Traffic Engineering and Highway Safety Bulletin 22-04
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Development Planning

In This Issue…

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Overview

The process of planning for development occurring on a military installation is critical. In the civilian world, when a development is planned, local municipalities and departments of transportation typically require a study to determine the volume of traffic that will be generated by the proposed facility (commonly referred to as a Traffic Impact Study). In addition, the study will identify the necessary improvements to the local road network to mitigate the impacts caused by the generated traffic. The intent is to not allow the traffic to cause an increase in delay to unacceptable levels. Without an approved traffic impact study, the facility is not allowed to be built. In the military world, this step is often skipped, and developments are constructed without regard to traffic impacts along roadways and intersections near the planned development, resulting in excess delay on roadways leading to the site. Entry control facilities (gates) can also be affected, especially if new personnel are added to the population.

For the purposes of this bulletin, development refers to the addition of a facility (of any use or size), which might bring vehicles, pedestrians, or bicycles to an area. Properly accommodating development must include not only properly constructing the building/facility, but also include constructing properly designed roadways and intersections outside of the facility. This includes constructing proper site access and the necessary roadway improvements to address traffic impacts resulting from the development, even if impacts are not at the direct location of the site.

It is critical to ensure that the site is designed properly and that the site plan is reviewed properly. This would (at a minimum) include reviewing aspects related to traffic circulation, pedestrian accommodations, reduction of conflict points, parking lot design, and design vehicle accommodation. Architectural/Engineer firms are often contracted for the design of the site; but the review responsibilities fall upon representatives from the installation and/or another contracting body such as U.S. Army Corps of Engineers (USACE) or the Navy Facilities Engineering Systems Command (NAVFAC).

This bulletin is intended to provide guidance on the traffic engineering aspect of the planning process when development is set to occur. It also identifies crucial traffic engineering aspects that should be considered in the review of the site construction plans.

As part of the development process, follow UFC 3-200-01 on Installation Master Planning and UFC 3-201-01 on Civil Engineering.

Site Selection

The location of a development is an important decision that must be made early in the planning process. A high turnover development, such as a fast-food restaurant or gas station, is ideal for busier locations near other development or in quadrants of major intersections to attract traffic passing by the location. A larger development, such as an office building or educational campus, can be located on large parcels away from other areas since this would give more room to properly design the site. This is conducive to the fact that most of the traffic to this site would be new trips destined for the site, versus pass-by style trips or existing trips already on the network that stop at a development out of convenience.

In the case of a military installation, classrooms should be built within walking distance of dorms to minimize commuting distance and eliminate the need for vehicular dependence and/or parking. Requiring an unnecessary internal commute is undesirable as it contributes to congestion throughout the base and increases overall commuting costs. In general, good practice is to locate a site that is of an adequate size for the development proposed. If the site is too small, the development should not be compressed to fit. If possible, obtain a larger site of more land next to the site. This is often simpler on military bases where property ownership is not an issue. If space is constrained, consider reducing the scope of the facility to match the space available. Adding more floors to a building is a common method of maximizing space available, however parking for that building remains an issue. Underground parking beneath a building is often used in constrained downtown areas. But on military installations where force protection is considered, underground parking may not be feasible.

Traffic Considerations

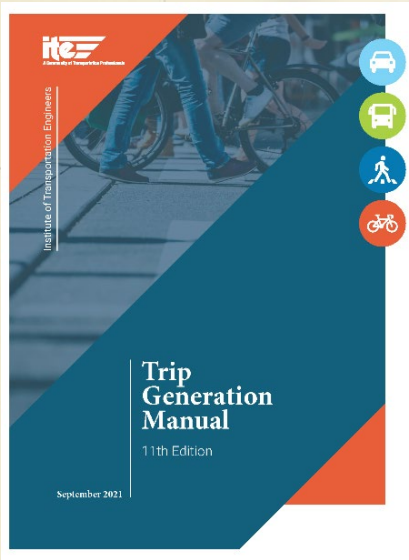
Several different types of development can occur on a military base which commonly include buildings for office-type use, an Exchange or commissary, restaurants, housing areas, schools, and recreational facilities. These land uses can attract significant amounts of traffic. Parking lots must be sized to accommodate the planned traffic volume and the parking duration/utilization the traffic must also be able to drive to and arrive at the destination in a safe and efficient manner.

