Traffic Engineering & Highway Safety Bulletin

Military Surface Deployment and Distribution Command Transportation Engineering Agency
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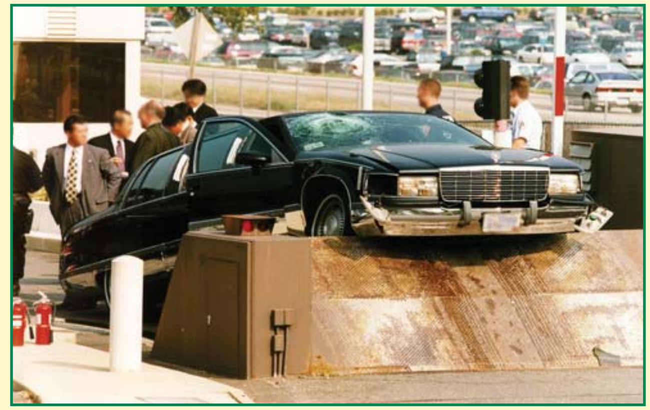
Special Edition – Priority Topic
Safety Requirements at Active Vehicle Barriers

Entry Control Facilities and Access Control Points

Purpose and Priorities

The objective of an entry control facility (ECF) or access control point (ACP) is to secure the installation from unauthorized access and intercept contraband while maximizing vehicular traffic flow and overall safety. Thus, ECF/ACP designs and operations must consider security, safety (of motorists and guards), traffic flow, and aesthetics.

- **Security** - Security elements must consider various threat scenarios and maintain perimeter security for the installation. An ECF/ACP must accommodate random antiterrorism measures (RAM) as identified by security forces.
- **Safety** - Safety measures such as retroreflectorization, impact attenuators, lighting, signals, and properly placed signing and pavement markings are an integral part of providing a safe approach for drivers entering or exiting the installation. Security forces safety includes provisions for personnel protection against attack, or errant drivers, as well as considerations for climate, location, and orientation.
- **Traffic Flow** - The ECF/ACP needs to be capable of meeting the traffic demand with little or no delay under FPCON Bravo+ and function at or below capacity at CHARLIE.



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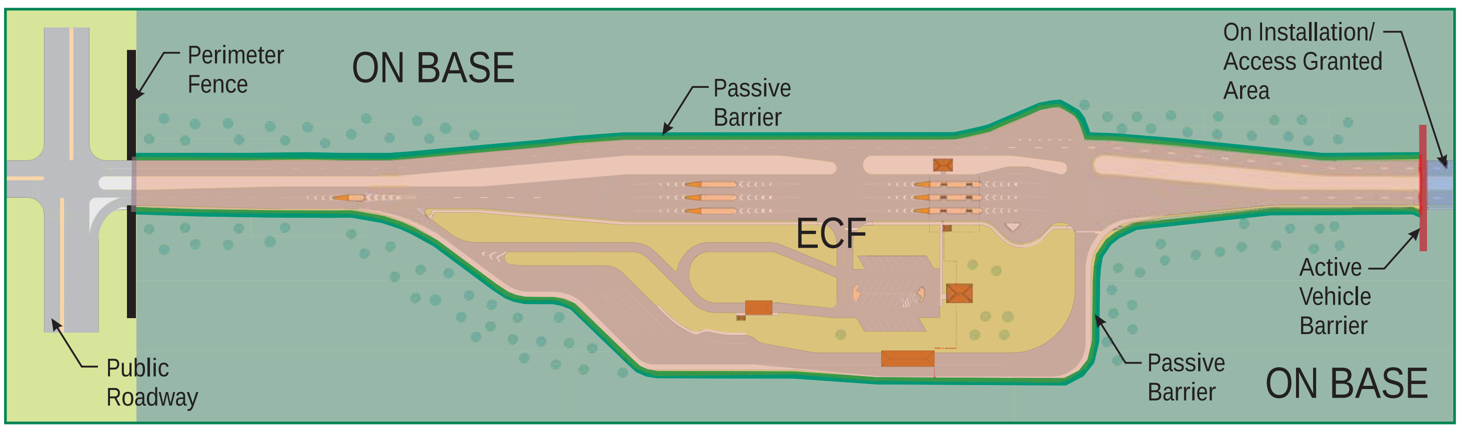
- **Aesthetics** - The ECF/ACP should provide a sense of arrival for the approaching individual. At a minimum, the ECF/ACP should impart an immediate impression of professionalism, good landscape architecture, and commitment to facilities excellence.

Often these priorities can conflict unless proper planning, design, implementation, and operations take place. No example better represents this potential conflict than the use of active vehicle barriers (AVBs). AVBs are in-roadway barriers that can be deployed to prevent entry of unauthorized vehicles. There are various types of AVBs, including bollards, arresting nets, and pop-up wedges. Although AVBs are an important security element, especially in the event of a "gate runner," the use of AVBs creates a risk to innocent motorists if not properly designed, implemented, and operated. **An AVB capable of stopping large, moving vehicles can cause significant damage to vehicles and can cause injury or even death to vehicle occupants.** Thus, AVB designs must include adequate safety and traffic control features to ensure the safety of innocent motorists entering and exiting the ECF/ACP.



What Guidance Exists?

UFC Guidance on Deployment of AVBs

In 2005, the final Unified Facilities Criteria ("the UFC") on **Security Engineering: Entry Control Facilities/Access Control Points** is scheduled to be released. The UFC presents a unified approach between military service branches regarding the design features necessary to ensure that infrastructure constructed today will have the flexibility to support future technologies, a changing threat environment, and changes in operations. The UFC provides planning, design, construction, sustainment, restoration, and modernization criteria, which applies to the military departments, the defense agencies, and DoD field activities. With regard to AVBs or final denial barriers, the UFC states the following:

*"…**the purpose of the final denial barrier is to stop unauthorized vehicles from entering the installation.** Some individuals who attempt to enter the installation without authorization are lost, confused, or inattentive, but there are also those whose intent is to "run the gate." A properly designed final denial barrier will take into account both groups, minimizing the risk to individuals who have made an honest mistake and providing a properly designed barrier (based on the specified threat) to stop those with hostile intentions…**The design and operation of the ECF should include provisions to protect innocent users of the ECF from operation of the final denial barrier whether deployment is accidental, during a test, or during an actual response to a threat.** Where possible, incorporate an appropriate delay time (minimum of 4 seconds) into the barrier control sequence to allow sequencing of traffic signals and lights at the final denial*

barrier to allow vehicles approaching the barrier to either clear it or stop safely in front of it before it deploys. Automatic detection loops embedded in the pavement around the active vehicle barrier system can be used to avoid deployment of the vehicle barrier when an authorized vehicle is within the loop detection zone and the barrier is activated…"

Threat Containment and the Role of AVBs

Many installations require AVBs at the end of the threat response zone as a mechanism to provide containment if the ECF's/ACP's security is compromised by a potential threat. There are many different types of AVBs and the barrier rating is dependent on service requirements and installation needs. Design AVBs with a safety scheme that allows all road users to safely clear the barrier or stop in advance of it prior to deployment.

