Traffic Engineering and Highway Safety Bulletin 18-02

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ACTIVE VEHICLE BARRIER (AVB) SAFETY SCHEMES

In This Issue...

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Overview

Active vehicle barriers (AVBs) are used as the final security measure to stop a potential threat vehicle at an entry control facility/access control point (ECF/ACP). *NOTE: The terms entry control facility and access control point are interchangable depending on the military Service and for the purposes of consistency this bulletin will use entry control facility.* While securing the installation is critical, it is required that every AVB installation operate with an SDDCTEA-approved barrier safety scheme. This is intended to provide proper warning to maximize safety for innocent motorists.

Multiple UFCs are written that apply to ECF design. These include:

- **UFC 4-020-02FA Security Engineering: Concept Design**
- **UFC 4-020-03FA Security Engineering: Final Design**
- **UFC 4-022-01 Security Engineering: Entry Control Facilities / Access Control Points**
- **UFC 4-022-02 Selection and Application of Vehicle Barriers, with Change 1.**

These are found on the WBDG site at: http://www.wbdg.org/

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 the AVB deployment(s) would be less than if the threat was not contained and was able to reach its intended target on base. This is a valid point; however, safety can be designed into AVB systems to make AVB deployments safer. Also, there are many reasons for AVB deployment other than a "true" and immediate threat. The following are reasons why non-threat-related deployments could occur:

☑ False Threats – Guards have only a few critical seconds to decide if a vehicle is a threat. Vehicles initially considered to be a threat are often just lost, confused, or inattentive, and are not true threats to the installation.

☑ Accidental Deployment – Although protective features should be in place to prevent accidental deployments, several have occurred injuring road users and destroying vehicles.

☑ 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, protests, 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.

Knowing that the system is safe, the guards would have a sense of comfort knowing that a barrier activation for a vehicle that is later determined to not be a true threat would not have devastating consequences to innocent motorists.

SDDCTEA has developed several different AVB safety schemes for different applications. The appropriateness of each scheme varies by number of travel lanes, presence of intersections, roadway geometry, and traffic demand. This bulletin will discuss each safety scheme currently approved by SDDCTEA.

Response Zone Length Considerations

The strategy for threat containment consists of four components: detect the threat; delay the threat, deploy the barriers, and defeat the threat. A barrier system must provide sufficient delay time to accommodate these four components.

The response zone length requirements must consider the various threat scenarios, the means of detection, the initial velocity, and the acceleration of the threat vehicle. UFC 4-022-01 and 4-022-02 have specific guidance on these calculations.

The response zone length calculation may be the most critical calculation made when developing an ECF. The UFCs provide the primary equations for calculating response zone length and discuss minimum values for velocity, acceleration, and reaction time when evaluating each threat scenario.

Detect the threat. Provide a minimum of 3 seconds for guards to detect and react to the threat. Typically, the point of detection is from the ID check island. An alternative to this is to relocate the point of detection into the approach zone through the use of advance speed detection and wrong-way detection in the outbound lanes.

Signal Safety Interval. Installation signals and hybrid beacons must provide a safety interval to provide the innocent driver time to react and either stop before or pass over the AVB. For the Conventional Traffic and Safety Control System, the safety interval is 4 seconds.

Deploy the barriers. When calculating response zone lengths, 2 seconds must be used for barrier activation time. While different barrier safety schemes are based on different methods of delaying the threat vehicle and different signalization options, the barrier activation time in the calculation is constant. One exception to this is when the barriers will be operated in a normally up position. In this situation, the two-second requirement is negated. The two-second time used in the planning stage should not be confused with actual deployment times for barriers which may be 2 seconds or less.

Defeat the threat. With the Conventional Traffic and Safety Control System, a total timeline of 9 seconds must be provided to defeat the threat vehicle. The 9 seconds is based on the three components above: 3 seconds for guard reaction time, 4 seconds for the traffic signal safety interval, and 2 seconds for barrier activation.

Per the Army Standard for Access Control Points: “AVBs shall include an AVB safety scheme developed and/or approved by the SDDCTEA”

Per UFC 4-022-01: “The design and operation of the ECF/ACP must include provisions to protect innocent users of the ECF/ACP from operation of the AVB whether deployment is accidental, during a test, or during an actual response to a threat.”

Per UFC 4-022-02: “Warning signs, lights, bells, and bright colors should be used to mark the presence of a barrier and make it visible to oncoming traffic. These safety features must always be provided to ensure personnel safety.”

Conventional Traffic and Safety Control System

The Conventional Traffic and Safety Control System for AVBs is shown in figure 1. The conventional system is based on a nine-second timeline, as previously described. Since this system provides a free-flow movement, it can handle approximately 1800 vehicles per hour per lane.

Proper signing, signals, pavement markings, and delineation are required on both inbound and outbound approaches to the AVB. The following bullets summarize the requirements, as illustrated on figure 1.

- ☑ Two signal heads, a modified R10-13A-TEA sign (BARRIER SIGNAL), and a luminaire must be provided at the AVB device for one or two lane approaches. (Contact SDDCTEA for approaches with three or more lanes.)
- ☑ The signal heads at the AVB must always be 12-inch hybrid emergency signals or 12-inch red/yellow/green signals.
- ☑ Hybrid signals shall remain dark until the Emergency Fast Operate (EFO) sequence has been initiated. Once the barrier initiation sequence has been started, the hybrid signals will indicate 3 seconds of solid yellow and 4 seconds of alternating flashing red, before the barrier is fully deployed and continue flashing alternating red until the AVB is deactivated.
- ☑ A W3-3B-TEA sign (BARRIER ACTIVATED WHEN FLASHING) supplemented by a W16-2 (XX FEET) and two flashing yellow beacons must be installed a minimum of 140 feet prior to the mast arm. The 140-feet minimum is applicable for 25 mph only, if a higher speed limit is utilized through the response zone refer to the MUTCD for sign placement.
- ☑ Standard signals shall remain solid green until the EFO sequence has been initiated, the solid green signal indication then changes to a solid yellow signal for 3 seconds, followed by a solid red indication. The barrier begins to deploy 1 second after the signal turns red.
- ☑ An R10-6A sign (STOP HERE ON RED) must be installed 40 feet prior to the mast arm assembly.
- ☑ A W3-3A-TEA sign (ACTIVE BARRIER AHEAD) sign may be installed in advance at a location determined by a qualified traffic engineer.

AVB System Co-located at an Intersection

AVBs should be co-located with a downstream controlled intersection if the inbound traffic queue from the intersection extends through the proposed AVB location, or if the proposed AVB location is too close to the controlled intersection for outbound traffic to safely stop after traveling through the intersection. Generally, this is required when the AVB location would be within 300 feet of an adjacent intersection. An exception may be made with an approved traffic engineering study.

When an AVB system is co-located at an intersection, the intersection does not necessarily have to be signalized; however, additional analysis is required for proper traffic control and AVB safety. It is necessary to safely stop vehicles before entering the intersection and prevent vehicles from striking or holding down the AVBs on the outbound lanes. Note that the co-located system cannot be used at a roundabout due to conflicting traffic control between the barrier signals and the yield control required at a roundabout.

The design of the intersection should be conducted by a qualified traffic engineer who has an understanding of operational analysis. In most cases, co-location of an AVB system to a downstream intersection will result in a minimal increase in overall deployment costs and may result in decreased operational costs.

For unsignalized intersections that do not meet MUTCD signal warrants, a flash phase sequence may be utilized to imitate/reinforce the existing traffic control. For example, a two-way stop controlled intersection can implement a flashing yellow sequence for the free flow approaches and a flashing red sequence for the stop controlled approaches. An all-way stop controlled intersection can implement a flashing red sequence for all approaches.

With this system, under normal operations (for an intersection that meets signal warrants), the intersection operates under traditional traffic signal control. When the EFO is activated, the approaches that had been green immediately display yellow then red, and the approaches that had been red remain red. The timeline components are similar to the timeline components used for the conventional system, but the all-red clearance time must be longer due to the outbound vehicles needing to clear both the intersection and the barrier. This results in a total required time of approximately 12 seconds. The exact time required varies by location and depends on the intersection width.

Proper signing, signals, pavement markings, and delineation are required on the AVBs and intersection approaches as illustrated in figures 2 and 3. The following bullets summarize the requirements:

- ☑ A mast arm assembly with a minimum of two signal heads (one pole mounted and one mast mounted) and a luminaire must be provided on all intersection approaches. An additional mast arm assembly with a minimum of two signal heads (one pole mounted and one mast mounted) shall be provided at the inbound AVB on the near side approach. The signal heads on the inbound far side mast arm shall be optically programmed.
- ☑ The signal heads must always be 12-inch red/yellow/green even if the signal at the intersection operates under flash sequence.
- ☑ Signal indications at the intersection shall operate under normal conditions until the EFO sequence has been initiated. After initiation, the green or flashing yellow indications change to steady yellow signal indication (clearance) before changing to steady red signal indications. All approaches shall remain in all red phase until AVBs have been lowered. NOTE: If an approach is operating flashing red, the flashing red indication shall change to steady red upon initiation of the EFO sequence.
- ☑ An R10-6A sign (STOP HERE ON RED) must be installed 40 feet prior to the inbound AVB mast arm assembly. An R10-6A sign should be installed for all other approaches adjacent to the stop lines.
- ☑ A W3-3B-TEA sign (BARRIER ACTIVATED WHEN FLASHING) supplemented by a W16-2 (XX FEET) or W16-6P (Supplemental Arrow) and two flashing yellow beacons must be installed a minimum of 100 feet prior to the stop line of the inbound approach. On all other approaches, the W3-3B-TEA sign shall be installed a minimum of 50 feet prior to the stop line.
- ☑ A W3-3A-TEA sign (ACTIVE BARRIER AHEAD) supplemented by a W16-2 (XX FEET) or W16-6P (Supplemental Arrow) may be installed in advance at a location determined by a qualified traffic engineer.

When co-locating AVBs at an intersection remember:

- ☑ The minimum clearance time is 3 seconds of yellow time plus 1 second of red time, however, the width of the intersection may require additional time (up to 7 seconds) for the outbound vehicle to clear the final denial barrier.
- ☑ Additional time requirements due to width will require revalidation of threat calculations and a larger response zone.
- ☑ Pedestrians can be accommodated as described; however, discourage crossing on the AVB leg of the intersection.

AVB System Staggered at an Intersection

An alternative AVB system can be incorporated at an intersection where the additional time required for an outbound vehicle to clear the intersection (i.e., 12 sec+ threat containment time) cannot be met. To eliminate the additional clearance time required, outbound AVB(s) can be moved a minimum of 200 feet away from the intersection towards the identification check area. Both the inbound and outbound AVB(s) locations must meet the minimum response time of 9 seconds for signals and beacons and 5 seconds if utilizing the stop controlled safety scheme. When utilizing this strategy, the outbound threat will typically govern the design of the ECF. To mitigate a wrong way threat, consider using either wrong way detection, or an alternate alignment for the outbound lanes by adding more curvature or other geometric roadway features.

Proper signing, signals, pavement markings, and delineation are required on the approach to the AVBs for the inbound and outbound lanes as illustrated in figures 4 and 5. The following bullets summarize the requirements:

- ☑ Mast arm assemblies with minimum two signal heads (one pole mounted and one mast mounted) shall be provided at the intersection for all approaches. The signal heads on the inbound far side mast arm shall be optically programmed.
- ☑ The signal heads at the inbound AVB and intersection must always be 12-inch red/yellow/green.

  Signal indications at the intersection shall operate under normal conditions until the EFO sequence has been initiated. After initiation, the approaches displaying green indications change to steady yellow signal indication, then change to steady red signal indications. All approaches shall remain in all red phase until AVBs have been lowered.
- ☑ A mast arm assembly with a minimum of two signal heads (one pole mounted and one mast mounted), a modified R10-13A-TEA sign (BARRIER SIGNAL), and a luminaire must be provided at the outbound AVB device.
- ☑ An R10-6A sign (STOP HERE ON RED) must be installed 40 feet prior to the AVB mast arm assembly.
- ☑ The signal heads at the outbound AVB must always be 12-inch hybrid emergency signals or 12-inch red/yellow/green as an alternate option. The hybrid signals shall remain dark until the EFO sequence is initiated. Once initiated, the hybrid signals flash yellow for 1 second, then change to steady yellow for 3 seconds, followed by flashing or steady red signal indications as the barrier activates.
- ☑ A W3-3B-TEA sign (BARRIER ACTIVATED WHEN FLASHING) supplemented by a W16-2 (XX FEET) and two flashing yellow beacons must be installed a minimum of 140 feet prior to the inbound and outbound AVB mast arm. The 140 feet minimum is applicable for 25 mph only, if a higher speed limit is utilized through the response zone refer to the MUTCD for sign placement. A supplemental W3-3B sign may be installed on the outbound approach prior to the traffic signal as appropriate.
- ☑ A W3-3A-TEA sign (ACTIVE BARRIER AHEAD) sign may be installed in advance at a location determined by a qualified traffic engineer.

