VAW) threats by terrorists, will benefit emergency management and law enforcement officials responsible for developing protective measures for large crowds, as well as community planners focused on improving pedestrian/bicycle safety in congested vehicle locations.

Finally, an organization needs to remember that an individual's intent to destroy a facility or kill others with a vehicle will not follow the "rules of the road" implemented for traffic safety. One-way streets, traffic lights, grass fields, bus stops, median strips, or small single-standing trees planted along the perimeter of a facility should not be considered security mitigation measures. Instead, they could be used as a primary access route by the attacker.

1.1 Purpose and Application

This primer provides information on VSBs to help transportation organizations understand the issues and options once they have established their own risk management plan, completed the risk assessment process, and identified critical transportation infrastructure. This primer also serves as a companion document to existing guidance and standards. All resources and practices should be carefully reviewed and selected or adapted to fit the specific project needs of an agency. The agency is responsible for complying with existing Federal, State, and local statutes, policy, and regulations that apply to the implementation of material presented in this document. Adherence to transportation sector safety and government/industry best security practices is strongly encouraged.

2 Background

The National Academy of Science's Transportation Research Board, through its National Cooperative Highway Research Program (NCHRP), funded a series of reports (NCHRP Report 525: Surface Transportation Security) to help transportation organizations address security disciplines such as cyber, operational, physical, and personal. In 2009, Volume 14 of [Security 101: A Physical Security Primer for Transportation Agencies](#) was published, introducing the basic principles in the development and implementation of a physical security program. Since that document was issued, there have been advancements in security technology, standards for the verification of technology performance, explosive mixtures, as well as terrorist tactics and procedures.

The FHWA Office of Infrastructure has invested in assessing the risks and associated mitigations of highways, roadways, tunnels, bridges, and supporting infrastructures to ensure they are safe and secure. In 2017, FHWA sought the technical expertise from USDOT's John A. Volpe National Transportation Systems Center (Volpe Center) to consolidate the latest information from the U.S. and UK counterterrorism, security, and transportation government agencies, industry, and academia on VSB technology, standards, and their implementation. Volpe Center experts synthesized publicly available VSB information to assist the FHWA Office of Infrastructure, FHWA Field Offices, State, local, and Tribal highway departments gain a better understanding of VSB technology, terminology, and how they can improve the resilience of critical transportation infrastructure. The project initially focused on mitigating risks from the highway speed impact of trucks into critical transportation infrastructure. Input from the FHWA Office of Infrastructure and stakeholders expanded the synthesis to include vehicle access points of transportation facilities and perimeters. The Volpe Center was also asked to include potential options that organizations may use to address VAW attacks, which have increased in recent years.

3 Vehicle Security Barriers and the Risk Management Process

Organizations should identify the critical assets they are responsible for, which may include staff, the general public, bridges, tunnels, and operating facilities. The risk management process can be accomplished through several means. Risk assessment methods are a component of the risk management plan and process. Thus, the risk management plan should first establish what risk assessments are required. Risk assessment methodologies are similar in nature, but each methodology calculates risk differently by taking into account threat, consequence, vulnerability, countermeasures, or other parameters. The details of each component can vary among the methods, but the common core concepts shared by the various risk assessment methods are:

- **Criticality/Consequence Assessment:** Describes the criticality of the asset and the consequences of attacks on the asset.
- **Threat Assessment:** Describes the plausible threats to the asset.
- **Vulnerability/Countermeasure Assessment:** Describes the vulnerabilities of the asset and existing security countermeasures.
- **Risk Assessment:** Calculates the security risks of the asset using the results of the Criticality Assessment, Threat Assessment, and Vulnerability/Countermeasure Assessment components.

The Department of Homeland Security, Transportation Security Administration (DHS/TSA) Highway Division provides the following tools to assist the transportation sector with conducting security risk and vulnerability assessments. Additional information can be obtained through the provided e-mail.

- The **Highway Baseline Assessment for Security Enhancements (BASE)** is a voluntary, risk-based program designed to identify security vulnerabilities within the various highway transportation modes and, in turn, offers mitigation options for reducing those vulnerabilities. Contact HighwaySecurity@dhs.gov for additional information.
- The **Transportation Security Template and Assessment Review Toolkit (T-START)** provides (1) an overview of security, (2) guidance on conducting a vulnerability assessment, and (3) instructions on completing a security plan. Contact HighwaySecurity@dhs.gov for additional information.
- The **TSA Highway Bridge and Tunnel Vulnerability Assessment Reports**, issued in mid-2016, were compiled by the U.S. Army Corps of Engineers (USACE) under contract to TSA to provide ramming mitigation guidance for 95 percent of the nation's bridges and virtually all of its tunnels. The reports are classified as Sensitive Security Information (SSI) and available only on a need-to-know basis through TSA. USACE engineers identified both structural and operational vulnerabilities in the nine most common bridge construction types and all three tunnel construction types, then identified the most cost-effective mitigation approach. Threats addressed in the six-year program

included impact by vehicle or vessel, hand-held and vehicle-borne improvised explosive devices, chemicals and fire. To obtain a copy, contact TSA at HighwaySecurity@tsa.dhs.gov.

For non-transportation specific locations, additional risk assessment information is available from government agencies,⁴ i.e., DHS/FEMA,^{5,6} National Institute of Building Sciences, the New York Police Department,⁷ and security industry associations such as ASIS, International and the Security Industry Association (SIA).⁸

A vehicle can be used as a terrorist weapon either as a vehicle-borne improvised explosive device (VBIED) or as a VAW. It is more likely the vehicle will be involved in an accident, which could cause the same catastrophic damage (explosion, structural collapse, or fire) rendering the critical asset unusable or leading to the loss of life. For this reason, it is important to include all plausible threats and their consequences in the risk assessment process. VSB systems can help reduce the level of risk if the risk assessment determines that the existing risk is greater than an organization is willing to accept.

3.1 Vehicle Security Risk Overview

When determining the proper vehicle risk mitigation measure, an organization should understand that the process is similar to deciding safety mitigations. A major difference that should be considered, is that when looking from a counterterrorism perspective, an agency should consider that the vehicle operator is intentionally driving a vehicle into an area to cause as much damage and death as possible.

Safety and legal considerations should be included in the decisionmaking process to employ VSBs, particularly if it is operationally adjacent to or in proximity to a public roadway. The type of VSB selected, the desired penetration limitation of the barrier, and the maximum achievable speed of a vehicle at the point of impact could present a significant safety hazard to an errant vehicle and its occupants. Where possible, safety vehicle barriers prior to VSBs should be considered. However, in urban environments or locations with insufficient distances to implement vehicle safety barriers, the use of VSBs only may be possible.

When considering risks posed by vehicles, organizations should think about how vehicles can be used against their assets and the public. The United Kingdom Centre for the Protection of

⁴ The Whole Building Design Guide website reviews risk assessment requirements and tools. (www.wbdg.org/resources/riskanalysis.php).

⁵ Department of Homeland Security (DHS) 2012 Threat and Hazard Identification and Risk Assessment Guide. Available at: https://www.fema.gov/media-library-data/8ca0a9e54dc8b037a55b402b2a269e94/CPG201_htirag_2nd_edition.pdf. [Accessed 2/26/2018].

⁶ Federal Emergency Management Agency (FEMA). 2007. Site and Urban Design for Security: Guidance against Potential Terrorist Attacks, Risk Management Series, no. 430. Available at: <https://www.fema.gov/media-library/assets/documents/12746>. [Accessed 2/26/2018].

⁷ New York City Police Department (NYPD) 2009 Engineering Security: Protective Designs for High Risk Buildings. Available at: https://www1.nyc.gov/assets/nypd/downloads/pdf/nypd_engineeringsecurity.pdf. [Accessed 2/26/2018].

⁸ ASIS, International (2015) Standard (RA): Risk Assessment. ANSI/ASIS/RIMS RA.1-2015. Available at: <https://iapsc.org/news/ansiasisrims-ra-1-2015-risk-assessment-standard/>. [Accessed 2/26/2018].

National Infrastructure (CPNI) describes six categories of how a vehicle can be used maliciously.⁹

- **Parked:** A VBIED may be parked close to a vulnerable location.
- **Encroachment:** A hostile vehicle may be able to exploit gaps in perimeter protection, or tailgate a legitimate vehicle through a vehicle access control point.
- **Penetrative:** A vehicle may be used to weaken and/or breach a building or physical perimeter or obstruction.
- **Deception:** A hostile vehicle may be modified to replicate a legitimate vehicle (i.e., “Trojan” vehicle), or the occupants of a vehicle may provide false information to get through a staffed vehicle access point.
- **Duress:** A guard could be forced to grant hostile vehicle access, or a legitimate driver could be forced to drive their vehicle into an area.
- **Vehicle as a weapon:** A vehicle being used with hostile intent to harm people and/or damage property.

3.2 Vehicle Risk Mitigation Process

Development of technical and performance requirements is recommended for sites where protection from vehicles has been identified in the risk management process. Based on these requirements, VSB specifications can be determined. In 2014, the Combatting Terrorism Technical Support Office/Technical Support Working Group (CTTSO/TSWG), developed three resources to assist Federal, State, and local agencies, industry, and international government agencies select Power Assisted Vehicle Barriers (PAVB). CTTSO/TSWG’s [Guide to Active Vehicle Barrier \(AVB\) Specification and Selection Resources](#) incorporates expertise from across the U.S. counterterrorism community and the UK CPNI. The reference guide and additional tools specific to active VSBs are available from the CTTSO/TSWG and DHS websites. The process has been incorporated below and expanded to include passive VSBs.¹⁰

VSB selection involves identification of the best technology to meet required specifications. There are four main sections in the CTTSO/TSWG resource guide, each geared to assist users at different stages of the specification and selection processes. The four sections are:

1. **Site Planning and Design:** Introduces planning activities leading to a site design that establishes the relationship between site design and VSB selection. Performance of the listed planning activities generates information for selecting the criteria used in VSB specification and the selection processes.
2. **Determining Selection Criteria:** Presents a compilation of selection criteria that have been employed to date throughout the security and VSB industry.

⁹ Integrated Security, A Public Realm Design Guide for Hostile Vehicle Mitigation, 2nd Edition. Centre for the Protection of National Infrastructure. Crown Copyright 2014. pp 6-8.

<https://www.cpmi.gov.uk/system/files/documents/40/20/Integrated%20Security%20Guide.pdf>. [Accessed 8/29/18].

¹⁰ CTTSO/TSWG, Guide to Active Vehicle Barrier (AVB) Specification and Selection Resources (2015). Page 0-2. Available at: https://www.cttso.gov/sites/default/files/subgroup_thumbnails/PAVB%20Specification%20and%20Selection%20User%20Guide.pdf. [Accessed 11/19/2018] and <https://www.dhs.gov/sites/default/files/publications/Guide-to-Active-Vehicle-Barrier-2014-508.pdf> [Accessed 11/19/2018].