The traffic a development attracts is referred to as traffic generated. This is quantified as the number of trips generated, typically broken down into trips entering and exiting the site. Different types of development can attract traffic at different times of the day. For operational analysis purposes, the peak hour traffic either of adjacent street traffic or of the generator is typically the period analyzed, specifically the morning and evening peak hours. If the roadway network is significantly busy near the site, the peak hour of adjacent street traffic should be analyzed because the traffic caused by the development typically does not generate a significant proportion of traffic to change the time of the peak on the roadway (Note that even though the development-generated traffic may not change the peak time of the road network, the combination of street traffic and development traffic may require intersection improvements such as the addition of turn lanes, changes to the traffic signal timing/phasing, etc.) If the roadway network has relatively low traffic volumes compared to the development, or if the development generates traffic at a time that does not coincide with the peak hour of traffic of the adjacent roadway network, the peak hour of the generator should be considered because the peak hour of street traffic can change to be governed by the site once it opens.

Different common types of development can have specific characteristics:

- ☑ Office land uses may have a peak around the lunch hour, due to people leaving to get lunch. This would warrant that the mid-day peak hour be evaluated. Travel patterns may be different since the lunch destination could be in a different direction from the point of origin in the morning.
- ☑ Locations that cater to lunchtime traffic, such as fast-food or high turnover restaurants, or even Exchanges and/or food courts, often peak during the lunch hour. In this case, a midday peak must be considered since it can likely govern.
- ☑ A housing area can generate a significant number of trips. These trips are spread throughout the course of the day but governs during the morning and evening peaks.
- ☑ Schools may have an earlier evening peak than adjacent street traffic due to earlier dismissal times. In such cases, the school may have a distinct peak that must be considered.

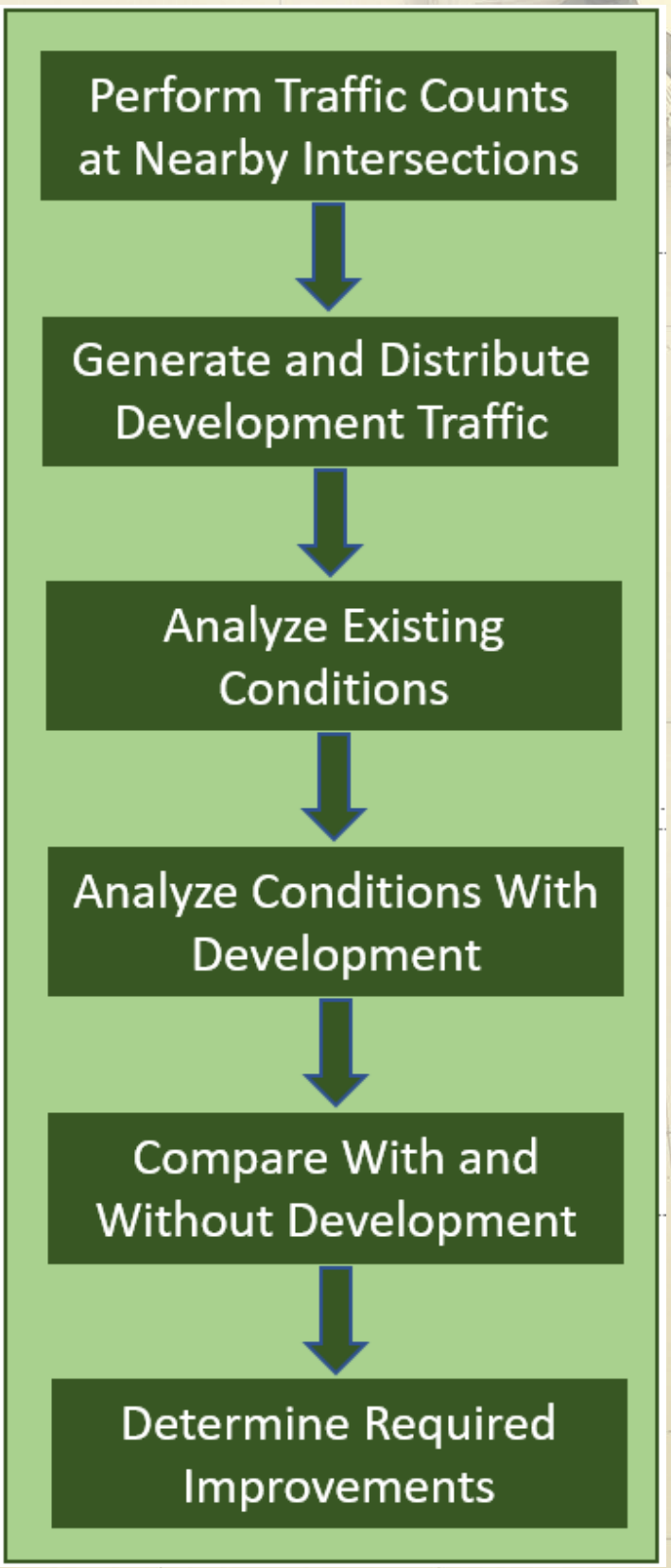
The amount of traffic generated by a facility can be estimated using the ITE *Trip Generation Manual*. This publication can be used to estimate trips generated by various types of facilities, for different peak hours, and by different variables such as floor area or number of employees.