When staggering AVBs at an intersection remember:

- ☑ The entire intersection must be signalized even though only the inbound AVB(s) will be located at the intersection
- ☑ Minimum response time of 9 seconds must be met for both the inbound and outbound AVBs
- ☑ Raised median with passive barrier is required between the inbound and outbound AVB locations
- ☑ Design rejection points and deploy wrong way detection to minimize the possibility of a threat vehicle traveling the wrong way down the outbound lanes

High Efficiency Presence Detection Scheme

The high efficiency presence detection scheme (figures 6 -9) is a modified version of vehicle presence detection (obsolete). The system uses a conventional traffic signal with detection to improve traffic flow across the AVBs.

If there are no vehicles detected, the traffic arm is down and the traffic signal is red. When a vehicle approaches, it is detected, the traffic arm rises and the signal turns green allowing the vehicle to continue. If more vehicles are following, the signal remains green, the traffic arm stays up and vehicles continue on. Once the last vehicle exits and a new vehicle is not detected after a few seconds, the traffic signal turns yellow then red and the traffic arm lowers.

If EFO activation takes place when the signal is green:

- ☑ Traffic signal changes to yellow then red and the traffic arm lowers; however, the vehicle near the traffic arm at the time of activation can pass through the system.
- ☑ BARRIER ACTIVATED WHEN FLASHING sign is activated immediately.

- ☑ DO NOT ENTER LED blank-out signs are activated when traffic signal turns red provided the inductive loops on either side of the AVB are not activated.
- ☑ Traffic signal controller scans multiple sensor inputs in each lane for vehicle presence over the entry and exit safety loops before AVB deploys.

If EFO activation takes place when the traffic arm is down and the signal is red:

- ☑ AVBs deploy immediately unless a vehicle is activating one of the inductive loops immediately adjacent to the AVB.
- ☑ BARRIER ACTIVATED WHEN FLASHING sign and DO NOT ENTER LED blank-out signs are activated immediately.

Some installations may opt to operate with barriers up during off-peak periods. This provides an added security benefit because the AVBs are deployed when there is no vehicle demand. If a vehicle drives up to the traffic arm, it is detected and the barriers retract allowing the vehicle to pass. Operating with the barrier up during off-peak periods provides an additional security benefit by not being vulnerable to a wrong-way threat in the outbound lanes.

This AVB safety scheme requires a timeline of 7 seconds; comprised of 3 seconds for guard reaction, 2 seconds for a yellow traffic signal safety interval, and 2 seconds for barrier activation. The capacity of this system is approximately 1200 vehicles per lane per hour.

Stop Control Scheme

The Stop Control Scheme (as illustrated in figure 10) is an alternate AVB strategy to signalization. It utilizes stop signs instead of conventional or presence detection signalization at AVBs to reduce the required response time and distance. By utilizing stop signs, motorists are forced to stop at the barriers eliminating the required safety time with signalization (yellow and red time). This system is useful where there is limited real estate and vehicle volumes are below 800 vehicles per hour per lane.

During normal operations, the DO NOT ENTER LED blank-out signs, red signals, and amber warning beacons are dark. When the EFO sequence is initiated, the amber warning beacons on the BARRIER ACTIVATED WHEN FLASHING sign, the DO NOT ENTER LED blank-out signs and the steady red signals are activated. The traffic signal controller then scans the safety loops for the presence of vehicles. If no vehicles are present, the AVBs deploy immediately or immediately after vehicles have finished traversing the safety loops.

With this scheme, a total of 5 seconds is required, comprised of 3 seconds for guard reaction, and 2 seconds for barrier activation.

Barrier-Up Operations

Barrier-up or barrier normally closed operations (as illustrated in figure 11) is often used at low-volume locations where there is limited conventional operations, or where security requirements necessitate complete and continual containment.

This system uses two sets of barriers per lane, such that one is always closed as the other is lowered to allow entry or exit of a vehicle. Since at least one barrier is always up, no timeline is required for this scheme. EFO activation will cause both initial and final AVBs to deploy if the safety induction loops do not detect vehicles.

In normal applications, barrier-up operations cannot process more than 150 vehicles per hour. With manually-operated barriers, guards must not only grant entry to inbound vehicles, but also lower the barriers to allow outbound travel. Additionally, the constant cycling of barriers can increase maintenance and operational costs.

Barrier-Up Vehicle Platooning Operations

Vehicle platooning (as illustrated in figure 12) 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, vehicles enter and queue at the approach to the second set of deployed AVBs. Once the platoon or "sally port" area is filled, guards deploy AVBs at the ID check area and retract the second set of AVBs. Once the AVBs have been changed, the platoon discharges, and guards reverse the AVBs, and the process starts again. As with the Barrier-Up Operations scheme, one barrier is always up; therefore, no timeline is required for this scheme.

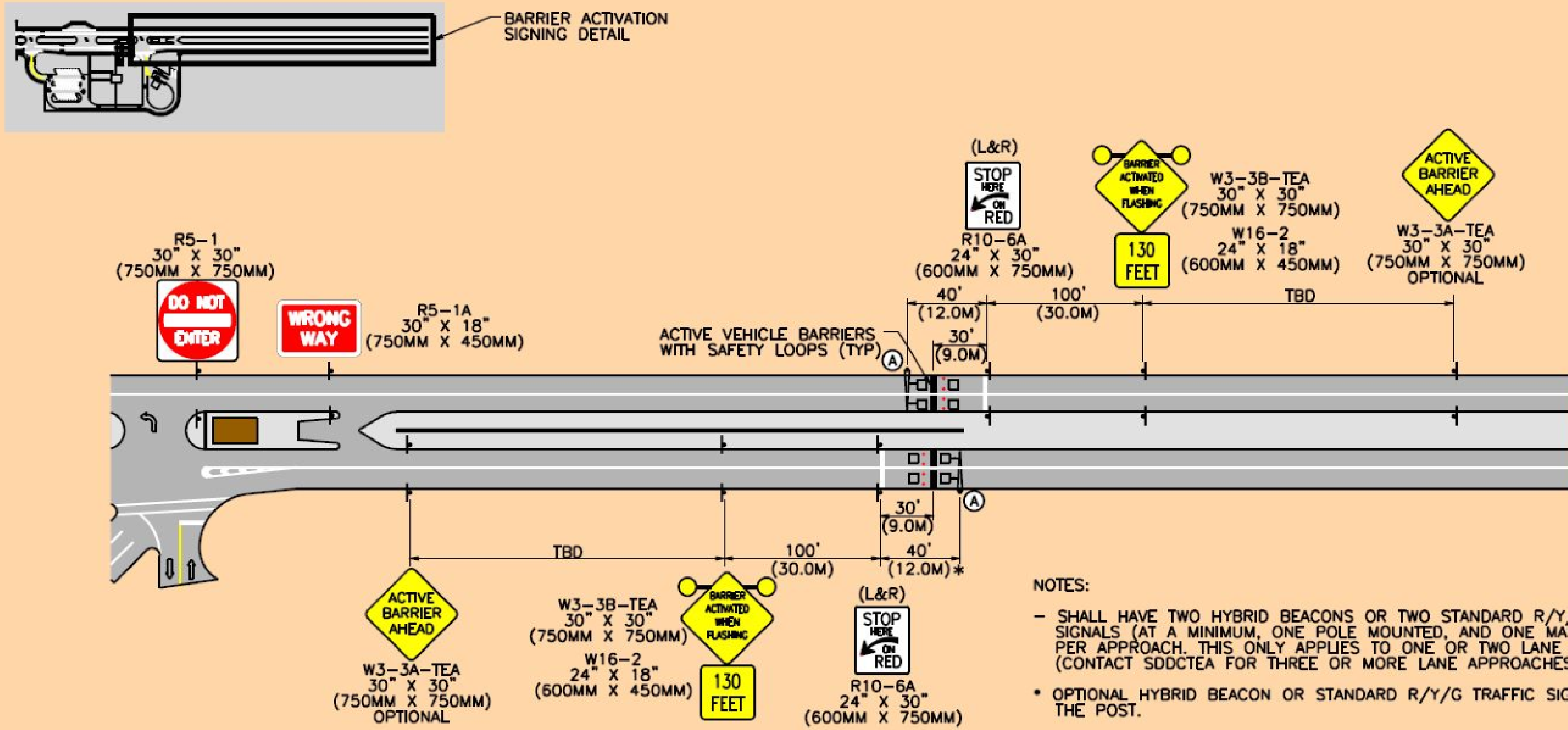
Barrier-up vehicle platooning can be sized to fit many situations, but typically AVBs should be around 300 feet apart to maximize operations. With this configuration, motorists' delays will increase versus conventional operations. Maximum capacity for vehicle platooning is approximately 175-200 vehicles per hour per lane.

Summary of SDDCTEA Safety Schemes for AVB Operations

The table on page 19 summarizes the response time, capacity and pros and cons with regard to different barrier safety schemes.

All AVBs shall conform to one of the presented safety schemes per military regulation and federal requirements. Deviations from the solutions shown should be reviewed and approved by SDDCTEA.

FIGURE 1: Conventional Traffic and Safety Control System



NOTES:

- SHALL HAVE TWO HYBRID BEACONS OR TWO STANDARD R/Y/G TRAFFIC SIGNALS (AT A MINIMUM, ONE POLE MOUNTED, AND ONE MAST MOUNTED) PER APPROACH. THIS ONLY APPLIES TO ONE OR TWO LANE APPROACHES. (CONTACT SDDCTEA FOR THREE OR MORE LANE APPROACHES).

* OPTIONAL HYBRID BEACON OR STANDARD R/Y/G TRAFFIC SIGNAL ON THE POST.

BARRIER ACTIVATION SIGNING DETAIL

CONVENTIONAL TRAFFIC SAFETY CONTROL SYSTEM	OPERATIONAL SEQUENCING FOR EMERGENCY FAST OPERATION (MIN FOR SAFETY - 25 MPH (40KPH) DESIGN SPEED)											
	TRAFFIC CONTROL	-	1	2	3	4	5	6	7	8	9	10
		NORMAL OPS	GUARD PERCEPTION AND REACTION TIME TO THREAT (EFO BUTTON)			YELLOW CHANGE (MUTCD MINIMUM)			ALL RED SAFETY	DEPLOYING BARRIER		THREAT CONTAINED
	WARNING SIGN WITH BEACONS	DARK	DARK	DARK	DARK	ALT FY	ALT FY	ALT FY	ALT FY	ALT FY	ALT FY	ALT FY
	HYBRID BEACON	DARK	DARK	DARK	DARK	STEADY YELLOW	STEADY YELLOW	STEADY YELLOW	ALT FR	ALT FR	ALT FR	ALT FR
	TRAFFIC SIGNAL	G	G	G	G	Y	Y	Y	R	R	R	R
	IN-ROADWAY LIGHTS OR ON BARRIER	DARK	DARK	DARK	DARK	DARK	DARK	DARK	FR	FR	FR	FR
	ACTIVE VEHICLE BARRIER	DOWN	DOWN	DOWN	DOWN	DOWN	DOWN	DOWN	DOWN	ACTIVATED	ACTIVATED	DEPLOYED

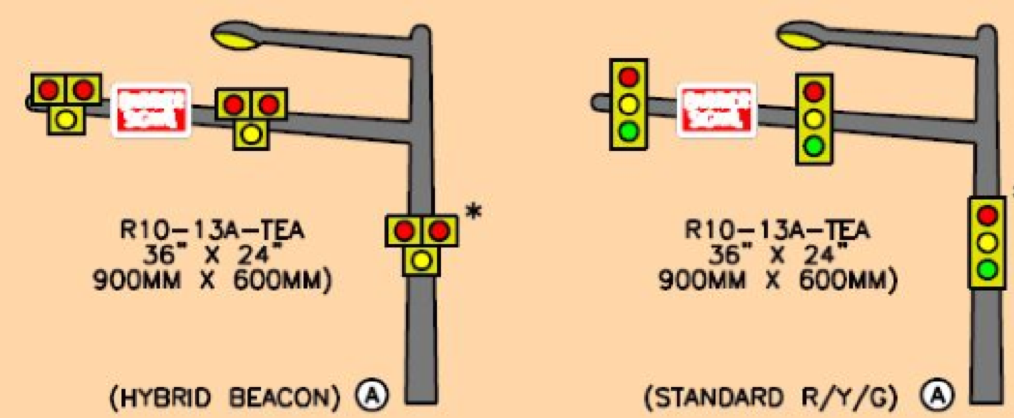


FIGURE 2: AVB System Co-Located at an Intersection (1/2)

NOTES

GENERAL:

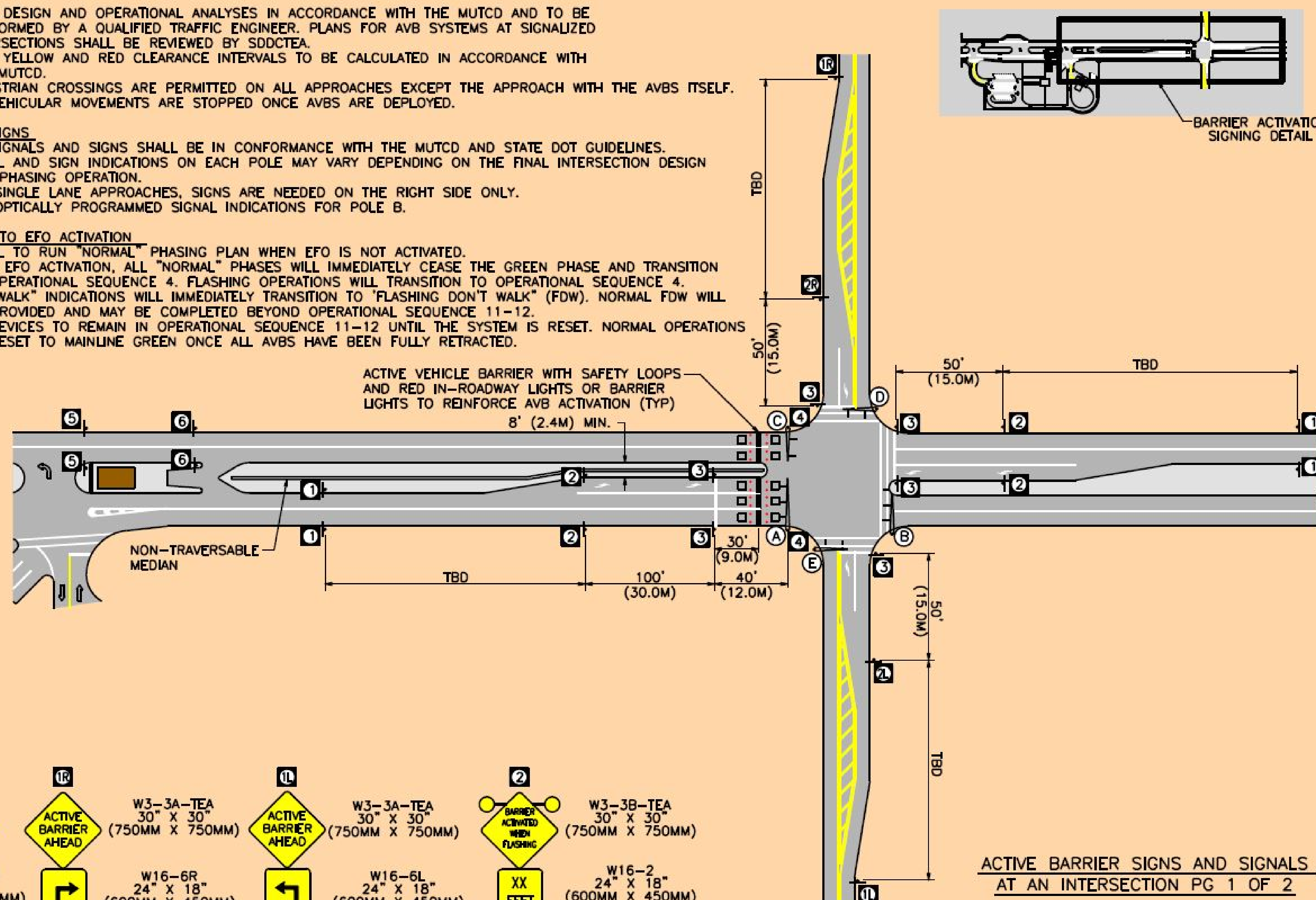
1. FINAL DESIGN AND OPERATIONAL ANALYSES IN ACCORDANCE WITH THE MUTCD AND TO BE PERFORMED BY A QUALIFIED TRAFFIC ENGINEER. PLANS FOR AVB SYSTEMS AT SIGNALIZED INTERSECTIONS SHALL BE REVIEWED BY SDDCTEA.
2. FINAL YELLOW AND RED CLEARANCE INTERVALS TO BE CALCULATED IN ACCORDANCE WITH THE MUTCD.
3. PEDESTRIAN CROSSINGS ARE PERMITTED ON ALL APPROACHES EXCEPT THE APPROACH WITH THE AVBS ITSELF.
4. ALL VEHICULAR MOVEMENTS ARE STOPPED ONCE AVBS ARE DEPLOYED.

SIGNALS AND SIGNS

5. ALL SIGNALS AND SIGNS SHALL BE IN CONFORMANCE WITH THE MUTCD AND STATE DOT GUIDELINES.
6. SIGNAL AND SIGN INDICATIONS ON EACH POLE MAY VARY DEPENDING ON THE FINAL INTERSECTION DESIGN AND PHASING OPERATION.
7. FOR SINGLE LANE APPROACHES, SIGNS ARE NEEDED ON THE RIGHT SIDE ONLY.
8. USE OPTICALLY PROGRAMMED SIGNAL INDICATIONS FOR POLE B.

NORMAL MODE TO EFO ACTIVATION

9. SIGNAL TO RUN "NORMAL" PHASING PLAN WHEN EFO IS NOT ACTIVATED.
10. UPON EFO ACTIVATION, ALL "NORMAL" PHASES WILL IMMEDIATELY CEASE THE GREEN PHASE AND TRANSITION TO OPERATIONAL SEQUENCE 4. FLASHING OPERATIONS WILL TRANSITION TO OPERATIONAL SEQUENCE 4.
11. ALL "WALK" INDICATIONS WILL IMMEDIATELY TRANSITION TO 'FLASHING DON'T WALK" (FDW). NORMAL FDW WILL BE PROVIDED AND MAY BE COMPLETED BEYOND OPERATIONAL SEQUENCE 11-12.
12. ALL DEVICES TO REMAIN IN OPERATIONAL SEQUENCE 11-12 UNTIL THE SYSTEM IS RESET. NORMAL OPERATIONS TO RESET TO MAINLINE GREEN ONCE ALL AVBS HAVE BEEN FULLY RETRACTED.



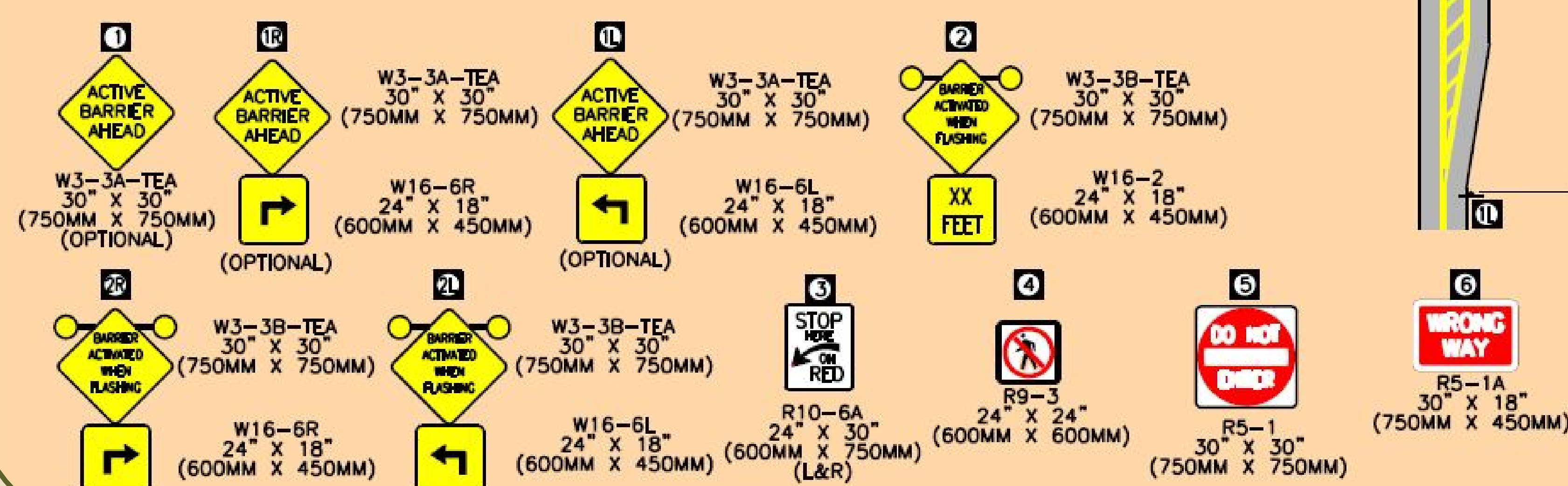
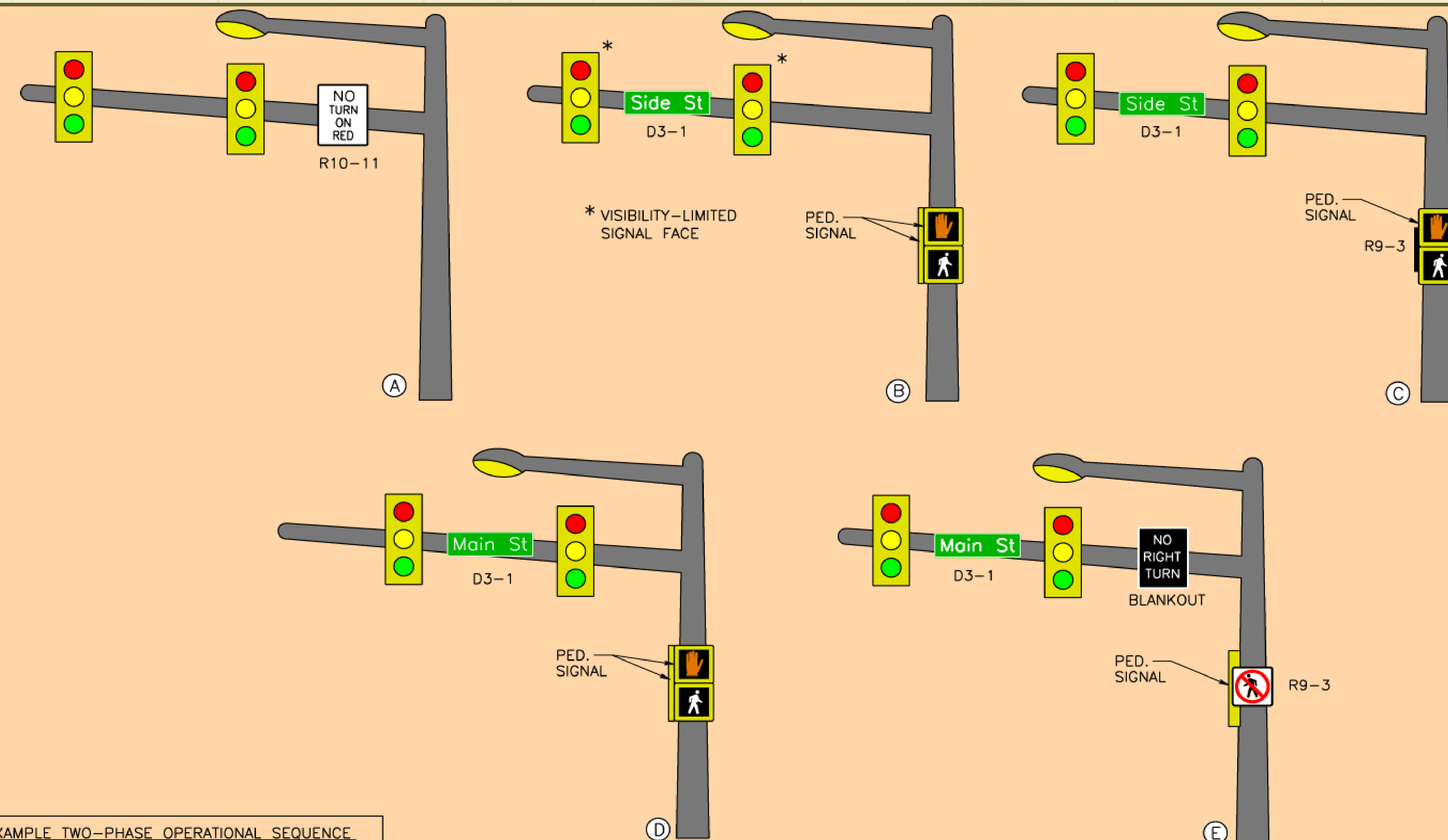
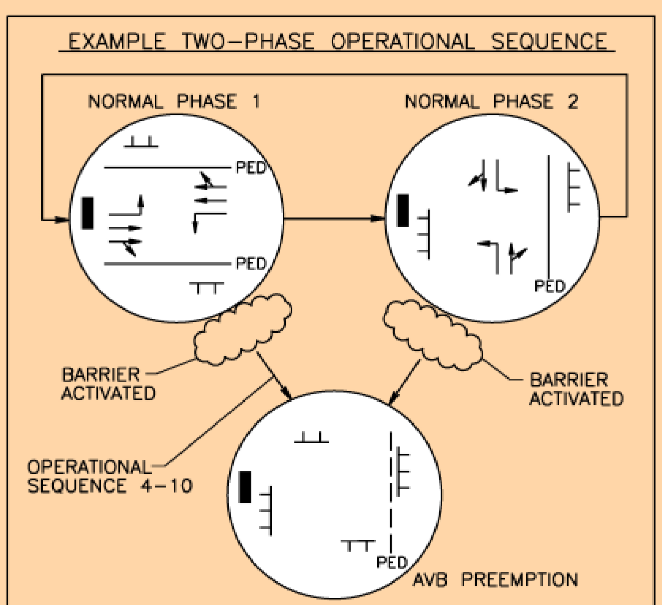