3. **Writing Specifications:** Helps structure specifications into a document that can be shared with manufacturers. A sample specification is available from the CTTSO/TSWG website.
4. **Selecting Model Specifications:** Offers a point of contact to obtain a searchable spreadsheet of model specification information available electronically from the CTTSO/TSWG website. The intent of this spreadsheet is to serve as a starting point to identify and explore AVB models and then contact manufacturers to further assess desired models. This tool provides the most benefit if used after determining selection criteria informed by detailed planning.¹¹

Selection of a VSB should be based on site conditions and results of the user, operational, performance, and technical requirements developed with stakeholders. Particular attention for general public safety and highway operations, such as safety inspections and maintenance work by highway personnel should be considered. Organizations should consult with manufacturers on current and more detailed information regarding products and available options.

3.3 Traffic Calming

The use of traffic-calming methods to reduce the maximum possible speed of a vehicle approaching access points, as well as at locations along the perimeter where a vehicle could breach a perimeter barrier system is recommended. The Institute of Traffic Engineers (ITE) and FHWA developed guidance for traffic calming for safety considerations.¹² When implementing traffic calming for security considerations, it is recommended:

- Do not rely on vertical deflections, such as through the use of raised crosswalks or speed bumps/pillows to slow a vehicle operator, whose **intent** is to destroy or kill their target.
- Horizontal deflections, such as chicanes or traffic circles **will force** the operator to reduce speed or lose control of the vehicle (i.e., roll over).

Traffic calming can be used for permanent locations or temporary events. By reducing the maximum possible speed of the vehicle by the time it reaches the vehicle access control point, or the perimeter barrier:

- The maximum kinetic energy is reduced, which may allow the use of lower rated VSB systems.
- It can allow security or law enforcement to determine if a vehicle is a threat prior to its arrival at the vehicle access control point.

Consideration must be given to improved vehicle handling and acceleration characteristics in modern vehicles, and their future improvements. These improvements are seen in all vehicle classes from small cars to heavy trucks, and allow vehicles to maneuver at greater speeds and with greater stability, which affects the distances between the horizontal deflections. Vehicle acceleration improvements will also affect the distance from the last deflection to the potential impact location.

¹¹ This information was valid when the CTTSO/TSWG was released in 2014. It will not have barrier information, which has since been tested and listed on the USACE/PDC website.

¹² ITE. Traffic Calming Measures. Available: <https://www.ite.org/traffic/tcdevices.asp>. [Accessed 3/5/2018].

An additional point in determining a traffic-calming method is assessing what class of vehicle will be allowed to travel through the barrier or device. A design that prevents or slows heavy trucks may not affect cars, versus a method designed to slow cars may prevent large box trucks, articulated trucks, busses, or first responders (such as fire trucks) from entering the area. In some cases, having designated entrances for large vehicles may be desired.

The DOT/FHWA/Office of Infrastructure/Office of Bridges and Structures can help State/local/Tribal DOTs and highway departments address vehicle risk and security concerns.

4 Vehicle Security Barrier Categories

Barriers may be natural or man-made. Natural barriers can include wetlands, fields, rivers, lakes, and forests. Man-made barriers include canals, artificial ponds, berms, trenches, bollards, walls, and fences. From a security perspective, barriers can clearly define property lines, prevent accidental access into areas, channel pedestrian and vehicles in a predictable manner, and deter, delay, or potentially stop those with malicious intent from gaining easy access to an organization's asset, such as a building, operating equipment, bridge pier, or people.¹³

There are four categories of commercially available VSBs: passive, active, arresting, and improvised.¹⁴ Each of the four barrier categories are available in fixed/permanent or portable/movable configurations. A fixed barrier is permanently installed or requires heavy equipment to move or dismantle. Examples include hydraulically operated rotation or retracting systems, pits, and concrete or steel barriers. A portable/movable barrier system can be relocated from place to place, and may require heavy equipment to assist in the transfer or may be trailer mounted. Typical examples include hydraulically operated, sled-type, surface-mounted planters, wedge or steel plate systems, highway concrete safety barriers, vehicles, or filled 55-gallon drums that are not set in foundations.¹⁵

There are variants of how each of these categories can be defined. For this primer, the following definitions are compiled from industry and government sources.

4.1 Active Barrier Systems

An active barrier requires some action, either by personnel, equipment, or both, to permit or deny entry of a vehicle. The system has some form of moving parts. Active barrier systems include barricades, wedges, steel plates, bollards, beams, and gates. Figure 1 provides an example of an active barrier system.

¹³ FEMA 430, Site and Urban Design for Security: Guidance Against Potential Terrorist Attacks (2007), Chapter 4.

¹⁴ Security Engineering: Selection and Application of Vehicle Barriers (Unified Facilities Criteria (UFC) UFC 4-022-02), 8 June 2009, Change 1, 9 August 2010. pp. 23-24. VSBs are also available in portable configuration, which may have application for organizations requiring short-term protective measures rather than permanent installation.

¹⁵ Unified Facilities Criteria (UFC). Selection and Application of Vehicle Barriers, 4-022-02 8 June 2009, Change 1, 9 August 2010. Available: https://www.wbdg.org/FFC/DOD/UFC/ufc_4_022_02_2009_c1.pdf. [Accessed 8/30/2018].

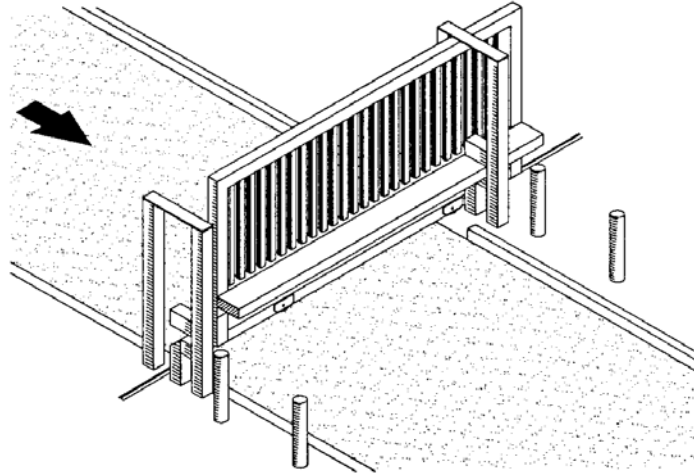


Figure 1. Illustration. Example of an active barrier system, a linear crash gate.

4.2 Passive Barrier Systems

A passive barrier has no moving parts and does not allow for vehicle entry. Passive barrier effectiveness relies on its ability to absorb energy and transmit the energy to its foundation. Highway concrete safety barriers (Jersey barriers), bollards or posts, tires, ponds, ditches, and reinforced fences are examples of passive barriers.

Passive barriers are fixed in place and do not allow for vehicle entry. These are to be used away from vehicle access points. The majority of these barriers are constructed in place.

4.3 Arresting Barrier Systems

An arresting barrier stops vehicle impacts in a quick, controlled manner minimizing potential injury to vehicle occupants. Typical arresting barrier systems are nets, entanglement systems that wrap around a vehicle's wheels, and tire shredders. These systems will allow the vehicle to travel some distance past the barrier, with the exact distance affected by several factors such as the size and speed of the impacting vehicle compared to specifications of the barrier. For example, an entanglement system that is designed to stop a personal-size vehicle may have negligible effect on a heavy truck. For vehicles equipped with "run flat" tires or heavy vehicles with multiple axle or thick rubber tires, tire shredders/puncture systems will not be effective. Figures 2 and 3 provide examples of passive and active/arresting-type barriers.



Figure 2. Photo. Passive entanglement barrier.



Figure 3. Photo. Active arresting barrier.

4.4 Improved Barrier Systems

An improvised barrier is a general category for those systems whose primary purpose is not to be used as a VSB. Examples of improvised systems include construction vehicles/equipment, large rocks, and large vehicle tires. In crisis situations, or for temporary measures, improvised barrier systems may be used, however, they may not be as effective as dedicated VSBs. Construction vehicles or first-responder vehicles may be used in a temporary situation, or deployed as traffic-calming measures in a chicane configuration. Figure 4 depicts an improvised or landscape passive VSB used to stop a large vehicle.



Figure 4. Photo. Example of passive, improvised, or landscape VSB used to stop a heavy vehicle.

Organizations should consult with Federal agencies such as DOT/FHWA/Office of Infrastructure/Office of Bridges and Structures, DHS/Transportation Security Administration/Highway Division, DHS/National Protection and Programs Directorate, CTTSO/TSWG, or law enforcement for assistance in determining the suitability of a proposed improvised vehicle barrier system.

4.5 Fixed-Barrier Systems

A fixed-barrier system is permanently installed or requires heavy equipment to move or dismantle. Examples include hydraulically operated rotation or retracting systems, pits, and

concrete or steel barriers. Fixed-barrier systems can be either active or passive. Figure 5 provides an illustration of a fixed-barrier system.

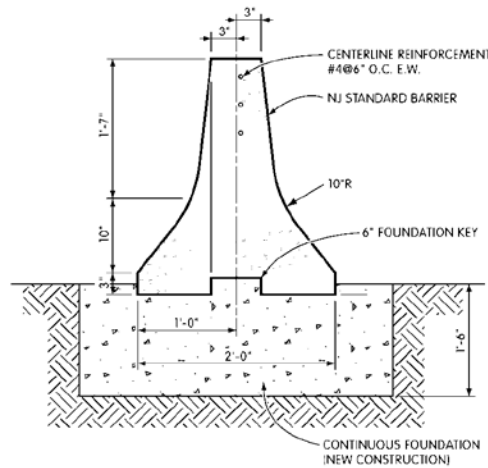


Figure 5. Illustration. Example of a fixed barrier, or precast non-reinforced concrete median.

4.6 Portable/Movable Barrier Systems

A portable/movable barrier system can be relocated from place to place, and it may require heavy equipment to assist in the transfer. Hydraulically operated, sled-type, barricade systems, highway medians, or filled 55-gallon drums that are not set in foundations are typical examples. Portable/movable barrier systems can be either active or passive. Figure 6 provides an example of a portable or movable barrier system—a maximum security vehicle steel plate barrier.



Figure 6. Photo. Example of a portable/movable active VSB.

For risks posed at vehicle access points, the use of active barrier systems is required. Passive barrier systems are used along the perimeter of a facility, which can also be used to restrict or channel pedestrian access. When mitigation measures are implemented in multiple layers, a greater risk reduction can be achieved against different types of scenarios.