The location of AVBs is dependent on the length of the response zone. The minimum length of the response zone is calculated based on:

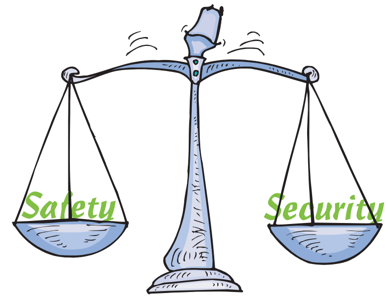
- **Velocity** and location of the threat vehicle when it is detected.
- Rate of threat vehicle **acceleration.**
- **Guard response, safety, and deployment time**.

The rate of acceleration is dependent on the type of vehicle. Generally, the acceleration capabilities of threat vehicles are known.

What does that mean?

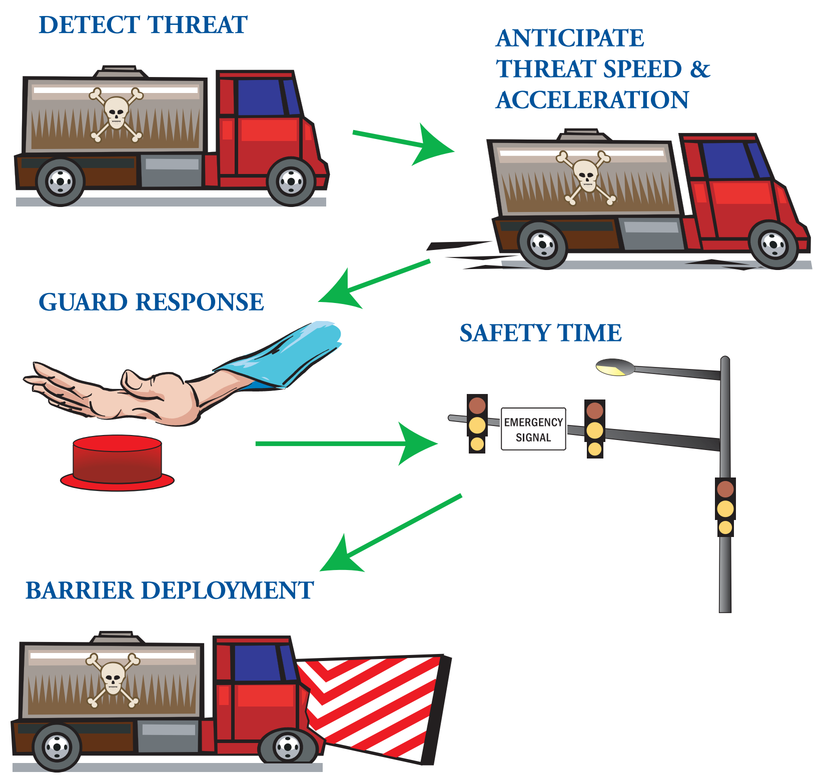
Basically, it means that not only should you consider the force protection requirements (guard reaction and barrier deployment) when implementing AVBs, but also safety requirements (signaling sequence and sufficient reaction time for motorists to either clear the barrier area or stop in advance of it).

Does Security Outweigh Safety?



It is often stated or questioned that security provisions should outweigh safety considerations. The argument is that if a threat attempts an attack, the number of innocent motorists injured or killed due to AVB deployments and the threat itself at the final denial barrier, should be less than if the threat is not contained and is able to reach its intended target. These are valid points and considerations; however, safety can be designed into AVB systems. There are many reasons for AVB deployment in addition to a "true" and immediate threat. In these situations, **it is not acceptable for innocent road users to be injured or killed**.

Threat Containment



- **False Threats** – Often a vehicle is considered a threat due to its actions at the ECF/ACP; however, upon further investigation some of these "threats" are just confused motorists. Here are representative examples:
  - **Retirees** – Many installations have a significant retired population who use installation facilities. Often, these retirees are less familiar with present day security procedures, especially at ECFs/ACPs where there is significant signing and motorist decisions. At one installation, a retiree drove over the curb and through the grass instead of following the signage when directed to the visitor's center.

  - **Toll Plaza** – At one installation, directly adjacent to a limited access roadway, officials noted that many unfamiliar/lost motorists thought the installation's ECF/ACP was a toll plaza. After they tossed 50 cents toward the guard, they drove away not realizing they had just violated the ECF/ACP.
- **Accidental Deployment** – Although protective features should be in place to prevent accidental deployments, several have occurred injuring road users and destroying vehicles.

- **Protesters** – One installation had two separate gate runners who wanted to prove that land occupied by the military was still theirs. Both gate runners (foreign nationals) were protesters and were apprehended. Each posed no physical threat by vehicle, weapon, or explosive to personnel or property.
- **AVB Testing** – Many AVB systems require periodic testing to keep the system operational. Incorporating safety schemes with AVB deployments allow testing under traffic conditions.
- **Other Security Deployments** – Many installations will deploy barriers if a security alarm is activated anywhere on installation property. Although these may be valid security concerns (thefts, robberies, internal security violations, etc.) that may warrant "locking down" the installation, there is often sufficient reaction time to deploy AVBs in a secure and safe manner. Also, installations will often deploy barriers when lanes or gates are closed during the day or night.

You Need to Follow the MUTCD!

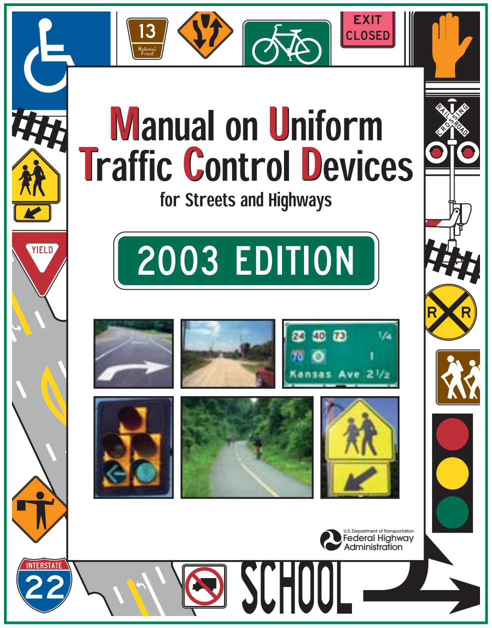
Joint Regulation (AR 55-80, OPNAVINST 11210.2, AFMAN 32-1017, MCO 11210.2D, and DLAR 4500.19) on the Department of Defense (DoD) Transportation Engineering Program identifies in Section 3-11 the Military's Highway Safety Program requirements:

- Under General: "This section prescribes the policies and procedures related to DoD highway safety needs. It implements 23 USC 402, DODD 4510.11, and DoDI 6055.4."
- Under General: **"This regulation applies to all military installations and activity sites that have streets and/or parking facilities, and a workforce of 1,000 or more personnel."**
- Under Policies: **"Installation commanders will develop and maintain their roadways to nationally accepted standards that provide a safe driving environment for all drivers and passengers."**
- Under Traffic Control Device Plan: "This plan provides for the periodic review of existing traffic control devices and the systematic replacement of substandard and deteriorated devices. All installation **traffic signals, signs, and pavement markings will be in substantial conformance to FHWA's *Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD)*** (http://mutcd.fhwa.dot.gov). **Variances in the design and application of installation traffic control devices from the standards contained in *MUTCD* must be approved by MTMC (now SDDC) and FHWA."**

Other supporting regulations include:

- DoDD 4510.11 on DoD Transportation Engineering
- DoDD 4715.1 on Environmental Security
- DoDI 6055.4 on DoD Traffic Safety Program

Safety and the MUTCD



In order to satisfy the necessary safety requirements in deploying AVBs, **AVBs must be designed, implemented, and operated in accordance with the Federal Highway Administration's (FHWA), *Manual on Uniform Traffic Control Devices***. Thus, AVB safety requirements include providing indication to road users of AVB activation and providing sufficient clearance time for road users to clear or stop prior to AVB deployment. When considering AVB designs and locations, the total response time must be considered:

- Guard reaction = 3 seconds minimum
- Time for safety and traffic signalization = 4 seconds minimum
- Deployment time = 2 seconds minimum

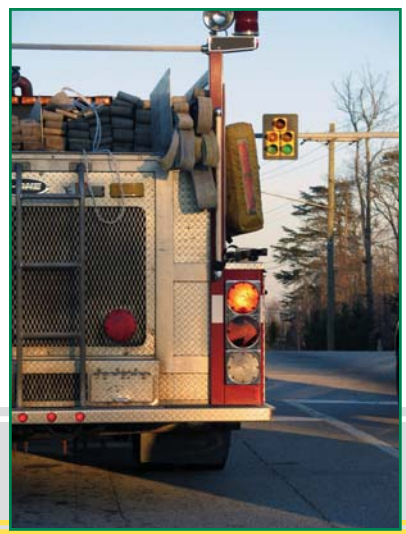
- TOTAL = 9 seconds minimum.

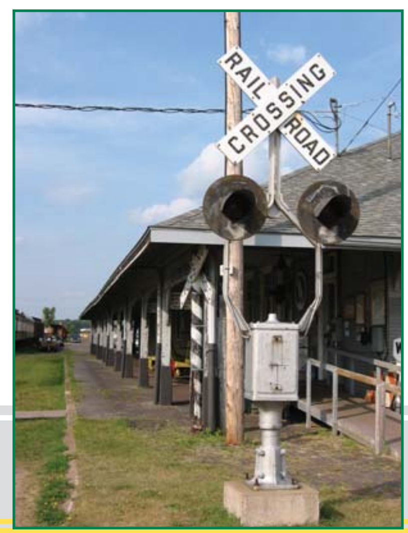
The 4 seconds minimum safety time includes time for traffic control signals to sequence to alert motorists of pending AVB deployment. Signals must provide time for motorists approaching the barrier to either pass over it or safely stop in front of it. Also, at 25 mph (40 km/h), 150 feet (45.7 meters) of wet stopping sight distance is needed for a driver to react and stop the vehicle. If a vehicle is 110 to 149 feet (33.5 to 45.4 meters) from the barrier, it will take the driver 4 seconds to safely traverse the barrier since it must be assumed that the driver cannot safely stop the vehicle. This time may be more dependent on operational procedures and site conditions such as grade.

Some may question if the 4 seconds for safety and signalization is warranted, but all comparable real world conditions include these safety operations into their systems:

- **Railroad Crossing Activations** – Flashing red signals to road users must operate at least 20 seconds before arrival of any train when train speeds are ≥ 20 mph. Requires at least 3 seconds of flashing red signals prior to start of arm's downward movement and 5 seconds of arm deployment prior to train's arrival. Minimum safety clearance time equals 8 seconds plus time for arm movement from vertical to horizontal position.
- **Emergency Vehicle Preemption** – Requires that traffic see a yellow clearance (3 to 6 seconds) and red clearance (not exceeding 6 seconds) depending on traffic speeds and engineering judgment.
- **Automated Movable Bridges** – Requires that traffic see a yellow clearance (3 to 6 seconds) and red clearance (not exceeding 6 seconds) depending on traffic speeds and engineering judgment.

Ultimately, although security and safety considerations should be at the forefront of ECF/ACP designs including AVBs, installation officials must be mindful of the potential tort liability that exists if AVBs are not properly designed for safety that road users are accustomed too and required by the national *MUTCD*.





Calculating Response Zone Length

The determination of the response zone length requirements must consider the various type(s) of threat scenarios, the means of detection, the initial velocity, and the acceleration of the threat vehicle. The UFC as well as most service branches have specific guidance on these calculations. Ultimately, the calculated response zone requirement should be considered a minimum and should be maximized whenever feasible to further ensure threat containment and road user safety.

The response zone length calculation may be the most critical calculation made when developing an ECF/ACP since threat containment and road user safety are of paramount importance. If a high-speed attack can be detected through manual or automated means in the approach zone, the response zone (on straight alignments) may still need to exceed 670 feet to accommodate covert threats (assuming acceleration of 11.3 ft/sec^2 and velocity initial of 35 mph) and to accommodate guard response and safe barrier deployment. If there is no advance detection (speed, wrong-way, etc.) to alert of high-speed threats, the response zone lengths may need to be significantly longer to accommodate high-speed threats.

In general, treat calculated response as minimums such that both security and safety can be better addressed. Where reasonable and practical, locate AVBs at a site that makes the implementation of security and safety devices more practical. In many cases, one can locate AVBs at the first major intersection beyond the ID check area, provided that minimum response zone requirements are met. When collocated at the first major intersection, integrate AVBs preemption design with the intersection traffic control. Ultimately, the placement of AVBs requires:

- Calculation of minimum response zone lengths based on specific threat scenarios.
- Extra distance when practical and feasible.
- Site assessments to determine the feasibility of placement.
- Coordination with traffic control devices and nearby intersections.