The traffic impact study (TIS) includes an analysis of the intersections within the impact area of the planned development. The existing or base conditions, with no development-generated traffic, are analyzed first to assess how the system is currently operating. The TIS analyzes the intersections within the study area for the existing conditions, the future year with the completed development, and a design year typically 5-10 years after the completion of the development construction. The future and design years should analyze the intersections within the study area with the existing intersection traffic control, turn lanes, through lanes, etc. If the analysis results show that the development-generated traffic impacts the intersection operation to an unacceptable level, then mitigations measures should be recommended and evaluated to show that they will result in acceptable intersection operation. Mitigation may include installation of traffic signals, adjustments to traffic signal timing and phasing, turn lanes, or additional through lanes.

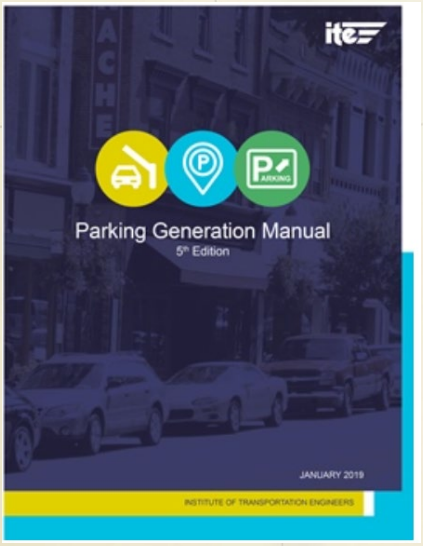
The required improvements should always be part of the project. If it is intended that the improvements be added as part of a later project, there could be risk that the project be cancelled or that the improvements be built after the facility is opened, thereby worsening delays during construction. Also, since the study should identify capacity and traffic control for the site driveway, it is necessary to have the study completed early so the site access can be sized correctly.

Traffic Impact Study Steps



Parking Lots

Parking lots for a facility are an important design consideration. With parking being in short supply in many urbanized, built-up bases, the proper parking lot size for a development is critical. The number of parking spaces for many designs is often based on the level of expected population, (such as 90% of the facility's population) on the premise that a given amount of people will walk, bike, or carpool while at the same time others will be absent due to TDY, vacation or other leave. (100 percent utilization is typically considered "over-design" and not standard based upon traffic engineering standard practice.) This has the potential for brief times of insufficient parking capacity since assumptions for personnel walking or biking may not be accurate, especially in bad weather. A parking lot designed to be nearly full can also result in wasted time and fuel from traffic circling the nearly full lot trying to find an empty space.



The ITE *Parking Generation Manual* is a resource that can be used to forecast parking utilization for a facility, like predicting the traffic generated. The data is based on observations from various types of facilities. Variables are often facility area or personnel assigned. An advantage of using data from a publication is that it is consistent with practice in the civilian world to provide enough available parking. However, installations should strive to minimize parking to the maximum extent possible through efficient land-use practices that support shared-use parking, transit, and alternative modes of transportation.

UFC 3-201-01 Table B-2 identifies parking requirements for several different military base-related land uses. While this table represents minimum requirements for installations, using ITE's manual represents a best practice more consistent with the non-military world. Since it is based on actual parking observations, it is more in line with expected parking needs for a unique facility.