FIGURE 3: AVB System Co-Located at an Intersection (2/2)

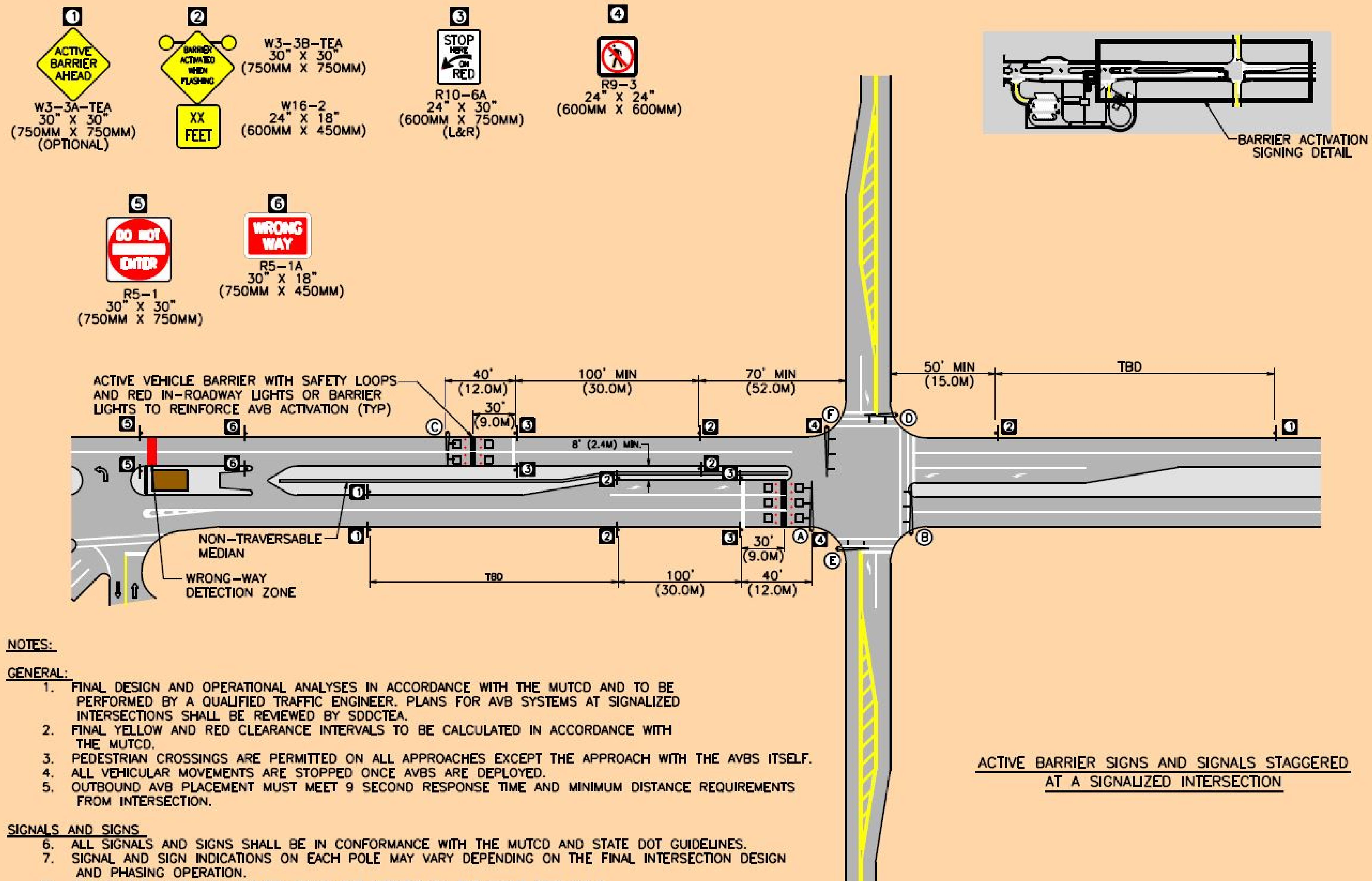




ACTIVE BARRIER SIGNS AND SIGNALS AT AN INTERSECTION PG 2 OF 2

AVB SYSTEM COLLOCATED AT AN INTERSECTION	OPERATIONAL SEQUENCING FOR EMERGENCY FAST OPERATIONS (MIN FOR SAFETY – 25 MPH (40KPH) DESIGN SPEED)											
	TRAFFIC CONTROL	–	1	2	3	4	5	6	7	8	9	10−11	12
		NORMAL OPS	GUARD PERCEPTION AND REACTION TIME TO THREAT (EFO BUTTON)			YELLOW CHANGE (MUTCD MINIMUM)			ALL RED SAFETY	ALL RED SAFETY	ALL RED SAFETY	DEPLOYING BARRIER	THREAT CONTAINED
	WARNING SIGN WITH BEACONS	DARK	DARK	DARK	DARK	ALT FY	ALT FY	ALT FY	ALT FY	ALT FY	ALT FY	ALT FY	ALT FY
	TRAFFIC SIGNAL	G	G	G	G	Y	Y	Y	R	R	R	ALL RED	ALL RED
	IN−ROADWAY LIGHTS ON BARRIER	DARK	DARK	DARK	DARK	DARK	DARK	DARK	FR	FR	FR	FR	FR
	ACTIVE VEHICLE BARRIER	DOWN	DOWN	DOWN	DOWN	DOWN	DOWN	DOWN	DOWN	DOWN	DOWN	ACTIVATED	ACTIVATED/ DEPLOYED
	NO RIGHT TURN BLANKOUT (POLE E)	DARK	DARK	DARK	DARK	DARK	DARK	DARK	NRT	NRT	NRT	NRT	NRT

FIGURE 4: AVB System Staggered at an Intersection (1/2)



NOTES:

GENERAL:

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2. FINAL YELLOW AND RED CLEARANCE INTERVALS TO BE CALCULATED IN ACCORDANCE WITH THE MUTCD.
3. PEDESTRIAN CROSSINGS ARE PERMITTED ON ALL APPROACHES EXCEPT THE APPROACH WITH THE AVBS ITSELF.
4. ALL VEHICULAR MOVEMENTS ARE STOPPED ONCE AVBS ARE DEPLOYED.
5. OUTBOUND AVB PLACEMENT MUST MEET 9 SECOND RESPONSE TIME AND MINIMUM DISTANCE REQUIREMENTS FROM INTERSECTION.

SIGNALS AND SIGNS

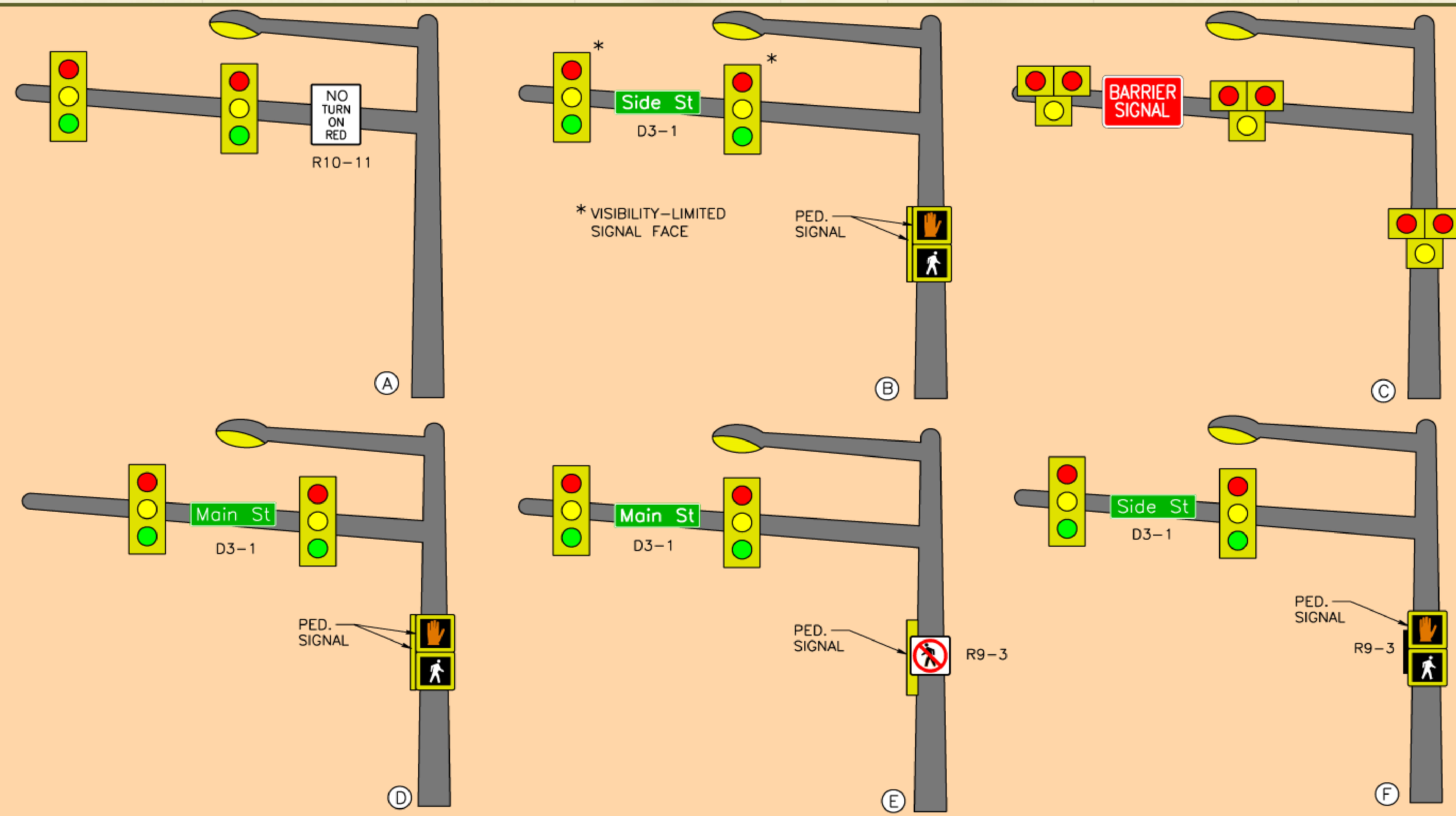
6. ALL SIGNALS AND SIGNS SHALL BE IN CONFORMANCE WITH THE MUTCD AND STATE DOT GUIDELINES.
7. SIGNAL AND SIGN INDICATIONS ON EACH POLE MAY VARY DEPENDING ON THE FINAL INTERSECTION DESIGN AND PHASING OPERATION.
8. FOR SINGLE LANE APPROACHES, SIGNS ARE NEEDED ON THE RIGHT SIDE ONLY.
9. USE OPTICALLY PROGRAMMED SIGNAL INDICATIONS FOR POLE B.

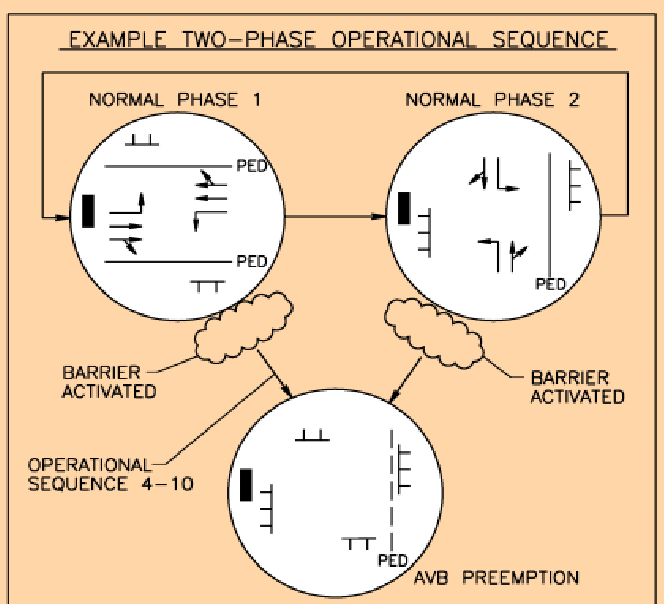
NORMAL MODE TO EFO ACTIVATION

10. SIGNAL TO RUN "NORMAL" PHASING PLAN WHEN EFO IS NOT ACTIVATED.
11. UPON EFO ACTIVATION, ALL "NORMAL" PHASES WILL IMMEDIATELY CEASE THE GREEN PHASE AND TRANSITION TO OPERATIONAL SEQUENCE 4. FLASHING OPERATIONS WILL TRANSITION TO OPERATIONAL SEQUENCE 4.
12. ALL "WALK" INDICATIONS WILL IMMEDIATELY TRANSITION TO 'FLASHING DON'T WALK" (FDW). NORMAL FDW WILL BE PROVIDED AND MAY BE COMPLETED BEYOND OPERATIONAL SEQUENCE 10.
13. ALL DEVICES TO REMAIN IN OPERATIONAL SEQUENCE 10 UNTIL THE SYSTEM IS RESET. NORMAL OPERATIONS TO RESET TO MAINLINE GREEN ONCE ALL AVBS HAVE BEEN FULLY RETRACTED.