5 Vehicle Security Barrier Performance Standards

For vehicle safety barriers, the performance certification testing, either through the Manual for Assessing Safety Hardware (MASH) or the National Cooperative Highway Research Program (NCHRP) 350—*Recommended Procedures for the Safety Performance Evaluation of Highway Features* standards, are at an impact angle less than 25 degrees. For highway safety barrier systems, the goal is “either contains and redirects the vehicle away from a roadside obstacle, decelerates the vehicle to a safe stop, readily breaks away or fractures or yields, allows a controlled penetration, or is traversable, without causing serious injuries to the vehicle’s occupants...”¹⁶ The purpose of a VSB is to prevent vehicles from gaining unencumbered access beyond the barrier, with the highest performance measure earned when the dynamic penetration distance of less than 1 meter with the impact angle of 90 degrees is achieved. For nearly all VSBs, with the exception of arresting barriers, vehicle occupants will sustain severe to fatal injuries upon impact, unless the vehicle is traveling at a very slow speed.

In 1985, the U.S. Department of State (DOS) Bureau of Diplomatic Security developed the first performance standard for VSB impact testing. This initial standard was updated in 2003,¹⁷ and remained the only Federal standard until DOS stopped certifying industry systems in 2009 and issued an industry standard produced by ASTM International in 2007. ASTM’s F2656 /F2656M Standard Test Method for Crash Testing of Vehicle Security Barriers was updated in 2015 and 2018. ASTM F2656 has specific criteria for cars, pick-up trucks, and medium/heavy/and cab-over trucks. ASTM F2656/F2656M is available from ASTM International for those organizations seeking additional details on the performance standard methodology.

5.1 Current Standards

ASTM F2656/F2656M-18a, and the UK’s Publicly Available Specification 68 (PAS 68)—*Impact Test Specifications for Vehicle Security Barrier Systems* are the two primary VSB performance standards currently used in the U.S. and UK, respectively. The DOS performance rating designation (K4, K8, and K12) is still used by manufacturers who had their systems certified before 2009. Federal agencies have accepted the certified ATSM F2656 results from independent, ASTM-approved testing facilities since 2008.

The U.S. Army Corps of Engineers, Protective Design Center (USACE/PDC) maintains the Unified Facilities Criteria (UFC) for DoD facilities, and is available on the Whole Building Design Guide website.¹⁸ The U.S. and UK have agreed to share VSB and other security countermeasures’ performance and operational requirements; research, development, test and evaluation (RDT&E) program information; and risk/vulnerability information. Since the early-2000s, the

¹⁶ *Manual for Assessing Safety Hardware*, American Association of State Highway and Transportation Officials, 2009. Page 1.

¹⁷ DOS standard. SD-STD-02.01, Revision A, March 2003 “Test Method for Vehicle Crash Testing of Perimeter Barriers and Gates.

¹⁸ Unified Facilities Criteria: Selection and Application of Vehicle Barriers. Available: <http://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc>. [Accessed 8/30/2018].

U.S. and UK have collaborated on the ASTM F2656/F2656M and PAS 68, which has successfully led to the establishment of ISO/IWA 14-1:2013 *Vehicle Security Barriers—Part 1: Performance requirement, vehicle impact test method and performance rating*.¹⁹ A fourth standard, CWA 16221, *Vehicle Security Barriers—Performance requirements, test methods and guidance on application*²⁰ and the ISO/IWA standards are predominately referenced in Europe and Asia. Some VSB manufacturers sell their products globally and may only test to a single performance standard.

In both the U.S. and UK, the ASTM F2656/F2656M and PAS 68 tests are conducted by industry using independent ISO-certified testing facilities. The testing facility produces a report for the manufacturer that certifies the VSB impact performance against the test standard selected by the manufacturer. When the impact tests are funded by industry, the results belong to them and can be obtained from those entities. When the Federal government funds the tests, the information and results belong to the government, which are then usually shared between the U.S. and UK's security organizations and military departments. The DoD Anti-Ram Vehicle Barrier Listing maintained by the USACE/PDC lists those systems whose manufacturers have submitted certified test reports and additional documents required and validated by USACE/PDC. The latest version of the DoD Anti-Ram Vehicle Barrier Listing is available from the USACE/PDC website and is updated quarterly.²¹

Under ASTM F2656/F2656M, barrier manufacturers are required to utilize an accredited independent testing laboratory. Laboratory accreditation must be done in accordance with ISO/IEC 17025. VSB performance certification is achieved through actual performance impact testing and is not provided based on modeling and simulation. Table 1 provides a summary of ASTM F2656/F2656M-15 impact condition designations.

¹⁹ Vehicle security barriers-Part 1: Performance requirement, vehicle impact test method and performance rating. Available: <https://www.iso.org/standard/64736.html>. [Accessed 2/27/2018].

²⁰ CWA 16221: 2010-Vehicle security barriers. Performance requirements, test methods and guidance on application. Available: <https://shop.bsigroup.com/ProductDetail/?pid=00000000030237303>. [Accessed 2/27/2018].

²¹ USACE/PDC. Available: <https://pdc.usace.army.mil/library/BarrierCertification/index.html>. [Accessed 8/30/2018].

Table 1. Summary of ASTM F2656/F2656M-15 impact condition designation.²²

Test Vehicle	Median Weight (LBS/KGS)	Impact Speed (MPH/KPH)	Kinetic Energy (FT-KIPS/KJ)	Certification Designator
Small Passenger Car (SC)	2,430 (1,100) 2,420+55 (1,100+25)	30 (50)	78 (106)	SC30
		40 (65)	131 (179)	SC40
		50 (80)	205 (271)	SC50
		60 (100)	295 (424)	SC60
Full-size Sedan (FS)	4,630 (2,100) 4,630 + 110 (2,100 +50)	30 (50)	37 (203)	FS30
		40 (65)	247 (342)	FS40
		50 (80)	387 (519)	FS50
		60 (100)	557 (810)	FS60
Pickup Truck (PU)	5,070 (2,300)	30 (50)	164 (222)	PU30
		40 (65)	273 (375)	PU40
		50 (80)	426 (568)	PU50
		60 (100)	613(887)	PU60
Standard Test Truck (M)	15,000 (6800) 26,00 – 33,000 (11,800 – 14,970)	30 (50)	451(656)	M30
		40 (65)	802 (1,110)	M40
		50 (80)	1,250 (1,680)	M50
Class 7 Cabover (C7)	15,873 (7,200) 26,000-33,000 (11,800 – 14, 970)	30 (50)	497 (673)	C730
		40 (65)	884 (1,199)	C740
		50 (80)	1,381 (1,872)	C750
Heavy Goods Vehicle (H)	60,000 (27,000) 65,000 (29,500)	30 (50)	1,950 (2,850)	H30
		40 (65)	3,470 (4,810)	H40
		50 (80)	5,430 (7,280)	H50

5.1.1.1 Penetration Limits

The ASTM standard has three distinct penetration levels: P1, P2, and P3. (The 2015 revision of the ASTM F2656 standard no longer includes the P4 designation for distances greater than 30 meters that was introduced in the initial 2007 version.) The penetration measurement rates the maximum dynamic distance, or the total distance traveled by the front edge of the cargo bed beyond the pre-impact, inside edge of the barrier. For example, a P1 designator is assigned to a barrier if the maximum dynamic penetration is 1 meter or less, whereas the P3 designator is assigned if the dynamic penetration of a vehicle’s cargo bed is greater than 7.01 meters, but not greater than 30 meters. The dynamic range is used to determine the penetration distance versus the final location of the front edge of the cargo bed as the vehicle may retract toward the initial impact location depending on the barrier type or other conditions. Table 2 provides the ASTM F2656M-15 dynamic penetration ratings.

²² ASTM, International, ASTM F2656/F2656M-15, Standard Test Method for Crash Testing of Vehicle Security Barriers. July 2015. Page 5. Adapted, with permission from ASTM F2656/F2656M-15 Standard Test Method for Crash Testing of Vehicle Security Barriers, copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

Table 2. ASTM F2656M-15 dynamic penetration ratings.²³

Designation	Dynamic Penetration Rating (ft.)
P1	<= 1 (<= 3.3 ft.)
P2	1.01 to 7.0 (3.31 to 23.0 ft.)
P3	7.01 to 30 (23.1 to 98.4 ft.)

5.1.1.2 ASTM F2656/F2656M-15 “M” Rating versus Department of State “K” Rating

From 1985 through January 2009, the Federal government used a standard developed by DOS for crash testing of VSBs. The vehicle barrier testing conducted from March 2003 through January 2009 were accomplished against the DOS standard SD-STD-02.01, Revision A, March 2003 *Test Method for Vehicle Crash Testing of Perimeter Barriers and Gates*. If the test vehicle (15,000 lbs. diesel truck) cargo bed traveled greater than 3.3 ft. (1m), the DOS did not provide a certification designation. Table 3 shows the DOS STD-02.01 versus ASTM F2656/F2656M-15 designations.

The DOS standards only addressed medium-duty trucks with a gross vehicle weight (GVW) of 15,000 lbs. The UK PAS 68 standard was the first to address other vehicle types. The 2007 release of the ASTM F2656 incorporated other vehicle types such as passenger cars, pick-up trucks, and heavy goods trucks, similar to the UK PAS 68 standard. The ASTM F2656 standard maintains the DOS SD-STD-02.01 15,000 lbs. test truck as the “Standard Test Truck” with the “M” designator.

Those vehicle barrier systems that have **not** been modified since they received the DOS certification prior to January 2009 are listed on the publicly available list maintained by the USACE/PDC and updated quarterly.²⁴ Some VSBs are not listed on the USACE/PDC list if the manufacturer has not met USACE/PDC requirements to have the barrier listed.

Table 3. DOS STD-02.01 versus ASTM F2656/F2656M-15 designations.

DOS “K” Designator	ASTM Equivalent	Sample Explanation for 30 mph Test Results Comparison K4-M30P1
K4	M30P1	15,000 lbs. (6,80Kg) diesel truck traveling at 30 mph with the front edge of the cargo bed traveling no more than 3.3 ft. (1m) beyond the back edge of the VSB.
K8	M40P1	
K12	M50P1	

²³ ASTM, International, ASTM F2656/F2656M-15, Standard Test Method for Crash Testing of Vehicle Security Barriers. July 2015. Page 6. Adapted, with permission from ASTM F2656/F2656M-15 Standard Test Method for Crash Testing of Vehicle Security Barriers, copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

²⁴ DoD Anti-Ram Vehicle Barrier List. Available: <https://pdc.usace.army.mil/library/BarrierCertification/index.html>. [Accessed 10/30/2018].