From a site design standpoint, it is preferred that the parking lot be located adjacent to the building it serves, versus across a street. While locating a parking lot across a street can have force protection benefits, doing so exposes increased vehicle-pedestrian risk and conflict, and should be avoided to the extent possible.

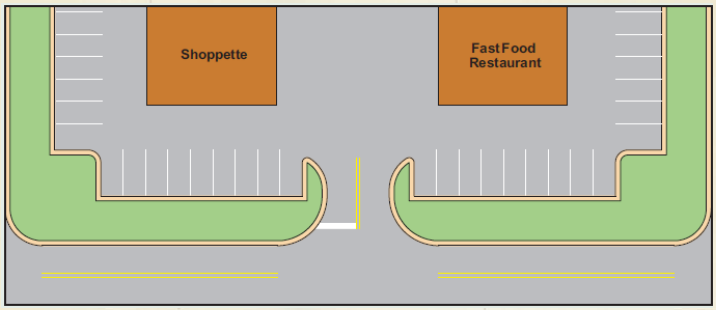
Access Management

The number and location of site access points (driveways) to a development is important. Smaller facilities typically have one access point, but larger developments may require two or more based upon traffic volumes, site layout, traffic circulation, delivery, or service vehicles, etc. Corner parcels often have two driveways, with one fronting each roadway. When driveways are located close to intersections, especially signalized intersections, it is important to verify that driveway operations will not impact traffic signal operations. An evaluation of the intersection queues for the through lanes and any turn lanes along intersection approach where the access point to the development is located is critical for safety and operation. The queuing analysis should ensure that traffic at the intersection does not block the development access point or that traffic to the development does not impact the intersection. Should the analysis identify potential for conflicts, relocating the development access point or restricting access point movements may be necessary, i.e., right-in/right-out access to the development.

When the development's entrance is located too close to a major intersection or on a high-volume roadway, typically two-way traffic exceeding 18,000 - 24,000 vehicles per day, then a right-turn in/right-turn out access point should be evaluated. Consider combining access points with other adjacent developments to be able to drive through one site to access another. If several land uses share one driveway, it may warrant signalization, which could benefit access to all businesses. This also can help to maximize distance from the access to a corner parcel and a major intersection.

Example Right-Turn In/Right-Turn Out Access Configuration

Example of Combining Accesses for Unrelated Businesses (Source: SDDCTEA Pamphlet 55-17)



Site Layout

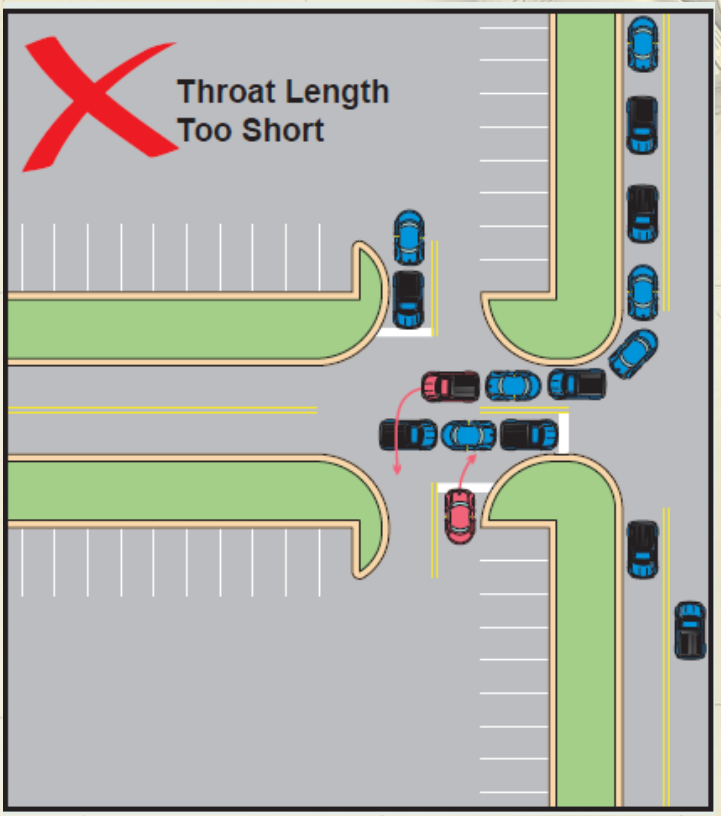
The layout of the site should blend the building location, parking, vehicular access, and pedestrian access in a logical manner. For developments geared to low turnover such as office buildings, parking lots should link the site driveways to sidewalks connecting to the building. Developments geared toward high turnover are similar, but other features must be considered. Restaurants with drive-through service must be designed to minimize conflicts with vehicles accessing the drive-through window, pedestrians and vehicles parking, and the site accesses. Drive-through queuing analysis should also be performed to ensure traffic does not back up onto the off-site roadways.