ACTIVE BARRIER SIGNS AND SIGNALS STAGGERED AT A SIGNALIZED INTERSECTION

FIGURE 5: AVB System Staggered at an Intersection (2/2)

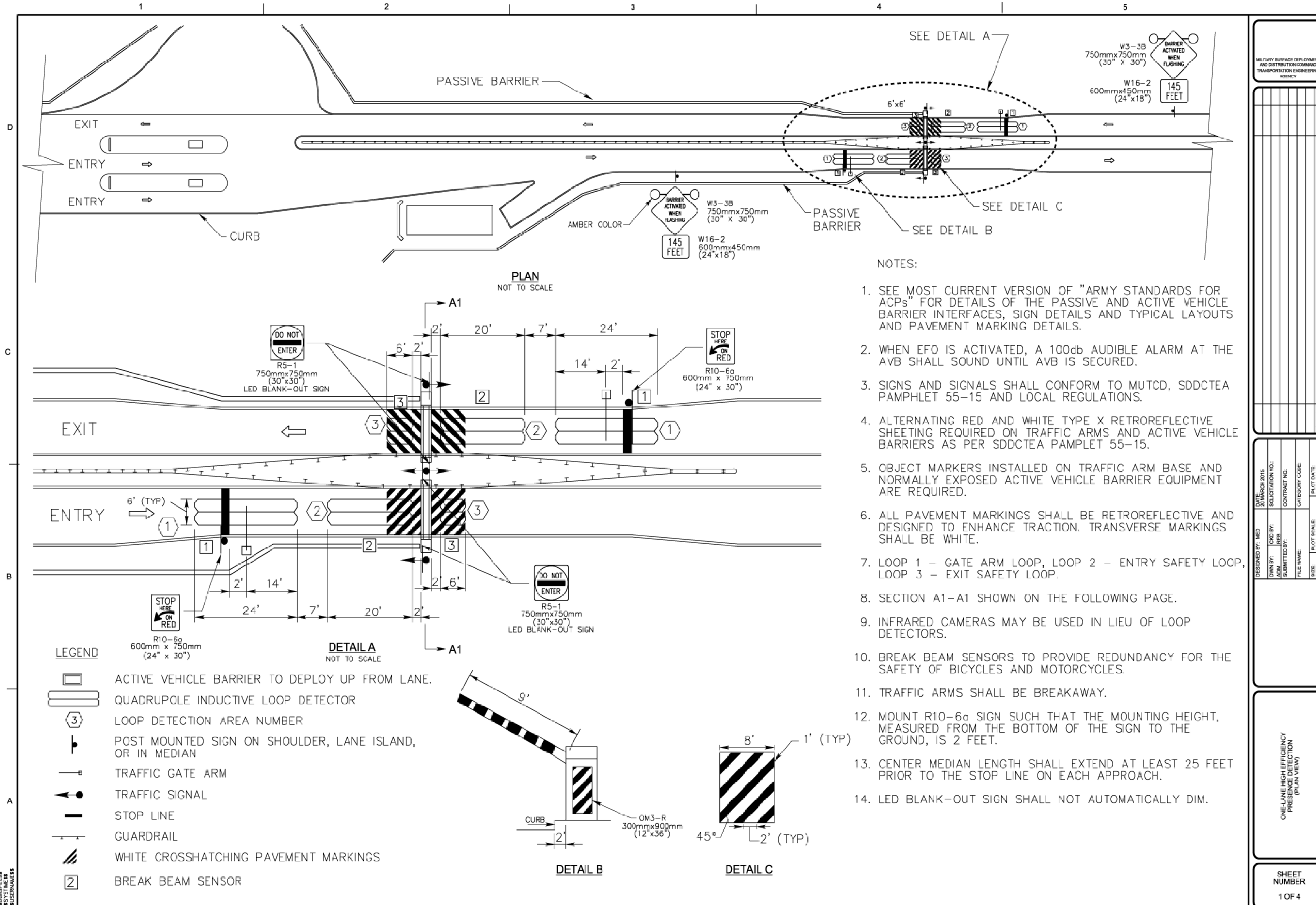




ACTIVE BARRIER SIGNS AND SIGNALS STAGGERED AT AN INTERSECTION PG 2 OF 2

	OPERATIONAL SEQUENCING FOR EMERGENCY FAST OPERATIONS (MIN FOR SAFETY − 25 MPH (40KPH) DESIGN SPEED)											
	TRAFFIC CONTROL	−	1	2	3	4	5	6	7	8	9	10
		NORMAL OPS	GUARD PERCEPTION AND REACTION TIME TO THREAT (EFO BUTTON)			YELLOW CHANGE (MUTCD MINIMUM)			ALL RED	DEPLOYING BARRIER		THREAT CONTAINED
AVB SYSTEM STAGGERED AT AN INTERSECTION	WARNING SIGN WITH BEACONS	DARK	DARK	DARK	DARK	ALT FY	ALT FY	ALT FY	ALT FY	ALT FY	ALT FY	ALT FY
	HYBRID BEACON	DARK	DARK	DARK	DARK	FLASHING YELLOW	STEADY YELLOW	STEADY YELLOW	STEADY YELLOW	ALT FR	ALT FR	ALT FR
	TRAFFIC SIGNAL	G	G	G	G	Y	Y	Y	STEADY RED	STEADY RED	ALL RED	ALL RED
	IN−ROADWAY LIGHTS ON BARRIER	DARK	DARK	DARK	DARK	DARK	DARK	DARK	FR	FR	FR	FR
	ACTIVE VEHICLE BARRIER	DOWN	DOWN	DOWN	DOWN	DOWN	DOWN	DOWN	DOWN	ACTIVATED	ACTIVATED	DEPLOYED

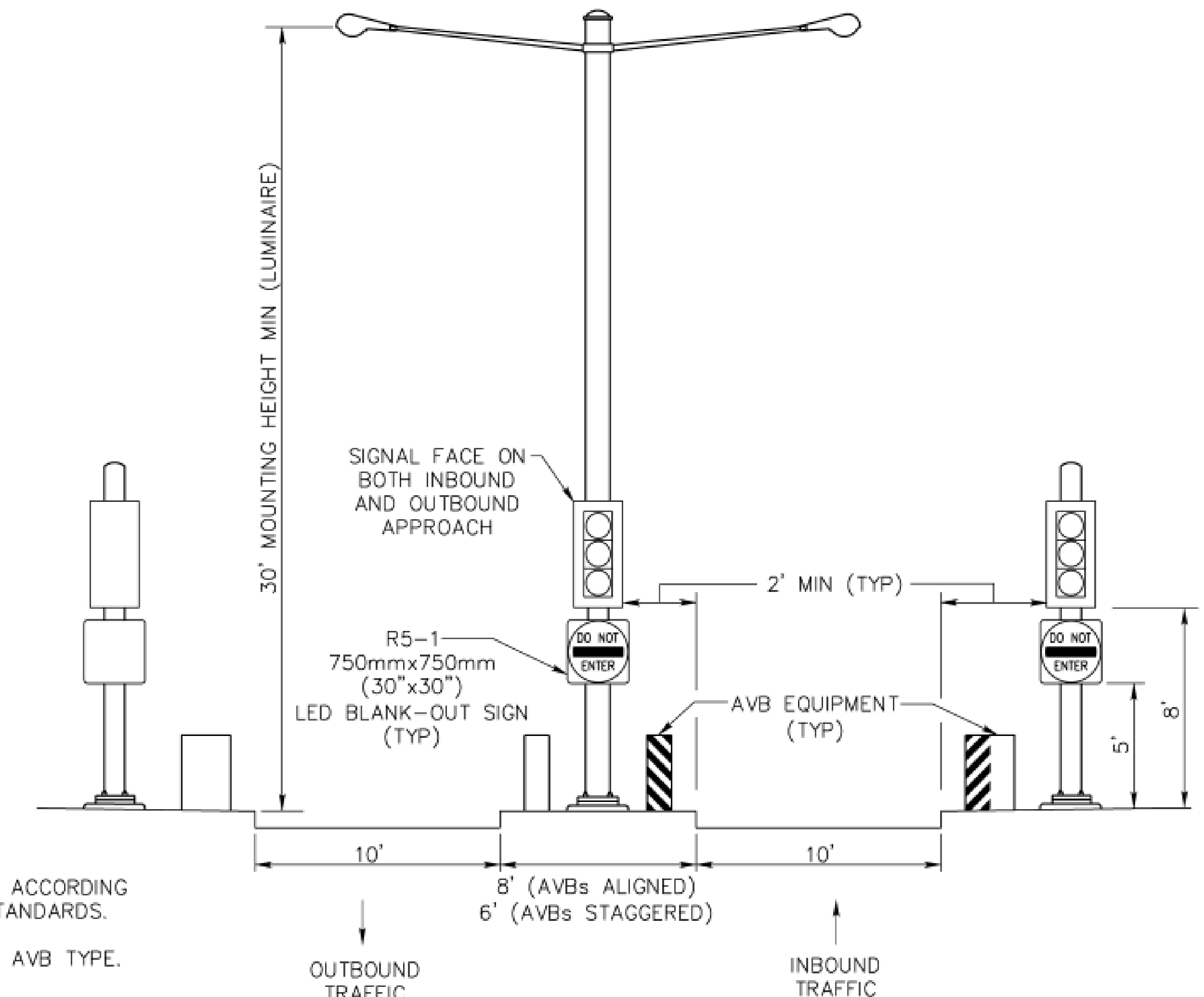
FIGURE 6: One-Lane High Efficiency Presence Detection (Two-lane Cross Section) (1/2)



NOTES:

1. SEE MOST CURRENT VERSION OF "ARMY STANDARDS FOR ACPs" FOR DETAILS OF THE PASSIVE AND ACTIVE VEHICLE BARRIER INTERFACES, SIGN DETAILS AND TYPICAL LAYOUTS AND PAVEMENT MARKING DETAILS.
2. WHEN EFO IS ACTIVATED, A 100db AUDIBLE ALARM AT THE AVB SHALL SOUND UNTIL AVB IS SECURED.
3. SIGNS AND SIGNALS SHALL CONFORM TO MUTCD, SDDCTEA PAMPHLET 55–15 AND LOCAL REGULATIONS.
4. ALTERNATING RED AND WHITE TYPE X RETROREFLECTIVE SHEETING REQUIRED ON TRAFFIC ARMS AND ACTIVE VEHICLE BARRIERS AS PER SDDCTEA PAMPLET 55–15.
5. OBJECT MARKERS INSTALLED ON TRAFFIC ARM BASE AND NORMALLY EXPOSED ACTIVE VEHICLE BARRIER EQUIPMENT ARE REQUIRED.
6. ALL PAVEMENT MARKINGS SHALL BE RETROREFLECTIVE AND DESIGNED TO ENHANCE TRACTION. TRANSVERSE MARKINGS SHALL BE WHITE.
7. LOOP 1 – GATE ARM LOOP, LOOP 2 – ENTRY SAFETY LOOP, LOOP 3 – EXIT SAFETY LOOP.
8. SECTION A1–A1 SHOWN ON THE FOLLOWING PAGE.
9. INFRARED CAMERAS MAY BE USED IN LIEU OF LOOP DETECTORS.
10. BREAK BEAM SENSORS TO PROVIDE REDUNDANCY FOR THE SAFETY OF BICYCLES AND MOTORCYCLES.
11. TRAFFIC ARMS SHALL BE BREAKAWAY.
12. MOUNT R10–6a SIGN SUCH THAT THE MOUNTING HEIGHT, MEASURED FROM THE BOTTOM OF THE SIGN TO THE GROUND, IS 2 FEET.
13. CENTER MEDIAN LENGTH SHALL EXTEND AT LEAST 25 FEET PRIOR TO THE STOP LINE ON EACH APPROACH.
14. LED BLANK–OUT SIGN SHALL NOT AUTOMATICALLY DIM.