6 Vehicle Barrier Systems Characteristics

As discussed in Chapter 4, there are four general VSB categories. It is strongly recommended that organizations employ ASTM or DOS-certified systems (if that particular model has not been modified since receiving certification in 2008). This chapter provides recommendations to ensure the VSB system proposed by a vendor is certified. This chapter also provides examples of different VSBs and salient characteristics with images from vendors who have a certified system on the DoD Anti-Ram Vehicle Barrier List as of August 2018. The images and references to companies are for examples only and their inclusion or omission shall not be taken as an endorsement by the U.S. Government.

The ability of a VSB to successfully protect an area from unauthorized vehicles depends on many factors. Two critical VSB factors are the material strength of construction and how the barrier disperses the kinetic energy transferred to it from a vehicle impact. Manufactured VSBs (bollards, wedges, gates, beams, and swing arms) use steel to provide the structural strength required. The type and thickness of the steel is based on the manufacturer's design to mitigate a particular vehicle type and speed. Manufacturers may treat the steel to protect it from corrosion or have it fit aesthetically with the intended environment.

VSB height is directly dependent on the class of vehicle the barrier is intended to stop. The minimum recommended height of a VSB to stop a medium-duty truck is 30 inches, with a preferred height of 39 inches. This is measured from the road surface to the top of the VSB. In areas with sidewalks, organizations gain the benefit of the curb height when the VSB is installed near the curb edge.

6.1 VSB Foundations

Soil conditions and knowing what is under the proposed VSB location are required prior to developing the procurement specification.²⁵ The VSB foundation is a critical element of a barrier's success and its ability to stop a vehicle, and it can be deep or shallow. Typical foundations are deep, at a minimum of 48 inches, whereas shallow-foundation VSBs can range from 8 to 24 inches. Deep foundations allow for single bollards to withstand higher speeds and larger vehicle impacts. In recent years, the industry has moved toward shallower foundations to address the numerous issues associated with underground utilities in urban areas; high water tables; and land ownership or the authorization of the owner to modify the land below grade.

Shallow-foundation VSBs require greater surface area than deep foundations to achieve the same performance. In the case of bollards, where the deep foundation could be used for a single bollard, a shallow-foundation VSB with the same performance criteria would require a very large area. For example, connecting shallow-foundation bollards beneath the surface in an array and increasing the width of the concrete foundation behind the array can have the equivalent capability of a deep-foundation barrier.

²⁵ Ibid. Page 24.

Knowing the soil conditions where the foundation will be installed is important for selecting the correct VSB. VSB manufacturers can provide information on the minimum soil characteristics required for their VSB to perform properly.

6.2 Life Cycle Costs Considerations

When selecting the proper VSB, life cycle costs should be included, not just the initial acquisition and installation costs. For shallow-foundation VSBs, including the cost to replace part/all of the damaged VSB or its foundation at some point in its lifetime should be considered. The initial cost for a shallow-foundation VSB may be less expensive than a deep foundation, but the shallow foundation may fracture from minor impacts requiring replacement/repair of the foundation and VSB compared to a deep-foundation system, which may have had minimal damage under the same conditions.²⁶ The cost of preventative maintenance, such as watering and maintaining annual flowers or bushes in planters or cleaning an active barrier's components of road salt following winter, or the drains before winter should be included.

6.3 Active Vehicle Security Barriers

Active VSBs are used primarily at vehicle access control points leading into a controlled area such as maintenance yards, operations facilities, and parking garages/lots. Activation of the system is generally through security staff, electronic keypad, or badge readers. To exit the area, buried loop detectors can be used or an electronic keypad or badge reader. These options also provide an organization with an electronic log of vehicle entrance and egress. Active systems require ancillary equipment such as loop detectors, control units, and power to operate. Integration of closed circuit television (CCTV) with the electronic access control log is a physical security best practice recommendation. This assists in physical security, but provides operational safety advantages as well.

If an organization implements non-staffed access control operations, they should ensure that only one authorized vehicle passes through or over a VSB at a time. If more than one vehicle attempts to pass in a properly implemented security configuration, the following vehicle (attempting to piggy-back on the lead authorized vehicle) will be damaged and potential injury to the vehicle occupant(s) could result. The severity of damage and injuries can be affected by the speed of the vehicle at the time of impact, as well as the VSB operation. In some cases, vehicles have been destroyed and occupants severely injured due to piggy-backing. In high-risk locations, the use of multiple VSBs to create a sally port can be used to reduce the risk of following unauthorized vehicles attempting to gain access while an authorized vehicle is egressing.

6.3.1 Active Bollards

Active bollards are vertical hollow steel pipes that retract into the ground or raise/lower flush to the road surface. The effectiveness of bollard systems depends on how the system disperses the energy from the vehicle impact. VSB foundation is a critical element, whether it is a deep or shallow foundation. Actuation of the bollard can be performed through pneumatics, electrically, or hydraulically.

²⁶ CTTSO/TSWG, Guide to Active Vehicle Barrier (AVB) Specification and Selection Resources (2015). Page 39.

Active bollard systems can be configured as single or multiple bollards in an array, depending on the manufacturer and required stopping performance. Performance ratings range from M30/P1 (K4) to M50P1 (K12). Figures 7 to 9 provide examples of bollards currently in use.



Figure 7. Photo. M30P1 retractable single bollard—model J355 HA-M30 (KH).



Figure 8. Photo. M50P2 retractable 3-bollard array—NMSB VI.

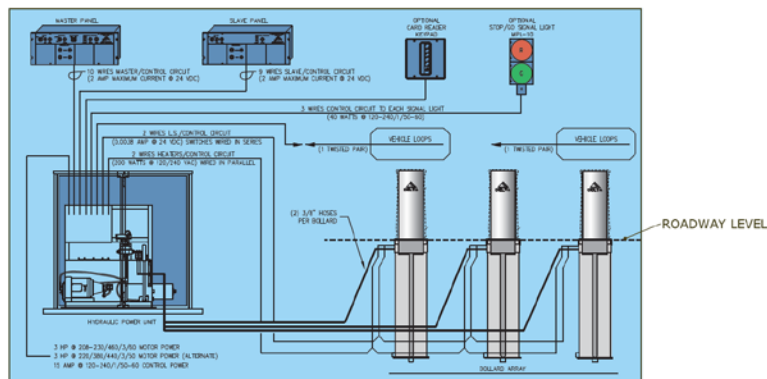


Figure 9. Illustration. Sample bollard array installation with controllers.

6.3.2 Wedges

Wedges, also called blockers in the UK or barricades in DoD UFC documentation, are active VSBs that are available in permanent (deep or shallow foundations) or mobile/portable (surface mounted or trailer) configurations with certified performance rating ranging against medium duty trucks (15,000 lbs. GVW) from M30P2 (K4L2) to M50P1 (K12).

An organization or agency should consider the type of foundation needed and what may be located underground where the wedge barrier will be installed. Typical underground issues may include utilities, high water table, etc.

The following images are courtesy of the UK CPNI. Figures 10 to 12 provide examples of deep-foundation, surface-mounted, and shallow-mounted wedges.



Figure 10. Photos. Examples of standard deep-foundation wedges.



Figure 11. Photos. Examples of surface-mounted wedges.



Figure 12. Photos. Examples of shallow-mounted wedges.



Figure 13. Photo. Delta HD300 High Security Barrier.

6.3.3 Drop-Arm Beam

Drop-arm beam barriers are similar to common parking lot vehicle control devices, with added features that categorize them as VSBs. These added features can include steel or plastic arm construction; a receptacle for the lowered arm to securely rest in; and both the arm receptacle and arm pivot points embedded or heavily bolted to a concrete pad for each end. This type of VSB can be operated manually, electrically, hydraulically, or pneumatically depending on the requirements and options offered by the manufacturer.^{27,28}



Figure 14. Photo. M30P1 active drop beam barrier—model M530.

²⁷ FEMA-430: Chapter4: Perimeter Security Design. Page 43.

²⁸ Unified Facilities Criteria (UFC). Selection and Application of Vehicle Barriers, 4-022-02 8 June 2009, Change 1, 9 August 2010. Page 47.



Figure 15. Photo. K12 Automated/manual swing arm—model DSC7000.

6.4 Passive VSB Examples

6.4.1 Wire Rope

Wire braided rope/cable systems are used in highway safety applications per the MASH standard. The comparison of MASH-approved cable barriers to ASTM F2656-07/15 certified security barriers was not conducted in preparing this primer. ASTM F2656 certified passive cable barriers are available with ratings ranging from M30P1 to M50P1/M50P3.

6.4.2 Passive Bollards

A fixed bollard is generally constructed with a half-inch thick steel wall cylinder and concrete. The diameter of the cylinder, the height of the bollard relative to the height of the vehicle the bollard is designed to stop, and the manner in which the bollard is attached to the ground are three key characteristics that will determine its effectiveness in stopping a vehicle. Bollards can be implanted in the ground by themselves or in an array, linked together above the surface or through the shared foundation. The recommended above-ground height of a bollard is 38 inches. Through proper engineering and understanding the risks at locations where VSBs will be deployed, shorter bollards may be possible.²⁹

Bollards are versatile and can be used by themselves or intermixed with other VSBs. Some bollards can be landscaped or hidden inside planters, or used in streetscapes such as bicycle racks or benches to be more aesthetically pleasing. Coverings can be provided by most bollard manufacturers to address physical appearance. The covers will not affect the bollard's ability to stop a vehicle, since the effectiveness in stopping a vehicle is the ability to transfer kinetic energy to the bollard's foundation and surrounding soil. Certified fixed bollards with barrier ratings ranging from K4-K12 to PU50 to M50 are listed in the DoD Anti-Ram Vehicle Barrier List.^{30,31}

²⁹ FEMA-430: Chapter4: Perimeter Security Design, pp. 22-23.

³⁰ Ibid. Page 23.

³¹ DoD Anti-Ram Vehicle Barrier List. Available: <https://pdc.usace.army.mil/library/BarrierCertification/index.html> [Accessed 8/30/2018].



Figure 16. Photos. Urban streetscape incorporating passive bollards.



Figure 17. Photos. Passive bollard installation. Deep foundation versus shallow foundation.

As reported in *FEMA-430, Site and Urban Design for Security: Guidance against Potential Terrorist Attacks (2007)*, guidance when deploying bollards in an urban area includes:³²

- Spacing between 36 and 48 inches depending on the kind of traffic expected and the needs of pedestrians, people with strollers and wheel chairs, and the elderly must be considered.
- In long barrier systems, bollards should be interspersed with other streetscape elements such as hardened benches, light poles, or decorative planters.
- Bollards should be kept clear of Americans with Disabilities Act (ADA) access ramps and the corner quadrants at streets.
- Bollards should be arranged in a linear fashion in which the center of the bollards is parallel to the center line of existing streets.