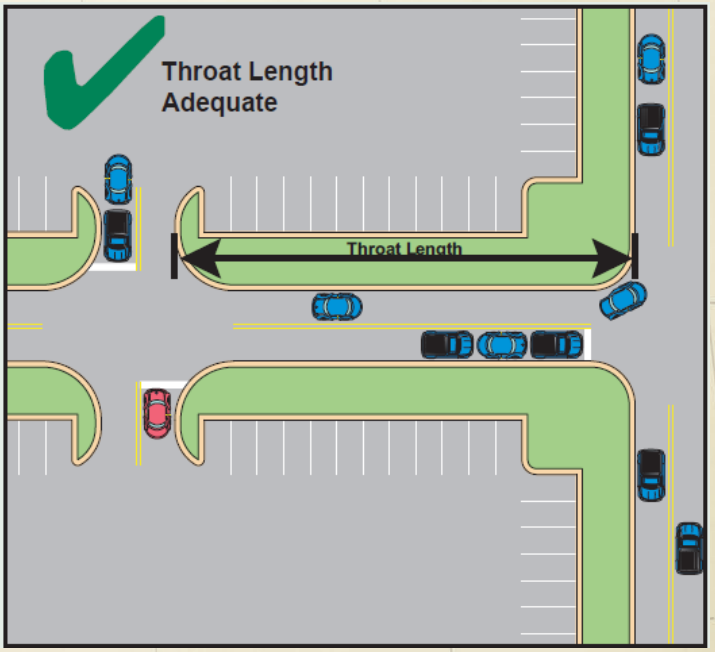
Shoppettes are often characterized by high volume turnover traffic that utilize the gas pumps, convenience store, or both. When designing these types of facilities, locate parking stalls adjacent to the building and gas pumps far enough from the parking stalls to properly allow vehicle parking maneuvers and traffic flow between the gas pumps and parking stalls.

Larger developments, such as shopping centers, commissaries, and Exchanges, generate significant amounts of traffic. The primary entrance leading to these facilities requires a long throat length between the external roadway and the first internal intersection to the site. This throat length is used for queuing for outbound traffic and for funneling inbound traffic for turning correctly once internal to the site. It spaces out intersections so possible queues do not impact an adjacent intersection. The figures at right illustrate adequate and inadequate throat lengths and corresponding traffic impacts.

Throat Length Comparison

(Source: SDDCTEA Pamphlet 55-17)