OPERATIONAL SEQUENCING FOR EMERGENCY FAST OPERATIONS									
	TRAFFIC CONTROL	GUARD REACTION			SAFETY INTERVAL		DEPLOYING BARRIER		THREAT CONTAINED
	TIMELINE (SEC)	1	2	3	4	5	6	7	--
ONE- LANE HIGH EFFICIENCY PRESENCE DETECTION	W3-3B WARNING SIGN WITH BEACONS	DARK			ALTERNATING FLASHING YELLOW				
	DO NOT ENTER LED BLANK-OUT SIGN	DARK			"DO NOT ENTER" ILLUMINATED				
	TRAFFIC SIGNALS	NORMAL OPERATIONS			YELLOW		RED		
	TRAFFIC ARM	NORMAL OPERATIONS			BEGIN DOWN		DOWN		DOWN
	100 dB HORN	SILENT			ACTIVATED				
	ACTIVE VEHICLE BARRIER	DOWN					DEPLOYED		DEPLOYED



SECTION A1-A1
NOT TO SCALE

NOTES:

1. DESIGN ALL POLE FOUNDATIONS ACCORDING TO LOCAL REGULATIONS AND STANDARDS.
2. AVB SUPPORT WIDTHS VARY BY AVB TYPE.
3. DESIGN ALL LED BLANK-OUT SIGNS ACCORDING TO THE MUTCD.
4. ALL SIGNALS SHALL BE LED AND HAVE TUNNEL VISORS WITH LOUVERS AND BACKPLATES. 8-INCH INDICATIONS SHALL BE USED.
5. MEDIAN AND LANE WIDTHS SHOWN ARE RECOMMENDED. CHANGES MAY BE MADE WITH APPROVAL FROM SDDCTEA.
6. HEIGHT TO BOTTOM OF THE DO NOT ENTER SIGN AND THE HEIGHT TO BOTTOM OF THE SIGNAL IS REQUIRED.

ONE-LANE HIGH EFFICIENCY PRESENCE DETECTION SECTION A1-A1

SHEET NUMBER 2 OF 4

FIGURE 8: Two-lane High Efficiency Presence Detection Scheme (1/2)

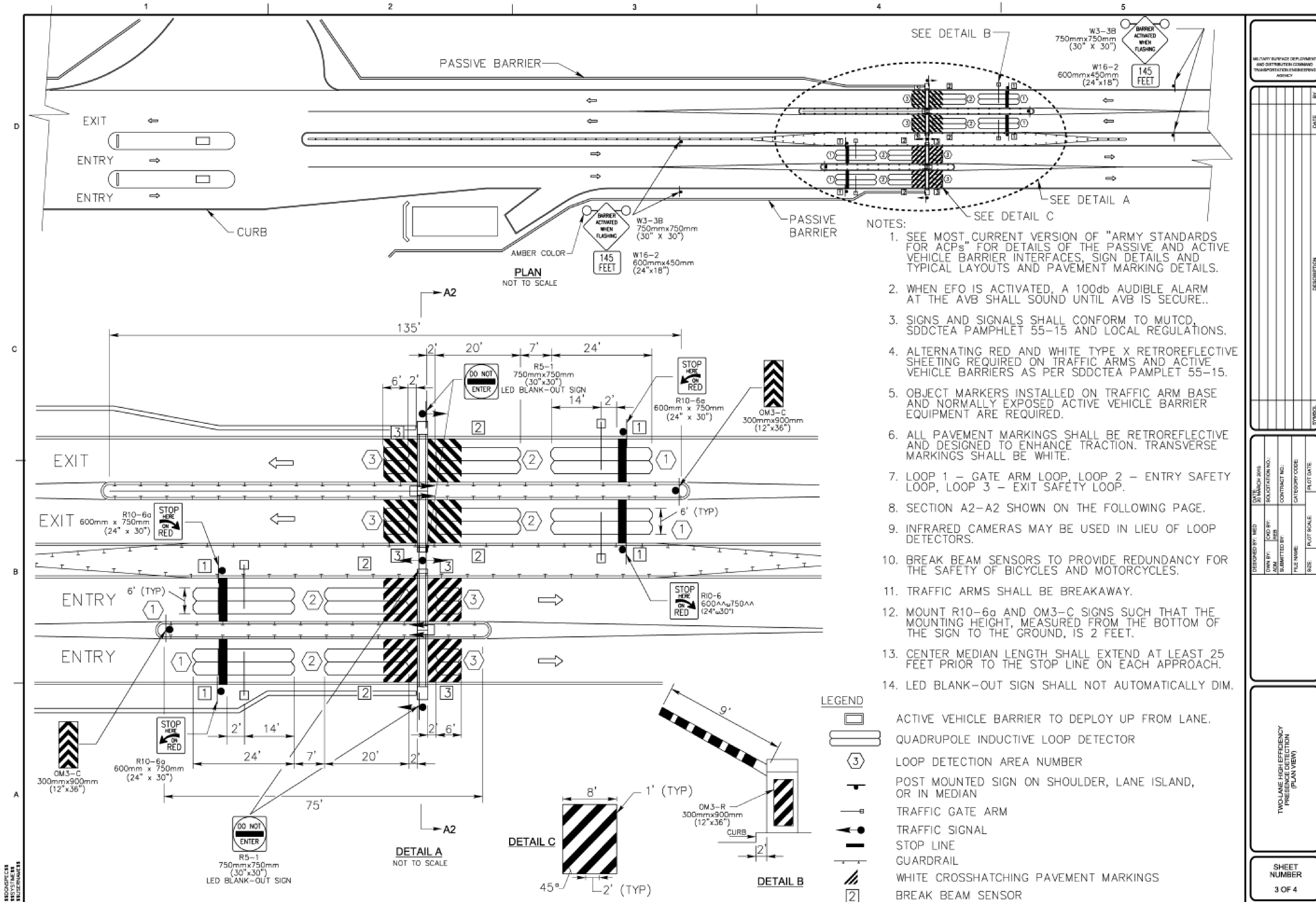
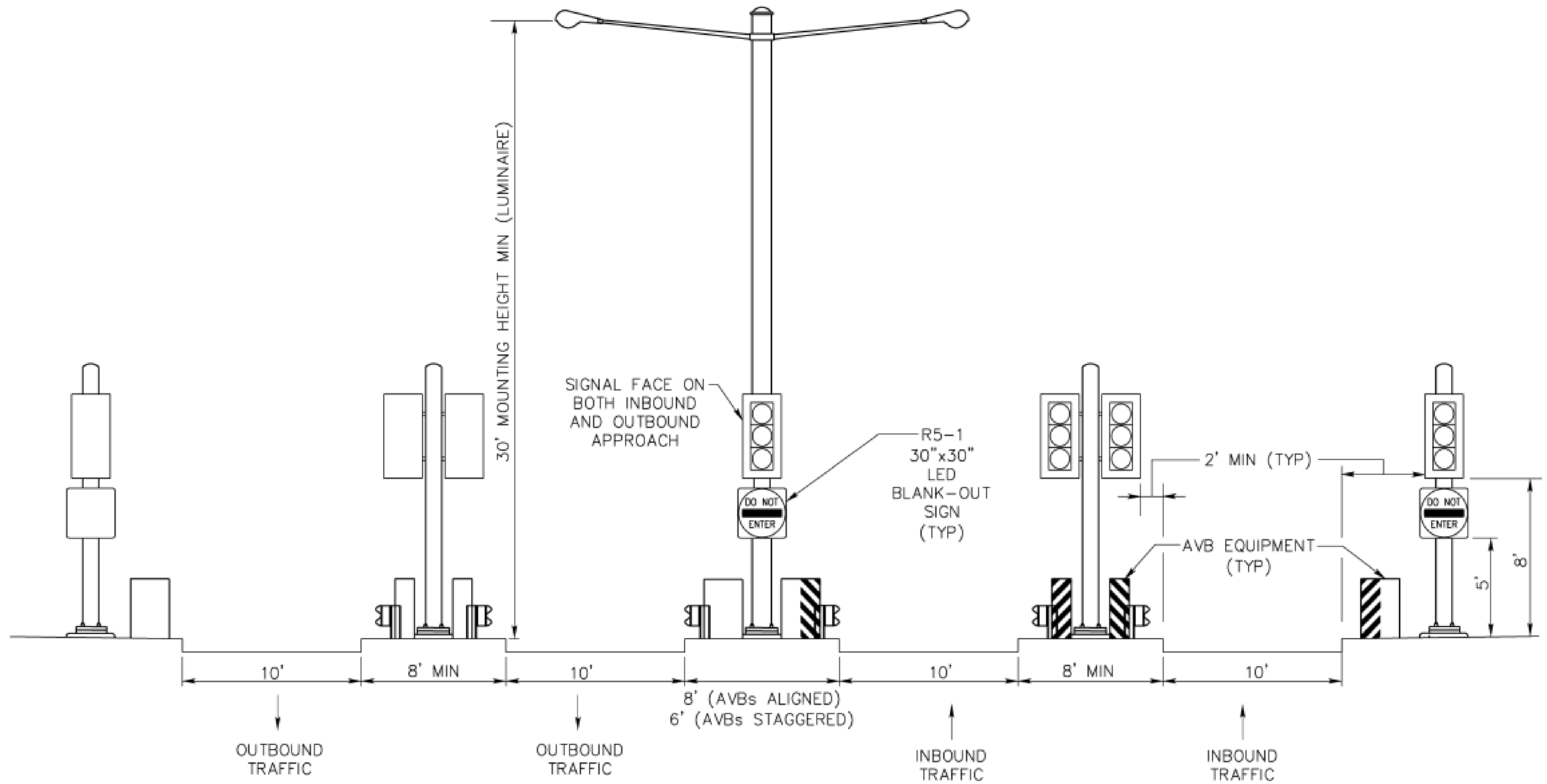


FIGURE 9: Two-lane High Efficiency Presence Detection Scheme (2/2)

	OPERATIONAL SEQUENCING FOR EMERGENCY FAST OPERATIONS								
TWO- LANE HIGH EFFICIENCY PRESENCE DETECTION	TRAFFIC CONTROL	GUARD REACTION			SAFETY INTERVAL		DEPLOYING BARRIER		THREAT CONTAINED
	TIMELINE (SEC)	1	2	3	4	5	6	7	--
	W3-3B WARNING SIGN WITH BEACONS	DARK			ALTERNATING FLASHING YELLOW				
	DO NOT ENTER LED BLANK-OUT SIGN	DARK			"DO NOT ENTER" ILLUMINATED				
	TRAFFIC SIGNALS	NORMAL OPERATIONS			YELLOW		RED		
	TRAFFIC ARM	NORMAL OPERATIONS			BEGIN DOWN		DOWN		DOWN
	100 dB HORN	SILENT			ACTIVATED				
	ACTIVE VEHICLE BARRIER	DOWN					DEPLOYED		DEPLOYED



SECTION A2-A2
NOT TO SCALE

NOTES:

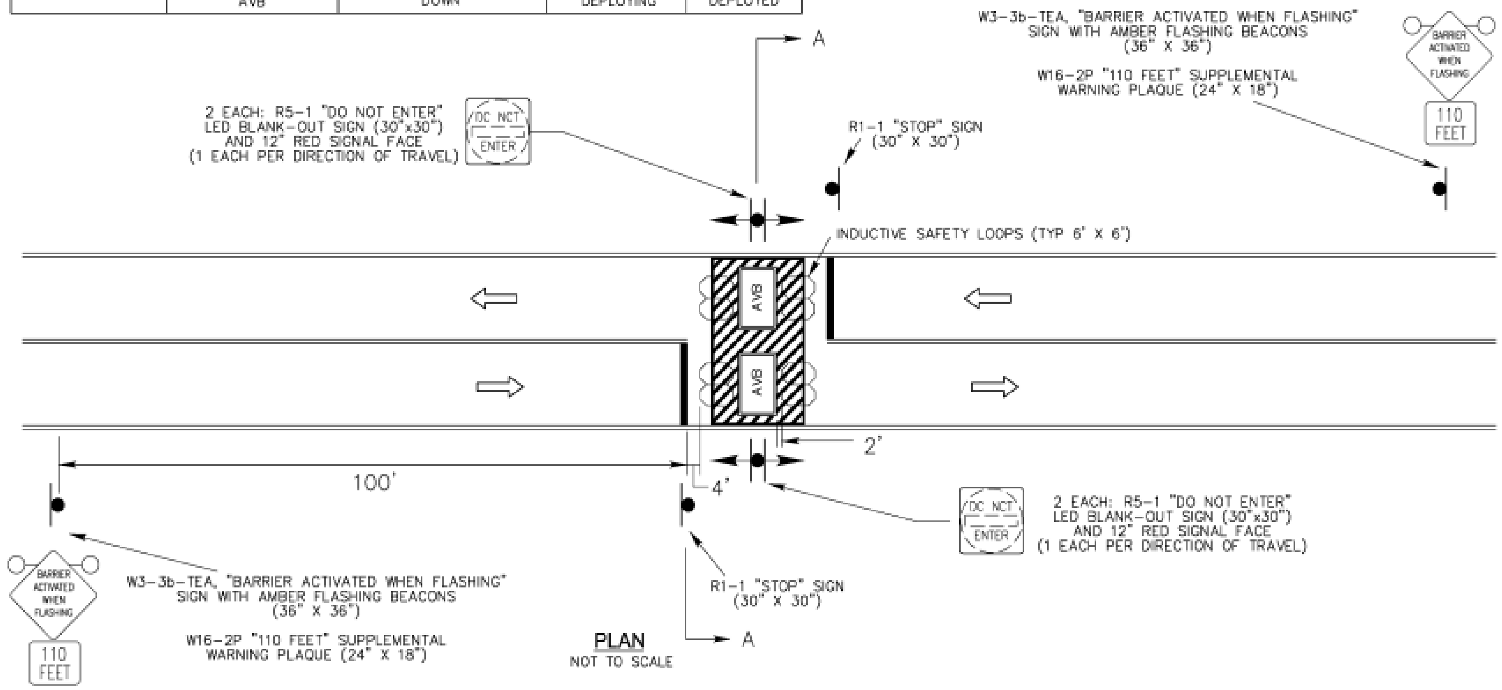
1. DESIGN ALL POLE FOUNDATIONS ACCORDING TO LOCAL REGULATIONS AND STANDARDS.
2. AVB SUPPORT WIDTHS VARY BY AVB TYPE.
3. DESIGN ALL LED BLANK-OUT SIGNS ACCORDING TO THE MUTCD.
4. ALL SIGNALS SHALL BE LED AND HAVE BACKPLATES. LOUVERS ARE OPTIONAL BASED ON SITE CONDITIONS. 8-INCH INDICATIONS SHALL BE USED.
5. MEDIAN AND LANE WIDTHS SHOWN ARE RECOMMENDED. CHANGES MAY BE MADE WITH APPROVAL FROM SDDCTEA.