6.4.3 Knee Walls

A reinforced concrete knee wall barrier is a short wall that rests on a footing. The entire footing and part of the wall are embedded in soil or a crushed stone mixture. Figures 18, 19, 20, and 22 from the DoD UFC 4-022-02, updated in August 2010 represent cross sections of this type of

³² FEMA-430: Chapter4: Perimeter Security Design, page 25.

barrier.³³ Knee wall testing against medium-duty trucks has resulted in vehicles stopping within 1 meter of the knee wall. It is not known if performance testing using larger vehicles, such as the ASTM Heavy Goods categorized vehicles has been performed. The DoD Anti-Ram Vehicle Barrier List does not provide information on knee wall testing.

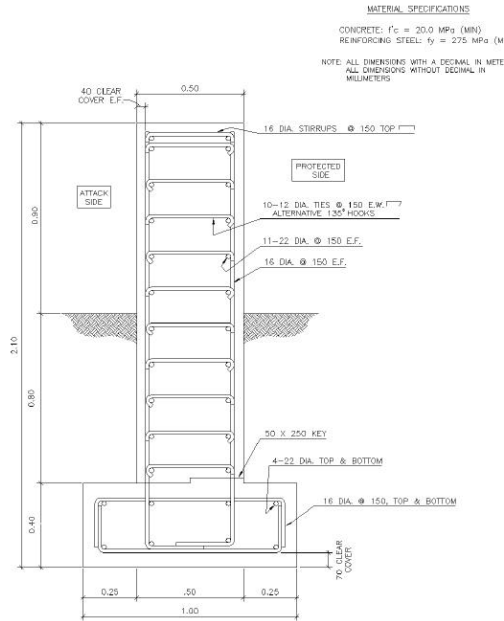


Figure 18. Illustration. Anti-ramming knee wall foundation.

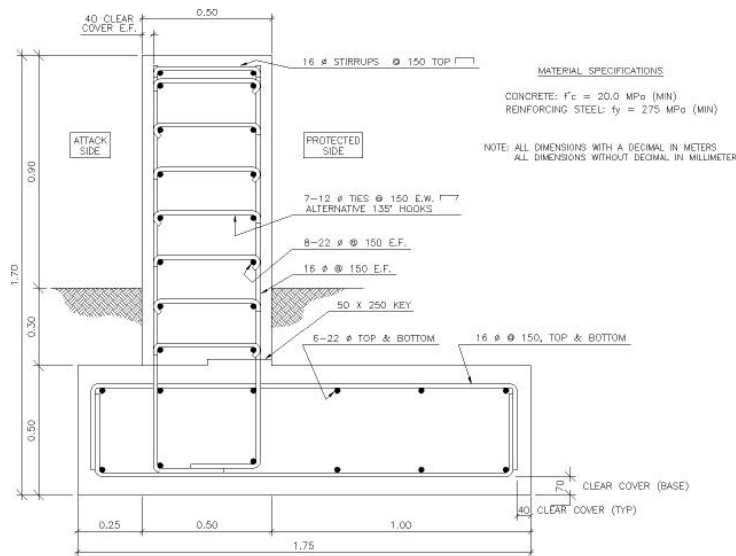


Figure 19. Illustration. Anti-ramming knee wall section.

³³ Unified Facilities Criteria (UFC). Selection and Application of Vehicle Barriers, 4-022-02 8 June 2009 Change 1, 9 August 2010, pp. 70-72.

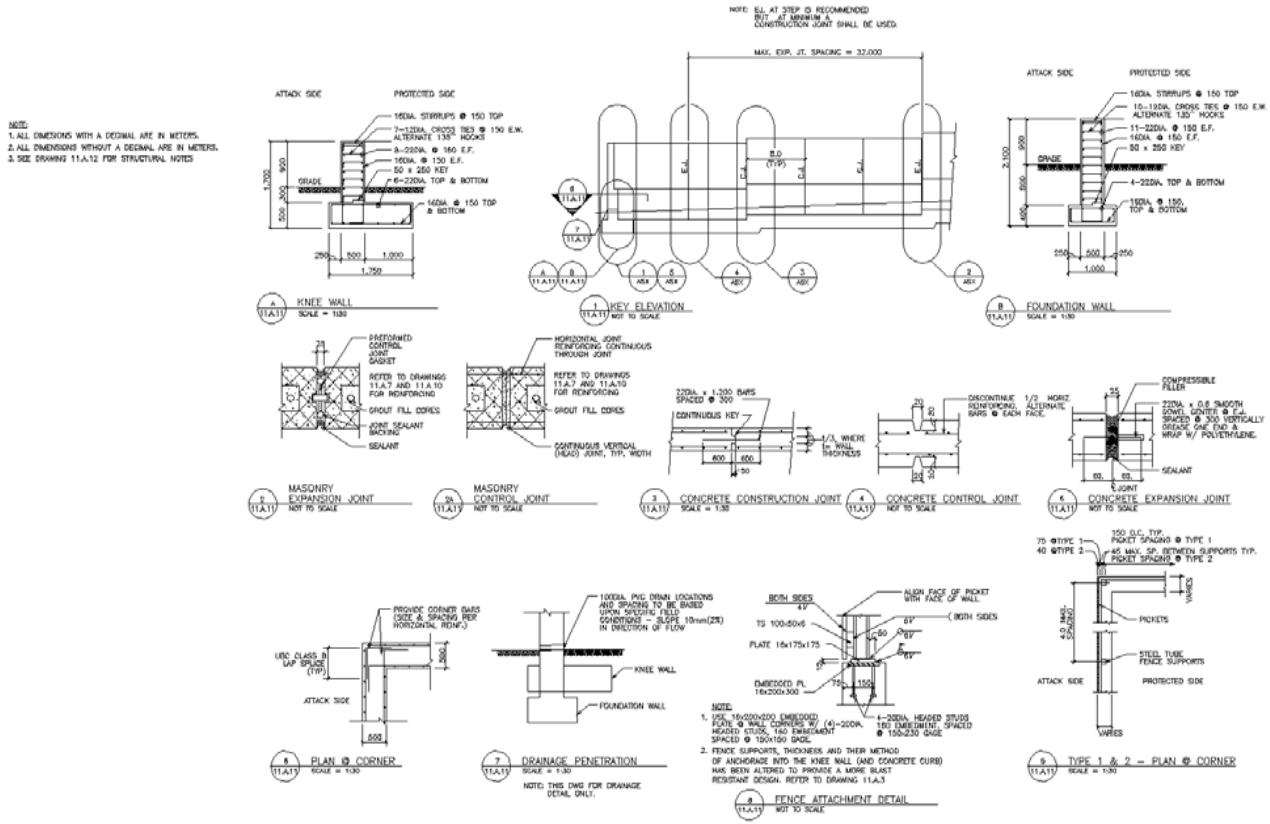


Figure 20. Illustration. Reinforced concrete knee wall details.



Figure 21. Photos. Knee wall or ha-ha wall.

6.4.4 Concrete Highway Safety Barriers

A concrete highway median (also known as a Jersey barrier) can be effectively used as a perimeter vehicle barrier, **but only if the medians are securely fastened together**. It can either be erected from pre-cast tongue-and-groove sections or cast in place with special concrete-

forming equipment. As safety barriers, they are more effective when the impact angle is less than 30 degrees, as the vehicle will be deflected back toward the direction it was traveling. Complete penetration is possible with light vehicles, however, damage to the vehicle will be extensive. If the potential impact angle from the threat vehicle is expected to be greater than 30 degrees, the safety barrier should be either anchored in a concrete foundation or sequential barriers connected to each other using a minimum of 3/4-inch steel cable.

Concrete highway safety barriers are available in different heights and widths. The type of threat vehicle and proximity to public roadways will affect the selection of the proper safety barrier for use as a VSB.³⁴

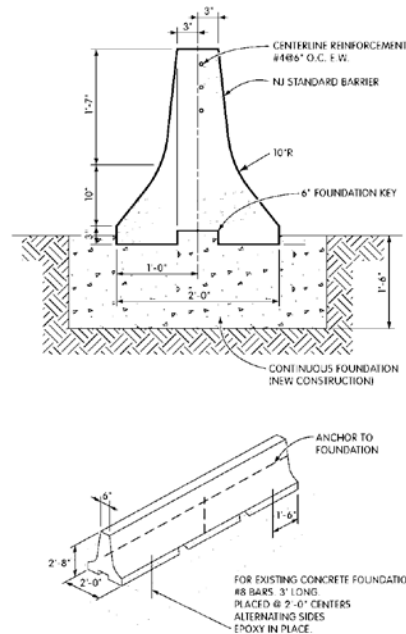


Figure 22. Illustrations. Highway concrete safety barrier—embedded.

Figure 23 shows the results of a 30 mph impact test conducted by the USAF Force Protection Battlelab in the early 2000s. In similar 50 mph impact tests, the vehicle penetrated 20 feet and sustained heavy damage. It was observed that vehicle occupants would have been seriously or critically injured in a similar impact.³⁵

³⁴ Pages 56-57 of UFC-4-022-2.

³⁵ Ibid.



Figure 23. Photos. 2003 USAF and DOS test conducted at 30 mph versus original DOS standard.

During the vehicle barrier test, a section of the barrier was broken and overturned. These barriers should be set in a concrete foundation, as shown for applications where the impact angle exceeds 30 degrees. The barriers should also be securely tied together to be effective.³⁶

Concrete barriers in larger configurations have been used by the DoD and other organizations to protect facilities from large vehicle and VBIED attacks. Effective results were obtained by placing packed soil on the protected side and grading it appropriately to minimize erosion and the need to stabilize. Figure 24 shows an example of a concrete barrier with packed soil on the protected side.³⁷



Figure 24. Photos. Heavy goods vehicle performance test.

6.4.5 Inertial (Sand/Earth Filled)

Barrier systems have been developed that use local soil to provide an effective VSB. Systems range from boxes similar to ISO shipping containers that are built up in a corrugated, compartment-style configuration, to large fabric bundles that are stacked on top of each other (Figure 25). The design basis threat (DBT) determines the mass needed to stop a designated truck. This is accomplished by building the barrier to the needed height and width, providing the required mass to stop a vehicle.

³⁶ Ibid.

³⁷ These tests, as well as the inertial VSB tests, conducted in 2006 by CTTSO/TSWG were used to develop the ASTM F2656 Heavy Goods vehicle test criteria, so no certifications were provided to the VSB manufacturers from these tests.



Figure 25. Photos. Earth-filled barriers versus heavy goods truck performance test.