The Needed Response Zone Length Should:

- Be calculated by engineers with input from security forces staff.
- Be developed with consideration of service and UFC requirements.
- Consider specific design threat characteristics.
  - Type of threat (high-speed, covert, etc.)
  - Location of detection
  - Initial velocity
  - Maximum threat velocity
  - Threat vehicle acceleration
- Accommodate guard response.
- Incorporate road user traffic controls to enable safe barrier deployment per *MUTCD* standards.

Preferred Control Systems

The preferred, conventional traffic and safety control system for AVBs is shown on the subsequent concept. The goal of traffic control devices associated with the AVBs is to provide a quick response to a potential threat while still protecting innocent ECF/ACP users in the area.

Proper signing and delineation are required on the approach to the AVBs for the inbound and outbound lanes.

- ❖ A mast arm assembly with three signal heads, an emergency R10-13 sign (EMERGENCY SIGNAL), and a luminaire must be provided at the active vehicle barrier device.
- ❖ The signals at the active vehicle barrier must always be 8-inch flashing yellow until the barrier deployment sequence has been initiated. Once the barrier initiation sequence has been started, the flashing yellow signal indications change to steady 12-inch yellow signal indications (clearance) before changing to 12-inch solid red signal indications.
- ❖ A R10-6A sign (STOP HERE ON RED) must be installed 50 feet (15.2 meters) prior to the mast arm assembly.
- ❖ A W3-3 sign (SIGNAL AHEAD) supplemented by a W11-12P Modified sign (SIGNALS RED BARRIERS UP WHEN FLASHING) and two flashing yellow beacons must be installed 150 feet (45.7 meters) prior to the mast arm.
- ❖ A W3-3A MODIFIED sign (ACTIVE BARRIER) supplemented by a W16-2 (XX FEET) sign must be installed in advance at a location determined by a qualified traffic engineer.

AVB deployment should be triggered through programmable logic associated with the traffic signal controller. In other words, barrier controls should be dependent on the signaling (and safety) sequencing of the traffic controller. For more guidance on the deployment of active vehicle barriers and the components/logic involved, contact SDDCTEA.

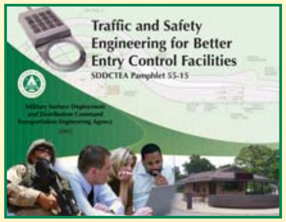
WARNING!

‼ Currently installed AVB systems controlled by guards without any advance warning and control lights/signs prior to deployment do not meet Military Safety Standards and the *MUTCD*.

‼ Currently installed AVB systems with barrier control lights that flash or go steady red from a flashing yellow beacon upon activation violate the clearance Standards of *MUTCD* Sections 4D.12 and 4D.13, "Flashing Operations of Traffic Control Signals" and "Preemption and Priority Control of Traffic Control Signals," respectively.

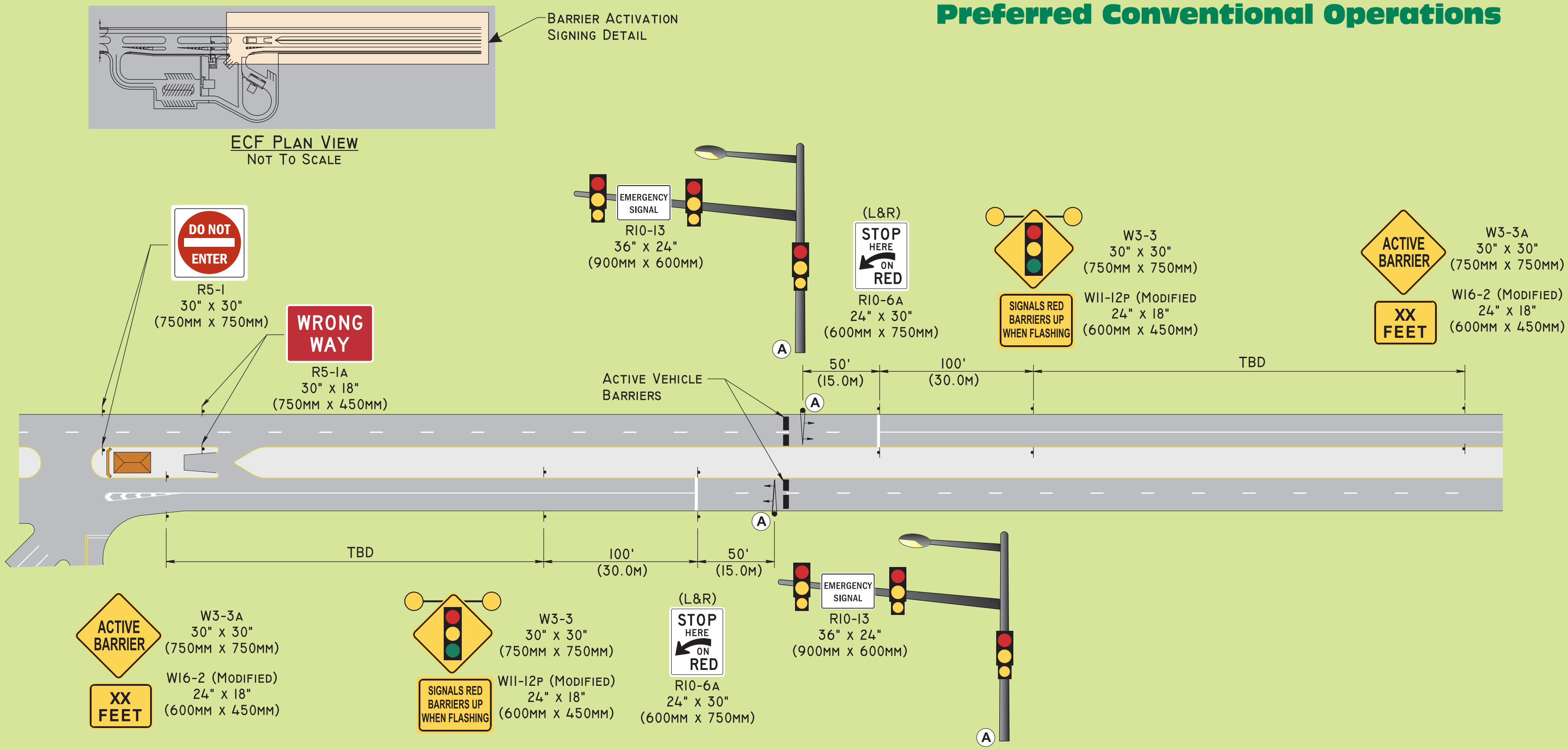
SDDCTEA Can Help

The challenge of containing threats while maximizing the safety of innocent motorists is not easily addressed. Engineers and planners must work with security forces to identify threat scenarios and to develop solutions. Prior to and since September 11, SDDCTEA has been involved in the secure and safe development of ECFs/ACPs. SDDCTEA can help installations address these challenges.