TWO-LANE HIGH EFFICIENCY PRESENCE DETECTION SECTION A2-A2

SHEET NUMBER 4 OF 4

FIGURE 10: Stop Control Scheme

STOP CONTROL AVB SAFETY SCHEME	OPERATIONAL SEQUENCING FOR EMERGENCY FAST OPERATIONS					
TRAFFIC CONTROL	GUARD REACTION			BARRIER DEPLOYMENT		THREAT CONTAINED
TIMELINE (sec)	1	2	3	4	5	– –
W3–3b–TEA WARNING SIGN WITH BEACONS	BEACONS DARK			ALTERNATING FLASHING YELLOW		
DO NOT ENTER LED BLANK–OUT SIGN	DARK			"DO NOT ENTER" ILLUMINATED		
RED SIGNAL	DARK			STEADY RED		
100 dB HORN	SILENT			ACTIVATED		
AVB	DOWN			DEPLOYING		DEPLOYED



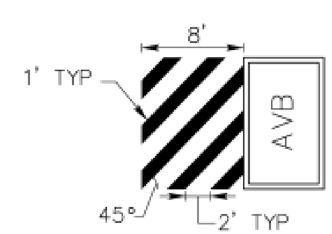
PLAN
NOT TO SCALE

NOTES:

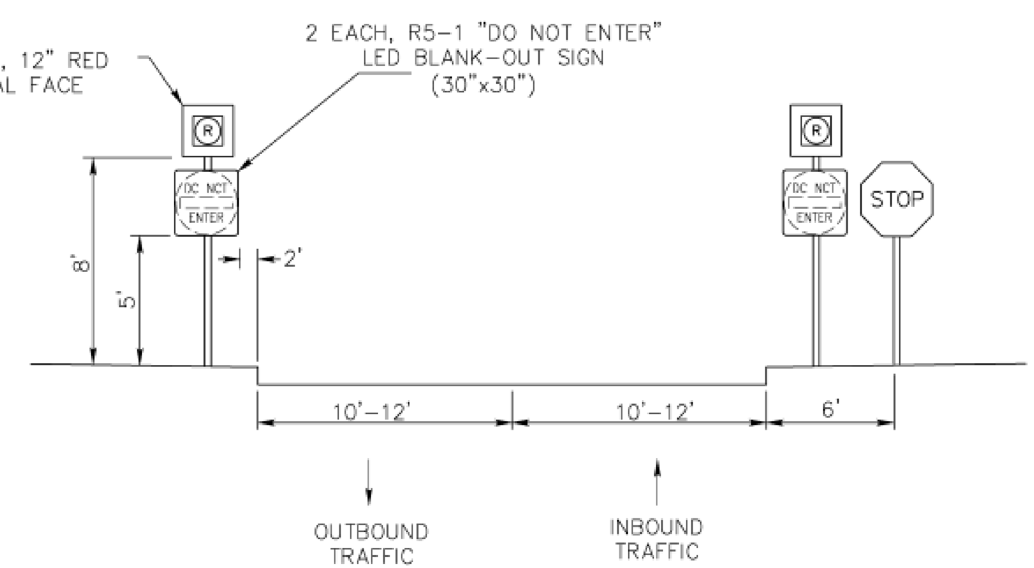
1. THIS SCHEME IS NOT INTENDED FOR USE WHERE TRAFFIC VOLUME EXCEEDS 800 VEHICLES PER HOUR PER LANE.
2. WHEN EFO IS ACTIVATED, A 100dB ALARM LOCATED AT THE AVB SHALL SOUND FOR AT LEAST 10 SECONDS, AND BE DIRECTED TOWARDS ONCOMING TRAFFIC; BOTH DIRECTIONS.
3. SIGNS AND SIGNALS SHALL CONFORM TO THE MUTCD, AND SDDCTEA PAMPHLETS 55–15 AND 55–14.
4. ALTERNATING RED AND WHITE STRIPING REQUIRED ON AVBs AS PER SDDCTEA PAMPHLET 55–15.
5. MUTCD COMPLIANT OBJECT MARKERS ARE REQUIRED ON ALL EXPOSED AVB EQUIPMENT WITHIN THE CLEARZONE.
6. ALL PAVEMENT MARKINGS SHALL BE RETROREFLECTIVE. NO PASSING AND NO PARKING ZONES SHALL APPLY 300' EITHER SIDE OF THE AVB.
7. SIGNAL AND SIGN POSTS SHALL HAVE FRANGIBLE BASES WITH FOUNDATIONS DESIGNED TO LOCAL REGULATIONS AND STANDARDS.
8. ALL SIGNALS SHALL BE LED AND HOODED WITH BACKPLATES. 12–INCH INDICATIONS SHALL BE USED.
9. UNDER EFO CONDITION, AVBs SHALL BE DESIGNED TO OPERATE INDEPENDENTLY IN CONJUNCTION WITH SAFETY LOOP DETECTION.
10. PLAN DETAILS ARE TYPICAL AND MAY BE ADJUSTED TO MEET SITE CONDITIONS UNDER COORDINATION WITH SDDCTEA.

LEGEND

- ACTIVE VEHICLE BARRIER (AVB)
- QUADRUPOLE INDUCTIVE LOOP DETECTOR
- POST MOUNTED SIGN
- AVB SIGNAL
- AVB SIGNAL AND SIGNS ASSEMBLY
- STOP LINE
- TRAFFIC FLOW
- AVB ENVELOPE PAVEMENT MARKING – WHITE



AVB ENVELOPE PAVEMENT MARKING DETAIL



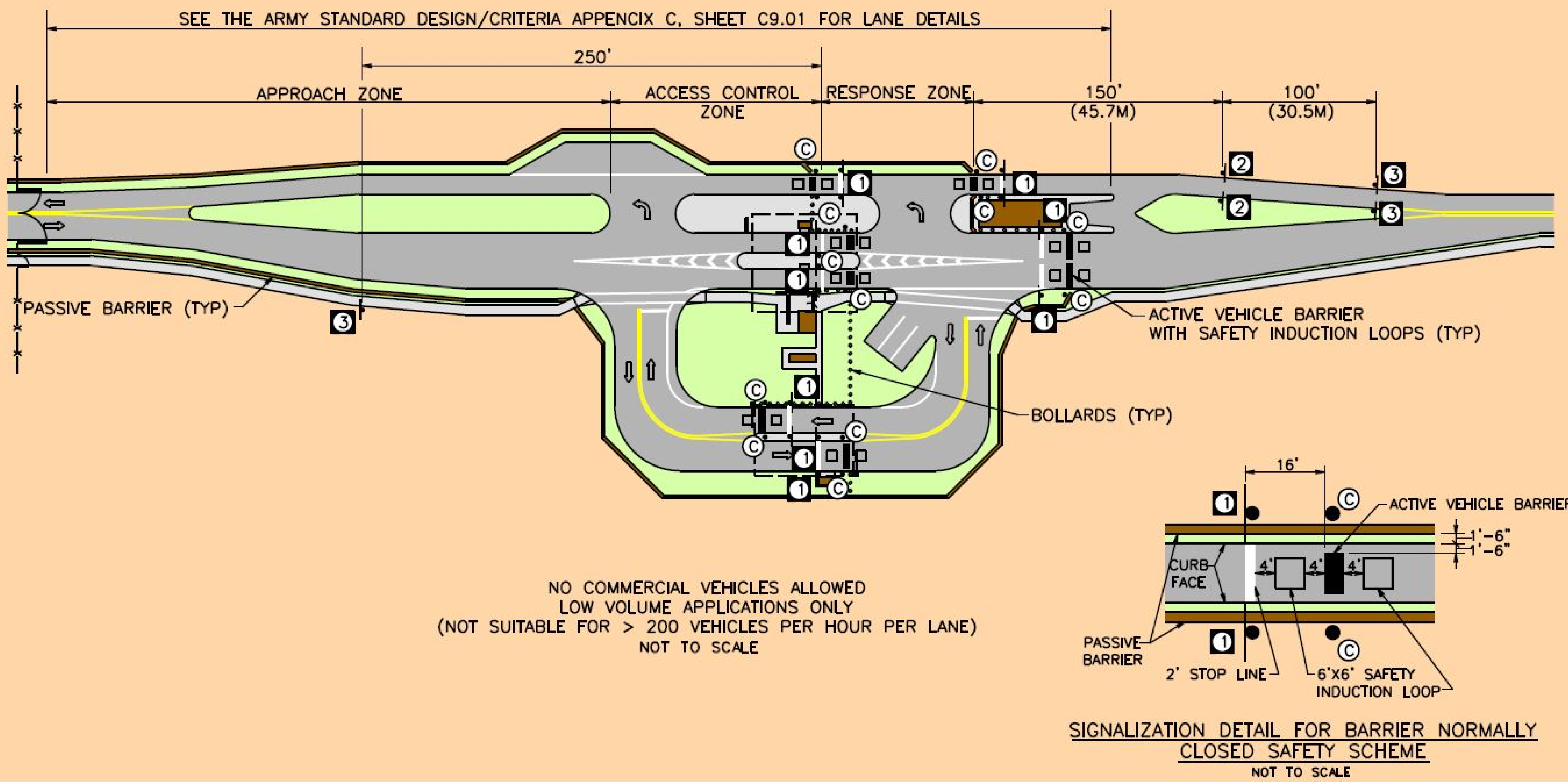
SECTION A-A
NOT TO SCALE

FINAL
MARCH 2015

STOP CONTROL AVB SAFETY SCHEME

SHEET NUMBER 1 OF 1

FIGURE 11: Barrier-Up Operations Scheme



NOTES:

1. SEE ARMY ACP STANDARD DESIGN FOR MORE DETAILED DRAWINGS.
2. BARRIERS ARE NORMALLY CLOSED. ID CHECK AREA OR GATEHOUSE GUARD OPENS BARRIER FOR EACH INBOUND OR OUTBOUND VEHICLE AND THEN IMMEDIATELY CLOSES IT BEHIND THEM.
3. MOUNT TRAFFIC SIGNALS ON BOTH SIDES OF ROADWAY.
4. TILT TRAFFIC SIGNALS INWARD SUCH THAT THEY CAN BE SEEN ONLY FROM APPROPRIATE LANE, OR USE VISIBILITY LIMITED SIGNAL FACE.