Extensive tests have been conducted on inertial barrier systems since the 1990s by the U.S., UK, and industry to improve performance and maintainability. With some barriers, government testing and operational usage have shown that specific products successfully protected assets from flooding and explosive blasts.

6.4.6 Safety Barriers—Sand or Water Filled

Sand-filled and water-filled VSBs are commonly used on highways and in municipal settings. These safety barriers have been tested against truck impacts by U.S. and UK security and military organizations for security applications. These safety barriers have been tested in single rows connected with wire rope, in a triangle formation with increasing mass of barrels progressing from the attack side toward the protected side, and other configurations.

Sand-filled highway safety barrels were tested using a standard truck traveling at highway speed. The truck suffered only minor damage and was halted using the test facilities remote braking feature. Water-filled barriers have been tested against standard trucks traveling at highway speeds, and are ineffective in stopping the vehicles. No formal PAS68 or DOS certification was provided from the tests conducted in 2004, and no information has been found showing these systems are effective against trucks operating in a hostile manner traveling at highway speeds or greater. The significant difference in performance between highway safety barriers and inertial VSB discussed earlier is the effective mass differences between the barrier systems.

Safety barrels placed in front of VSBs along the perimeter or leading up to a vehicle access point may assist in slowing non-hostile vehicles and reducing potential life-threatening injuries to the occupants versus impacting the VSB at higher speeds.



Figure 26. Photos. Sand-filled highway safety barrels—pre- and post-test against medium-duty truck.

6.4.7 Planters

Planters can be effectively used as VSBs and as traffic-calming devices when properly engineered. There are many variables that need to be addressed when selecting planters as VSBs. A planter can be surfaced mounted, installed a few inches below the surface, or used to conceal bollards. Planters can be integrated into streetscape along sidewalks, incorporated into a knee wall, or used to break up a continual line of bollards along a perimeter.

Organizations should consider maintenance costs associated with planters, as well as vegetation in the planter. Costs for the vegetation, ensuring water properly drains from the planter, particularly in regions where freezing occurs, are commonly overlooked items.

Individual planters mounted on the sidewalk resist impact through inertia and friction between the planter and the pavement. Increasing friction by roughing the ground surface or selecting a high-friction material for the base of the planter are two options to reduce movement of surface-mounted planters. Given the mass of a planter or multiple planters in the same area, organizations should consider underground utilities and any structural issues. For a successful design, the maximum displacement of the planter should be less than the setback distance to the building.³⁸

A plinth (base of a platform) or a raised, reinforced planter wall can be placed as close as possible to the curb, are other possible passive barriers. The walls must extend beneath the grade; existing below ground site conditions need to be considered. If curbside parking is allowed, at least 18 inches of space is needed to open a vehicle door. According to the SDDCTEA Pamphlet 55-17 Better Military Traffic Engineering³⁹ and MUTCD/AASHTO Roadside Design

³⁸ FEMA 427, Primer for Design of Commercial Buildings to Mitigate Terrorist Attacks (2003), pg. 6-3. Available: <https://www.fema.gov/media-library/assets/documents/2171>. [Accessed 8/30/2018].

³⁹ Traffic and Safety Engineering for Better Entry Control Facilities, 2014. Available: https://www.sddc.army.mil/sites/TEA/Functions/SpecialAssistant/TrafficEngineeringBranch/Pamphlets/SDDCTEA_Pamphlet_55-15.pdf. [Accessed 8/30/2018].

Guide,⁴⁰ however, at least 24 inches should be allowed. Consideration for pedestrian access and compliance with ADA regulations should be included in the selection process.

A reinforced concrete planter barrier is shown in Figure 27.⁴¹ Testing conducted in the early 2000s using the DOS standard achieved a K12 (15,000 lbs. medium-duty truck impacting at 50 mph, with less than 1 meter of penetration from the inside edge of the planter). Multiple vendors offer planters as VSBs. The DoD Anti-Ram Vehicle Barrier List does not include planters as VSBs.

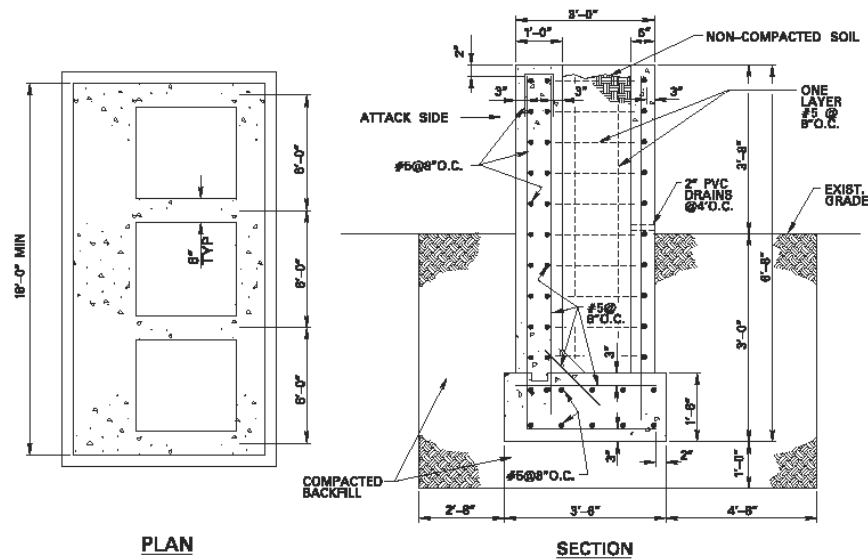


Figure 27. Illustrations. Reinforced concrete planter.

In 2009, the New York City Police Department released a document for their jurisdiction to help prevent and mitigate terrorist actions. They discouraged the use of planters as VSBs citing concerns for first responders to quickly access areas, as well as occupants fleeing an area. They also mentioned fragmentation during an explosion, which can cause injuries as an additional concern.⁴² The DHS and DoD do include surface-mounted planters as a viable mitigation measure.

6.4.8 Post and Beam

Passive post and beam rated VSBs are used along extended perimeters as sections of the barrier can be long. For those provided in the August 2018 DoD Anti-Ram Vehicle Barrier List, the length ranged from 142 to 492 ft. between the two end posts. To achieve these long lengths, barrier manufacturers integrate steel cables through the rails. The barrier and penetration ratings for these types of VSBs range from M301 to M50P1, depending on the vendor.

⁴⁰ FHWA, *Manual on Uniform Traffic Control Devices*. Available: <https://mutcd.fhwa.dot.gov/>. [Accessed 8/30/2018].

⁴¹ Page 59 of UFC-4-022-2.

⁴² Engineering Security: Protective Design for High Risk Building, New York Police Department. 2009. Page 35.



Figure 28. Photo. Post and Beam.



Figure 29. Photo. M50P1 Post and Beam model Ross-XL-501.



Figure 30. Photo. Sample beam multi-strand wire cable interior.

6.5 Arresting Systems/Entanglement Systems

The purpose of an arresting barrier is to stop the impacting vehicle in a controlled manner, minimizing potential injury to vehicle occupants. Typical systems are vertical nets designed to capture the vehicle, or horizontal nets designed to entangle wheels and axles. There are available systems that allow the vehicle to travel some distance past the barrier. There are also ASTM F2656/F2656M-15 M50P1 certified systems, with the exact distance affected by several factors such as the size and speed of the impacting vehicle compared to specifications of the barrier. An entanglement system designed to stop a passenger vehicle may have negligible effect on a heavy truck.



Figure 31. Photo. Active arresting barrier.

6.6 Landscape Designed Barriers

Natural barriers, such as lines of mature trees, canals, ponds, ditches and berms, soft sand, multi-level terraces, and large rocks are acceptable types of Crime Prevention through Environmental Design (CPTED). CPTED is defined as “the proper design and effective use of the environment can lead to a reduction in the fear of crime and the incidence of crime to an improvement in the quality of life.”⁴³ Application of CPTED can help improve access control, reduce crimes such as assaults and vandalism, and clearly define perimeter borders while impeding or preventing vehicles or pedestrians from accessing a controlled area. The following sections focus on approaches suitable for preventing unencumbered vehicle access or denying vehicle access using landscaping. Additional information on the application of CPTED principals is available from Federal agencies such as DHS and the Justice Department/National Institute of Justice, and the UK CPNI website; and security industry associations such as ASIS International and the International CPTED Association.

6.6.1 Berms and Trenches

Berms and trenches have been used to protect the perimeter of facilities by military organizations and villages for thousands of years. Military organizations developed berms and trenches to prevent or delay infantry, horse-mounted troops, or armored vehicles from breaching a perimeter. In some cases, these designs have not changed. Berm and trench designs were tested again during the mid-2000s by the U.S. military and UK government using sport utility vehicles (SUVs). The following conclusions were determined from the UK tests:⁴⁴

- Asymmetric V-shaped ditches with an inclined angle greater than 65 degrees and a total width and depth equal to or greater than 5 and 1.2 meters, respectively, were able to stop the SUV test vehicle.
- The approach terrain on the attack side of the ditch should not have any incline or spoil, and preferably should have a slight decline.

⁴³ Dr. C. Ray Jeffery, ASIS 2016 Annual Symposium, Session: Encompassing Effective SPTED Solutions in 2016 and Beyond. September 4, 2016. Dallas, TX.

⁴⁴ UFC 4-022-02 Selection and Application of Vehicle Barriers, with Change 1. Available at: <https://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc/ufc-4-022-02>, pp. 60-62. All-terrain vehicles and sport utility vehicles were the focus of these tests. [Accessed 8/27/2018].

- Ditches will stop a fast vehicle attack provided the vehicle drops more than 75 percent of its wheel diameter in the space provided.
- Trapezoidal ditches should be avoided in general due to a concern that a vehicle can drive in and out of the ditch in a slow attack.



Figure 32. Photo. Anti-vehicular ditch with berm.

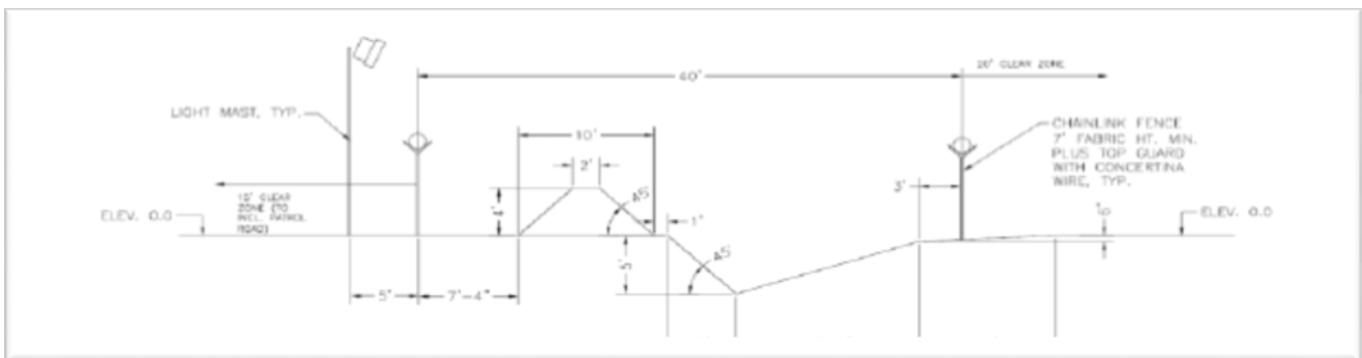


Figure 33. Illustration. Anti-vehicular ditch profile with incline slope requiring stabilization.