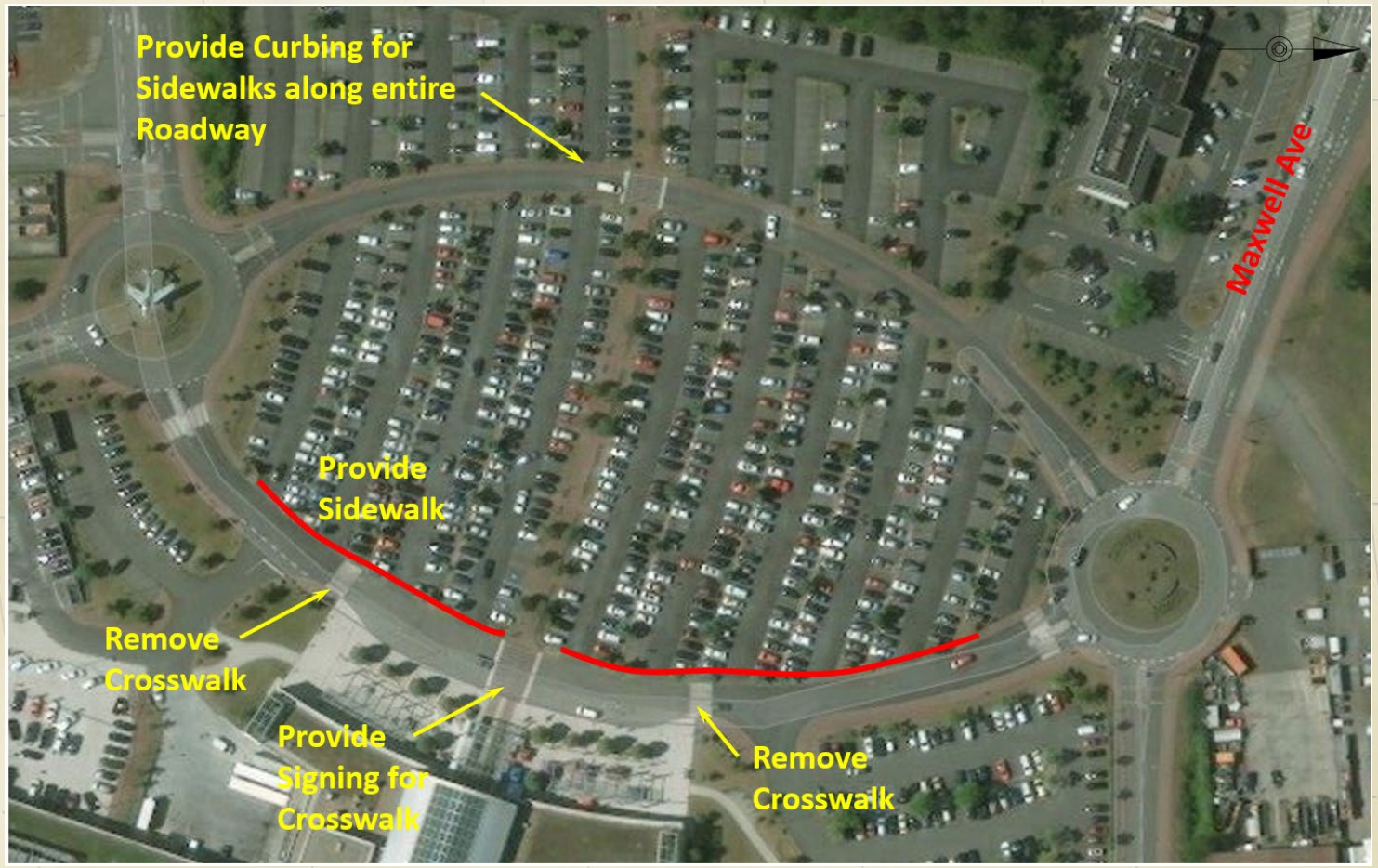


Primary traffic routes should not be designed to be directly in front of the building to reduce conflicts between vehicles and pedestrians accessing the building/facility. Providing an option away from the building, at the back of the parking lot, can reduce these vehicle-pedestrian conflicts. Vehicular traffic should still have access to the front of the building, as this can help with dropping people off or loading vehicles. Crosswalks should be consolidated in front of the building to minimize the number of locations where pedestrians are encouraged to cross, thereby reducing pedestrian-vehicle conflict points. The figure below shows consolidation of crosswalks in front of a base exchange building, along with addition of sidewalks running parallel to the circulation roadway to encourage pedestrians to walk to the crosswalk.

For lower-turnover development, such as office buildings where vehicles typically park either for extended time periods, longer walking distance are expected between the parking space and the building. Parking can be located farther from the building as a result. Ideally, parking for a building should be located such that pedestrians are not required to cross a street. Locating the parking lot across the street from the building may result in need for a marked, midblock crosswalk. Some layouts do not allow for the building and its parking to be co-located on the same side of the street. If the parking must be located across the street from the building it serves, one potential advantage is that stand-off distance between the building and vehicles is provided.

Recommendation for Consolidation of Crosswalks at Existing BX

(Source: Installation Aerial Imagery)



Design Vehicles

The proper design vehicle for a development can vary by location and function. If most vehicles accessing the facility are passenger cars, the site should be designed for this vehicle type. Consider the need for occasional large vehicles, such as delivery vehicles, emergency vehicles, snowplows particularly in northern climates, or school or transit buses. At a minimum, access aisles to parking lots should be designed for a single unit truck to provide a buffer more than a passenger car. Access points to buildings should be designed for the largest vehicle expected, which may vary by use. It is acceptable for large vehicles to offtrack into adjacent lanes if they are so infrequent so as to not impede traffic.