- ❖ ACP/ECF Alternatives Analysis and Traffic Engineering Studies – more than 60 to date
- ❖ Development of *Traffic and Safety Engineering for Better Entry Control Facilities* – 100+ page manual with traffic and safety design guidance scheduled for 2005 release
- ❖ Development of safety and traffic control schemes
- ❖ AVB location assessments and safety scheme selection

Preferred Conventional Operations



Barrier Activation Signing Detail

Traffic Control and Safety at Active Barriers	Operational Sequence Per Second [Min for Safety - 25 MPH (40 KPH) Design Speed]											
	Traffic Control	-	1	2	3	4	5	6	7	8	9	10
		Normal Ops	Guard Perception and Reaction Time to Threat (Button)			Yellow Clearance (MUTCD Minimum)			All Red	Deploying Barrier		Threat Contained
Sign and Signal Warning System	Warning Sign with Beacons	BLANK	BLANK	BLANK	BLANK	ALT FY	ALT FY	ALT FY	ALT FY	ALT FY	ALT FY	ALT FY
	Traffic Signal	FY	FY	FY	FY	Y	Y	Y	R	R	R	R
	In-Roadway Lights or Barrier	BLANK	BLANK	BLANK	BLANK	BLANK	BLANK	BLANK	FR	FR	FR	FR
	Active Barrier	DOWN	DOWN	DOWN	DOWN	DOWN	DOWN	DOWN	DOWN	ACTIVATED	ACTIVATED	DEPLOYED

Response Zone Alternatives

In many cases, it is not practical or feasible to provide the distance needed for a conventional, straight response zone to accommodate the threat scenario and response and safety time. The only way to minimize the total distance is to:

- ❖ **Manage Threat Speed** - The length of the response zone can be minimized, or the available response time increased, by using passive barriers or roadway layout to control the velocity of threat vehicles as they travel through the ECF/ACP zones.
- ❖ **Manage Time** - Change the operational features through technology so that the time can be managed.

Manage Threat Speed

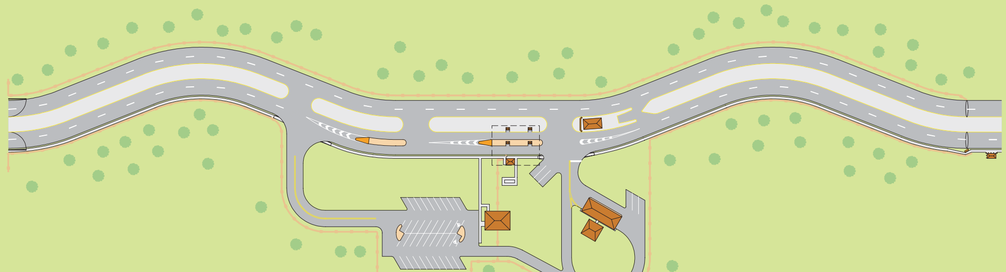
Manage threat speed uses geometric constraints to physically limit the maximum attainable threat speed. By limiting threat speed, distances needed to accommodate response and safety time can be decreased.

Manage Time

Manage time includes alternatives to better manage response and safety time. Although many of these strategies can reduce the minimum length of the response zone, they often put more reliance on the use of other technologies. In all cases, they still must include traffic and safety control in conformance with the *MUTCD*.

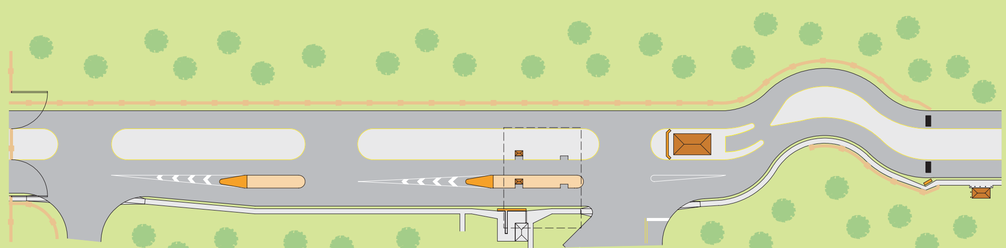
Category and Treatment	Threat Speed Management: Chicanes Traffic Calming Chicanes Curves/Turns
Pros	❖ Utilizes geometric constraints to physically limit both "normal" and "threat" speeds ❖ Can be designed to compliment aesthetic attributes
Cons	❖ May cause some minor reductions in roadway capacity due to controlled speeds – make sure you consider traffic flow impacts ❖ May not be suitable for trucks ❖ Potential for more sideswipe collisions ❖ Roadway (and lane assignment) controls (passive barriers and lane separators) may be necessary to control threat vehicle paths ❖ Snow removal may be challenging in cold weather climates
Design and Traffic Control Considerations	❖ Additional drainage features may be required ❖ In all cases, conventional safety and traffic control requirements must be satisfied ❖ Additional signs and markings are required in conformance with the *MUTCD*

CHICANE



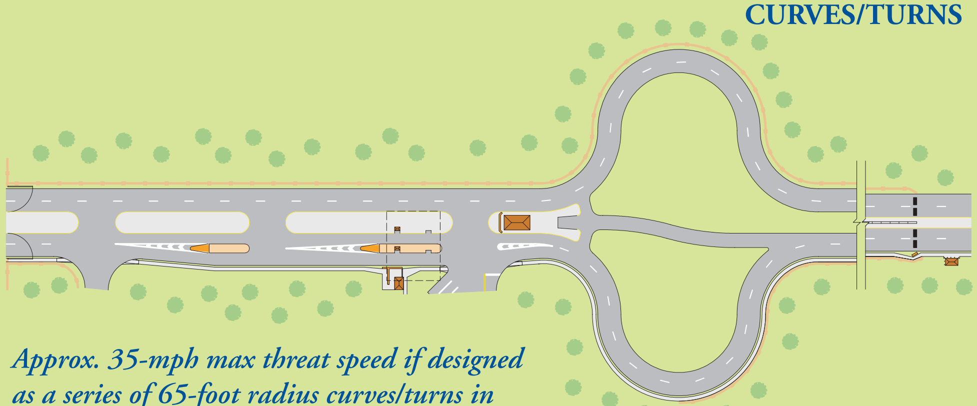
Approx. 50-mph max threat speed if designed (w/ lane dividers) to AASHTO 25-mph design criteria

TRAFFIC CALMING CHICANE



Approx. 25-mph max threat speed if designed to ITE's Traffic Calming Standards. Not suitable for more than 175 vehicles per hour. Not suitable for trucks.