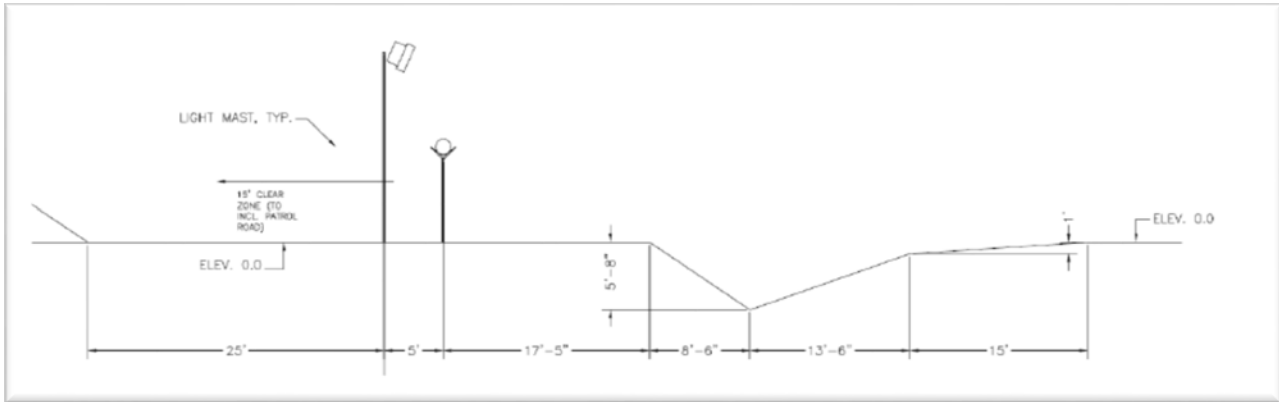


Figure 34. Illustration. Anti-vehicular ditch profile with maximum incline slope not requiring stabilization or berm.

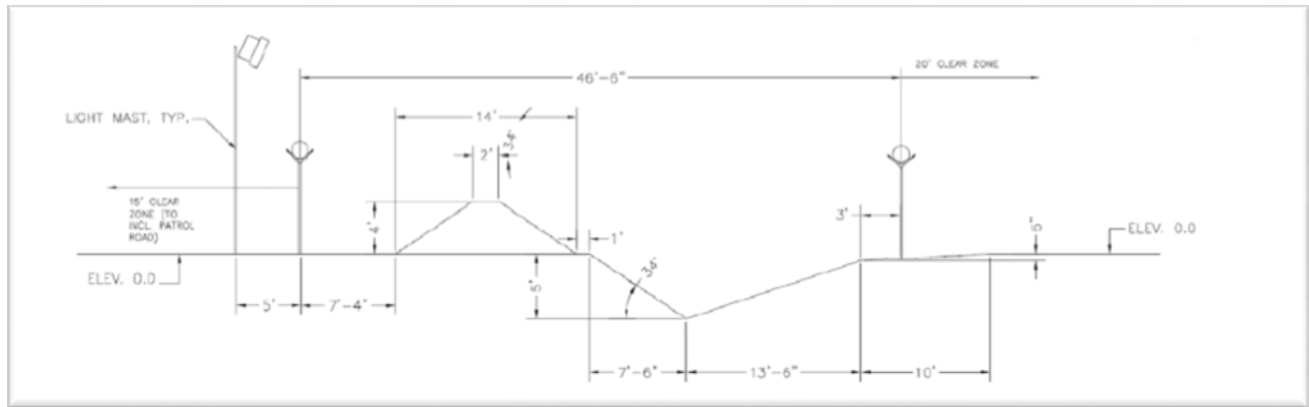


Figure 35. Illustration. Anti-vehicular ditch profile with maximum incline slope not requiring stabilization.

The UK tests were not part of a comprehensive design project for anti-vehicular ditches that allowed the ditch profile to be optimized based on both resistance to moving vehicle attack and practical construction considerations. The U.S. Navy Facility Engineering Center used observations from the UK tests to develop three sample profiles (Figures 33-35) to protect facilities against high-speed attacks as well as low-speed incursions by all-terrain vehicles and SUVs.

The primary differences are the angles coming out of the trench in Figure 33 (45 degree slope) versus Figure 35 (34 degrees). The 45 degree slope provides the greatest challenge to a vehicle attempting to climb over, but it requires material such as concrete riprap or sand bag covers to prevent the soil from flowing down into the bottom of the trench. The 34 degree angle does not require additional material to prevent the soil from falling back into the trench on its own, however, additional vehicles may be able to climb up to the protected side. Including the berm increases the difficulty in both cases. Erosion and maintenance of the proper angles on the protected side will need to be addressed based on local conditions. Based on work the UK CPNI

conducted, their recommendation is a 50 degree positive angle with a minimum height of 49.21 inches, as this will defeat the greatest number of all-terrain vehicles.⁴⁵

6.6.2 Rocks

Large rocks can be integrated into the streetscape as shown in Figure 36, or they may be placed linearly along the perimeter. Rocks, independent of their size, should be embedded into the surface. This will prevent them from being pushed out of the way by slow-speed vehicles and help prevent the rocks from moving if impacted by high-speed vehicles.



Figure 36. Photo. Large rocks integrated with bollards in recreational area.

6.6.3 Tiger Trap

The tiger trap barrier is a section of ground designed to collapse when sufficient weight is placed on it, dropping far enough to prevent whatever caused the ground to collapse from getting out. For VSB applications, a system can be designed to allow pedestrians to walk on the area, but collapse if a vehicle is present. Similar systems have been designed and installed at the end of airport runways to stop aircraft from leaving the tarmac. For VSB applications, tests were conducted by the USACE on certain designs and produced results approximately equivalent to the DOS K12 standard.⁴⁶ This type of VSB presents risks to any vehicle, such as utility trucks, highway maintenance vehicles, and first responders as the ground could collapse as well.⁴⁷

6.7 Improvised Barrier Systems

Improvised VSBs using highway construction trucks have had limited testing. Based on the testing completed under the CTTSO/TSWG program from 2004-2008, highway construction vehicles were effective in preventing a single high-speed standard test truck (GVW 15,000 lbs. at 50 mph) from driving beyond the primary impact location. The impact from the attacking truck caused the barrier vehicles to be moved from their initial locations. The use of large

⁴⁵ UFC 4-022-02 Selection and Application of Vehicle Barriers, with Change 1, page 63. Available: <https://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc/ufc-4-022-02>, [Accessed 8/30/2018].

⁴⁶ Ibid. Chapter 4. Page 46

⁴⁷ Ibid. Chapter 4. Page 46.

vehicles is a visual deterrent, helping reduce the speed of an attacking vehicle. Vehicles attempting to impact barrier trucks provide a clear indicator of individual intent, which can allow for law enforcement and first responders to act accordingly. Figures 37 to 39 provide some examples of highway construction vehicles used as improvised VSBs.

Organizations concerned about VBIED attacks should contact DOT/FHWA/Office of Infrastructure/Office of Bridges, CTTSO/TSWG, DHS/NPPD, or respective Joint Terrorism Task Force (JTTF) for guidance prior to deploying vehicle improvised barriers. The UK has conducted performance testing with a variety of wheeled vehicles as improvised barriers. Based on these tests, UK CPNI does not recommend the use of vehicles as VSBs.⁴⁸



Figure 37. Photos. Two dual-axle highway vehicle barrier heavy goods truck performance test.



Figure 38. Photos. Dual-axle highway vehicle barrier standard test truck performance test.

⁴⁸ Conversation held April 2017 with CPNI-Volpe Center.



Figure 39. Photos. Single-axle highway vehicle barrier standard test truck performance test.

7 Lessons Learned and Best Practices

The following information comprises lessons learned and recommended best practices from multiple government agencies and industry. Additional information is available in the [Guide to Active Vehicle Barrier \(AVB\) Specification and Selection Resources](#).

7.1 Factors Affecting Expected Performance

The operational performance of a VSB can be adversely affected depending on several factors, ranging from poor preventative maintenance or installation, impacts (either accidental or intentional), and sabotage (via cyber, mechanical, or explosive means).

- If a barrier is attacked by an explosive or mechanical device, its effectiveness will not be the same had the barrier been protected. If the barrier is attacked by any size explosive charge or mechanical attack, its effectiveness will not be equivalent had the barrier been protected. When systems are fielded, it is important that measures are taken to prevent items from being placed against/adjacent to the VSB.
- Organizations should determine how they will maintain surveillance (either through security/guard force or CCTV) on the VSB during the mitigation selection phase of their risk management process.
- If an explosive device is used such as an improvised explosive device (IED), VBIED, or PBIED placed against the VSB; or a vehicle impacting a VSB (regardless of the vehicle speed), the structural integrity of the barrier will be compromised and should be inspected/replaced as soon as possible.

7.1.1 Explosive Threats

- If an organization's threat concern is an explosive versus ramming attack or complex attack (such as multi-vehicle either VBIED/VAWs, VBIED, or VAWs with active shooter or secondary/tertiary IEDs located at pedestrian/evacuation choke points and first responder incident command locations) organizations are encouraged to consult their Federal/State/local bomb-disposal units, DHS/Office of Bomb Prevention or National Protection and Programs, or states Joint Terrorism Task Force (JTTF) for support.
- All VSBs are affected by explosives, but they will behave differently and have different risks. When assessing the risk caused by an explosive event, an additional step in the risk assessment process is recommended.
- In the event of an attack and explosion, debris from the barriers may become high-speed projectiles depending on the size of explosive charge, the type of explosives used, and the distance between the explosion and the VSB.
- The effectiveness of the VSB will be significantly reduced when it is directly exposed to an explosion. If the VSB is dislodged from its location, it may become part of the debris field where it could impair penetration into the protected area and impede first responder vehicle access to the area.