The table below summarizes common design vehicles, that should be considered, for various areas on a military installation.

Suggested Design Vehicles for Various Installation Locations

Area \ Vehicle	Passenger Car	Bus	Truck	RV
POV Gate	X	X		X
POV Gate, Outbound			X	
Housing Area		X		
Parking Lot	X			
Truck Gate			X	
Camping Area				X
Arterials			X	
Collector Roadways		X	X	X
Route to Loading Dock			X	
Warehouses			X	
Industrial Areas			X	
School Routes		X		
Residential Alleys	X			
Residential Driveways	X			

Pedestrian and Bicycle Considerations

Pedestrians and bicycles should be considered as part of site design. With increasing emphasis on walkability, fitness, and less dependence on automobiles, pedestrian and bicycle facilities are increasingly beneficial. Pedestrians should be accommodated by continuous sidewalks, connecting between the external site sidewalks and any pedestrian destination in the development, including the doorways, parking lots, and any sidewalks within the site. As with any traditional crosswalk connecting to a sidewalk, curb ramps must be provided, and they must meet PROWAG requirements. Lane widths should not exceed 12 feet for roadways and access points within the site. Lane widths as narrow as 10 feet can be used to further reduce speeds and maintenance costs. It is preferred, but not required, to have a narrow grass strip between the road and sidewalk. The sidewalk should be at least 4 feet in width for PROWAG compliance, or wider if considerable pedestrian traffic is expected. Most state departments of transportation construct 5-foot sidewalks to negate the requirement of providing a 5'x5' passing space every 200 feet.

Crosswalks should be signed and marked in compliance with Manual on Uniform Traffic Control Devices requirements and TEA's *Crosswalk Warrant and Guidelines*. A crosswalk should be located at controlled intersections, and uncontrolled locations where warranted based on the TEA *Crosswalk Warrant and Guidelines*.

Bicycle access should be considered in design. Bike lanes can be provided adjacent to roadway travel lanes, but in their absence, bikes can travel in the roadway travel lane. Bikes traveling on the existing external roadway, or planned to after the site opens, most likely travel in either the shoulder, if present, or in the travel lane. Development driveways have lower traffic volumes as compared to adjacent roadways, so it is usually not necessary to provide bike lanes adjacent to the development access points. If multi-use trails are present, they can be used for both bicycles and pedestrians. Multi-use trails differ from sidewalks in that they are wider, typically 8 to 10 feet in width, to allow for bidirectional flow or passing in the same direction.

Most developments should be equipped with bike racks for parking and locking bikes. Like vehicular parking design, parking duration for bicycles should be considered. Retail developments typically have shorter duration parking requirements as compared to office buildings. Both development types should provide

adequately sized bicycle parking facilities. Bike racks should be in a place out of the way of pedestrians passing through, pedestrians entering and exiting the building, emergency exits, designated locations for smoking, landscaping, and roadway travel lanes. They can be located under a canopy to provide an opportunity for lighting and rain protection since exposure to rain and the elements can cause bikes to rust, but this is not often practical especially for short-term bike parking, and therefore not necessary.

Internal Signing and Markings

Traffic control devices, such as signing and pavement markings internal to a site, must meet MUTCD requirements. It is sometimes mistakenly believed that since a parking lot or internal circulation roadway is not a "real" roadway, they are not required to follow MUTCD standard marking and signing requirements. This is only partially true because parking areas and driving aisles within the parking area do not need to conform to the MUTCD as a roadway does. Primary driveways of larger developments, such as an Exchange or Commissary, should conform to the MUTCD, since they function as a roadway and often intersect a primary roadway on base. That said, if an area need not conform to the MUTCD, this does not mean that a traffic control device in place can be in violation of the MUTCD. It only means that traffic control devices are not necessary at these locations.

There are certain low volume thresholds beneath which pavement markings are not required. Specifically, neither centerlines nor edgelines are required where average daily traffic volumes are less than 6,000 vehicles per day. They may be used, which is often beneficial, but they are not required. Above these thresholds, they must be used as would be with any other roadway.