CURVES/TURNS



Approx. 35-mph max threat speed if designed as a series of 65-foot radius curves/turns in conformance with AASHTO and MUTCD. *Not suitable for trucks.*

New and Improved BMTE 2005 CD to be Released

Watch for an updated version of the *Better Military Traffic Engineering* (BMTE) CD-ROM, coming this fall! This interactive multimedia CD-ROM has been developed by SDDCTEA to address traffic safety deficiencies on military posts, and can be used as reference or to train installation personnel on the proper installation and use of traffic control and safety devices. Topics include: signs and pavement markings; traffic signals; intersections; roadside safety; gates (ECFs); and parking lots. Each module includes voiceovers, text "closed captioning," video clips, animation, and original illustrations. Version 2 has been updated to include information from the new *MUTCD* as well as post-9/11 issues.

Vehicle Presence

The Vehicle Presence operational strategy is a unique and complex approach to reducing the minimum response zone length while NOT sacrificing security or safety. Basically, the system functions as a means of flow control inside the threat response zone:

- ❖ Each authorized vehicle must individually stop (red signal indication) just prior to the AVB.
- ❖ If no AVB activation takes place at that time, the vehicle receives a green signal indication. Only one vehicle can proceed on the short green signal as posted by a regulatory sign stating "ONE VEHICLE PER GREEN."
- ❖ If AVB activation takes place with a vehicle stopped on a red signal indication:
  - o The lane signal indication remains red (preemption hold).
  - o A traffic arm is deployed with flashing lights supplemented by a post mounted sign reading, "BARRIER ACTIVATED WHEN FLASHING."
  - o Traffic signal controller scans multiple sensor inputs in each lane for vehicle presence (of prior released vehicles, disabled vehicles, defective detectors, etc.) prior to and after the barrier before the AVB deploys.

The system in its normal operation works in a similar fashion to ramp metering configurations in many metropolitan areas. Effectively, the system permits the reduction of time associated with vehicle braking and stopping since every vehicle is required to stop regardless of activation.

If utilized, the Vehicle Presence scheme shall be designed, installed, and operated with several safeguards:

- ❖ Vehicle Detection at AVBs – Detectors/sensors shall detect vehicles prior to and just after the AVB in order to suppress activations until the traversing vehicle has cleared.
- ❖ Detection of Bicycles and Motorcycles – Detectors/sensors shall detect bicycles and motorcycles.
- ❖ System Safety Check – The microprocessor controller shall check both operational status and detection status prior to its "Start Up" deployment. Under no circumstance will the AVB deploy when one or more detectors is (are) not operational, is (are) offline with system, or have a call.
- ❖ Queue Preemption Phase – The system shall allow for vehicle queue preemption in case of back-ups associated with the AVB system.
- ❖ Emergency Fast Operate - If guards initiate the "Emergency Fast Operate" command during queue preemption, the lane control signal shall change from flashing "Yellow" to solid "Yellow" for 3 seconds and then to solid "Red" for 2 seconds.

ATTENTION - Vehicle Presence

"Best operational alternative for traffic flow"

"Possible operational and maintenance issues"

"Potential threat vulnerabilities depending on design characteristics"

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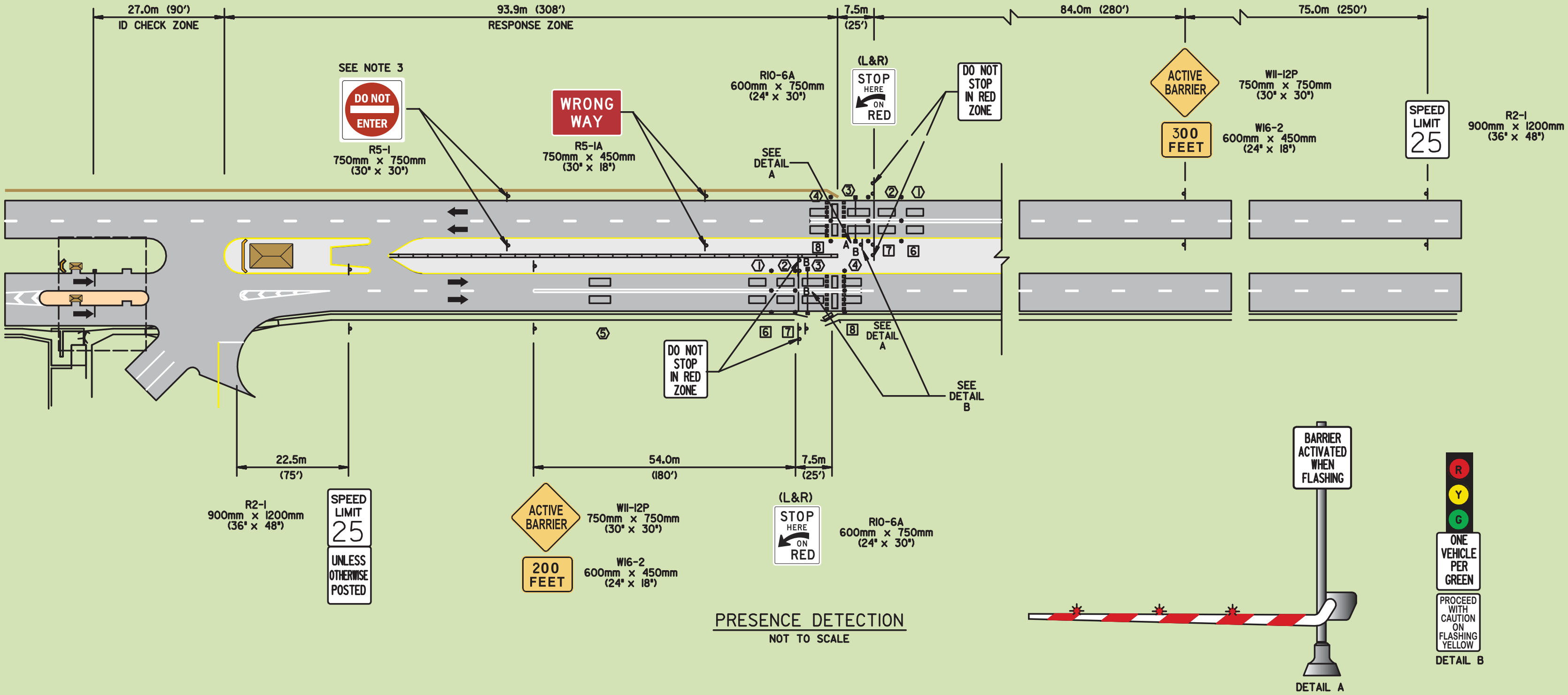


For more design guidance contact SDDCTEA.