7.2 VSB Selection

For organizations focused on medium- and heavy-goods vehicles operating at highway speeds or above, ASTM M50, C750, or H50 are the certified systems rating that correspond to that requirement. VSBs certified at lower speeds will affect the vehicle's ability to operate, but the distance the vehicle will continue to travel is unknown. CTTSO/TSWG conducted performance tests in 2006 of a heavy-goods vehicle impacting a DOS-certified K12 active wedge barrier at 50 mph. The VSB stopped the truck as designed, but the cargo bed penetrated a considerable distance beyond the VSB (Figure 40).



Figure 40. Photo. Heavy goods truck post-impact with K12 active wedge VSB.

- Tire shredders should not be considered vehicle barriers. They are available in small, portable systems that are commonly used by law enforcement. These devices are normally used for traffic-control purposes and are designed to slow or stop a vehicle by deflating the tires. These systems may also not be effective against modern “run flat” tires, heavy-duty truck tires, or extra-wide tires that can bridge over two or more spikes. Tire shredders have a very limited capability to stop a vehicle.⁴⁹

7.3 Site Installation

The selection and implementation of VSBs should be based on local conditions and is beyond the high-level guidance provided in this primer.

- The placement of approved highway safety barriers to deflect errant vehicles away from the VSB along roadways or a location's perimeter; traffic calming leading up to vehicle access point; or an arresting vehicle device may be desired in locations where there is significant probability of an accidental impact to the VSB. Measures should be taken to reduce the kinetic energy of a vehicle as much as possible prior to reaching the VSB.
- Security best practice provides layers of protection so that the outer and inner layers of a barrier will still be able to delay or repel a hostile/terrorist act, giving law enforcement and first responders time to respond and enable individuals who may be in danger to seek shelter or safely evacuate the area.
- Key components in the effectiveness of VSBs are the foundations and soil conditions.

⁴⁹ See UFC-022-2, Page 66.

- Frictional coefficients of VSB and surrounding road surface are equivalent for all local weather conditions to ensure motorist (motorcycle, automobile, and trucks), bicyclists, and pedestrians do not increase safety risks.⁵⁰
- Information cited in several of the references used for this primer provide safety recommendations to consider when implementing/installing barriers.
- In some locations, there is no standoff between roadways and critical infrastructure, such as the bridge piers depicted on the cover of this primer. If a risk assessment determined that mitigation is required, the bridge piers and surface area under the bridge structure should be easier to protect than the bridge piers adjacent to the roadways. Locations such as these should be considered with safety, security, and highway operation organizations working collaboratively to develop an approach to address highway safety and protect critical infrastructure from anticipated hazards and risks.
- Highway operations should be involved when determining protective measures, such as VSBs, to ensure the implementation of security risk countermeasures do not adversely impact safety operations, such as the ability to conduct safety inspections or preventative maintenance, or repositioning of highway assets during special events.

7.4 Contracts

- It is recommended that organizations investing in VSBs, verify that the systems selected have successfully concluded independent performance testing against the ASTM F2656/F265M or the other VSB performance standards stated in Chapter 5.
- Contracting officers should require in Requests for Proposals that responding vendors provide copies of the independent testing facilities performance rating findings.
- In performing market surveys, organization should contact vendors for further information if they state a VSB has been tested according to the ASTM F2656, versus receiving a certified performance rating based on ASTM F2656.
- Modeling and simulation results may not provide the equivalent performance results of actual ASTM F2656 testing. Organizations should rely on certified performance impact test results only.
- DOS has not certified industry VSBs against their standard since early 2009.
- The General Services Administration (GSA) offers VSBs under [Schedule 84, Category 246 35 1, Physical Access Control Systems \(PACS\)](#), which is available to Federal, State, local, and Tribal government acquisition personnel. The GSA has an involved process to review vendors and the vendor's products and/or services. Some vendors offer discounted

⁵⁰ Retractable Vehicle Security Barriers. Maintaining Road Surface Friction. Available: <https://www.cpni.gov.uk/system/files/documents/50/05/Retractable%20Vehicle%20Security%20Barriers%20-%20Maintaining%20Road%20Surface%20Friction.pdf>. [Accessed 8/30/2018].

prices through the use of the GSA schedule, but may offer additional services, which are not listed on the GSA schedule.

- It is recommended that the GSA schedule be reviewed as part of the market survey process to identify vendors and needed VSB systems, training, maintenance, and repair services.
- Before selecting a particular VSB system, it is recommended that organizations investigate if the manufacturer has a local Valued Added Reseller or other representative in the area where the organization is looking to place the system.
- Organizations should consult with their physical security and access control vendors to determine what active VSB systems may be integrated into the organization's existing physical security system and if remote operation capability is available.
- DHS/FEMA offers a standardized equipment list that organizations may use with FEMA-related grant programs to acquire VSBs. This list does not contain specific vendors, but a category under which allowable equipment could be procured.
- For VSBs, the applicable subcategory is 14SW-01-WALL. The following link will provide a listing of the applicable grant programs. Organizations are encouraged to contact their State's DHS/National Protection and Programs Directorate representative for further assistance <https://www.fema.gov/authorized-equipment-list-item/14sw-01-wall>.

8 DHS Grant Recommendations

The DHS-approved equipment list website provides the following information on VSBs:

<https://www.fema.gov/authorized-equipment-list-item/14sw-01-wall>

14SW-01-WALL—Barriers: Fences; Jersey Walls

Description: Obstacles designed to channel or halt pedestrian or vehicle-borne traffic in order to protect a physical asset or facility.

Grant Notes: Grantees should leverage private assets where appropriate when implementing security enhancements at privately owned critical infrastructure facilities.

FEMA-Related Grant Programs:

- Emergency Management Performance Grants (EMPG)
- Intercity Bus Security Grant Program (IBSGP)
- Port Security Grant Program (PSGP)
- State Homeland Security Program (SHSP)
- Tribal Homeland Security Grant Program (THSGP)
- Transit Security Grant Program (TSGP)
- Urban Areas Security Initiative Program (UASI)
- Amtrak-(IPR-Amtrak)
- Nonprofit Security Grant Program (NSGP)

Organizations should contact their State or local DHS NPPD or TSA office to determine the requirements, eligibility, and procedures. To receive copies of the certified test reports, the VSB manufacturer has to be contacted. Some manufacturers may provide letters from the independent testing facility stating that the findings of the performance test as the actual test report may contain proprietary information. Testing facilities may not be able to provide test result information of a particular manufacturers' VSB due to the contract between the testing facility and the manufacturer.

9 DHS Risk Assessment Resources and Guidelines

Training and Other Resources

- *First Observer/First Observer Plus* is a security domain awareness video training program focusing on delivery of a simple message to highway transportation professionals to “Observe, Assess, and Report” suspicious activities. See <http://tsa.gov/firstobserver> for more information.
- *Counterterrorism Guides* are intended to provide an awareness of specific issues that should be considered when developing and implementing your organization’s security plan. Contact HighwaySecurity@dhs.gov for more information.
- *Intermodal Security Training & Exercise Program (I-STEP)* provides exercise, training, and security planning tools and services to the transportation community. Contact HighwaySecurity@dhs.gov for more information.
- *Exercise Information System (EXIS)* is an online exercise tool that provides users with resources to design, document, and evaluate exercises for all transportation modes. See <http://exis.tsa.dhs.gov> for more information.
- *TSA Surface Transportation Cybersecurity Resource Toolkit for Small and Midsize Business (SMB)* is a collection of documents designed to provide cyber risk-management information to surface transportation operators. Contact TSA-Surface@tsa.dhs.gov for more information.

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The *Highway Baseline Assessment for Security Enhancements (BASE)* is a voluntary, risk-based program designed to identify security vulnerabilities within the various highway transportation modes and, in turn, offer mitigation options for reducing those vulnerabilities. Contact: HighwaySecurity@tsa.dhs.gov.

The *Transportation Security Template and Assessment Review Toolkit (T-START)* provides (1) an overview of security, (2) guidance on conducting a vulnerability assessment, and (3) instructions on completing a security and emergency plan. Contact: HighwaySecurity@tsa.dhs.gov.

First Observer Plus is a security domain awareness training program focusing on delivery of a simple message to highway transportation professionals to “Observe, Assess, and Report” suspicious activities. Available: <http://tsa.gov/firstobserver>. [Accessed 11/19/2018].

The *DHS Vehicle Ramming Attack Mitigation Video* provides information to assist with mitigating the evolving threat corresponding to vehicle ramming incidents with insightful technical analysis from public and private sector subject matter experts. It leverages real-world events, and provides recommendations aimed at protecting organizations as well as individuals against a potential vehicle ramming incident. Available: <https://www.dhs.gov/human-resources-or-security-professional>. [Accessed 11/19/2018].

Counterterrorism Guides are intended to provide an awareness of specific issues that should be considered when developing and implementing your organization’s security and emergency plan. Contact: HighwaySecurity@tsa.dhs.gov.

Intermodal Security Training & Exercise Program (I-STEP) provides exercise, training, and security planning tools and services to the transportation community. <https://www.tsa.gov/for-industry/intermodal-security-training-and-exercise-program>.

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Appendix A: Department of Defense Anti-Ram Vehicle Barrier List

USACE/PDC maintains a list of ASTM and/or Department of State-certified vehicle barrier systems that have been provided by the vehicle security barrier manufacturer following testing at an ISO-approved testing facility. The complete list is available from the [USACE/PDC public website](https://pdc.usace.army.mil/library/BarrierCertification/index.html). NOTE: Certificate errors and warning messages from your workstation may be encountered due to the manner that the USACE/PDC designates its website. (<https://pdc.usace.army.mil/library/BarrierCertification/index.html>)

The DoD Anti-Ram Vehicle Barrier List provides the following information based on information provided by the VSB manufacturer:

- Type of barrier
- Manufacturer and model number
- Special conditions or notes, i.e., 3-bollard array or single bollard
- Rating obtained
- Manufacturer website

Appendix B: Guide to Active Vehicle Barrier (AVB) Specification and Selection Resources

The Combatting Terrorism Technical Support Office/Technical Support Working Group (CTTSO/TSWG), developed the [Guide to Active Vehicle Barrier \(AVB\) Specification and Selection Resources](#). This guide provides information to help engineers, policy makers, security managers, intelligence analysts, and other security/safety professionals successfully determine Active Vehicle Barrier (AVB) specifications and select appropriate AVB models for a site requiring restricted access. The Department of State/Bureau of Diplomatic Security AVB specification template is presented below, and can be obtained from the CTTSO/TSWG or DHS websites. The State Department template can be for passive vehicle security barriers by modifying or excluding applicable sections.

Additional resources include:

- [Power Assisted Vehicle Barrier Specification and Selection Guidance Tool](#).
- [Specification Template Compilation](#).
- [Active Vehicle Barrier Selection Tool](#).