Signing must be consistent with the MUTCD. To the extent possible, standard signs must be used. If a standard sign cannot convey the message desired, contact TEA for assistance. It may be possible to reassess the condition to eliminate the need for a special sign. Signing often needs consideration on driveways and internal intersections. If site driveways or parking access aisles are one-way, be sure to sign appropriately.

This photo illustrates an alteration of the standard DO NOT ENTER (R5-1) sign panel used at a site access, violating the MUTCD. At a glance, this sign is easily misinterpreted.

Roadside Hazards

Roadside safety must be considered in site design. Provide roadway clear zones, or a width beyond the travel way free of roadside obstructions available in case a vehicle runs off the road, just as with any other roadway. Clear zone widths are a function of speed and traffic volumes, so since speeds and traffic volumes are relatively lower on development roadways, lower clear zone thresholds are often adequate. For example, for speeds of less than 40 MPH and design ADT volumes of less than 750 vehicles per day, a clear zone of 7-10 feet is required for side slopes of 4:1 or flatter.

This photo illustrates a light pole foundation extending approximately 4 feet above ground in the clear zone

Specific items to consider include the following:

- ☑ Light Poles – Ensure that the foundation extends 6 inches max above ground.
- ☑ Signposts – Ensure signposts in the clear zone are a breakaway design.
- ☑ Bollards – Do not use bollards to protect other fixed objects in the clear zone. Instead, it is preferred to remove or relocate the fixed object. At a minimum, the fixed object should be delineated with an object marker.
- ☑ Drainage features – Ensure that headwalls do not extend above ground.
- ☑ Fences and Pedestrian Control Railings – If used, ensure that they are out of the clear zone.
- ☑ Guardrails – Guardrails are intended to protect from more severe run off the road consequences, but guardrails are themselves hazards and should be used only where the consequences of hitting the barrier are less severe than the consequences of running off the road.

Site Plans

Site plans showing the design of the site layout are crucial. It is common for a contractor to develop the site plans, with installation personnel having review supervision over the project. The site plan should show design of features such as the building location, sidewalks, parking lot, site access points, landscaping, and drainage. It should also show signing and pavement marking design. The site plan should have a turning path analysis to ensure that the geometry is correct for the design vehicle. While the site plan generally falls into the civil or traffic engineering realm, it is assumed that the building plan is in the architectural realm, and beyond the scope of this bulletin. However, it would need to be part of a development design.

The following traffic engineering features should be considered in review of a site plan:

- Building located appropriately based on vehicular and pedestrian access.
- Proper pedestrian access, including crosswalks located properly, pedestrians not required to cross major traffic routes.
- Sidewalks connecting to parking lots and existing pedestrian walkways in a logical manner.
- Proper layout of parking lot, considering space size, ideal layout of access aisles, adequately sized access points linking the parking lot and the external roadway. See SDDCTEA Pamphlet 55-17 for additional discussion on parking requirements.
- Good access management for the site such as access point location with respect to other nearby access points and/or intersections
- Proper number of driveways for the projected amount of traffic.
- Opportunities to combine driveways with existing access points.
- Left turns in and out of the site operating safely with external roadway traffic.
- Traffic circulation is ideal for any vehicular-based service, such as an ATM or drive through restaurant. Drive through restaurant should have sufficient queue space for the anticipated queues.
- Verify that any proposed landscaping and proposed signs will not block sight distance for critical locations, such as crosswalks, intersections, and parking lot access aisles or signing. The type of landscaping proposed should not be of a type that will grow over a period of time to block sight distance.
- Verify that there are no potential fixed roadside objects or hazards.
- Verify that the correct design vehicle is used, including POVs, emergency vehicles, and/or delivery trucks
- Verify that if construction impacts an adjacent roadway open to traffic, that proper work zone traffic control is proposed.
- Plans should include any offsite improvements required as part of the traffic impact study, including turn lanes, roadway widening, and/or intersection improvements necessary to accommodate site traffic.
- Construction vehicle travel routes within the installation from the gate to the site should be shown, especially if there are areas of the base where construction traffic is not desired.

Some sites are constrained, and in such a case, it is critical that traffic issues be mitigated as much as possible. The engineering site plan should be developed to common design standards, such as those developed by AASHTO, FHWA, ITE, SDDCTEA, and DOD. Plan coverage should be complete to show the entire area where work is being done, including any off-site work.

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Mr. Bruce A. Busler, SES
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