Checkpoint Barrier-Up Operations

Barrier-up or barrier normally closed operations are often used at low-volume locations where there is limited conventional operations, or where security requirements necessitate complete and continual containment.

In practice, the AVBs are normally closed (1) until the vehicle is authorized for entry (2A). If the vehicle is to be rejected and the rejection turnaround is beyond the checkpoint (2B), a second set of AVBs can be deployed to prevent unauthorized entry by the rejected vehicle.

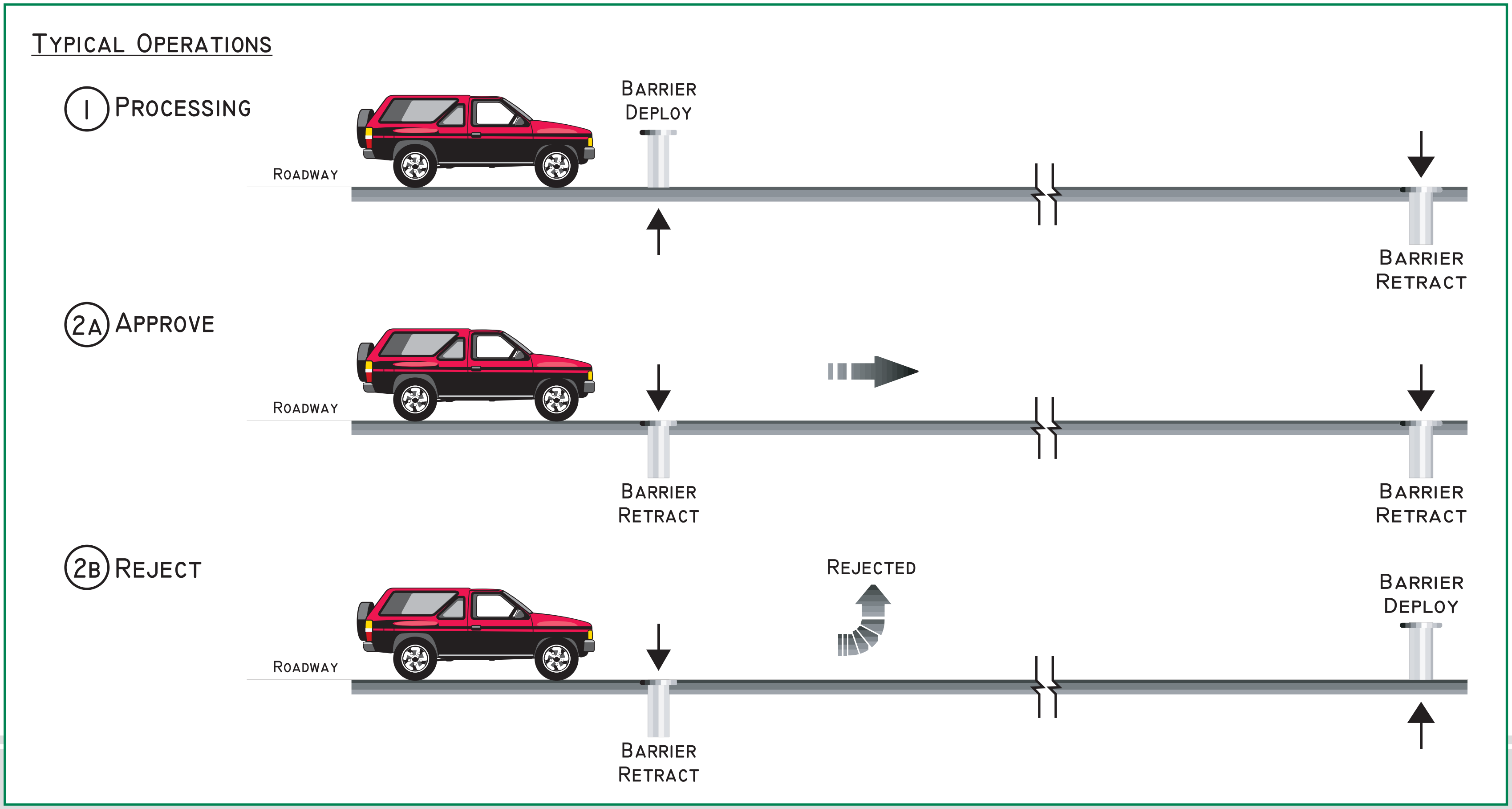
In normal applications, barrier-up operations cannot process more than 150 vehicles per hour. Additionally, the constant cycling of barriers can increase maintenance and operational costs.

ATTENTION - Barrier-up

"Significant decrease in traffic efficiency versus conventional operations - acceptable at low-volume locations only"

"Barrier maintenance issues due to constant cycling"

"Complete containment versus threats"



Barrier-Up Vehicle Platooning Operations

Vehicle platooning is similar to barrier-up operations, except checkpoint guards process several motorists and vehicles prior to authorizing final entry as a group.

As guards process traffic, (1) Vehicles enter and queue at the approach to the second set of deployed AVBs. (2) Once the platoon or "sally port" area is filled, guards deploy AVBs at the ID check area and retract barriers at the second set of AVBs. (3) Once the AVBs have been changed, the platoon discharges, and (4) guards reverse the AVBs, and the process starts again.

Barrier-up vehicle platooning can be sized to fit many situations, but typically AVBs should be around 300 feet apart to maximize operations. With this configuration, motorists' delays will increase and throughput capacity (processing capability) will decrease by approximately 40 to 50 percent versus conventional operations.