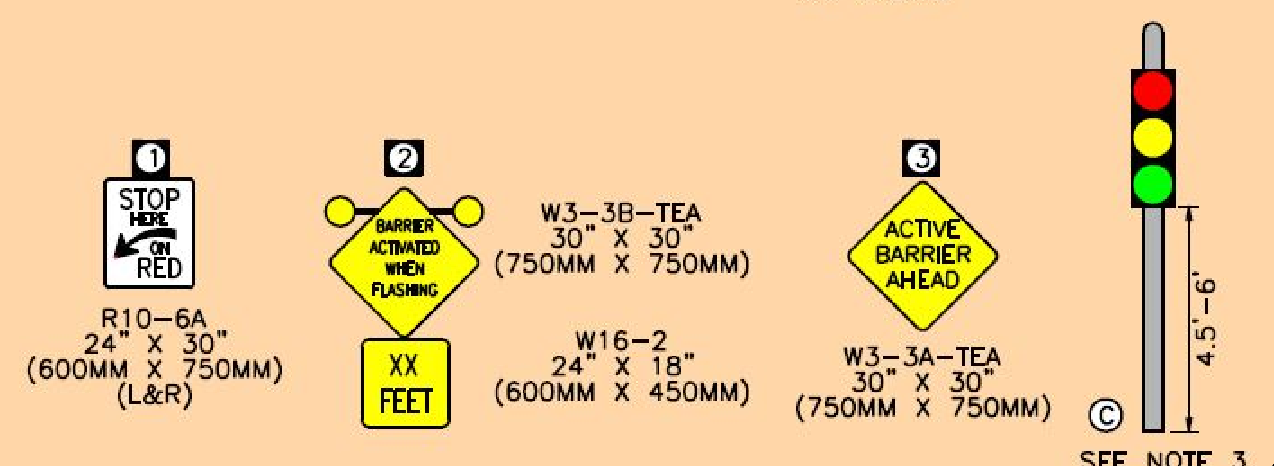
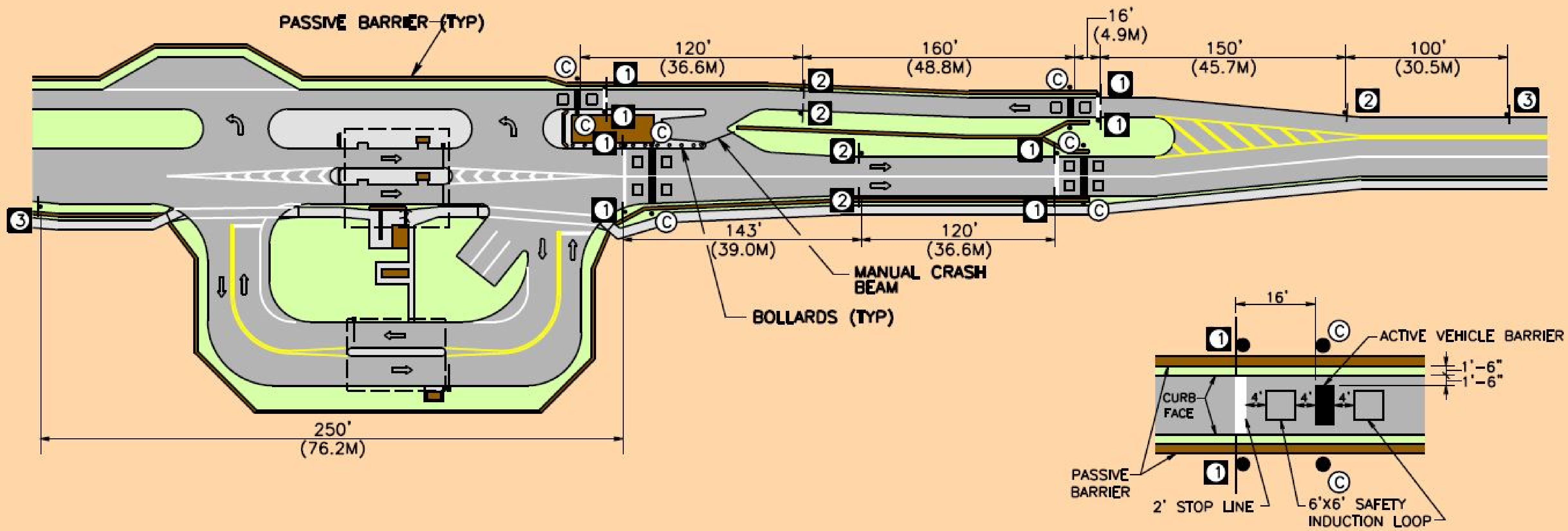


FIGURE 12: Barrier-Up Vehicle Platooning Operations Scheme

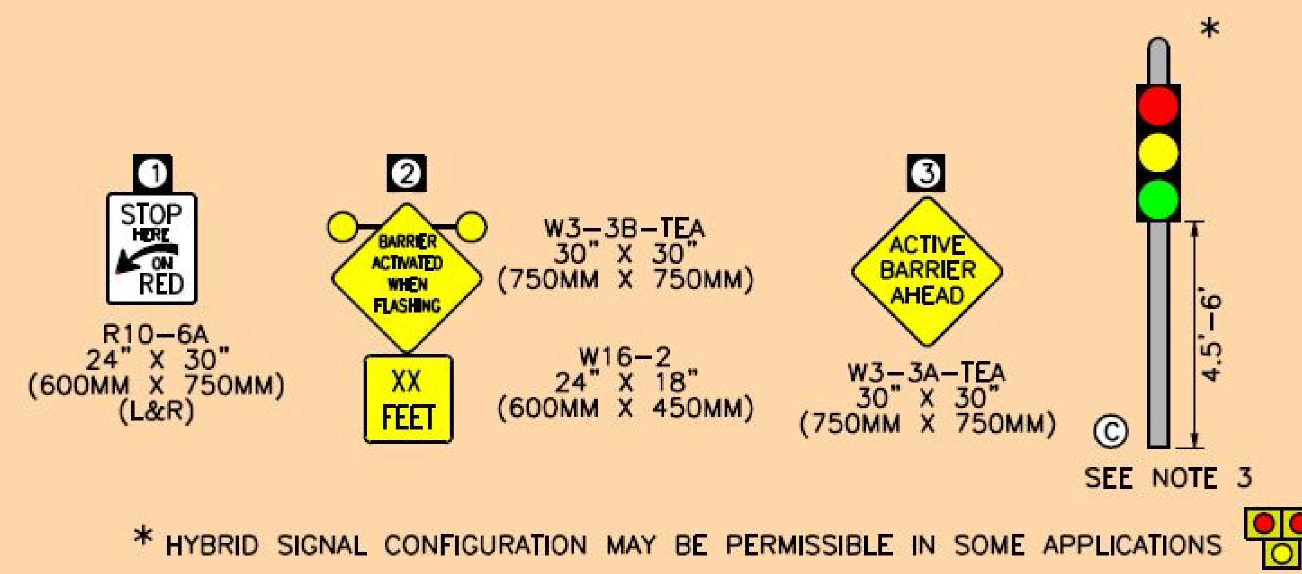


SIGNALIZATION DETAIL FOR BARRIER NORMALLY CLOSED SAFETY SCHEME

NOT TO SCALE

NOTES:

1. SEE THE ARMY ACP STANDARD DESIGN FOR MORE DETAILED DRAWINGS.
2. REPONSE ZONE LENGTH VARIERS WITH THE NUMBER AND TYPE OF VEHICLES TO BE QUEUED AND AVAILABLE REAL ESTATE. ADJUST SIGNS AND SIGN SPACING AS NECESSARY, BUT IN CONFORMACE WITH THE MUTCD.
3. AT AVB, MOUNT TRAFFIC SIGNALS ON BOTH SIDES OF ROADWAY, AS APPROACHING AVB.



* HYBRID SIGNAL CONFIGURATION MAY BE PERMISSIBLE IN SOME APPLICATIONS

AVB Scheme	Response Time	Capacity	Advantages	Disadvantages
Conventional	9 seconds	1800 veh/hr/ln	• Best capacity • Signal and barrier are one independent system	• Long response zone
Co-Located	Variable, 11-12 seconds typical	Dependent on capacity of signalized intersection	• One signal when a downstream signalized intersection exists • Have stopping conditions in an "expected" location	• Long response zone • More complex signal operations
Co-Located Staggered	9 seconds	Dependent on capacity of signalized intersection	• Less threat containment time required versus Co-Located	• Additional signal for outbound vs. Co-Located • Outbound lanes may require different alignment versus inbound
High Efficiency Presence	7 seconds	1200 veh/hr/ln	• Shortest response zone possible while allowing primarily free-flowing traffic	• Complex signal system
Stop Control	5 seconds	800 veh/hr/ln	• Shortest response zone possible with barrier-down operations • Ability to retrofit existing response zones	• All traffic must stop at the AVB at all times
Barrier-Up	0 seconds	150 veh/hr/ln	• Low threat risk – a barrier set is always up	• Guards must open barriers for inbound and outbound traffic • Low capacity • Constant cycling of barriers
Vehicle Platooning	0 seconds	200 veh/hr/ln	• Low threat risk – a barrier set is always up	• Guards must open barriers for inbound and outbound traffic • Low capacity • Constant cycling of barriers

Methods to Reduce Response Zones

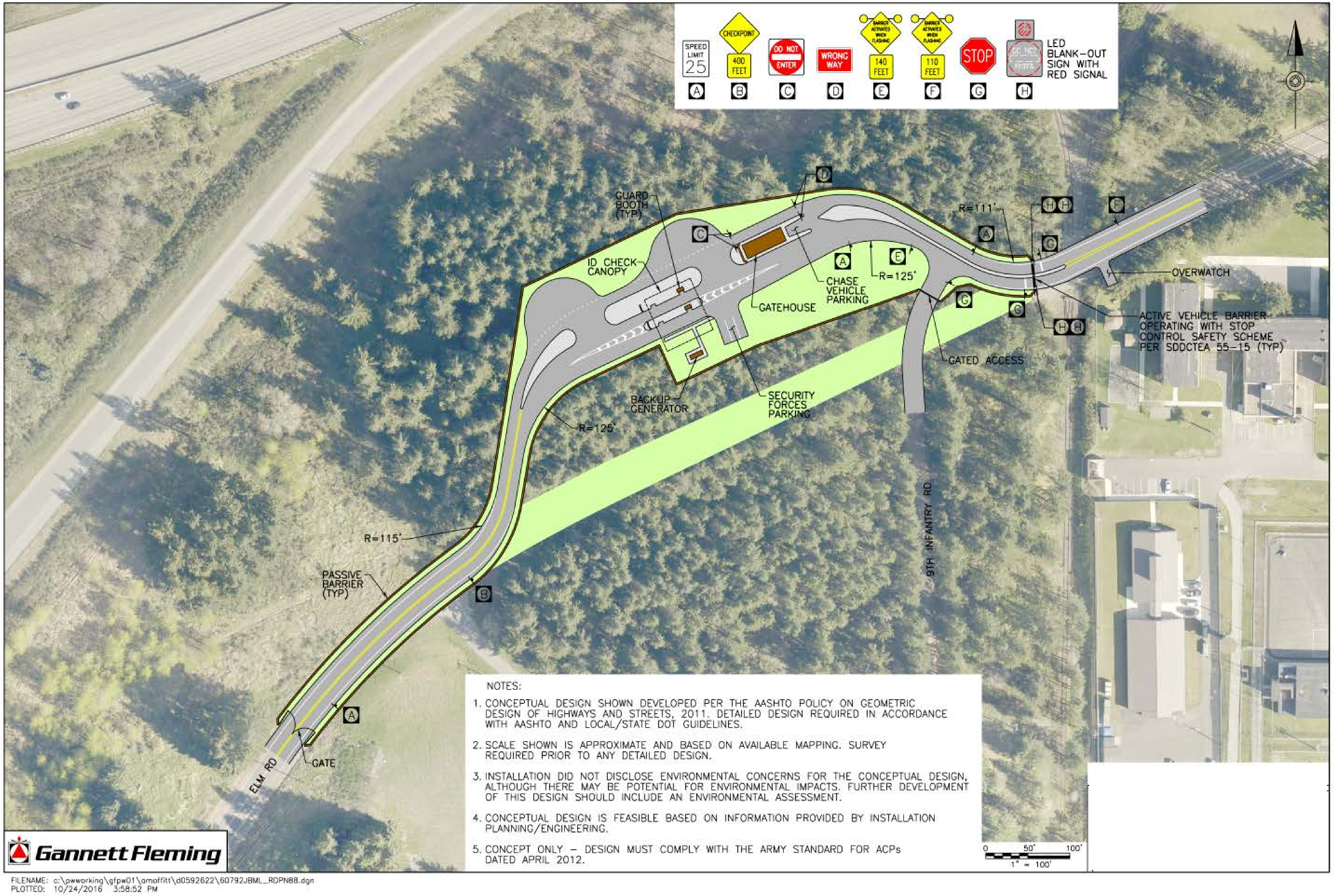
There are options available to assist in reducing the required response zone length, particularly when the required length cannot be achieved.

Advance Speed Detection can be utilized to move the point of detection outward in the approach zone, farther away from the location of the guards. Advance speed detection alerts the guards to a potential threat vehicle earlier, thereby reducing the distance a threat vehicle travels before being noticed. The speed that the detectors are set to must be fully evaluated. Lower speed settings are more prone to triggering false alarms, while higher speed settings may not provide the level of detection needed. The range of detection should be considered. Continuous detection requires complete coverage by the detection unit along the roadway within the approach zone and could become costly depending on the type of detector used. Point speed detection requires less detection because it is limited to one location across the roadway, but is vulnerable to vehicles accelerating after the point of detection.

Wrong Way Detection is similar to advance speed detection but is used in the outbound lanes to detect threat vehicles attempting to enter through the outbound lanes. Point detection is usually appropriate for wrong way detection.

Roadway Curvature within the response zone (and within the approach zone) is often used to physically limit the threat vehicle speeds. Curvature limits the speed of the vehicle by requiring it to slow to a speed which is navigable for the curve. If it travels too fast, it will spin out of control. This is illustrated in figure 13.

FIGURE 13: Roadway Curvature Example



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Reference List

- ☑ TEA Home: http://www.sddc.army.mil/sites/tea
- ☑ SDDCTEA Pamphlet 55-15: *Traffic and Safety Engineering for Better Entry Control Facilities*: https://www.sddc.army.mil/sites/TEA/Functions/SpecialAssistant/TrafficEngineeringBranch/Pages/default.aspx
- ☑ UFC 4-020-02FA Security Engineering: Concept Design
- ☑ UFC 4-020-03FA Security Engineering: Final Design
- ☑ UFC 4-022-01 Security Engineering: Entry Control Facilities / Access Control Points
- ☑ UFC 4-022-02 Selection and Application of Vehicle Barriers, with Change 1.