ATTENTION - Barrier Platooning

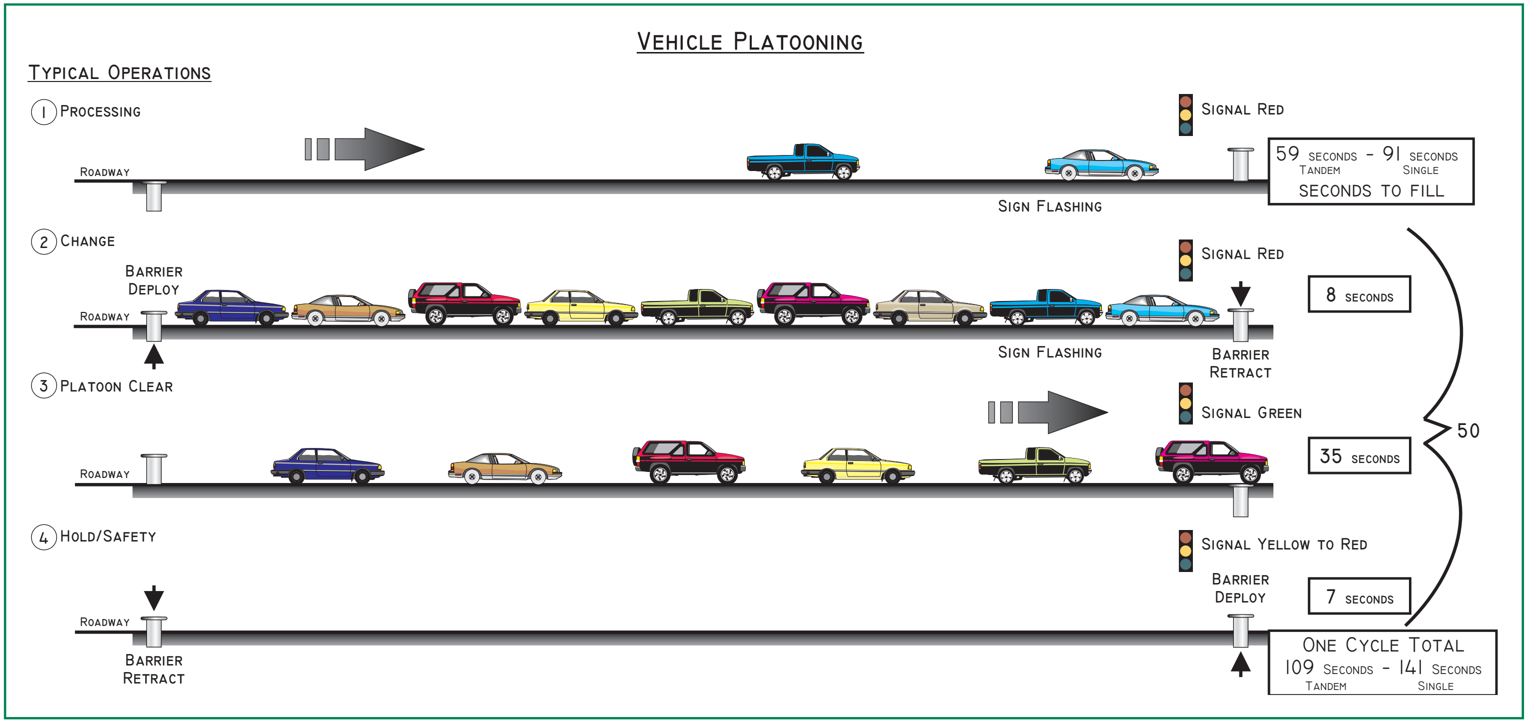
"40-50% decrease in traffic efficiency versus conventional operations"

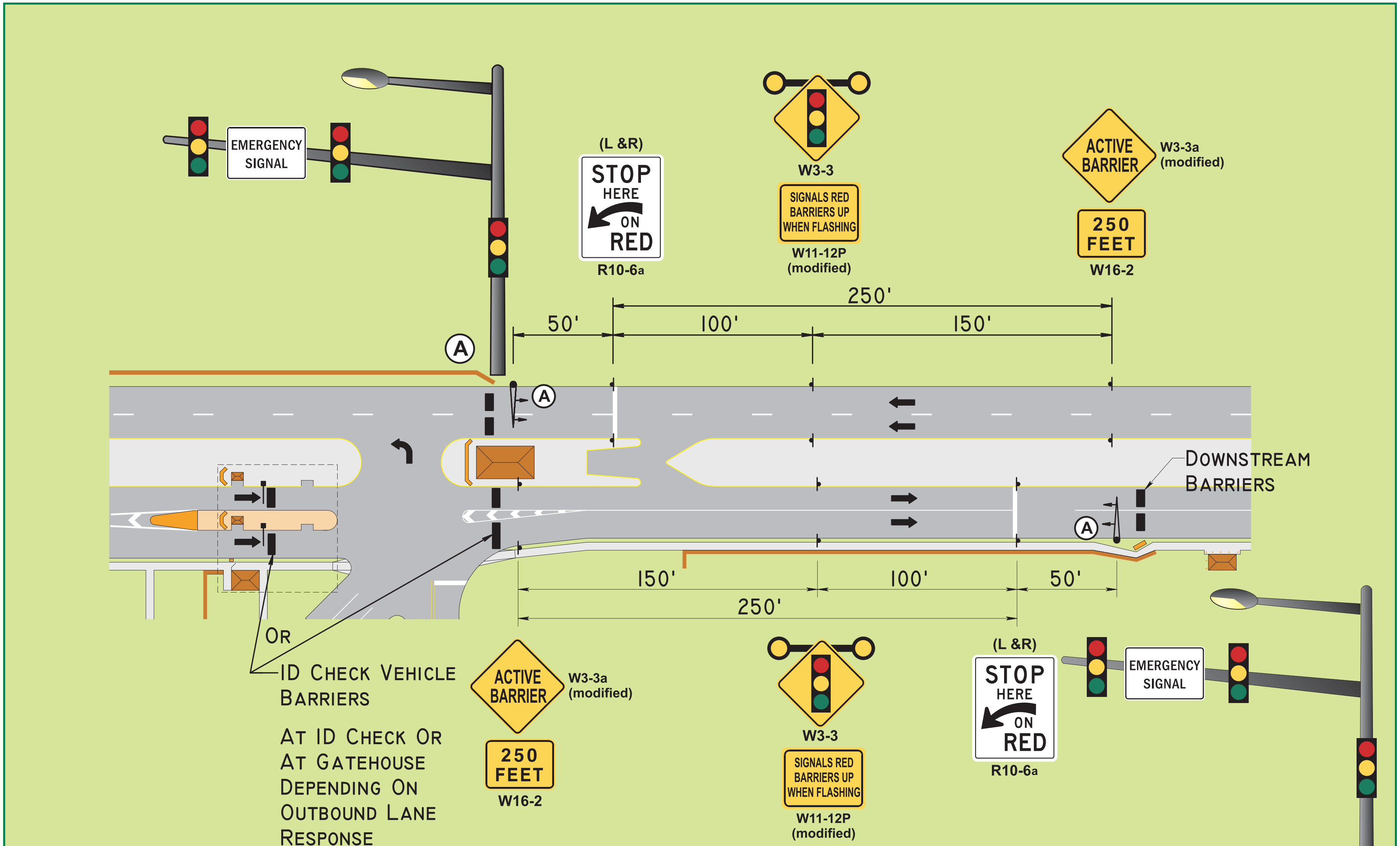
"Barrier maintenance issues due to constant cycling"

"Complete containment versus threats"

The traffic and safety control requirements are similar to conventional operations; however, some sign messages and signal indications are slightly different.

SDDCTEA can provide guidance on the appropriate use of Threat Speed Management techniques including: calculating "normal" and "threat" speeds, assessing conformance with design requirements, and developing and reviewing traffic and safety requirements.





ECF Configuration Based on Vehicle Usage Requirements

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